
**FACILITY DESCRIPTIONS
AND UPDATED COST ESTIMATES
FOR LAKE BERRYESSA ENLARGEMENT**

**Prepared by the CALFED Storage and Conveyance Refinement Team
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INTRODUCTION

The *Facility Descriptions and Updated Cost Estimates for Lake Berryessa Enlargement* has been prepared as part of the Storage and Conveyance Component Refinement Task of the CALFED Bay-Delta Program (CALFED or Program). CALFED's mission is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) system.

This report summarizes the principal features, estimated costs, and environmental considerations of enlarging Lake Berryessa from its present capacity of 1.6 million acre-feet (maf) to either 6.0 maf or 13.3 maf. This evaluation and others that are being performed by CALFED are intended to provide a facilities evaluation and updated cost estimates of representative storage and conveyance components. The objectives of the Lake Berryessa Enlargement evaluation are (1) to provide an updated cost estimate which represents a cost within the range expected if the project were to be constructed today and (2) to enable CALFED to equally compare this project against other projects that might be considered as part of a long-term CALFED solution strategy.

The cost estimate for the Lake Berryessa Enlargement is based on information in the California Department of Water Resources (DWR) July 1978 report *SWP Future Water Supply Program: Enlarged Berryessa Reservoir Reconnaissance Study*. The cost estimates presented by DWR in that report have been reviewed and adopted for this evaluation. Modifications have been made to reflect current design and safety standards where appropriate.

A preliminary evaluation of the environmental considerations associated with this project has also been included in this report. Fish, wildlife, plant, and cultural resources that could be affected have been described and potential impacts have been identified. The information for the evaluation of environmental considerations was gathered from existing literature and databases.

PROJECT BACKGROUND

The enlargement of Lake Berryessa has been considered by DWR since the 1960s for off-stream storage north of the Delta. In DWR's *North Coastal Area Investigation*, Bulletin 136, prepared in 1964, the State identified the "Greater Berryessa Project" which had the equivalent storage of Shasta, Oroville, Trinity, Folsom, and Auburn Reservoirs combined (approximately 14 maf). The Greater Berryessa Project was proposed to provide reregulation of imported water from the Eel River and storage of flood flows pumped from the Sacramento River. The study suggested that a large pumped-storage power generation installation could be included in the project.

In 1978, DWR, Division of Design and Construction completed *The SWP Future Supply Program - Enlarged Berryessa Reservoir Reconnaissance Study* (Berryessa Report), which identified three "Expanded Lake Berryessa Facilities." This report also identified the associated costs for 6.0, 9.0, and 13.3 maf storage reservoirs. This reservoir would serve as off-stream storage for excess water diverted from the Sacramento River. Stored water would be released during low flow periods to supplement flows in the Delta. This analysis includes the information presented in the Berryessa Report for the 6.0 and 13.3 maf Lake Berryessa enlargements.

FACILITIES DESCRIPTION

This section provides an overview of the major features that would be included in the proposed Lake Berryessa Enlargement. The principal reference used for this synopsis is DWR's 1978 Berryessa Report. That report provides a cost estimate and facilities description for enlarging Lake Berryessa and constructing the Lake Berryessa Intertie between the lake and the Sacramento River. The present evaluation focuses only on the enlargement of Lake Berryessa. The Lake Berryessa Intertie project is being evaluated separately by CALFED.

PROJECT LOCATION

The existing Lake Berryessa is located on Putah Creek about eight miles west of the town of Winters in Solano County (Figure 1). Putah Creek is an ephemeral stream that flows east out of the Coast Range into the Yolo Bypass, which is tributary to the Delta. The dam site for the enlarged reservoir would be located in the Putah Creek canyon about two miles downstream of the existing Monticello Dam. The Lake Berryessa Enlargement would inundate the existing Monticello Dam.

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The dam site is located in the Coast Range geomorphic province which typically includes Mesozoic marine sedimentary deposits. Much of the northwest-southeast trending ridge-valley topography of the Coast Range north of San Francisco Bay results from the northwest-southeast trending faults which cover much of the area. These faults run approximately parallel to the San Andreas Fault, which lies about 50 miles west of the project location. This area is seismically active; Winters was destroyed in an earthquake in 1892. Two known faults in the area include the Berryessa Thrust Fault and the Wragg Canyon Fault. It is possible that additional undiscovered faults are located in the area.

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PROJECT DESCRIPTION

The primary purpose of enlarging Lake Berryessa would be to store excess flows from the Sacramento River. The existing reservoir currently has a high storage-to-inflow ratio and enlarging the reservoir would not generate increased water supply opportunities from the Putah Creek watershed. With the construction of new or expanded conveyance facilities to connect an enlarged Lake Berryessa to the Sacramento River, the Lake Berryessa Enlargement could provide long-term storage for surplus Sacramento River flows.

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LAKE BERRYESSA ENLARGEMENT

The Lake Berryessa Enlargement consists of an enlarged storage reservoir, conveyance tunnels and canals, and pumping-generating plants. Two alternative storage capacities have been investigated for this evaluation: 6.0 maf and 13.3 maf. Both alternatives would require constructing a new rock-fill dam about two miles downstream of the existing dam site. Both alternatives would inundate the existing reservoir, which has a storage capacity of 1.6 maf. The enlargement of Lake Berryessa would also include the construction of new conveyance facilities featuring a 12,000-foot-long tunnel which would serve to move water into and out of storage.

Two alternative conveyance facilities which are the subject of similar evaluations being performed by CALFED are the extension of the Tehama-Colusa Canal and the construction of the Berryessa Intertie. The Tehama-Colusa Canal extension would deliver water to Lake Berryessa from diversions on the upper Sacramento River. The Berryessa Intertie would divert water from the Sacramento River in the vicinity of the Sacramento Weir and convey water to Lake Berryessa through a new canal and a series of pumping-generating plants. The Berryessa Intertie would also serve as the conduit to return water stored in Lake Berryessa to the Sacramento River for uses in the Delta. The Winters Pumping Plant was determined to be a common point among the alternatives and was used as an endpoint in the separate evaluations.

Lake Berryessa's proximity to the Delta and other existing or proposed facilities would enable the water stored in the reservoir to be used for environmental and water supply uses in the Delta.

The ability to deliver water to Lake Berryessa either from the Tehama-Colusa Canal Extension or the Berryessa Intertie would depend on ongoing activities associated with CALFED, the Central Valley Project Improvement Act, and Water Quality Standards for the Bay-Delta.

EXISTING FACILITIES

The existing Monticello Dam which impounds Lake Berryessa is located on Putah Creek at the Napa-Yolo county line, about eight miles west of Winters. It is owned and operated by the

Bureau of Reclamation as part of the Solano Project. Monticello Dam was completed in 1957 and consists of a concrete arch dam with the crest of the dam at 456 feet above mean sea level (MSL). At its normal water surface elevation of 440 feet above MSL, Lake Berryessa has a storage capacity of 1.6 maf and has a firm annual yield of 247,000 acre-feet. The existing reservoir develops all of the watershed's natural inflow, which averages about 350,000 acre-feet per year. The reservoir provides water to agricultural areas within Solano County through the Putah South Canal. The Putah South Canal is operated by Solano Irrigation District. Excess storage in Lake Berryessa is provided to the North Bay Aqueduct for use in the Napa Valley.

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PRINCIPAL FACILITIES

This section provides an overview of the major features associated with the Lake Berryessa Enlargement. These features include the embankment dam, inlet/outlet works, Berryessa Tunnel, Chapman Ranch Canal, Berryessa Pumping-Generating Plant, and the Winters Pumping-Generating Plant. The principal reference used for this synopsis was DWR's 1978 report *SWP Future Supply Program, Enlarged Berryessa Reservoir Reconnaissance Study*. The principal facilities of the Lake Berryessa Enlargement are listed on Table 1 and shown in Figure 2.

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The primary feature of the Lake Berryessa Enlargement would be the large off-stream storage reservoir formed by Lake Berryessa Dam on Putah Creek. The smaller reservoir would have a storage capacity of 6.0 maf, while the larger reservoir would have the same general configurations and a storage capacity of 13.3 maf.

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Conveyance facilities required for either of the Lake Berryessa Enlargement alternatives include the Berryessa Tunnel, Berryessa Pumping-Generating Plant, Chapman Ranch Canal, and Winters Pumping-Generating Plant. A schematic of both alternatives is shown on Figure 3.

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Main Dam

Two capacities for an enlarged Lake Berryessa are under consideration, 6.0 and 13.3 maf. For either expansion, a new, rock-filled dam would be located about two miles downstream of Monticello Dam on Putah Creek. Figure 4 shows the area-capacity curves for this location.

6.0 maf Lake Berryessa Enlargement: The smaller dam would be an earth and rock-fill dam rising 470 feet above the streambed. The dam crest elevation would be at 655 feet above MSL and would inundate a total of about 35,000 acres. The dam would have a total volume of approximately 27.6 million cubic yards.

13.3 maf Lake Berryessa Enlargement: The larger dam would be an earth and rock-fill dam rising 620 feet above the streambed. The dam crest elevation would be at 805 feet above MSL and would inundate a total of about 63,000 acres. The dam would have a total volume of approximately 62.3 million cubic yards.

Because of the potential for seismic activity, the crest width of the dam would be 40 feet wide and a freeboard of 30 feet would be used. The side slope area has been based on the Cedar Springs Dam, which was designed for a 0.15 g horizontal seismic acceleration. A side slope of 3:1 would be used on the upstream face and 2.25:1 on the downstream face.

The dam foundation stripping was assumed to be 15 to 30 feet. A grout curtain would be included to one-half the depth of the reservoir. Foundation grouting has been estimated to require two rows of holes on a primary spacing of 10 feet.

Based on available information, the embankment zoning would be similar to the Cherry Valley Dam. This design includes a larger section of impervious zone with a smaller rock zone. The selected design would be more economical based on local availability of materials. The

impervious zone would consist of clay alluvium material borrowed from within the reservoir area. Material for the gravel transition zones would be borrowed from the Cache Creek area and from the Putah Creek streambed. The pervious zone material would consist of a strong, durable basalt from Putman Peak and a less durable sandstone from Plesants Ridge and Blue Ridge.

Spillway Control Structure

The spillway for the reservoir would be located on the left abutment of the dam. For the 6.0 maf expansion, the spillway elevation would be at 600 feet above MSL. For the 13.3 maf expansion, the spillway elevation would be at 750 feet above MSL. The maximum probable flood flow of 50,000 cfs could pass over the top of the radial gates without overtopping the dam. In an emergency condition, the radial gates could be opened to provide a drawdown rate of 100,000 cfs under full reservoir head. The wall heights along the spillway would vary from 50 to 80 feet, and the spillway channel would have a constant bottom width of 100 feet.

Dam Outlet Works

The river outlet works would be sized to match the existing outlet for Monticello Dam and would provide a release capacity to Putah Creek no smaller than presently exists. The outlet works would consist of a low water intake structure and a high water intake tower. Both the 6.0 and 13.3 maf facilities would have a low water intake at 250 feet above MSL. For the smaller facility, the high intake tower would have a port at 440 feet above MSL. The larger facility would have ports at 440 feet and 600 feet above MSL. The 6.0 and 13.3 maf facilities would have river outlet works capacities of 30,000 cfs and 120,000 cfs, respectively, based on emergency release requirements of DWR's Division of Safety of Dams. The emergency release requirements are described below.

Emergency Release

In the event of potential emergency conditions, the outlet works and spillway would need to evacuate 10 percent of the maximum water depth within ten days as required by DWR's Division of Safety of Dams. With this criterion, the emergency drawdown flow for the 6.0 maf Lake Berryessa Enlargement alternative is estimated at 1.5 maf over 10 days. The release of 41.5 feet of storage through the spillway would vary from 100,000 cfs to 6,200 cfs over a ten-day period. Assuming a uniform river outlet works release rate over the entire head range yields an estimated river release capacity of 35,000 cfs to evacuate the full 41.5 feet within the ten-day period. The inlet-outlet works from the reservoir to the Berryessa Tunnel could accommodate 5,000 cfs, and therefore, the river outlet works must release 30,000 cfs.

For the 13.3 maf Lake Berryessa Enlargement, the outlet works and spillway would need to evacuate 10 percent of the maximum water depth within a ten-day period. With this criterion, the emergency drawdown flow is estimated at 3.2 maf over ten days. The release of the top 50 feet of storage (2.8 maf) could be accommodated through the spillway over an eight-day period, with flows varying from 100,000 to zero cfs. Assuming a uniform river outlet release rate over the entire head range for the ten-day period yields an estimated release requirement of 125,000 cfs to evacuate the full 56.5 feet. The inlet-outlet works from the reservoir to the Berryessa Tunnel could accommodate 5,000 cfs, and therefore, the river outlet works must release 120,000 cfs.

It should be noted that releases of this magnitude down Putah Creek would have significant undetermined impacts on downstream areas and would occur only in emergency situations when the safety of the dam was in question. The maximum observed flow on Putah Creek was 81,000 cfs in February 1942. After 1957, when Monticello Dam was constructed, the largest flow on Putah Creek was 18,700 cfs in March 1983.

Stilling Basin

For either expanded facility, the stilling basin invert elevation would be 150 feet above MSL and have a maximum capacity of 50,000 cfs. The stilling basin would be capable of handling the probable maximum flood flow of 50,000 cfs. However, it is anticipated the basin would be destroyed at the emergency drawdown rate of 100,000 cfs. These emergency flow conditions would only be made if the safety of the dam was threatened and such drastic action was needed to prevent dam failure.

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Berryessa Tunnel

The Berryessa Tunnel would extend from the Berryessa Pumping-Generating Plant to within the inundation area of either Lake Berryessa enlargement configuration, about one mile north of the proposed dam site. The Berryessa Tunnel would have a capacity of 5,000 cfs, an inside diameter of 25 feet, and a length of 12,000 feet. The tunnel would have horseshoe-shaped supports spaced at 2-foot intervals in unconsolidated material and at 6-foot intervals in stratified material.

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The available geologic information indicates that the tunnel would pass through three formations: the Tehama Formation, the Capay Formation, and the Great Valley Sequence. Approximately 1,100 feet of the tunnel would be within the Tehama Formation, which is composed of unconsolidated clays, silts, sands, and gravels. About 600 feet of the alignment would pass through the Capay Formation, which consists of mudstones and sandstones. The remaining 10,300 feet of the alignment would pass through the Great Valley Sequence, which is composed of alternating beds of sandstone, siltstone, and shale.

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Berryessa Pumping-Generating Plant

The Berryessa Pumping-Generating Plant would be located at the junction of the Berryessa Tunnel and the Chapman Canal. The Berryessa Pumping-Generating Plant would have a penstock length of 1,500 feet. For the 6.0 maf Lake Berryessa Enlargement, the pumping plant would have a maximum static head of 310 feet, a pumping energy requirement of 120 megawatts, and a generating capacity of 91 megawatts. For the 13.3 maf Lake Berryessa Enlargement, the pumping plant would have a maximum static head of 460 feet, a pumping energy requirement of 180 megawatts, and a generating capacity of 137 megawatts.

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Chapman Ranch Canal

The Chapman Ranch Canal would be located between the Winters Pumping-Generating Plant and the Berryessa Pumping-Generating Plant. It would be the same facility for either Lake Berryessa Enlargement configuration. It would be about 21,100 feet long and have a bottom width of 22.5 feet at 5,000 cfs capacity. It would be a concrete-lined, trapezoidal canal with 2:1 side slopes and would have a lined freeboard of three feet with an additional two feet up to the operating road. For sizing, the canal was assumed to have a design velocity of 4.0 feet per second. The canal would have an excavation volume of 2.57 million cubic yards and an embankment volume of 1.31 million cubic yards.

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Winters Pumping-Generating Plant

The Winters Pumping-Generating Plant would be located at the eastern end of Chapman Ranch Canal, the terminus of this evaluation. The Winters Pumping-Generating Plant would have a penstock 800 feet long. For both sizes of the Lake Berryessa Enlargement, the plant would have a maximum static head of 140 feet, a pumping energy requirement of 70 megawatts, and a generating capacity of 52 megawatts.

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Relocation

Regardless of the final alternative configuration selected, numerous roads would require relocation. These roads include Pope Valley Road, Capell Creek Road, Wragg Ridge, Blue Ridge, Aetna Springs, Bishop Mountain Road, and State Highway 128.

Several resorts and some recreational facilities are located along the existing lakeshore. These facilities and some private residences would need to be relocated for either enlargement alternative. The cost of relocating these facilities has not been included in this evaluation.

COST ESTIMATE

The cost estimate for the identified facilities is based on the DWR's 1978 Berryessa Report and includes only the costs of the facilities identified in the Berryessa Report. Additional project costs not identified in the report are not included in the estimate. Some of these additional costs include environmental documentation and mitigation, operation and maintenance, power, filling of the reservoir, recreational development and relocation, and interest during construction.

COST ESTIMATE METHODOLOGY

The basis of this cost estimate originates from the cost estimates in the 1978 Berryessa Report. These cost estimates have been reviewed and adopted for the present cost estimate update. Several items in the previous cost estimates were modified to ensure that current design standards and safety factors were incorporated.

General

The cost estimates for the 6.0 and 13.3 maf Lake Berryessa Enlargements were determined by applying current unit costs to quantities found in the Berryessa Report. Current unit costs were determined by escalating the unit costs found in the 1990 DWR report entitled *Los Banos Grandes Facilities Feasibility Report, Appendix A: Designs and Cost Estimates* (LBG Report). The unit costs were escalated to October 1996 dollars by using the Bureau of Reclamation's Construction Cost Trends indices. Wherever possible, these escalated LBG unit costs were applied to quantities taken from the Berryessa Report. If there was insufficient detail in the Berryessa Report to apply these escalated unit costs or if the LBG Report did not have a unit cost for a specific item in the Berryessa Report, the unit cost or lump sum cost from the Berryessa Report was escalated to October 1996 dollars.

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Right-of-Way Costs

Right-of-way costs of \$7,000 per acre were based on land use costs developed by the Bureau of Reclamation, Land Resources Branch (pers. comm. February 1997). The total project lands to be acquired would include a buffer around the maximum water surface area. The ratio of total project land to maximum water surface area used in the cost estimate is 1.32 based on data from the LBG Report.

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Outlet Capacity Adjustments

The river outlet works as sized in the Berryessa Report can release 1,200 cfs. In the event of potential emergency conditions, the outlet works and spillway must be able to evacuate 10 percent of the maximum water depth in ten days as required by DWR's Division of Safety of Dams. To develop costs for the river outlet works facility capable of releasing 30,000 cfs for the

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6.0 maf alternative and 120,000 cfs for the 13.3 maf alternative, the cost of the 1,200 cfs river outlet was factored by the following empirical equation:

$$\frac{(Cost)_1}{(Cost)_2} = \frac{Q_1^{3/6}}{Q_2^{3/6}}$$

This cost factor formula is typically valid over moderate ranges in capacity; the validity over larger ranges is undetermined. However, because the estimated cost of the outlet works is a relatively low percentage of the total project cost, the impact of any error resulting from utilizing this ratio beyond its valid range is considered to be within the range of the accuracy of the estimate.

Pumping-Generating Plant Costs

The pumping-generating plant cost estimates are based on actual construction costs for the Waddell Pumping-Generating Plant in Arizona, which was completed in 1994 and is similar in size and scope to the Berryessa Pumping-Generating Facility. To develop a cost for the Berryessa Pumping-Generating Facility, the actual construction cost of the Waddell Pumping-Generating Plant (escalated to October 1996 dollars) was factored by the following empirical equation:

$$\frac{(Cost)_1}{(Cost)_2} = \frac{HP_1^{6/10}}{HP_2^{6/10}}$$

The cost factor formula is typically valid over moderate ranges in horsepower; the validity over larger ranges is undetermined. The impact of any error resulting from utilizing this ratio beyond its valid range is also expected to be within the range of the accuracy of the estimate.

Contingencies and Other Costs

All contingencies and engineering, construction management, and administrative factors were determined by historical engineering judgment based on a similar level of cost estimation. Contingencies were chosen to be 20 percent, and engineering, construction management, and administration were chosen to be 35 percent. A cost range was developed for the project by subtracting 10 percent from the estimated capital cost for the low end cost and adding 15 percent to the estimated capital cost for the high end.

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PRELIMINARY COST FINDINGS

The 6.0 maf Lake Berryessa Enlargement would consist of a new earth and rock-fill dam and associated facilities that would increase the total storage available at the site by about four times the existing storage capacity. The total cost of this project is estimated to range from \$1,627 million to \$2,078 million. A detailed estimate of the cost of this facility is provided in Table 2a. Table 3 provides a summary of the costs of the principal project features.

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The 13.3 maf Lake Berryessa Enlargement would increase the available storage at the site by about eight times the existing storage capacity. The total cost of this project is estimated to range from \$2,483 million to \$3,173 million. A detailed estimate of the cost of this facility is provided in Table 2b. Table 3 provides a summary of the costs of the principal project features.

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ENVIRONMENTAL CONSIDERATIONS

This portion of the evaluation provides a summary of environmental considerations related to the proposed Lake Berryessa Enlargement. Fish, wildlife, plant, and cultural resources that could be affected by the project have been identified and the potential impacts described. For the most

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part, the information presented in this section was gathered from existing literature, with limited original research. No field work was conducted for this analysis.

The Lake Berryessa Enlargement would inundate an additional 15,600 to 43,600 acres of terrestrial wildlife habitat and several miles of warmwater stream habitat relative to the 6.0 maf and 13.3 maf Lake Berryessa Enlargement alternatives. Certain waterfowl species would benefit from increased water surface area in terms of foraging and rafting habitat. The project could have some beneficial effects on game fish production in the enlarged lake, and depending on release patterns and volumes, could positively or negatively affect cool-water species in the lower Putah Creek. There are no special-status fish species within the inundation area of either enlargement configuration. However, there are 11 special-status wildlife species and 18 sensitive and listed plant species that may be affected by the proposed project.

FISH, AMPHIBIANS, REPTILES, AND INVERTEBRATES

Lake Berryessa and Putah Creek provide habitat for both warmwater and coldwater fish species. Representative game fish species include largemouth bass, smallmouth bass, black crappie, white catfish, bluegill, spotted bass (introduced), Florida largemouth bass (introduced), rainbow trout, brown trout, coho salmon (introduced), and chinook salmon (introduced). Representative nongame fish species include California squawfish, California roach, golden shiner, carp, brown bullhead, and mosquito fish.

The existing fishery in Lake Berryessa would not be significantly impacted if the reservoir is operated in a manner similar to the present. However, increases in reservoir volume, shoreline length, and nutrient levels could be beneficial to game fish production. If water quality changes, resident warmwater game species, such as largemouth bass, sunfish and catfish, would exhibit lower reproductive success. Depending on release volumes and schedules, changes in water

releases to lower Putah Creek could positively or negatively affect cool-water species such as trout.

Potential fish losses resulting from enlarging Lake Berryessa could be mitigated by developing additional warmwater game fish cover in the lake, improving trout habitat along the lower portions of Putah Creek, and developing a detailed fishery management program for Lake Berryessa and Putah Creek.

GENERAL WILDLIFE

Wildlife habitat adjacent to Lake Berryessa and along Putah Creek supports a diverse faunal assemblage. Game species in the area include blacktail deer, California quail, mountain quail, mourning dove, wild turkey, and ring-necked pheasant. Representative furbearers include raccoon, spotted skunk, striped skunk, bobcat, gray fox, coyote, and opossum. Birds found in the area include waterfowl, wading birds, raptors, and various songbirds. Heron rookeries are located on the northern and southwestern shores of the lake. The lake serves as a wintering and rafting area for waterfowl.

The effects of the proposed enlargement of Lake Berryessa on wildlife would be mixed. Habitat for deer, small game animals, and birds would be reduced, but habitat for waterfowl would be increased.

SENSITIVE AND LISTED FISH AND WILDLIFE SPECIES

No special-status fish species are known to exist within the area of the Lake Berryessa Enlargement.

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According to the California Department of Fish and Game's (CDFG) California Natural Diversity Data Base records (Version 8/96), four wildlife species that are State or federally listed and seven wildlife species that are either candidates for listing or species designated by CDFG as "species of special concern" could potentially occur in the area affected by the proposed enlargement of Lake Berryessa.

The listed wildlife species that could be affected by the proposed project include Valley elderberry longhorn beetle (federal threatened), northern spotted owl (federal threatened), bank swallow (State threatened), and California freshwater shrimp (federal endangered/state endangered).

Wildlife species that are either candidates for State or federal listing or considered species of special concern by the CDFG, that could be affected by the proposed project include foothill yellow-legged frog and the northwestern pond turtle (both federal candidates/CDFG species of special concern) and sharp skinned hawk, golden eagle, prairie falcon, purple martin, and yellow breasted chat (all CDFG species of special concern).

VEGETATION

Vegetation within the inundation area of the 13.3 maf Lake Berryessa Enlargement consists primarily of the following approximate acreages: 24,000 acres of foothill woodland, 10,400 acres of scrub, 6,700 acres of grassland, 4,000 acres of agriculture lands, 1,600 acres of riparian vegetation, and 900 acres of disturbed areas.

The proposed enlargement of Lake Berryessa would impact approximately half of the Butts Canyon Natural Area and most of the Cold Canyon Ecological Reserve. The area contains two sensitive plant communities: dry riparian with willow and cottonwood along the narrow canyon bottom and oak-grey pine woodland along the slopes. Also, rare plant species occur in the area.

SENSITIVE AND LISTED PLANT SPECIES

Federal- or State-listed plant species or plants proposed for listing that may occur in the Lake Berryessa Enlargement area include Lake County western flax (State endangered), few-flowered navarretia (State threatened/proposed federal endangered), many-flowered navarretia (State endangered/proposed federal endangered), Boggs Lake hedge-hyssop (State endangered), slender orcutt grass (State endangered/proposed federal endangered), Napa blue grass (State endangered/proposed federal endangered), Contra Costa goldfields (proposed federal endangered), and Calistoga popcorn-flower (proposed federal endangered).

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Candidate plant species for federal listing that may occur in the project area include Socrates Mine jewelflower, legenere, Mt. St. Helena morning glory, Brewers western flax, drymaria-like western flax, snow mountain buckwheat, Calistoga ceanothus, Rincon Ridge ceanothus, and adobe lily.

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Colusa layia, which has been listed by the California Native Plant Society as being rare, threatened, or endangered in California and elsewhere, could also be affected by an enlarged Lake Berryessa.

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WETLANDS

The U.S. Fish and Wildlife Service's National Wetland Inventory Map was used to identify the existence of wetland areas that would be inundated by an enlarged Lake Berryessa. Based on the 13.3 maf Lake Berryessa Enlargement, there are approximately 12 miles of intermittent streambed, 8 miles of shrub-scrub wetland, 20 miles of forested wetland, 7 miles of seasonally flooded wetland (shallow marsh), one-half mile of seasonally flooded wetland (wet meadow), 140 acres of open water (artificially flooded wetlands), 120 acres of diked or impounded ponds, 10 acres of seasonally flooded ponds (shallow marsh), 4 acres of temporarily flooded ponds (wet meadow), and 20 acres of intermittently exposed, permanent ponds.

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CULTURAL RESOURCES

A total of 224 archeological and four ethnographic sites have been recorded in the area of the proposed Lake Berryessa enlargement. Of the archeological sites, 82 are significant. Three ethnographic sites contain human remains.

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Table 1
SUMMARY OF PHYSICAL CHARACTERISTICS
LAKE BERRYESSA ENLARGEMENT

	Existing (1.6 maf)	6.0 maf	13.3 maf
Reservoir			
Normal Pool Elevation (feet MSL)	440	660	750
Capacity at Normal Pool Elevation (maf)	2	6	13
Inundation Area (acres)	19,400	35,000	63,000
Main Dam			
Type	Concrete Arch	Rockfill	Rockfill
Height above Streambed (feet)	271	470	620
Embankment Volume (cubic yards)	326,000	27,600,000	62,300,000
Freeboard (feet)	16	30	30
Downstream Face Slope (horizontal on vertical)	0.3:1	2.25:1	2.25:1
Upstream Face Slope (horizontal on vertical)	vertical	3:1	3:1
Saddle Dams			
Number Required	-	-	-
Outlet Works			
Low Intake Tower Elevations (feet MSL)	NA	240	240
High Intake Tower Elevations (feet MSL)	NA	440	440
Capacity	1,200	30,000	120,000
Spillway Control Structure			
Capacity (cfs)	48,400	100,000	100,000
Invert Elevation (feet MSL)	456	550	700
Stilling Basin			
Capacity (cfs)	NA	50,000	50,000
Invert Elevation (feet MSL)	NA	150	150
Berryessa Tunnel			
Capacity (cfs)	NA	5,000	5,000
Length (feet)	NA	12,010	12,010
Berryessa Pumping/Generating Plan			
Maximum Static Head (feet)	NA	310	460
Pump Requirement (MW)	NA	120	180
Generating Capacity (MW)	NA	91	137
Penstock Length (feet)	NA	1,500	1,500
Chapman Ranch Canal			
Maximum Static Head (feet)	NA	5,000	5,000
Pump Requirement (MW)	NA	21,200	21,200
Generating Capacity (MW)	NA	2,570,000	2,570,000
Penstock Length (feet)	NA	1,310,000	1,310,000
Winters Pumping/Generating Plant			
Maximum Static Head (feet)	NA	140	140
Pump Requirement (MW)	NA	70	70
Generating Capacity (MW)	NA	52	52
Penstock Length (feet)	NA	800	800

Source: *SWP Future Water Supply Program, Enlarged Berryessa Reservoir Reconnaissance Study* (DWR, 1978).

Table 2a
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (6.0 MAF ALTERNATIVE)

D-004627

D-004627

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL. 78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
I. ROAD RELOCATIONS								
Roadway Excavation								
Pope Valley Road	529,000	CY				\$3.98	\$2,105,420	1, item V-b1
Capell Creek parallel	572,000	CY				\$3.98	\$2,276,560	1, item V-b1
Wragg Ridge	95,000	CY				\$3.98	\$378,100	1, item V-b1
Blue Ridge	5,479,000	CY				\$3.98	\$21,806,420	1, item V-b1
Aetna Springs	831,000	CY				\$3.98	\$3,307,380	1, item V-b1
Bishop Mountain Road	100,000	CY				\$3.98	\$398,000	1, item V-b1
Aggregate Base Class II	467,000	TON				\$19.15	\$8,943,050	1, item V-d
Liquid Asphalt	56	TON				\$382.95	\$21,445	1, item V-h
Asphaltic Concrete	101,500	TON				\$58.92	\$5,980,380	1, item V-c
SUBTOTAL ROAD RELOCATIONS							\$45,217,000	
II. PUMPING-GENERATING PLANTS								
Winters Plant (Q=5,000cfs, TDH=150, eff=75%, 113,460 HP)								
Structure, Equipment, and Electrical, Complete	Job	LS					\$142,433,000	2
Berryessa Plant (Q=5,000cfs, TDH=320, eff=75%, 242,040 HP)								
Structure, Equipment, and Electrical, Complete	Job	LS					\$225,518,000	2
SUBTOTAL PUMPING-GENERATING PLANTS							\$367,951,000	
III. PENSTOCKS								
Berryessa Pumping Plant								
Excavation (Structural + Common)	101,000	CY				\$12.20	\$1,232,200	1, item VII-a
Special Backfill (From LBG - Assumed @ 10% of Excavation Quantity)	10,100	CY				\$19.21	\$194,021	1, item VII-b
Penstocks - 12' Dia x 3 BBLs x 250' Long	602,000	LB				\$1.65	\$993,300	1, item VII-c
Penstock Appurtenances	33,000	LB				\$1.65	\$54,450	1, item VII-c
Sleeve Type Coupling	28,000	LB	110	222	\$8.00	\$16.15	\$452,073	3, page A17
Trifurcation	260,000	LB	110	222	\$2.00	\$4.04	\$1,049,455	3, page A17

Table 2a
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (6.0 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL. 78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Concrete (Includes Rebar)	1,500	CY				\$286.65	\$429,975	1, item VII-avg de
SUBTOTAL PENSTOCKS							\$4,405,000	
IV. CANAL INLET-OUTLET STRUCTURE (1 TOTAL)								
Structural Concrete (Includes Excav and Backfill)	800	CY				\$600.00	\$480,000	2
Radial Gates, 15'x15' (Includes hoist)	3	EA				\$90,000.00	\$270,000	4
Penstocks 12' Dia x 3 BBLs	462,000	LB				\$1.65	\$762,300	1, item VII-c
Concrete for Anchorage (Includes Rebar)	1,000	CY				\$256.15	\$256,150	1, item VII-avg de
SUBTOTAL INLET-OUTLET STRUCTURE & PENSTOCKS							\$1,768,000	
V. ELECTRICAL TRANS. AND INSTRUMENTATION								
Instrumentation								
Cable & Microwave Terminal @ Winters P/G Plant	Job	LS	108	190	\$55,000.00	\$96,759.26	\$96,759	3, page A95
Cable from Airport PP to Berryessa P/G Plant	11	MI	108	190	\$10,000.00	\$17,592.59	\$193,519	3, page A95
Cable & Microwave Terminal @ Berryessa P/G Plant	Job	LS	108	190	\$55,000.00	\$96,759.26	\$96,759	3, page A95
Electrical Transmission Line								
230KV Line from Airport PP to Berryessa P/G Plant	11	MI	111	217	\$150,000.00	\$293,243.24	\$3,225,676	3, page A93
SUBTOTAL ELECT. TRANS. & INSTRUMENTATION							\$3,613,000	
VI. BERRYESSA TUNNEL INTAKE WORKS								
Intake Structure Excavation	6,200	CY	108	226	\$8.00	\$16.74	\$103,793	3, page A11
Air Shaft Extension Excavation	800	CY	108	226	\$35.00	\$73.24	\$58,593	3, page A11
Intake Structure Comp. Backfill	7,600	CY	108	226	\$6.00	\$12.56	\$95,422	3, page A11
Air Shaft Comp. Backfill	300	CY	108	226	\$10.00	\$20.93	\$6,278	3, page A11
Intake Structure Common Backfill	6,600	CY	108	226	\$6.00	\$12.56	\$82,867	3, page A11
Gate Transition Structure Excavation	3,300	CY	108	226	\$90.00	\$188.33	\$621,500	3, page A11
Gate Shaft Excavation	7,300	CY	108	226	\$80.00	\$167.41	\$1,222,074	3, page A11
Gate Maintenance Chamber Excavation	5,300	CY	108	226	\$65.00	\$136.02	\$720,898	3, page A11
Drilling Grout Holes	3,400	LF				\$18.70	\$63,580	1, item I-q
Grouting	2,000	CF				\$25.60	\$51,200	1, item I-r

Table 2a
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (6.0 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL. 78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Intake Struct. Backfill Concrete (Incl. Rebar)	2,800	CY	108	226	\$65.00	\$136.02	\$380,852	3, page A11
Intake Structure Concrete (Includes Rebar)	7,800	CY				\$339.50	\$2,648,100	1, item VI-k
Air Shaft Extension Concrete (Includes Rebar)	180	CY				\$339.50	\$61,110	1, item VI-k
Gate Transition Struct. Concrete (Incl. Rebar)	4,200	CY				\$339.50	\$1,425,900	1, item VI-k
Gate Shaft Concrete (Includes Rebar)	3,500	CY				\$339.50	\$1,188,250	1, item VI-k
Gate Maint. Chamber Concrete (Incl. Rebar)	2,200	CY				\$339.50	\$746,900	1, item VI-k
Steel Liner Plate for Gate Transition Structure	81,800	LB	108	226	\$2.35	\$4.92	\$402,259	3, page A11
Rock Bolts	29,000	LF				\$64.14	\$1,860,060	1, item VI-y
Structural Concrete (Includes Rebar)	700	CY				\$339.50	\$237,650	1, item VI-k
Trashracks	59,000	LB				\$3.63	\$214,170	1, item VI-q
Piping - 10" & Larger	101,300	LB	108	226	\$7.00	\$14.65	\$1,483,857	3, page A11
Tunnel Gate	Job	LS	108	226	\$1,000,000.00	\$2,092,592.59	\$2,092,593	3, page A11
Gate Stem (320' Long)	Job	LS	108	226	\$15,000.00	\$31,388.89	\$31,389	3, page A11
Gate Slot Embedded Metalwork	Job	LS	108	226	\$300,000.00	\$627,777.78	\$627,778	3, page A11
Gate Shaft Embedded Metalwork	Job	LS	108	226	\$260,000.00	\$544,074.07	\$544,074	3, page A11
Gate Maintenance Chamber Metalwork	Job	LS	108	226	\$228,000.00	\$477,111.11	\$477,111	3, page A11
SUBTOTAL BERRYESSA TUNNEL INTAKE WORKS							\$17,448,000	
VII. BERRYESSA TUNNEL								
Dewatering	Job	LS	108	226	\$50,000.00	\$104,629.63	\$104,630	3, page A14
Common Excavation at Portals	700,000	CY	108	226	\$6.00	\$12.56	\$8,788,889	3, page A14
Tunnel Excavation	336,000	CY				\$128.27	\$43,098,720	1, item II-b
Excavation for Surge Chamber	220,000	CY	108	226	\$50.00	\$104.63	\$23,018,519	3, page A14
Structural Steel Supports	11,590,000	LB				\$3.66	\$42,419,400	1, item II-e
Timber for Supports	1,900	MBF				\$1,955.00	\$3,714,500	1, item II-f
Steel Tunnel Liner	3,755,000	LB	108	226	\$0.64	\$1.34	\$5,028,919	3, page A14
Drilling Grout Holes	80,000	LF				\$18.70	\$1,496,000	1, item I-q
Grouting	28,000	CF				\$25.60	\$716,800	1, item I-r
Concrete in 25' Dia Cast in Place Pipe	630	CY	108	226	\$150.00	\$313.89	\$197,750	3, page A14
Concrete in Tunnel	117,400	CY	108	226	\$64.00	\$133.93	\$15,722,904	3, page A14
Rebar in Tunnel @ 200#/CY	23,480,000	LB	108	226	\$0.40	\$0.84	\$19,653,630	3, page A14
Concrete in Surge Chamber (Includes Rebar)	75,000	CY				\$339.50	\$25,462,500	1, item VI-k

Table 2a
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (6.0 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL. 78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Steel Liner in Surge Chamber	16,500,000	LB	108	226	\$0.65	\$1.36	\$22,443,056	3, page A14
SUBTOTAL BERRYESSA TUNNEL							\$211,866,214	
VIII. CONVEYANCE FACILITIES (CHAPMAN RANCH CANAL)								
Canal								
Clear & Grub	7,420,000	SF	106	181	\$0.0137	\$0.0234	\$173,579	3, page A20
Channel Excavation	2,570,000	CY				\$2.00	\$5,140,000	2
Compacted Embankment	550,000	CY				\$0.80	\$440,000	2
Common Embankment	760,000	CY				\$0.50	\$380,000	2
Concrete Lining	50,000	CY				\$80.00	\$4,000,000	2
Operating Roads								
Gravel Surfacing	14,000	TON	109	237	\$5.25	\$11.42	\$159,812	3, page A20
Liquid Asphalt	80	TON				\$382.95	\$30,636	1, item V-h
Enos Creek Siphon - 3 Boxes								
Concrete (Includes rebar, excavation, backfill)	1,730	CY				\$600.00	\$1,038,000	2
Triple Box - 8'x10'x400'								
Concrete (Includes rebar, excavation, backfill)	1,500	CY				\$600.00	\$900,000	2
66" Structural Plate Pipe, t=0.109	348	LF				\$264.00	\$91,872	\$4.00/dia-"
72" Structural Plate Pipe, t=0.109	804	LF				\$288.00	\$231,552	\$4.00/dia-"
SUBTOTAL CONVEYANCE FACILITIES							\$12,585,000	
IX. DAM OUTLET WORKS								
Tunnel								
Open Cut Excavation	15,480	CY				\$3.38	\$52,322	1, item II-a
Common Backfill	6,020	CY	108	226	\$5.00	\$10.46	\$62,987	3, page A99
Wet-mix Shotcrete	206	CY	108	226	\$280.00	\$585.93	\$120,701	3, page A99
Structure Excavation	1,032	CY	108	226	\$10.00	\$20.93	\$21,596	3, page A99
Structure Backfill	1,574	CY				\$18.99	\$29,890	1, item XI-h
Ditch and Channel Excavation	3,096	CY	108	226	\$5.00	\$10.46	\$32,393	3, page A99
Rock Bolts	2,847	LF				\$64.14	\$182,607	1, item VI-y
Chain Link Fabric	258	SY	108	226	\$15.00	\$31.39	\$8,098	3, page A99

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Table 2a
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (6.0 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL. 78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Misc Metalwork	4,128	LBS				\$3.04	\$12,549	1, item II-k
Welded Wire Fabric	578	LBS	108	226	\$0.60	\$1.26	\$726	3, page A99
Intake Structures								
Concrete	4,774	CY				\$339.50	\$1,620,773	1, item VI-k
7.5'x7.5' Bulkhead Gates	9	EA	107	206	\$10,000.00	\$19,252.34	\$173,271	3, page A99
4.5' Dia Butterfly Gates	2	EA	107	206	\$70,000.00	\$134,766.36	\$269,533	3, page A99
4.5' Dia Hollow Jet Valve	2	EA	107	206	\$108,000.00	\$207,925.23	\$415,850	3, page A99
Fixed Wheel Gate for 11' Dia Outlet Tunnel	1	EA				\$108,000.00	\$108,000	4
Bridge								
Concrete	4,400	CY				\$423.51	\$1,863,444	1, item VI-gg
SUBTOTAL OUTLET WORKS							\$4,975,000	
Upsize Outlet Works for Emergency Evacuation (Increase Outlet Works from 1,200cfs to 30,000cfs)								
Cost Factor $(30,000/1,200)^{3/8} = 3.34$							\$16,617,000	
X. DAM SPILLWAY								
Excavation	1,300,000	CY				\$4.03	\$5,239,000	1, avg items IIa,IIIe
Backfill	6,000	CY				\$8.17	\$49,020	1, item III-f
Concrete (Includes Rebar)	41,500	CY				\$365.24	\$15,157,460	1, avg items IIh,IIIc,IIId
Radial Gates, 20'x50' (Includes hoist)	5	EA				\$510,000.00	\$2,550,000	4
SUBTOTAL SPILLWAY							\$22,995,000	
XI. ROCK DAM								
Foundation Excavation								
Colluvium & Alluvium	2,990,000	CY	105	176	\$2.00	\$3.35	\$10,023,619	3, page A96
Weathered Rock (2 mile haul)	563,000	CY	105	176	\$3.00	\$5.03	\$2,831,086	3, page A96
Impervious Core (3 mile haul)	7,660,000	CY	105	176	\$5.00	\$8.38	\$64,198,095	3, page A96
Gravel Zone (10 mile haul)	390,000	CY	105	176	\$6.25	\$10.48	\$4,085,714	3, page A96
Rock Zone - Basalt (5 mile haul)	19,600,000	CY	105	176	\$5.25	\$8.80	\$172,480,000	3, page A96
Grout Curtain								

D-004631

Table 2a
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (6.0 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL. 78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Drill Holes	40,400	LF				\$18.70	\$755,480	1, item I-q
Sacks of Cement	20,000	SACKS	105	176	\$10.00	\$16.76	\$335,238	3, page A96
SUBTOTAL ROCK DAM							\$254,709,000	
XII. RIGHTS-OF-WAY								
Reservoir (Includes Buffer Factor of 1.32)	19,800	AC				\$7,000.00	\$138,600,000	5
Conveyance Facilities	200	AC				\$7,000.00	\$1,400,000	5
SUBTOTAL RIGHTS-OF-WAY							\$140,000,000	
XIII. GENERAL RESERVOIR COSTS								
Clearing Cost	15,000	AC				\$1,097.00	\$16,455,000	1, item IV-a
SUBTOTAL							\$1,115,629,214	
CONTINGENCIES @ 20%							\$223,125,843	
ESTIMATED CONSTRUCTION COST							\$1,338,755,057	
ENGR, LEGAL, AND ADMIN @ 35%							\$468,564,270	
ESTIMATED CAPITAL COST							\$1,807,319,000	
ESTIMATED CAPITAL COST RANGE								
LOW (-10%)							\$1,627,000,000	
HIGH (+15)							\$2,078,000,000	

1. California Department of Water Resources, *Los Banos Grandes Facilities Report, Appendix A: Designs and Cost Estimates*, Table 4, December 1990.
2. Cost developed by Bookman-Edmonston Engineering.
3. California Department of Water Resources, Division of Design and Construction, *SWP Future Supply Program, Enlarged Berryessa Reservoir Reconnaissance Study*, July 1978/
4. Rodney Hunt Water and Sewage Control Equipment; Orange, Massachusetts.
5. Bureau of Reclamation, Land Resources Branch, February 1997, personal communication, Graham McMullen, Department of the Interior

Table 2b
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (13.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL.78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
I. ROAD RELOCATIONS								
Roadway Excavation								
Pope Valley Road	529,000	CY				\$3.98	\$2,105,420	1, item V-b1
Capell Creek parallel	572,000	CY				\$3.98	\$2,276,560	1, item V-b1
Wragg Ridge	95,000	CY				\$3.98	\$378,100	1, item V-b1
Blue Ridge	5,479,000	CY				\$3.98	\$21,806,420	1, item V-b1
Aetna Springs	831,000	CY				\$3.98	\$3,307,380	1, item V-b1
Bishop Mountain Road	100,000	CY				\$3.98	\$398,000	1, item V-b1
Aggregate Base Class II	467,000	TON				\$19.15	\$8,943,050	1, item V-d
Liquid Asphalt	56	TON				\$382.95	\$21,445	1, item V-h
Asphaltic Concrete	101,500	TON				\$58.92	\$5,980,380	1, item V-e
SUBTOTAL ROAD RELOCATIONS							\$45,217,000	
II. PUMPING-GENERATING PLANTS								
Winters Plant (Q=5,000cfs, TDH=150, eff=75%, 113,460 HP)								
Structure, Equipment, and Electrical, Complete	Job	LS					\$142,433,000	2
Berryessa Plant (Q=5,000cfs, TDH=470, eff=75%, 355,500 HP)								
Structure, Equipment, and Electrical, Complete	Job	LS					\$283,346,000	2
SUBTOTAL PUMPING-GENERATING PLANTS							\$425,779,000	
III. PENSTOCKS								
Berryessa Pumping Plant								
Excavation (Structural + Common)	101,000	CY				\$12.20	\$1,232,200	1, item VII-a
Special Backfill (From LBG - Assumed @ 10% of Excavation Quantity)	10,100	CY				\$19.21	\$194,021	1, item VII-b
Penstocks - 12' Dia x 3 BBLS x 250' Long	602,000	LB				\$1.65	\$993,300	1, item VII-c
Penstock Appurtenances	33,000	LB				\$1.65	\$54,450	1, item VII-c
Sleeve Type Coupling	28,000	LB	110	222	\$8.00	\$16.15	\$452,073	3, page A17
Trifurcation	260,000	LB	110	222	\$2.00	\$4.04	\$1,049,455	3, page A17
Concrete (Includes Rebar)	1,500	CY				\$286.65	\$429,975	1, item VII-avg de
SUBTOTAL PENSTOCKS							\$4,405,000	

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Table 2b
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (13.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL.78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
IV. CANAL INLET-OUTLET STRUCTURE (1 TOTAL)								
Structural Concrete (Includes Excav & Backfill)	800	CY				\$600.00	\$480,000	2
Radial Gates, 15'x15' (Includes hoist)	3	EA				\$90,000.00	\$270,000	4
Penstocks 12' Dia x 3 BBLs	462,000	LB				\$1.65	\$762,300	1, item VII-c
Concrete for Anchorage (Includes Rebar)	1,000	CY				\$256.15	\$256,150	1, item VII-avg de
SUBTOTAL INLET-OUTLET STRUCTURE & PENSTOCKS							\$1,768,000	
V. ELECTRICAL TRANS. AND INSTRUMENTATION								
Instrumentation								
Cable & Microwave Terminal @ Winters P/G Plant	Job	LS	108	190	\$55,000.00	\$96,759.26	\$96,759	3, page A95
Cable from Airport PP to Berryessa P/G Plant	11	MI	108	190	\$10,000.00	\$17,592.59	\$193,519	3, page A95
Cable & Microwave Terminal @ Berryessa P/G Plant	Job	LS	108	190	\$55,000.00	\$96,759.26	\$96,759	3, page A95
Electrical Transmission Line								
230KV Line from Airport PP to Berryessa P/G Plant	11	MI	111	217	\$150,000.00	\$293,243.24	\$3,225,676	3, page A93
SUBTOTAL ELECT. TRANS. & INSTRUMENTATION							\$3,613,000	
VI. BERRYESSA TUNNEL INTAKE WORKS								
Intake Structure Excavation	6,200	CY	108	226	\$8.00	\$16.74	\$103,793	3, page A11
Air Shaft Extension Excavation	800	CY	108	226	\$35.00	\$73.24	\$58,593	3, page A11
Intake Structure Comp. Backfill	7,600	CY	108	226	\$6.00	\$12.56	\$95,422	3, page A11
Air Shaft Comp. Backfill	300	CY	108	226	\$10.00	\$20.93	\$6,278	3, page A11
Intake Structure Common Backfill	6,600	CY	108	226	\$6.00	\$12.56	\$82,867	3, page A11
Gate Transition Structure Excavation	3,300	CY	108	226	\$90.00	\$188.33	\$621,500	3, page A11
Gate Shaft Excavation	7,300	CY	108	226	\$80.00	\$167.41	\$1,222,074	3, page A11
Gate Maintenance Chamber Excavation	5,300	CY	108	226	\$65.00	\$136.02	\$720,898	3, page A11
Drilling Grout Holes	3,400	LF				\$18.70	\$63,580	1, item I-q
Grouting	2,000	CF				\$25.60	\$51,200	1, item I-r
Intake Struct. Backfill Concrete (Incl. Rebar)	2,800	CY	108	226	\$65.00	\$136.02	\$380,852	3, page A11
Intake Structure Concrete (Includes Rebar)	7,800	CY				\$339.50	\$2,648,100	1, item VI-k
Air Shaft Extension Concrete (Includes Rebar)	180	CY				\$339.50	\$61,110	1, item VI-k
Gate Transition Struct. Concrete (Incl. Rebar)	4,200	CY				\$339.50	\$1,425,900	1, item VI-k

Table 2b
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (13.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL.78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Gate Shaft Concrete (Includes Rebar)	3,500	CY				\$339.50	\$1,188,250	1, item VI-k
Gate Maint. Chamber Concrete (Incl. Rebar)	2,200	CY				\$339.50	\$746,900	1, item VI-k
Steel Liner Plate for Gate Transition Structure	81,800	LB	108	226	\$2.35	\$4.92	\$402,259	3, page A11
Rock Bolts	29,000	LF				\$64.14	\$1,860,060	1, item VI-y
Structural Concrete (Includes Rebar)	700	CY				\$339.50	\$237,650	1, item VI-k
Trashracks	59,000	LB				\$3.63	\$214,170	1, item VI-q
Piping - 10" & Larger	101,300	LB	108	226	\$7.00	\$14.65	\$1,483,857	3, page A11
Tunnel Gate	Job	LS	108	226	\$1,000,000.00	\$2,092,592.59	\$2,092,593	3, page A11
Gate Stem (320' Long)	Job	LS	108	226	\$15,000.00	\$31,388.89	\$31,389	3, page A11
Gate Slot Embedded Metalwork	Job	LS	108	226	\$300,000.00	\$627,777.78	\$627,778	3, page A11
Gate Shaft Embedded Metalwork	Job	LS	108	226	\$260,000.00	\$544,074.07	\$544,074	3, page A11
Gate Maintenance Chamber Metalwork	Job	LS	108	226	\$228,000.00	\$477,111.11	\$477,111	3, page A11
SUBTOTAL BERRYESSA TUNNEL INTAKE WORKS							\$17,448,000	
VII. BERRYESSA TUNNEL								
Dewatering	Job	LS	108	226	\$50,000.00	\$104,629.63	\$104,630	3, page A14
Common Excavation at Portals	700,000	CY	108	226	\$6.00	\$12.56	\$8,788,889	3, page A14
Tunnel Excavation	336,000	CY				\$128.27	\$43,098,720	1, item II-b
Excavation for Surge Chamber	220,000	CY	108	226	\$50.00	\$104.63	\$23,018,519	3, page A14
Structural Steel Supports	11,590,000	LB				\$3.66	\$42,419,400	1, item II-e
Timber for Supports	1,900	MBF				\$1,955.00	\$3,714,500	1, item II-f
Steel Tunnel Liner	3,755,000	LB	108	226	\$0.64	\$1.34	\$5,028,919	3, page A14
Drilling Grout Holes	80,000	LF				\$18.70	\$1,496,000	1, item I-q
Grouting	28,000	CF				\$25.60	\$716,800	1, item I-r
Concrete in 25' Dia Cast in Place Pipe	630	CY	108	226	\$150.00	\$313.89	\$197,750	3, page A14
Concrete in Tunnel	117,400	CY	108	226	\$64.00	\$133.93	\$15,722,904	3, page A14
Rebar in Tunnel @ 200#/CY	23,480,000	LB	108	226	\$0.40	\$0.84	\$19,653,630	3, page A14
Concrete in Surge Chamber (Includes Rebar)	75,000	CY				\$339.50	\$25,462,500	1, item VI-k
Steel Liner in Surge Chamber	16,500,000	LB	108	226	\$0.65	\$1.36	\$22,443,056	3, page A14
SUBTOTAL BERRYESSA TUNNEL							\$211,866,000	

Table 2b
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (13.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL.78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
VIII. CONVEYANCE FACILITIES (CHAPMAN RANCH CANAL)								
Canal								
Clear & Grub	7,420,000	SF	106	181	\$0.0137	\$0.0234	\$173,579	3, page A20
Channel Excavation	2,570,000	CY				\$2.00	\$5,140,000	2
Compacted Embankment	550,000	CY				\$0.80	\$440,000	2
Common Embankment	760,000	CY				\$0.50	\$380,000	2
Concrete Lining	50,000	CY				\$80.00	\$4,000,000	2
Operating Roads								
Gravel Surfacing	14,000	TON	109	237	\$5.25	\$11.42	\$159,812	3, page A20
Liquid Asphalt	80	TON				\$382.95	\$30,636	1, item V-h
Enos Creek Siphon - 3 Boxes								
Concrete (Includes rebar, excavation, backfill)	1,730	CY				\$600.00	\$1,038,000	2
Triple Box - 8'x10'x400'								
Concrete (Includes rebar, excavation, backfill)	1,500	CY				\$600.00	\$900,000	2
66" Structural Plate Pipe, t=0.109	348	LF				\$264.00	\$91,872	\$4.00/dia."
72" Structural Plate Pipe, t=0.109	804	LF				\$288.00	\$231,552	\$4.00/dia."
SUBTOTAL CONVEYANCE FACILITIES							\$12,585,000	
IX. DAM OUTLET WORKS								
Tunnel								
Open Cut Excavation	15,480	CY				\$3.38	\$52,322	1, item II-a
Common Backfill	6,020	CY	108	226	\$5.00	\$10.46	\$62,987	3, page A99
Wet-mix Shotcrete	206	CY	108	226	\$280.00	\$585.93	\$120,701	3, page A99
Structure Excavation	1,032	CY	108	226	\$10.00	\$20.93	\$21,596	3, page A99
Structure Backfill	1,574	CY				\$18.99	\$29,890	1, item XI-h
Ditch and Channel Excavation	3,096	CY	108	226	\$5.00	\$10.46	\$32,393	3, page A99
Rock Bolts	2,847	LF				\$64.14	\$182,607	1, item VI-y
Chain Link Fabric	258	SY	108	226	\$15.00	\$31.39	\$8,098	3, page A99
Misc Metalwork	4,128	LBS				\$3.04	\$12,549	1, item II-k
Welded Wire Fabric	578	LBS	108	226	\$0.60	\$1.26	\$726	3, page A99
Intake Structures								
Concrete	4,774	CY				\$339.50	\$1,620,773	1, item VI-k
7.5'x7.5' Bulkhead Gates	9	EA	107	206	\$10,000.00	\$19,252.34	\$173,271	3, page A99
4.5' Dia Butterfly Gates	2	EA	107	206	\$70,000.00	\$134,766.36	\$269,533	3, page A99

Table 2b
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (13.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL.78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
4.5' Dia Hollow Jet Valve	2	EA	107	206	\$108,000.00	\$207,925.23	\$415,850	3, page A99
Fixed Wheel Gate for 11' Dia Outlet Tunnel	1	EA				\$108,000.00	\$108,000	4
Bridge								
Concrete	4,400	CY				\$423.51	\$1,863,444	1, item VI-gg
SUBTOTAL OUTLET WORKS							\$4,975,000	
Upsize Outlet Works for Emergency Evacuation (Increase Outlet Works from 1,200cfs to 120,000cfs)								
Cost Factor = $(120,000/1,200)^{3/8} = 5.62$							\$27,960,000	
X. DAM SPILLWAY								
Excavation	2,700,000	CY				\$4.03	\$10,881,000	1, avg items IIa,IIIa
Backfill	6,000	CY				\$8.17	\$49,020	1, item III-f
Concrete (Includes Rebar)	41,500	CY				\$365.24	\$15,157,460	1, avg items IIh,IIIc,IIId
Radial Gates, 20'x50' (Includes hoist)	5	EA				\$510,000.00	\$2,550,000	4
SUBTOTAL SPILLWAY							\$28,637,000	
XI. ROCK DAM								
Foundation Excavation								
Colluvium & Alluvium	4,883,000	CY	105	176	\$1.90	\$3.18	\$15,551,192	3, page A98
Weathered Rock	940,000	CY	105	176	\$3.00	\$5.03	\$4,726,857	3, page A98
Impervious Core	15,300,000	CY	105	176	\$4.50	\$7.54	\$115,405,714	3, page A98
Gravel Zone	623,000	CY	105	176	\$6.00	\$10.06	\$6,265,600	3, page A98
Rock Zone 1 - Basalt	20,000,000	CY	105	176	\$5.00	\$8.38	\$167,619,048	3, page A98
Rock Zone 2 - Sandstone	26,500,000	CY	105	176	\$3.75	\$6.29	\$166,571,429	3, page A98
Grout Curtain								
Drill Holes	55,400	LF				\$18.70	\$1,035,980	1, item I-q
Sacks of Cement	27,700	SACKS	105	176	\$10.00	\$16.76	\$464,305	3, page A98
SUBTOTAL ROCK DAM							\$477,640,000	
XII. RIGHTS-OF-WAY								
Reservoir (Includes Buffer Factor of 1.32)	56,800	AC				\$7,000.00	\$397,600,000	5
Conveyance Facilities	200	AC				\$7,000.00	\$1,400,000	5
SUBTOTAL RIGHTS-OF-WAY							\$399,000,000	

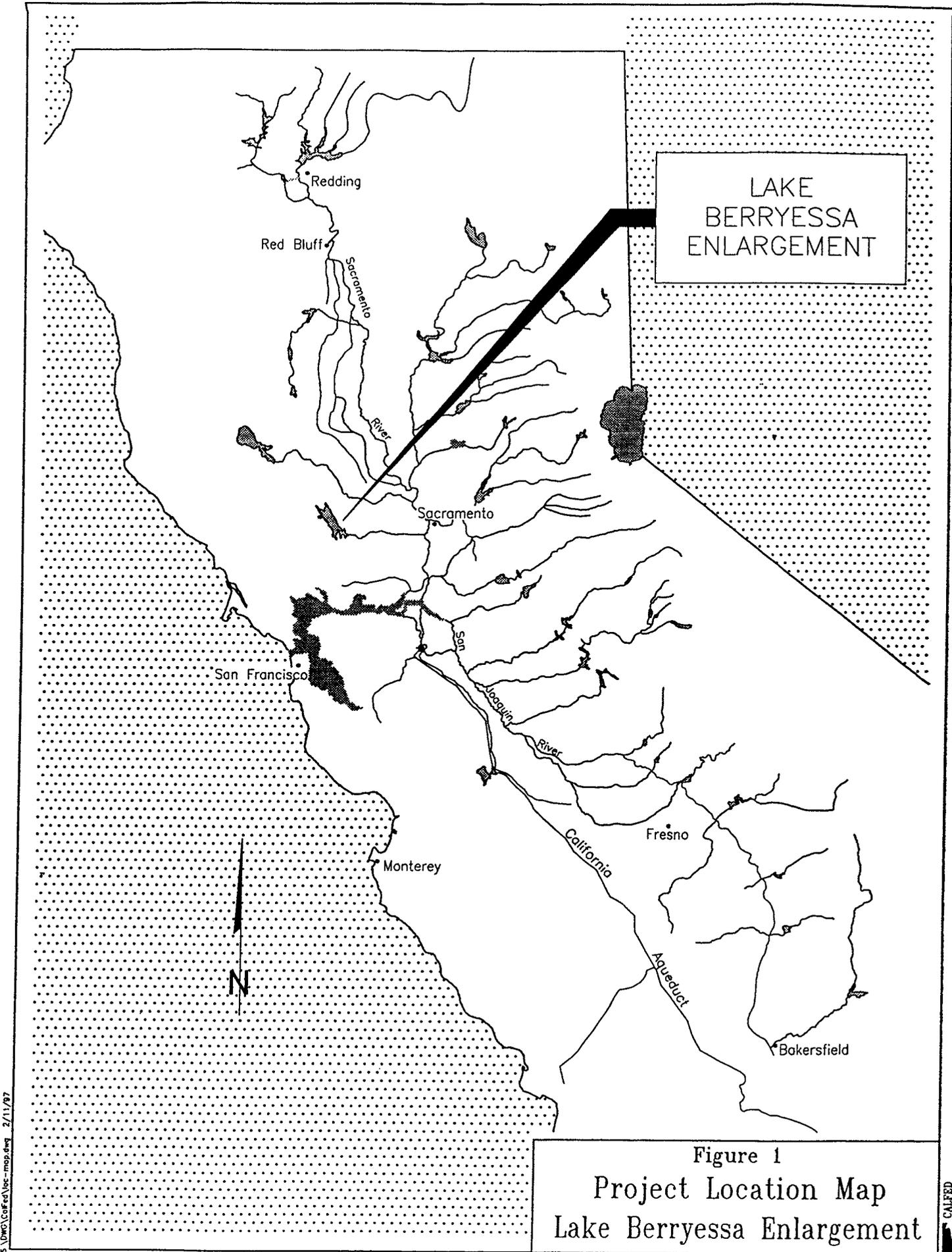
Table 2b
ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT (13.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JUL.78	USBR INDEX OCT. 96	UNIT COST JUL. 78	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
XIII. GENERAL RESERVOIR COSTS								
Clearing Cost	43,000	AC				\$1,097.00	\$47,171,000	1, item IV-a
SUBTOTAL							\$1,703,089,000	
CONTINGENCIES @ 20%							\$340,618,000	
ESTIMATED CONSTRUCTION COST							\$2,043,707,000	
ENGR, LEGAL, AND ADMIN @ 35%							\$715,297,000	
ESTIMATED CAPITAL COST							\$2,759,004,000	
ESTIMATED CAPITAL COST RANGE								
LOW (-10%)							\$2,483,000,000	
HIGH (+15%)							\$3,173,000,000	

1. California Department of Water Resources, *Los Banos Grandes Facilities Report, Appendix A: Designs and Cost Estimates*, Table 4, December 1990.
2. Cost developed by Bookman-Edmonston Engineering.
3. California Department of Water Resources, Division of Design and Construction, *SWP Future Supply Program, Enlarged Berryessa Reservoir Reconnaissance Study*, July 1978
4. Rodney Hunt Water and Sewage Control Equipment; Orange, Massachusetts.
5. Bureau of Reclamation, Land Resources Branch, February 1997, personal communication, Graham McMullen, Department of the Interior

Table 3
SUMMARY OF ESTIMATED COSTS
LAKE BERRYESSA ENLARGEMENT

Cost Item	Estimated Cost (\$Millions)	
	1.2 MAF	1.9 MAF
Dam		
Reservoir Clearing	\$16	\$47
Rock Dam	255	478
Spillway	23	29
Outlet Works	17	28
Subtotal:	311	582
Conveyance Facilities		
Berryessa Tunnel Intake Works	17	17
Berryessa Tunnel	212	212
Canal Inlet-Outlet Structure	2	2
Chapman Ranch Canal	13	13
Penstocks	4	4
Subtotal:	248	248
Pumping-Generating Plants		
Winter Pumping-Generating Plant	142	142
Berryessa Pumping-Generating Plant	226	283
Subtotal:	368	425
Road Relocations	45	45
Electric, Transmission, and Instrumentation	4	4
Right of Way	140	399
SUBTOTAL	1,116	1,703
Contingencies (20%)	223	341
ESTIMATED CONSTRUCTION COST	1,339	2,044
Engineering, Legal, and Project Administration (35%)	469	715
ESTIMATED CAPITAL COST	1,808	2,759
Capital Cost Range (minus 10% - plus 15%)	\$1,627 - \$2,078	\$2,483 - \$3,173



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Figure 1
 Project Location Map
 Lake Berryessa Enlargement



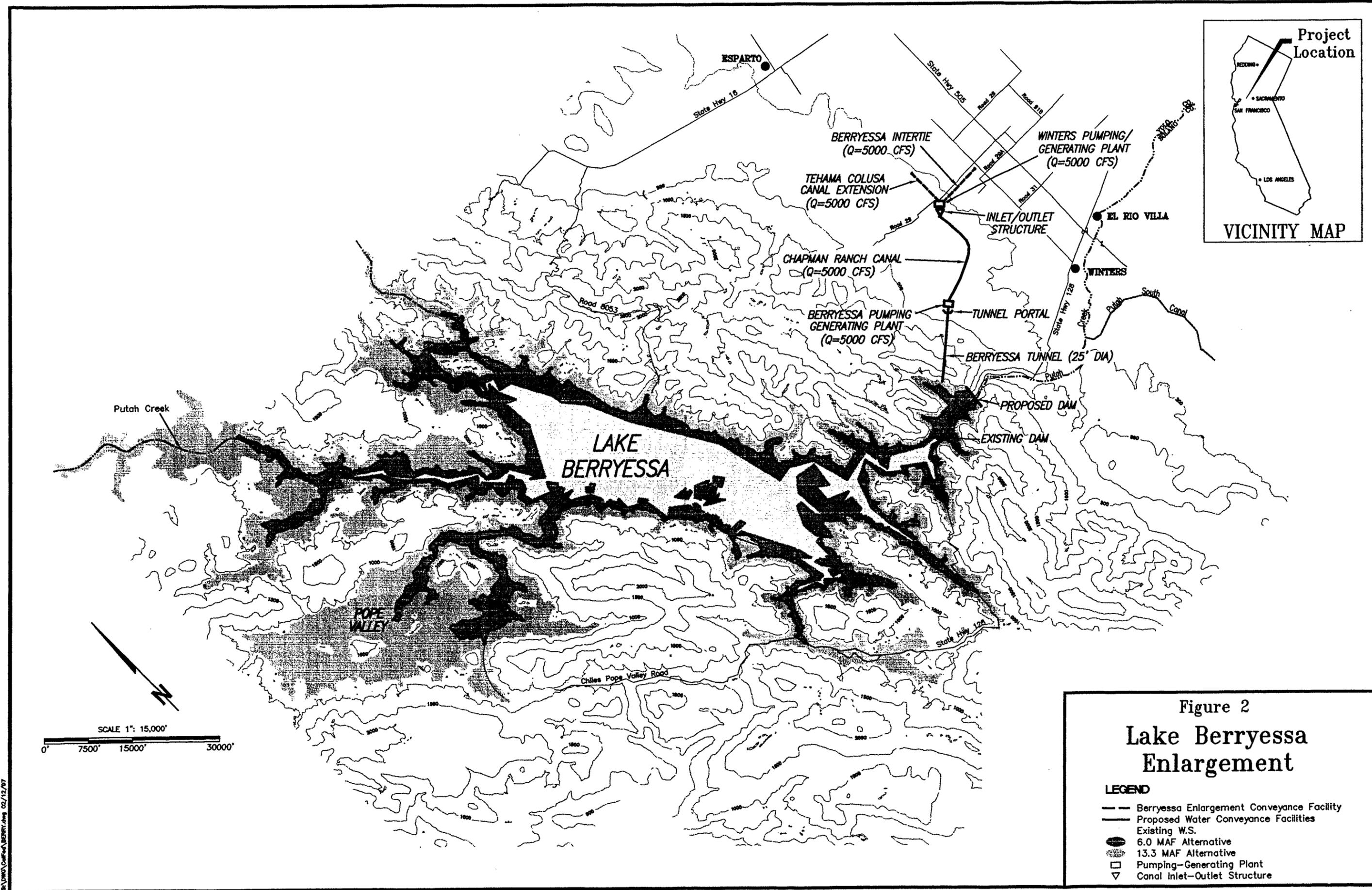
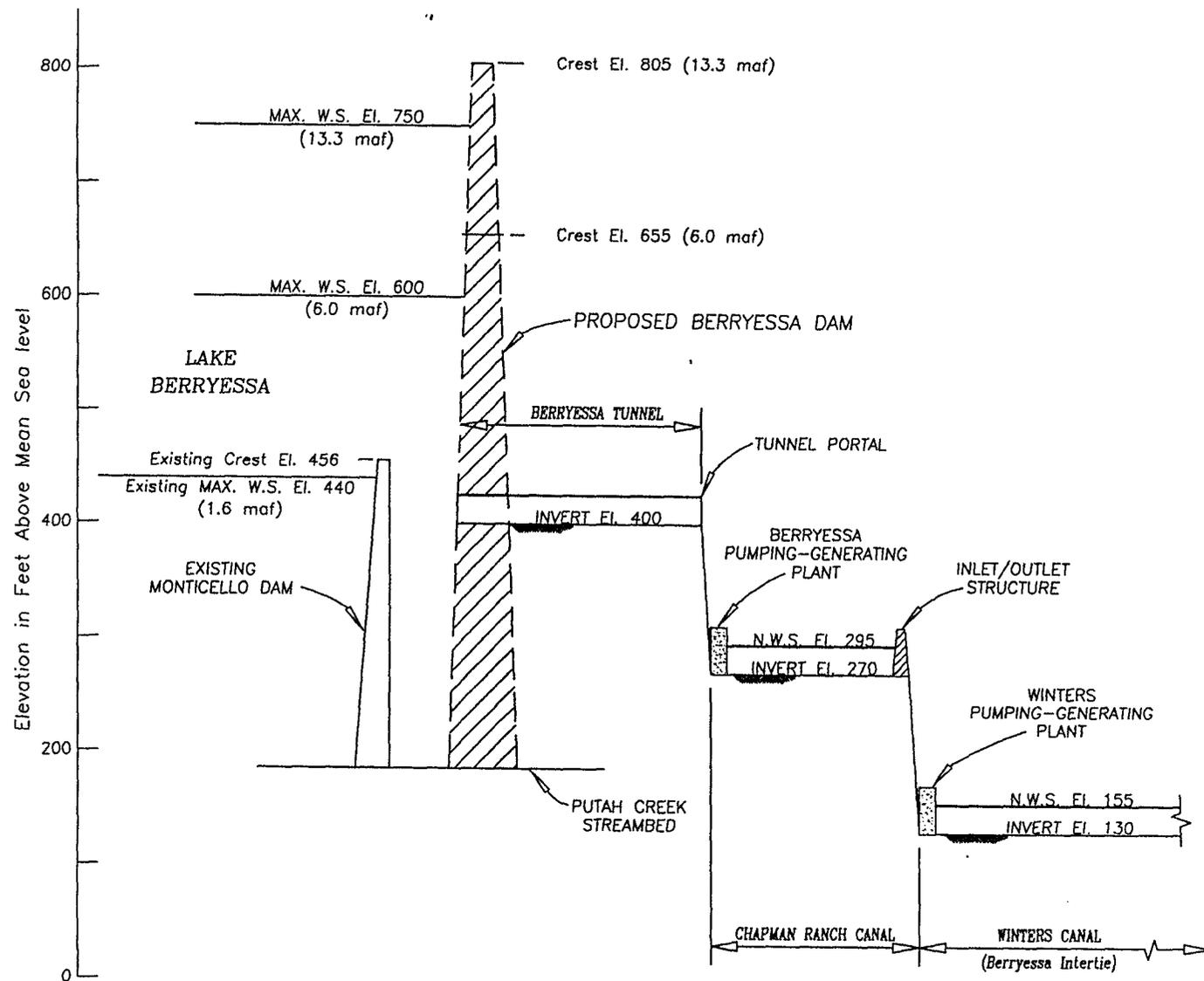


Figure 2
 Lake Berryessa
 Enlargement

- LEGEND**
- Berryessa Enlargement Conveyance Facility
 - Proposed Water Conveyance Facilities
 - Existing W.S.
 - 6.0 MAF Alternative
 - ⊗ 13.3 MAF Alternative
 - Pumping-Generating Plant
 - ▽ Canal Inlet-Outlet Structure



NOTE:
 THE BERRYESSA TUNNEL ENTERS THE RESERVOIR
 NORTH OF THE PROPOSED BERRYESSA DAM

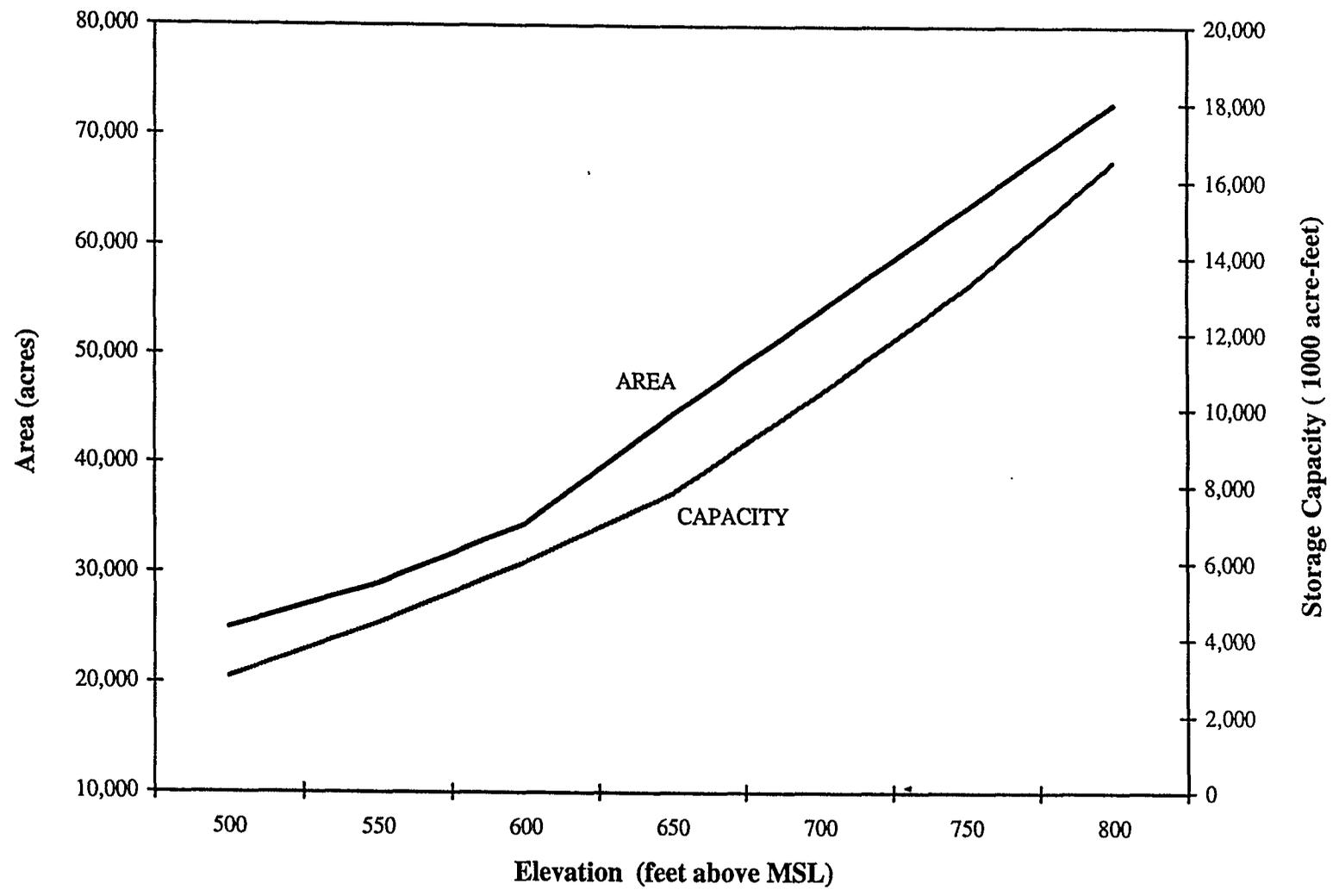
Figure 3
 Lake Berryessa Enlargement
 Schematic Profile



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Figure 4
AREA-CAPACITY CURVES
LAKE BERRYESSA ENLARGEMENT



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