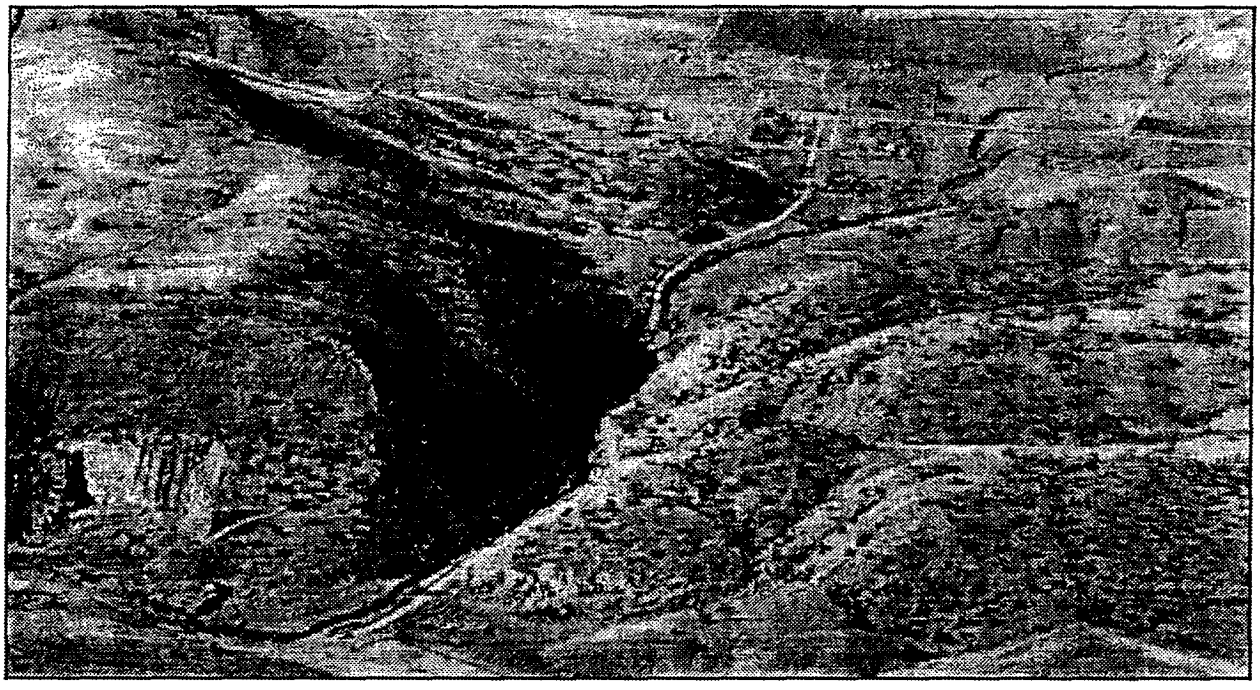
State of California
The Resources Agency
Department of Water Resources
Northern District

Reconnaissance Survey
Sites Offstream Storage Project



July 1996

PETE WILSON
Governor
State of California

DOUGLAS P. WHEELER
Secretary for Resources
The Resources Agency

DAVID N. KENNEDY
Director
Department of Water Resources

D-003650

D-003650

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Cover Photo: Looking west at Sites damsite on Stone Corral Creek with the community of Sites and the proposed reservoir area in the background

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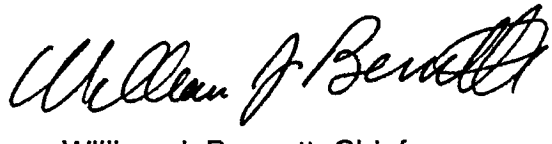
FOREWORD

Recently, the Department of Water Resources has received requests for information from individuals and the Northern California Water Association regarding the potential of an offstream storage reservoir at the Sites/Colusa site near Maxwell. Various versions of this project have been considered in several past planning studies; however, little current information is readily available. The existing information mainly consists of older, limited edition reports that are archived within water agencies.

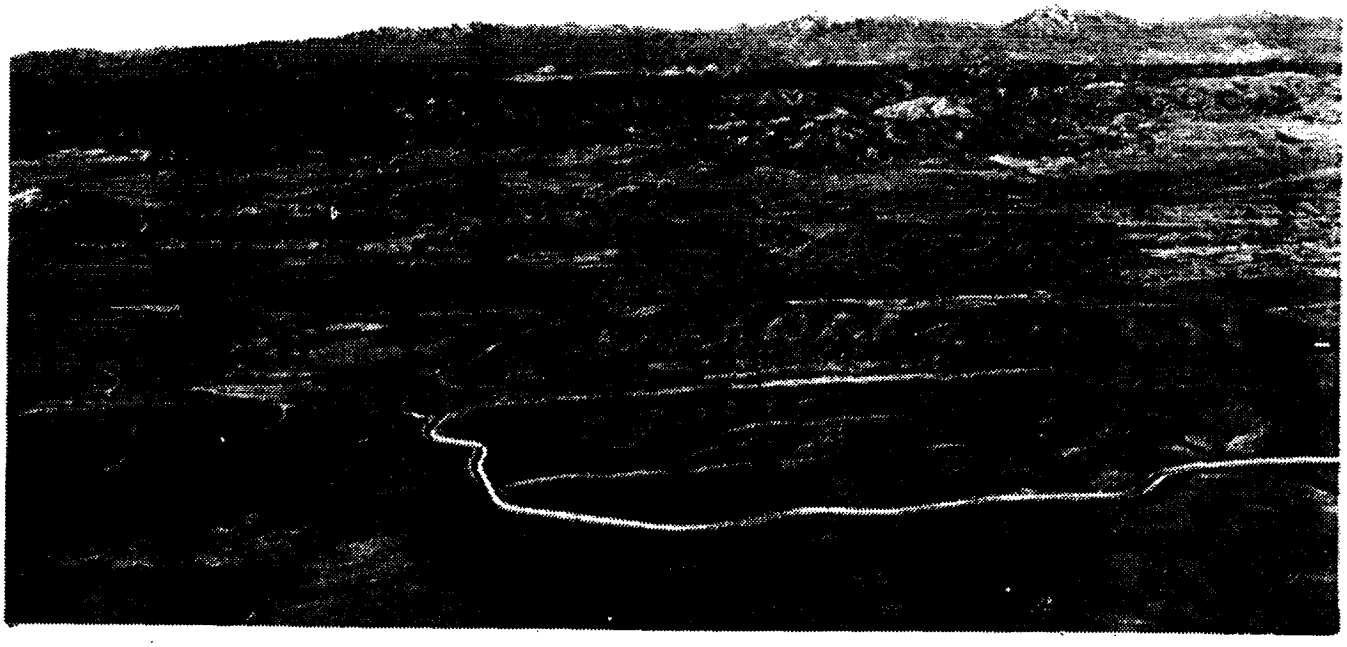
In response to this renewed interest, DWR has reviewed historic documents on a Sites/Colusa Project to assess its potential to augment local and statewide water supplies during drought periods. To generate basic environmental information, DWR conducted a brief investigation of current environmental literature, studied project area aerial photos, and conducted limited field work in the project area.

This report briefly summarizes the Sites/Colusa Project's planning history and updates earlier cost estimates to 1995 cost levels. At this stage, no insurmountable problems have been identified that would prevent construction and operation of this project. Rather, the project has several unique characteristics that make it an attractive candidate for further feasibility grade investigations. It has a significantly lower cost per unit of storage than most sites, the area is sparsely populated, and no major environmental or archeological problems have been identified within the offstream water storage site. The geography of the site permits a range of storage options to be considered, from a minimum of approximately 1.2 million acre-feet to a maximum of 3.0 million acre-feet.



William J. Bennett, Chief
Northern District

Aerial views of the Sites Project Damsites and surrounding area. The top photo is looking southwest along Logan Ridge and shows Golden Gate Damsite (foreground), Sites Damsite (background), and the south half of the Sites Reservoir area. The bottom photo shows the same area from a location east of the Tehama-Colusa Canal (foreground) near the existing Funks Reservoir looking west.



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PROJECT DESCRIPTION AND STUDY FINDINGS

The Sites Project would be located about 10 miles west of Maxwell in Antelope Valley across the drainages of Stone Corral and Funks creeks. The main dams and most of the project would lie within northern Colusa County, but Sites Reservoir would extend into southern Glenn County. Three projects of different sizes have been evaluated at this location: (1) Small Sites sized at a maximum of 1.2 million acre-feet, (2) Large Sites sized at a maximum of 1.8 million acre-feet, and (3) a still larger Colusa Project sized at 3.0 million acre-feet of storage. The Colusa Project would be formed by extending the Large Sites Project north into the Hunters and Logan creek drainages. The three projects - Small Sites, Large Sites, and Colusa - combined are referred to as the Sites/Colusa Project. They are all located in the same general area as shown on Figure 1.

All of these projects are offstream storage reservoirs as they have very little natural runoff and would have to be filled mainly by pumped diversions from the Sacramento River or its tributaries. The Tehama-Colusa and Glenn-Colusa Irrigation District canals are the main existing conduits through which a Sites/Colusa Project could be filled. These facilities have fish passage problems, discussed later, which must be resolved before large winter diversions into these canals would be feasible.

The Small and Large Sites Projects would be formed by constructing two main dams on Stone Corral and Funks creeks and several smaller saddle dams along the low divide between Funks and Hunters creeks. Even with the multiple dams, Sites is one of the most efficient storage locations in California when compared on the basis of dam volume to reservoir volume as shown on Figure 2. The larger Colusa Project would be formed by constructing two more large dams, in addition to those required for Large Sites, on Hunters and Logan creeks. Several additional saddle dams would also be required; the overall increase in dam volume required for the Colusa Project compared to Large Sites is almost five fold. Area capacity curves for these projects are shown on Figures 3 and 4.

In the basic formulation of each project, water would be diverted to the reservoirs from the Sacramento River in winter months when irrigation canals would not otherwise be in use. During the irrigation season, releases from these reservoirs could be made back to the canals in exchange for water which would otherwise have been diverted from the Sacramento River. This undiverted summer water would become available for other uses. Outside the irrigation season, reservoir releases could be made through the Colusa Basin drainage system. Fish screens at the river diversions would have to be modified to allow the diversion of large winter flows up to 2,000 cubic feet per second into each canal. Such modification would be complicated by existing endangered fish species, canal sedimentation, and debris issues.

Figure 1

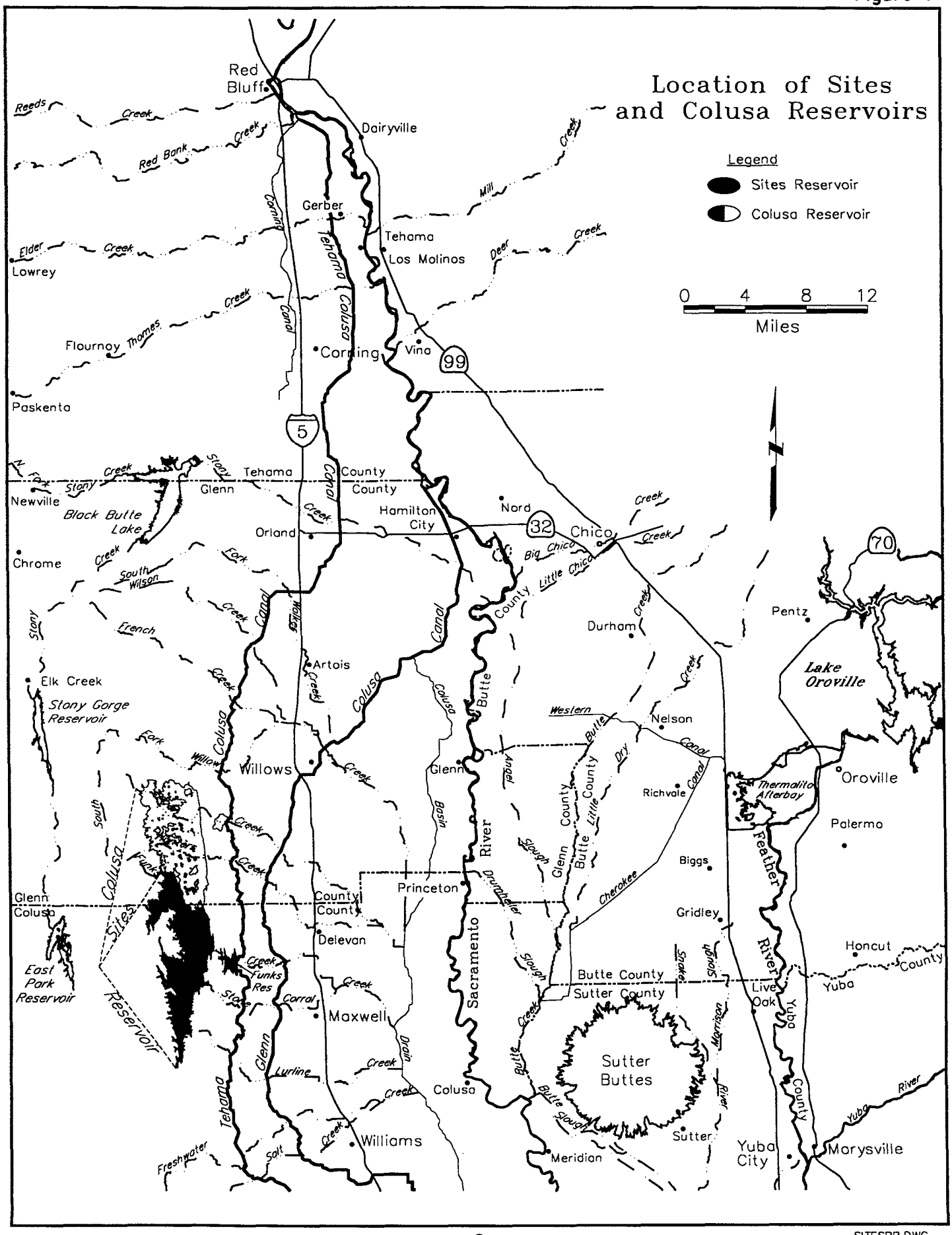

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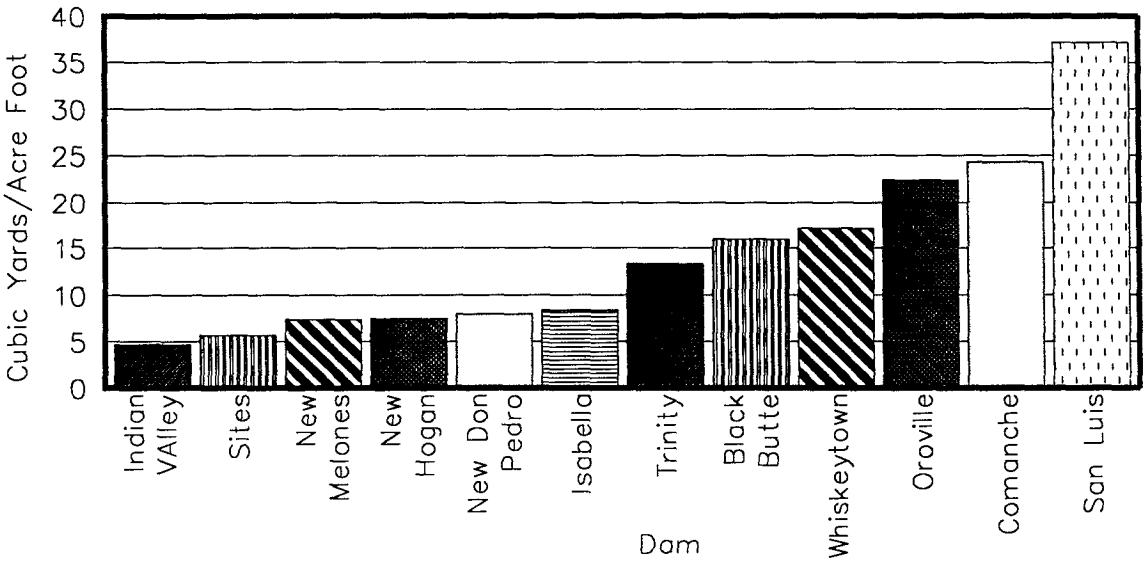
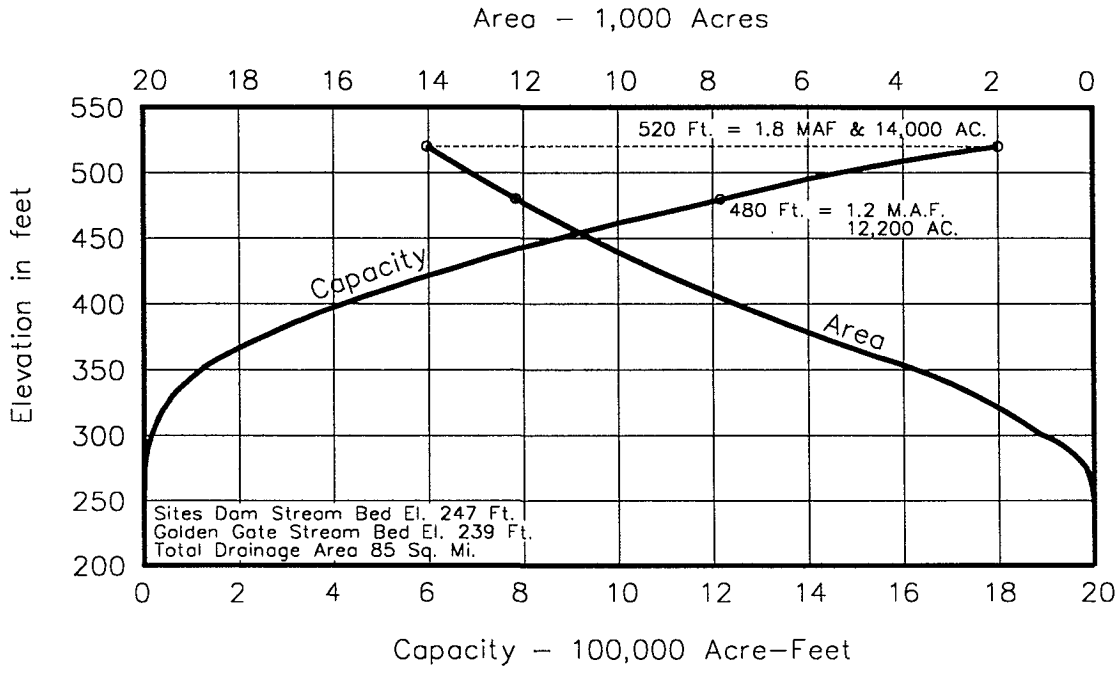
Figure 2



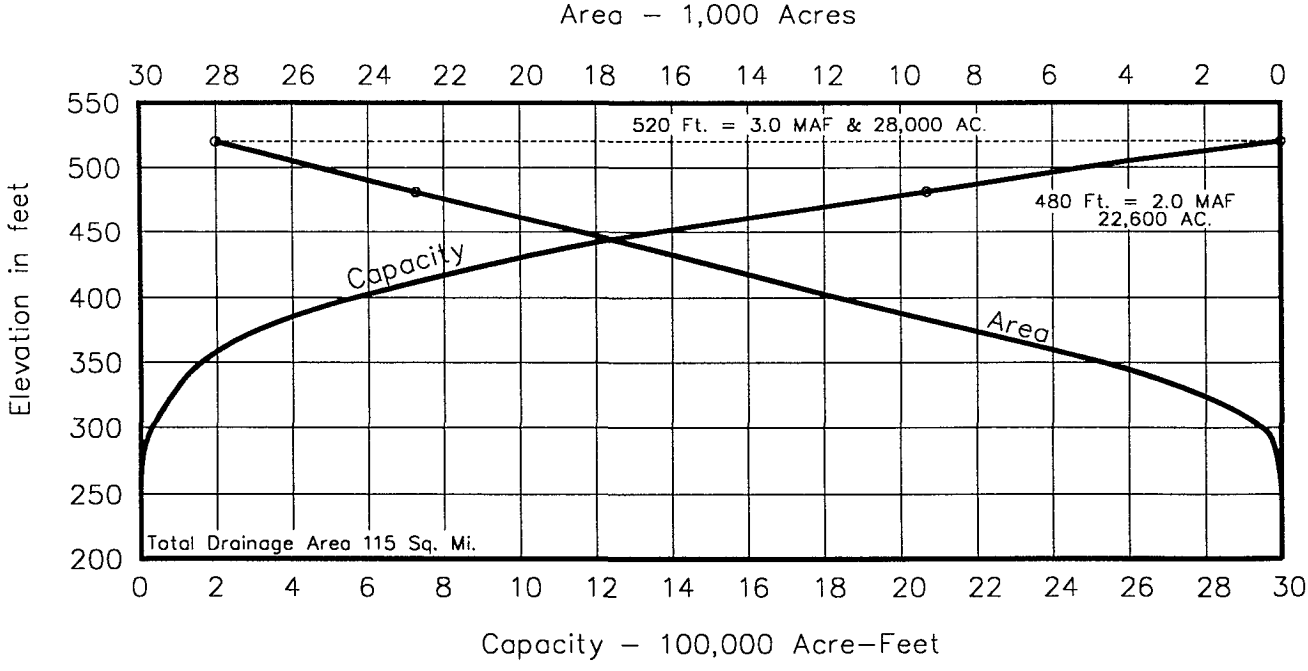
Ratio of Dam Volume to Reservoir Storage for Various Central Valley Embankment Dams

Figure 3



Sites Reservoir Area-Capacity Curves

Figure 4



Colusa Reservoir Area-Capacity Curves
(Excluding Willow Creek and Squaw Flat)

Water would be pumped from the T-C canal into Funks Forebay and then into Sites Reservoir. Water could also be pumped from the GCID canal near its existing intertie with the T-C canal. Once pumped into the T-C canal, GCID canal water would flow approximately 4 miles to Funks Forebay. An existing Funks Reservoir is on the Tehama-Colusa canal for water regulation purposes. An elevated and enlarged Funks Reservoir would be constructed at the same location as part of a large or small Sites project.

Water from the GCID Canal for Colusa Reservoir would be lifted in two stages. The first lift would be from a 3.8-mile long Willows canal connecting the GCID canal to the T-C canal. From here it would flow by gravity into Logan Forebay and through the 1.9-mile-long Logan canal to the main pumping plant at the top of Logan Dam as shown on Figure 7. Both pumping facilities could have power generation capabilities which would be used when water is released from the Reservoir.

The community of Sites, population 40, would be the only major relocation required for either reservoir, although the larger Colusa Project could displace as many as 100 people because of the greater area inundated.

The main benefit of a Sites/Colusa Project would be additional drought-year water supplies for agriculture, urban, and environmental uses. Other benefits would be lake recreation, local flood control, and the potential for conjunctive groundwater and surface water management to augment drought period water supply.

Cost estimates for the three Sites/Colusa Projects were originally made in earlier studies dating from 1964 to 1983. These earlier estimates were updated to 1995 cost levels using the U.S. Bureau of Reclamation Water and Power Cost Index. These updated capital costs range from $230 million for Small Sites, to $450 million for Large Sites and $1,140 million for Colusa. Only capital costs are presented in this report and the additional unknown or unestimated costs for environmental mitigation, modifications to the T-C and GCID canals, and operation (mainly pumping) of the projects are not included.

Findings

Various Sites/Colusa Projects have been looked at during the past four decades, but the investigation level has not been intensive enough to demonstrate economic feasibility. Review of these studies in a context of present knowledge of projected water needs and potential alternative supply sources leads to the following assessment:

1. The Sites/Colusa Project topography offers efficient water storage potential, but dams forming these projects would control small, relatively dry, drainage areas with little runoff. Therefore, Sites/Colusa would be practicable only as an offstream storage project supplied with water from other sources.

2. The most obvious potential source of water to a Sites/Colusa Project would be winter flows of the Sacramento River that are surplus to downstream requirements, which could be diverted into the T-C and GCID canals. Other sources that should be explored are Colusa Basin floodflows and connections to Oroville and Black Butte Reservoirs.

3. No insurmountable problems have been identified that would prevent construction and operation of a Sites/Colusa Project. The three reservoir sizes considered - Small Sites, Large Sites, and Colusa - define the practical range of project alternatives.

4. Sites Reservoir would have a significantly lower cost per unit of storage than the larger Colusa Project, primarily because of the large-volume dams required to impound the northern increment of storage on Hunters and Logan creeks. Sixty percent of the water storage of the Colusa Project can be obtained at the Sites compartment with a total dam volume of only 20 percent of that required for Colusa.

5. The Sites and Colusa Reservoir areas presently support small populations ranging from 40 to 100 people and contain few structures, utilities, or roads. Most of the land is used for grazing or dry farmed grain because little surface or groundwater is available for summer irrigation.

6. No major environmental or archeological problems are presently identified in the reservoir area. However, unresolved environmental problems concerning winter diversions for both the T-C and GCID canals must be addressed if this project is pursued.

7. The Large Sites Project (1.8 million acre-feet storage capacity) appears to offer promise as a surface water development alternative. It provides a large reservoir at this site with a relatively high water storage to dam volume ratio. Expanding the reservoir into the Hunters and Logan creek basins would lower this ratio and increase unit storage cost.

8. Although a Sites/Colusa Project could be configured in different ways, the primary benefit would be increased drought-period water yield north of the Delta ranging from 150,000 to 430,000 af/yr with presently estimated capital cost ranging from around $230 million to $1.14 billion. Other benefits would include reservoir recreation, conjunctive use opportunities, and flood control to the Maxwell and Colusa Basin areas.

9. Staging of the Sites/Colusa Project by starting with a smaller project and increasing its size in the future as economic and water demand conditions warrant is a possibility. The most obvious staging opportunity is to construct the Small or Large Sites Project and later enlarge it to the Colusa Project. If Large Sites is initially constructed, then neither Sites nor Golden Gate Dams would have to be raised for enlargement to the Colusa Project stage. Because of the large difference in the ratio of dam volume to reservoir volume between the Sites and Colusa projects, expanding the Sites Project into the Colusa Project will significantly increase the unit cost ($/ac-ft) of the larger projects water yield.

PAST STUDIES

The topographically attractive damsites on Stone Corral and Funks creeks must have been recognized by almost everyone who saw them since the early California settlement days. Both are deep narrow gorges with steep rock walls. The rock at Sites Damsite on Stone Corral Creek is hard enough to be used for masonry purposes, and large quantities were transported by railroad to San Francisco to help rebuild after the 1906 Earthquake.

The earliest published reference to a Sites Project is found in DWR Bulletin 3, *The California Water Plan 1957*, which mentions a 48,000 af offstream storage reservoir on Stone Corral and Funks creeks supplied by the T-C Canal.

The *Colusa Basin Investigation*, Bulletin 109, published by DWR in 1964 to evaluate potential flood control projects, considered two separate reservoirs of 5,800 and 7,600 af on Stone Corral and Funks creeks, respectively. An update of this report in 1990 found these reservoirs unjustified for flood control alone. However, a July 1995 draft report by the Colusa Basin Drainage District on its proposed "Water Management Program" recommends a 62-foot-high dam on Funks Creek which would impound 9,500 af in "Golden Gate Reservoir." Project benefits are listed as flood control and modest springtime irrigation yield. Not enough information is available to determine if this project would be economically justified.

Consideration of larger projects at the Sites location was first documented in December 1964 when the U.S. Bureau of Reclamation published its *West Sacramento Canal Unit Report*, which studied the feasibility of extending the T-C Canal (via a new West Sacramento Valley Canal) into Solano County near Fairfield. As part of this canal extension plan, a 1.2 maf Sites Reservoir was proposed. This study did not evaluate the potential of Sites as a stand alone project but only as part of the extended canal system. This is the most detailed study of the Sites Project and forms the basis for cursory studies which followed. The Bureau attempted to obtain funds for a full feasibility study of Sites in 1977; however, appropriations were never approved. The short concluding report ending this study in 1981 stated, "The 1976-77 Drought clearly demonstrated the need for additional surface water development. One means of increasing water supply is conservation of surplus flows by storage in off-stream reservoirs." Sites Reservoir is capable of conserving these surplus flows, thereby increasing water supply availability.

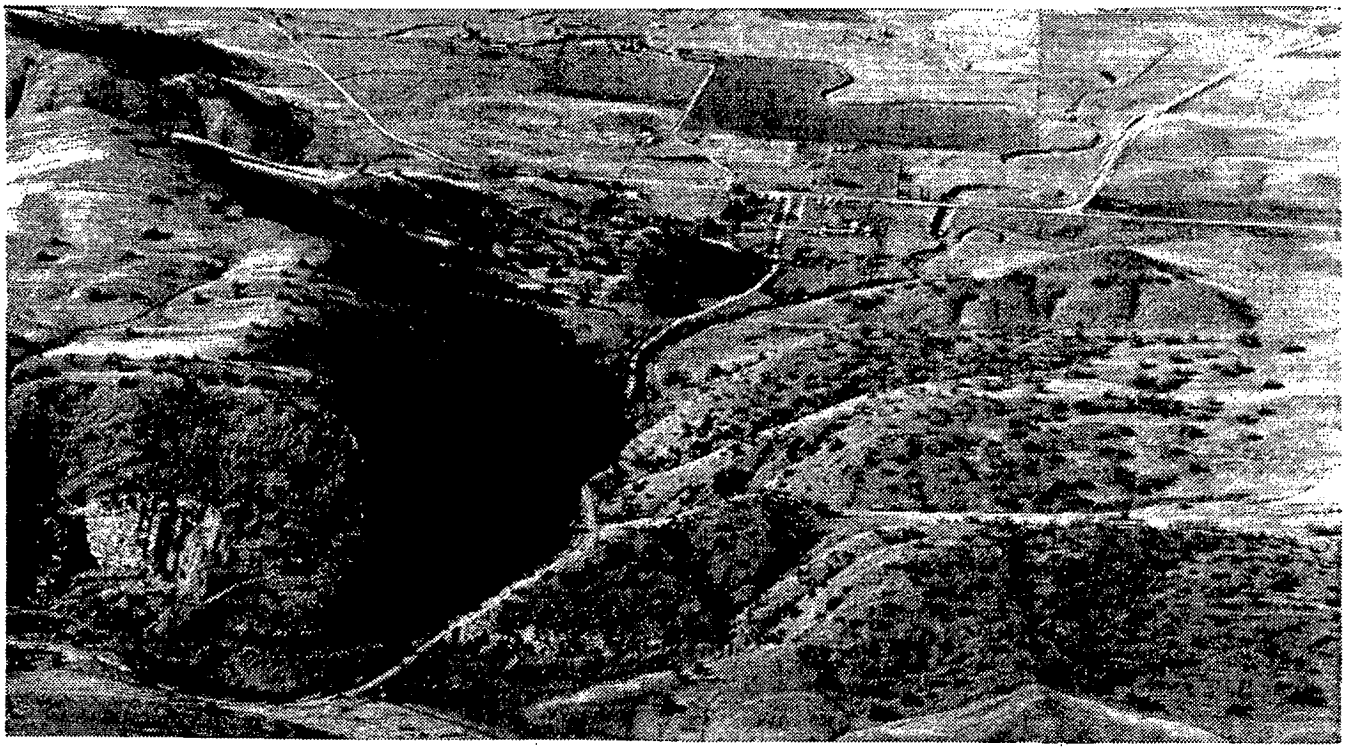
Throughout the 1960s and 1970s, Sites was considered a Bureau project, and DWR's only published Sites report was on a small-scale flood control project. However, DWR performed unpublished analyses of the larger Colusa Project's water supply potential in connection with regional investigations. In *North Coastal Area Investigation*, Bulletin 136, published by DWR in 1965, various conveyance routes were studied including the low-level westside conveyance system which included Colusa Reservoir. Two unpublished office reports in 1967 and 1968 on the Klamath-Trinity Development Projects included conveyance systems which terminated at Colusa

Reservoir. In 1975 a DWR progress report titled *Major Surface Water Development Opportunities in the Sacramento Valley* contained details of a Colusa Project. A slightly modified version of the Colusa Reservoir plan is shown in *State Water Project - Status of Water Conservation and Water Supply Augmentation Plans DWR Bulletin 76-81 (November 1981).* This report states that studies of Colusa Reservoir to date indicated that the incremental cost of storage would be excessive in comparison to storage costs of Sites Reservoir.

The next mention of Sites and Colusa reservoirs is contained in an August 1982 unpublished DWR office report titled *Enlarging Shasta Lake Feasibility Study - Descriptions of Alternative Storage Facilities.* This report relied on older studies and did not develop any new information. Likewise, information on the Sites or Colusa Projects is contained in the following reports prepared since 1982; all are based on previously developed information: (1) *Enlarging Shasta Lake Feasibility Study - Progress Report*, USBR-DWR Unpublished Draft - November 1983, (2) *Assessment of Bureau of Reclamation Planning Activities Involving New Water Supplies*, Limited USBR Office Report - September 1993, and (3) *Least-Cost CVP Yield Increase Plan - Appendix #6 Surface Storage and Conveyance*, USBR Office Report - September 1995.

In March 1990, the engineering consulting firm CH2M-Hill, Inc. prepared a long-range plan for GCID which included an 870,000 af Sites Reservoir with normal water surface elevation of 460 feet. This project was based on the Bureau's 1964 report but was judged nonimplementable by GCID because of the financing needed to cover the capital cost of $152 million. In 1993, CH2M-Hill published a small report on *Meeting California's Water Needs in the 21st Century*, which presented a conceptual Westside Storage and Conveyance System. This concept mentioned a Sites/Colusa Reservoir with a feeder pipeline from Lake Oroville. DWR's *California Water Plan Update*, Bulletin 160-93, included a description of the Westside Sacramento Valley Concept when discussing water supply management options.

In October 1995, Mr. Joe Patten with CH2M-Hill, in a formal presentation before the California Water Commission, recommended further study of a Sites/Colusa Project.



Sites Damsite on Stone Corral Creek (above) looking west including the community of Sites (background). Golden Gate Damsite on Funks Creek is shown below looking east including some of the reservoir area (foreground) and a portion of Funks Reservoir and the Tehama-Colusa Canal (background).

FORMULATION OF ALTERNATIVE PROJECTS

For this cursory project evaluation, project formulation centered around Large Sites (Figure 5), the largest project that could reasonably be constructed at the more efficient Sites compartment. Two other options, a Small Sites and the larger Colusa Project, are also discussed for comparison. Another option that should be considered is constructing the Large Sites project and, if future water needs and economic conditions warrant, expanding it into the northern Colusa compartment at the same maximum water surface elevation.

Project Design

The three sizes of projects considered at the Sites/Colusa location are (1) Small Sites (1.2 maf at 480 foot elevation), (2) Large Sites (1.8 maf at 520 foot elevation), and (3) Colusa (3.0 maf at 520 foot elevation). Other intermediate sizes are possible but these three alternatives bracket reservoir sizes thought practical for large-scale water conservation purposes. If the storage of either Large Sites or Colusa were increased above 1.8 maf and 3.0 maf respectively, the volume and number of saddle dams would increase substantially and seepage through Logan Ridge, which forms the eastern boundary of all reservoir options, might become an issue. The present 480-foot and 520-foot reservoir study elevations were selected partially because these contours are shown on U.S. Geological Survey quad maps (7-1/2 minute - 40 foot contour interval), which is the best mapping presently available. More detailed mapping will be required to determine exact reservoir elevation limitations and saddle dam sizes. The design details of the three projects considered are discussed below.

Small Sites Project

The Small Sites Project has probably received the most intensive study effort, although it was conducted more than 30 years ago and is somewhat outdated. Also, the 1964 report that contains the project evaluation (West Sacramento Unit, Central Valley Project) was broadly focused on extending the T-C Canal into Yolo and Solano counties. Sites Reservoir was just one of several features evaluated and it was not considered on its own merits as a stand-alone project. Even though the report estimated a benefit to cost ratio of over 3 to 1, the canal was never extended farther than just south of the Colusa County line and Sites Reservoir was never proposed for construction.

The engineering features of Small Sites would be very similar to Large Sites except that the maximum reservoir elevation would be 40 feet lower at elevation 480 feet and the maximum reservoir capacity would be 600,000 af less at 1.2 maf. The heights of the four saddle dams still required would be 40 feet shorter.

Drought period yield is estimated at around 155,000 af/yr. The 1964 construction cost estimate of $46 million updated to 1995 is around $230 million, not including energy, environmental mitigation, and canal conveyance upgrade costs. This

Figure 5

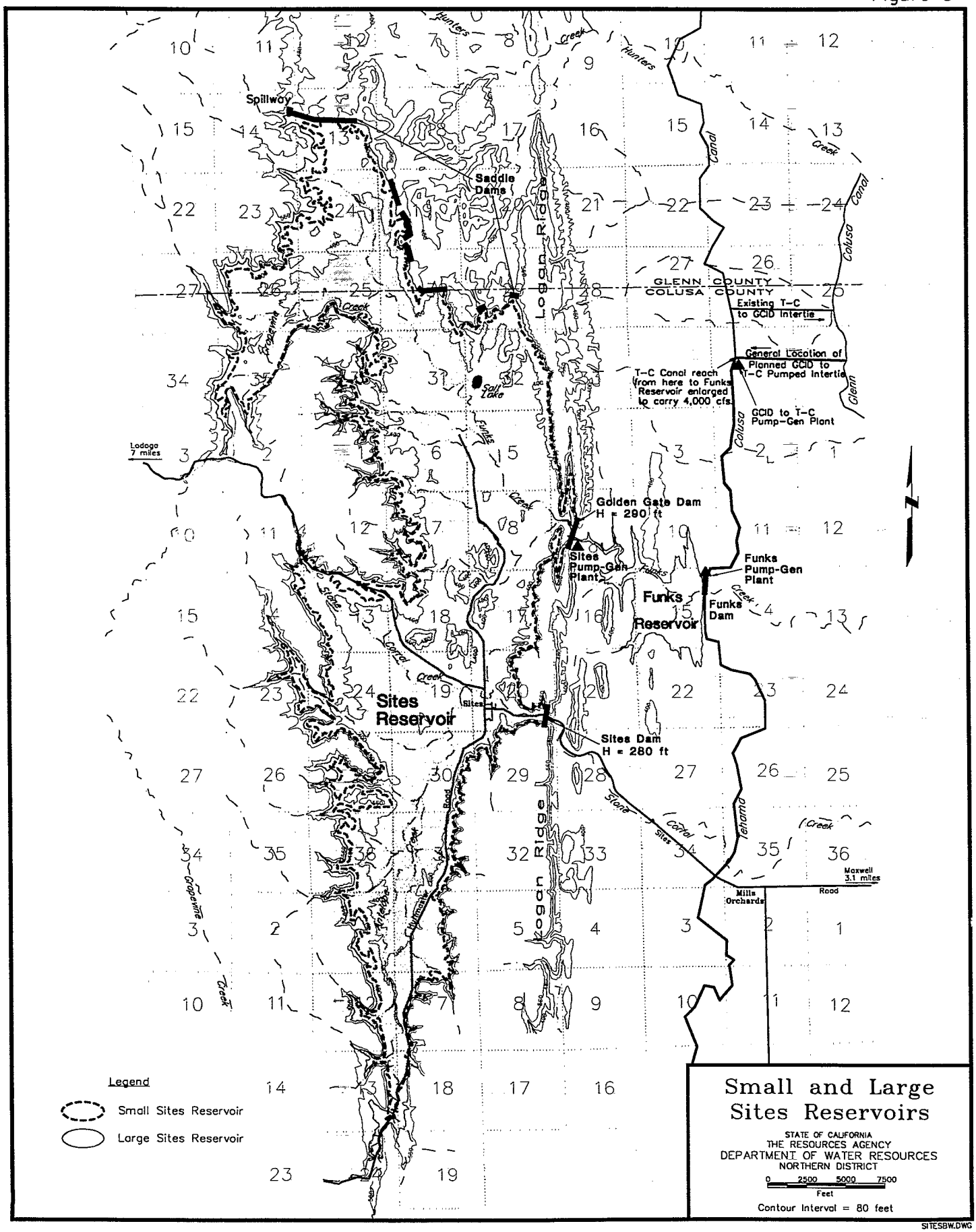


Table 1

PROJECT STATISTICS FOR THE SMALL SITES, LARGE SITES, AND COLUSA PROJECTS

Project Feature	Small Sites	Large Sites	Colusa
Storage (acre-feet)			
Gross	1,200,000	1,800,000	3,000,000
Dead	40,000	40,000	100,000
Dam Height (feet)			
Sites	240	280	280
Golden Gate	250	290	290
Hunters	----	----	270
Logan	----	----	260
Saddle Dams (Number & Height Range)	4 from 10 to 80 feet	7 from 15 to 100 feet	11 from 35 to 140 feet
Reservoir Elevation (feet)			
Maximum	480	520	520
Minimum	320	320	320
Natural Reservoir Inflow (acre-feet)			
Average Annual	15,000	15,000	20,000
Critical Period Average Annual	4,000	4,000	5,500
Reservoir Evaporation (acre-feet)			
Average Annual	30,000	40,000	90,000
Total Critical Period	184,000	220,000	500,000
Pumping (feet)			
Static Lift from T-C Canal			
Maximum	280	320	310
Minimum	120	120	110
Capacity			
Maximum (cubic-feet/sec)	2,000	4,000	4,000
Yield (acre-feet)			
Average Annual During Drought	155,000	240,000	430,000
Capital Cost ($million)			
Base Estimate	$ 46	$300	$750
Agency and Date	USBR - 1964	DWR - 1983	DWR - 1981
Updated to 1995 Using USBR Index	$230	$450	$1,140

Capital cost estimates do not include the substantial costs for pumping water into the reservoirs, constructing a GCID to T-C intertie (except for Colusa), or the fishery, wildlife, and vegetation mitigation. Also, current maximum winter diversion capacity from the Sacramento River into the T-C Canal is only 500 cfs. This capacity should be increased to around 2,000 cfs for Large Sites and Colusa, and combined with the approximately 2,000 cfs capacity available from the GCID Canal in order to fill a Sites/Colusa Project in less than 10 years. The cost of canal upgrading is not included.

project does not take maximum advantage of the topographic storage limits at this very efficient site. Much of the information contained in the following, more detailed Large Sites discussion below also applies to Small Sites. The optimum size for a Sites Project would be determined during a reconnaissance level investigation which would be performed next if these projects are studied further.

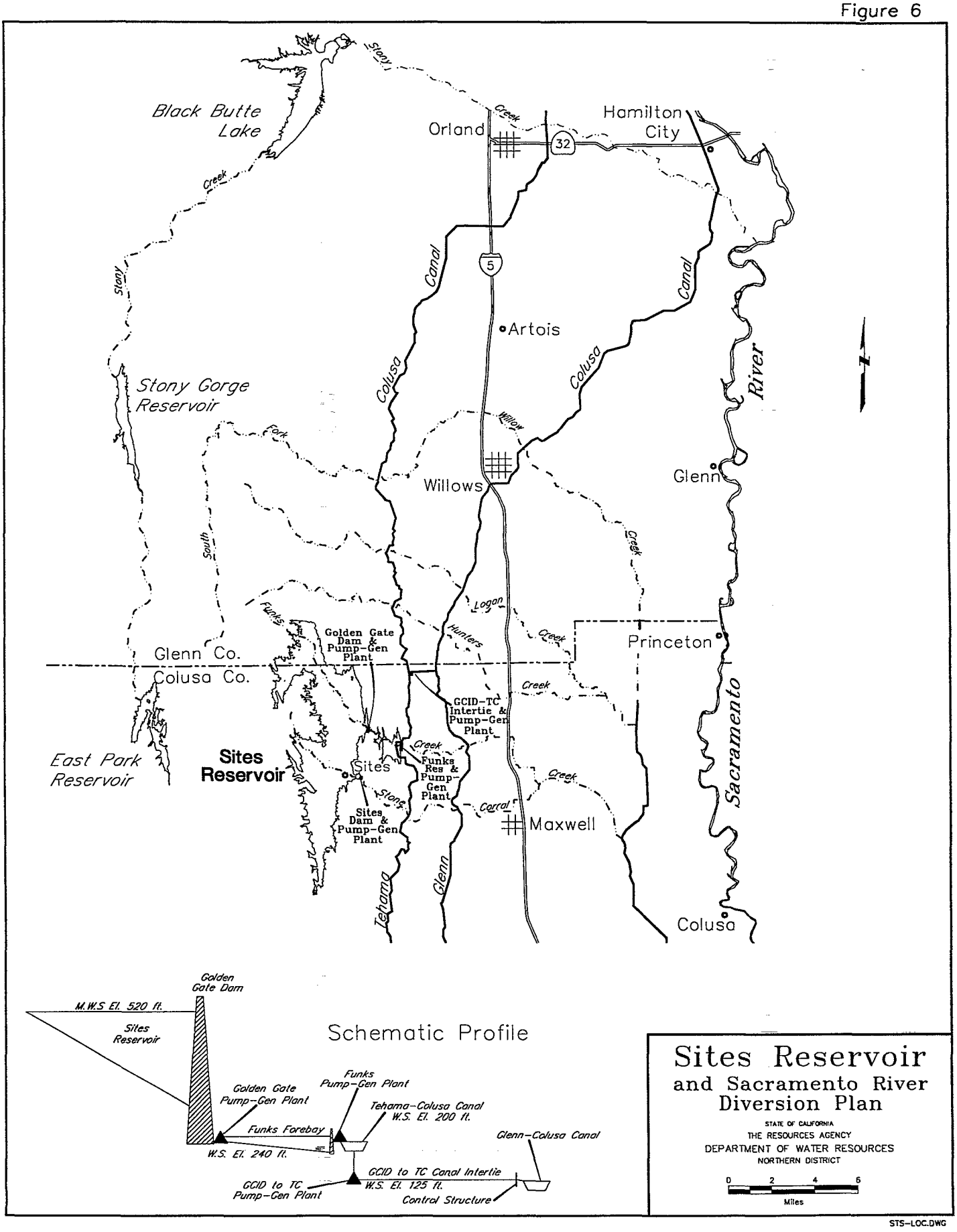
Large Sites Project

This project alternative (Table 1 and Figures 5 and 6) is the largest practical project formed by damming only Stone Corral and Funks creeks. DWR briefly investigated it at a cursory level in 1978 and the following information is based on that work.

The Large Sites Project is sized at a maximum practical elevation of 520 feet, which equals a reservoir surface area of 14,000 acres. The reservoir would be formed by a 280-foot-high Sites Dam on Stone Corral Creek and a 290-foot-high Golden Gate Dam on Funks Creek (plus seven saddle dams ranging up to 100 feet high). An 80-foot-high dam on Funks Creek, 3/4 mile downstream from Golden Gate Dam would replace the existing 40-foot-high dam to form a 17,000 af Funks Forebay Reservoir which would regulate inflow and outflow to and from Sites Reservoir. Pumping-generating plants would be located at three sites: (1) the base of Golden Gate Dam to pump water a maximum of 280 feet from Funks Reservoir into Sites Reservoir, (2) the intersection of the T-C Canal and Funks Reservoir to pump water a maximum of 40 feet from the canal into Funks Reservoir, and (3) along a new canal intertie to pump water 75 feet from the GCID Canal to the T-C Canal. The exact location of this new intertie canal has not been established. However, it would probably be near the existing T-C to GCID gravity intertie just south of the Glenn-Colusa county line because this is the closest point between the canals. This location would require increasing the T-C Canal capacity (from approximately 2,000 to 4,000 cfs) downstream of the intertie for approximately 4 miles. Therefore, the cost of constructing the intertie at the closest point between canals must be compared to that of constructing a longer intertie nearer Funks Creek, which would eliminate the need for enlargement of the T-C Canal. A small forebay-afterbay will probably be required at the connecting point on the GCID Canal. This series of pumping-generating plants will serve both the inflow and outflow requirements of a Large or Small Sites Project; however, the 1.2 maf Small Sites Project might be adequately served by only the T-C Canal if winter diversions of around 2,000 cfs are made possible in the future. Unresolved fishery issues presently limit winter diversions through the T-C Canal to less than 500 cfs because the diversion dam gates are raised then and all water must be pumped into the canal. Planned future pumping capacity is not greater than 500 cfs.

Seven saddle dams ranging in height from 15 to 100 feet would be required at the north end of Large Sites Reservoir to close the gaps between the small rolling mounds that form the divide between Funks and Hunters creeks. Any higher reservoir elevation would increase the length and height of these saddle dams. A 2,500-cfs-capacity spillway would discharge into a tributary of Hunters Creek at the northwest corner of the Reservoir next to the westernmost saddle dam. Because of the small,

Figure 6



relatively dry, tributary drainage area and Large Reservoir surface area, a small spillway is adequate. A 14-foot-diameter gated outlet pipe would discharge through Golden Gate Dam to Funks Creek to meet emergency reservoir evacuation requirements.

One potential problem with the earlier Large Sites Project formulation estimates was the excessive (greater than 10 years) fill period for the project using only the T-C Canal with a maximum capacity of 2,000 cfs for supply to Sites Reservoir. A fill period of less than 10 years would be desirable and possibly crucial to project feasibility. Doubling the pumping rate to around 4,000 cfs by using the maximum capacity of both the T-C and GCID canals should be considered for reducing both the fill and refill periods. However, these canals are not presently capable of diverting this level of flow during the winter because of unresolved fishery problems. This is an issue that needs considerable additional detailed study if a Sites/Colusa Project is pursued.

All Sites/Colusa Project alternatives will require substantial energy input to operate the lift pumps, even though approximately 40 percent to 60 percent of the pumping energy requirement will be offset by project-generated power. Average annual energy consumed at Large Sites is estimated at around 60 gigawatt hours while around 30 would be produced by project releases. The drought period yield of Large Sites is estimated at around 240,000 af/yr. An operation study anticipating future Delta outflow and water quality requirements and coordinating the operation of all major Sacramento Valley reservoirs would be required to accurately estimate project yield.

A 1983 DWR cursory cost estimate for the principal storage and conveyance facilities of Large Sites placed the construction cost at nearly $300 million and the total capitalized cost including operation and maintenance and energy at nearly $400 million. Updating these costs using the USBR Water and Power Cost Index equates to $450 million and $600 million, respectively. These costs are cursory level estimates which do not adequately account for environmental mitigation or construction costs of the GCID intertie or of upgrading the T-C and GCID canals' winter diversion capability and conveyance capacity (see note on Table 1).

One potential design option that might significantly reduce construction costs for the required dams would be the use of roller compacted concrete instead of earthfill. This technology should be evaluated in any future design work on the Sites/Colusa Project.

Colusa Reservoir

The most current information on this project is contained in DWR Bulletin 76-81 *State Water Project - Status*. The extension of Large Sites into the northern "Colusa compartment" forms the Colusa Project. It is necessary to build two large dams at the gaps in Logan Ridge where Hunter's and Logan creeks pass through and construct numerous small saddle dams along Logan Ridge. There is almost a 5 to 1 ratio between the volume (and cost) of combined Sites, Golden Gate, Hunter's, and Logan

dams at the 520-foot water surface elevation and just Sites and Golden Gate dams which would form Large Sites reservoir at the same elevation. This makes the Colusa Project considerably more expensive per increased unit of storage in comparison to Large Sites, although 1.2 maf of additional storage is made available.

The Colusa Project, like Large Sites, would be filled by winter and spring Sacramento River water surplus to downstream needs. This water would be transported to Colusa Reservoir through the existing T-C and GCID canals and pumped from the canals at a different location from that used for Large and Small Sites. This location is approximately 4 miles south of Willows and 9 miles north of Funks Reservoir as shown on Figure 7.

Facilities required for this conveyance system are: (1) Logan Forebay - a 400-af (Elevation 210) impoundment formed by a low earth dam on Logan Creek immediately west of the T-C Canal; (2) connecting canals - a 2,000 cfs, 4.2-mile Willows Canal between the GCID and T-C canals and a 4,000 cfs, 1.7-mile Logan Canal connecting Logan Forebay to the Logan pumping-generating plant located at the base of Logan Dam; and (3) pumping-generating plants - a 17-megawatt "Willows" plant at the confluence of the Willows Connector Canal and the T-C Canal which would lift 2,000 cfs 84 feet from the GCID Canal into the T-C Canal and an 86-megawatt "Logan" plant at the base of Logan Dam lifting water a maximum of 310 feet into Colusa Reservoir. The average annual amount of surplus winter and spring water that was estimated in 1981 to be divertible through the T-C and GCID canals is around 0.5 maf. Today, this amount is probably lower because of increased Delta and other downstream requirements. Also the allowable winter diversion capacities of both canals have been reduced substantially to minimize the impacts on listed winter run salmon. In the case of Red Bluff Diversion Dam the gates are raised during the winter which reduces the maximum diversion into the canal to around 500 cfs. For the GCID Canal, pumping restrictions are imposed on the canal until a new planned screen is constructed around the year 2001.

The drought-period yield of the Colusa Project was estimated in 1981 at around 0.43 maf/yr. Operating criteria at major projects and in the Delta are much different now than in 1981; this would probably reduce the potential yield of a Colusa Project.

The 1981 project capital cost estimate along with updated estimates for 1995 are shown in Table 2. The updated capital cost of around $1.1 billion may be reduced through use of roller compacted concrete instead of earthfill; however, this savings may be largely offset by presently undefined costs associated with required river diversion modifications. A comparison of capital costs to gross storage for all three Sites/Colusa Projects is shown on Figure 8.

Figure 7

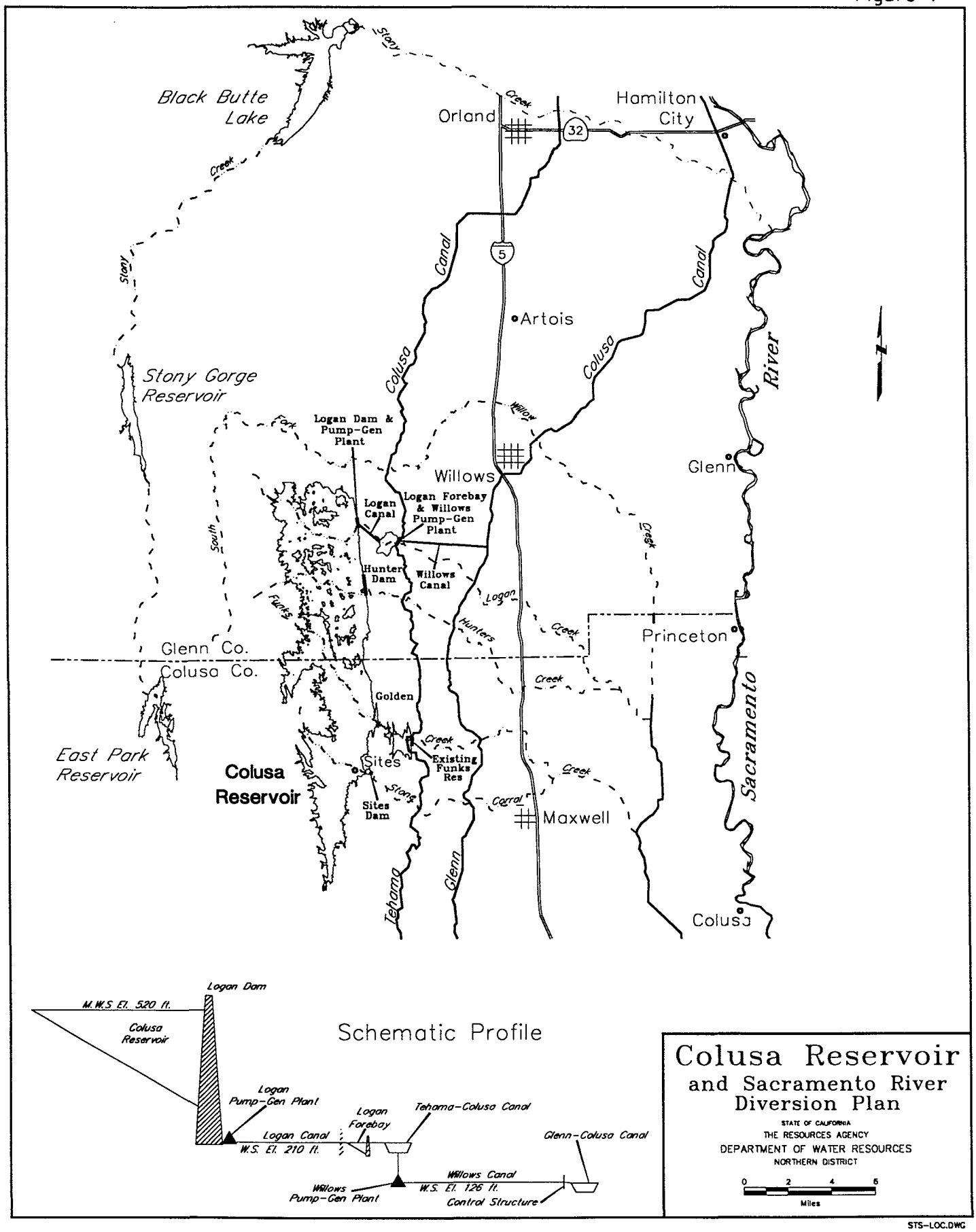
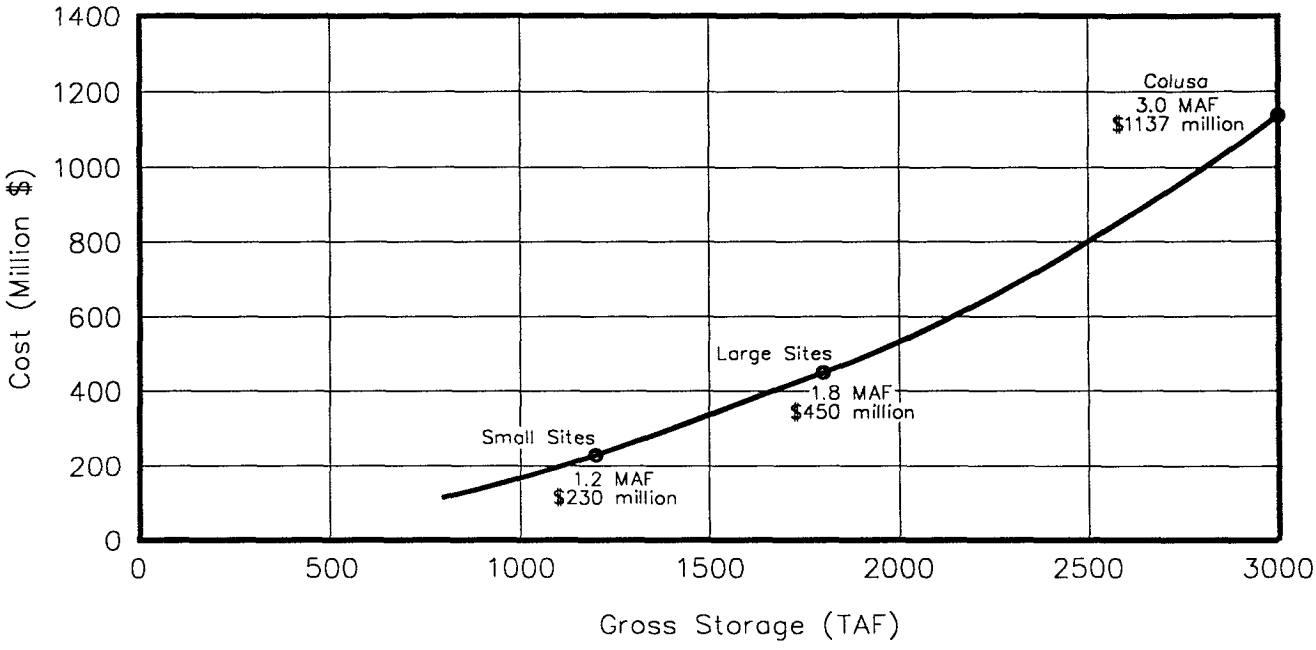


Figure 8



Sites/Colusa Projects Storage vs. Cost Comparison

This estimate does not include the substantial costs for pumping water into the reservoir, constructing a GCID to T–C intertie, or mitigating fishery, wildlife, and vegetation. Also, current maximum winter diversion capacity from the Sacramento River into the T–C Canal is only 500 cfs. This capacity should be increased to around 2,000 cfs and combined with the approximately 2,000 cfs capacity available from the GCID Canal in order to fill a Sites/Colusa Project in less than 10 years. The cost of upgrading these canals is not included in the estimates shown in Table 1.

Table 2

COLUSA PROJECT MAJOR FEATURES CAPITAL COST ESTIMATE
(1981 estimate updated to October 1995 using USBR index)
In $1,000,000

Colusa Reservoir	**1981 Base Estimate**	**October 1995 Indexed Estimate**
Sites Dam	31	47
Golden Gate Dam	53	79
Hunters Dam	318	477
Logan Dam	148	222
Outlet Works and Spillway	23	35
Reservoir Clearing and Facilities	50	75
Right-of-Way	17	25
Subtotal	640	960
Conveyance Facilities		
Willows Canal	17	26
Willows P-G Plant	26	39
Logan Canal	15	22
Logan P-G Plant	52	78
Logan Forebay	1	2
Power Transmission Facilities	7	10
Subtotal	118	177
Total Capital Cost	758	1,137

Issues Common to All Alternatives

Land and Relocations

The Sites/Colusa Reservoir area is very sparsely populated with less than 100 residents living in the potential project area. Land ownerships are large, as shown on Figure 9. Few utilities would have to be relocated but the road to Stonyford would have to be moved to a location outside the reservoir.

Geology and Construction Materials

Damsite geologic conditions in the study area are not thoroughly known, although USBR did some subsurface exploration in the 1960s and 1970s. Available information from this work will be obtained if a reconnaissance level study of a Sites/Colusa Project is pursued.

The availability of construction materials near the project site does not appear to be a problem. A 1978 field investigation memorandum by DWR indicates that six impervious material alluvial fill areas totaling more than 50 million cubic yards lie along stream channels within the Sites/Colusa Reservoir area. Rockfill quantities of at least 185 million cubic yards are located along Logan Ridge or in the reservoir area. No sand and gravel deposits are near the reservoir; the closest large source is north of Willows in an old channel of Stony Creek. The one-way haul distance is around 25 miles.

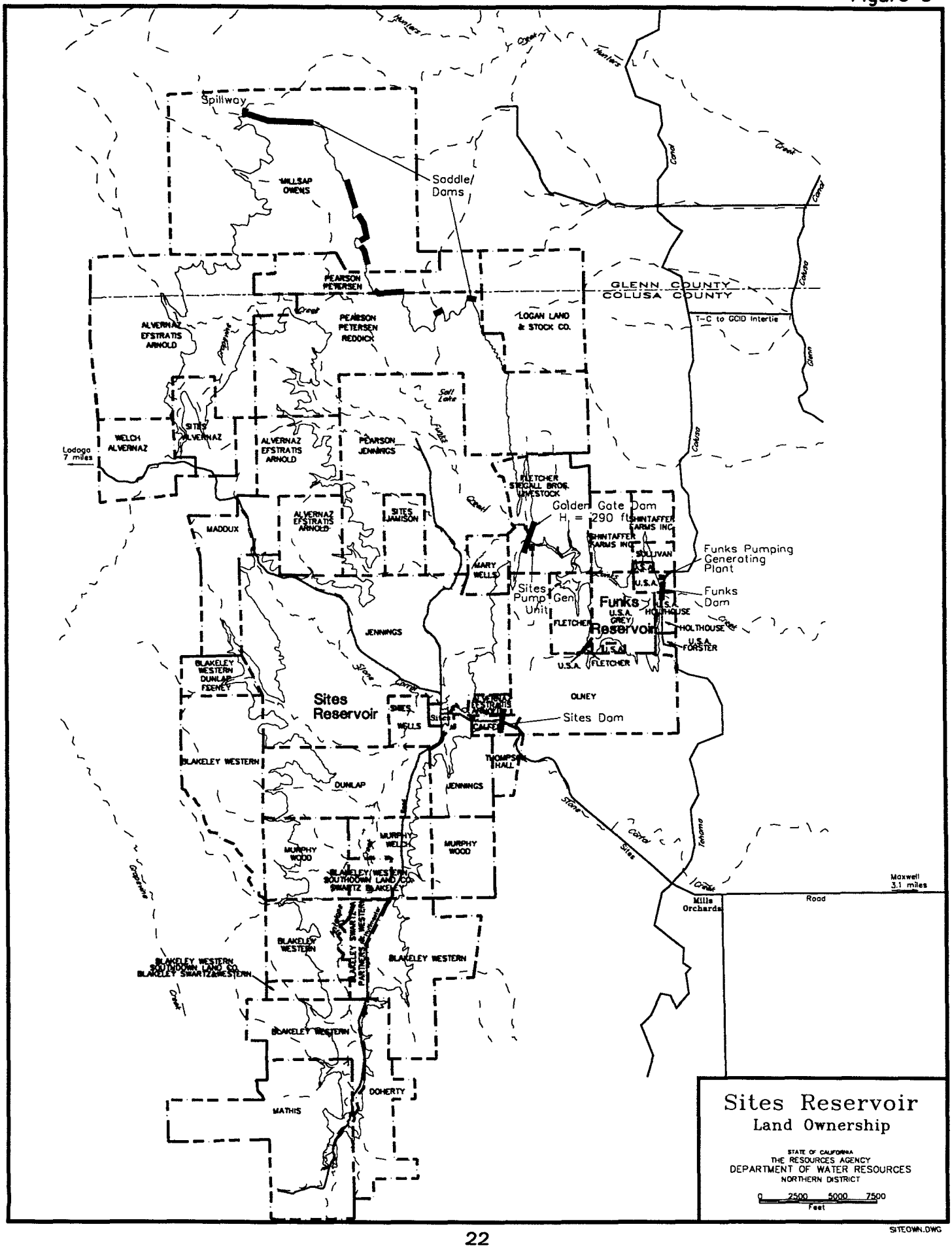
Probably the most significant technical factor affecting the construction of a Sites/Colusa Project is seismicity. No seismic investigation was conducted specifically for Sites/Colusa Reservoir; however, in 1988 an article in *The Journal of Geophysical Research* reported on studies from 1969 to 1985 of the seismicity of the area from Red Bluff to San Luis Reservoir. The paper stated:

> "Beneath the physiographic boundary between the Coast Ranges and the Great Valley, a fundamental tectonic boundary exists between the Coast Ranges province and the Sierran block. The Coast Ranges-Sierran Block boundary zone is a complex region of compressional tectonics and is the probable source of the 1892 Winters earthquake (ML 6.7) and the 1983 Coalinga earthquake (ML 6.7). ...tectonic deformation manifested by the Coalinga and other recent, moderate-sized earthquakes in the southern study area appears to be occurring along the full extent of the boundary."

Thus, the potential for large earthquakes exists along the Coast Ranges-Sierran Block boundary north to Willows and possibly farther.

Although this 1988 study was one of the first to imply large-scale potential for earthquake activity emanating from "hidden" faults along the western Great Valley,

Figure 9



other investigations have also examined the west side of the Sacramento Valley and identified several hot spots of microseismic activity related to "hidden" or "blind" faults. To date, the extent and potential of these hidden faults have yet to be adequately defined. This undefined potential for large-scale earthquake activity within the Sites/Colusa Project region could substantially affect the design of the facilities and deserves considerable additional study.

Hydrology

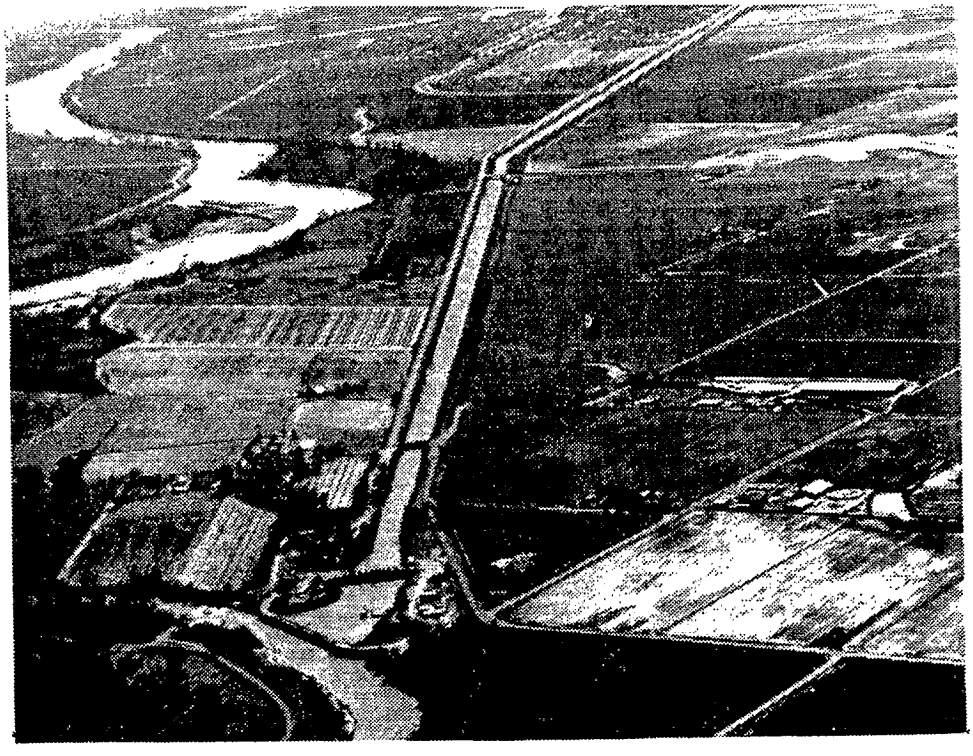
Project justification will greatly depend on the magnitude and timing of divertible flows from the Sacramento River. The winter flow data for the Sacramento River at Red Bluff Diversion Dam and the GCID Canal Diversion near Hamilton City need to be updated to estimate the future level of divertible flows surplus to downstream needs which are available for project filling. The frequently changing rules governing Delta outflow requirements and divertible flows by the State Water Project and Central Valley Project, along with more stringent water quality standards, make estimating future water availability a speculative process. However, a substantial majority of the divertible flows occurs during flood periods when Delta standards will have little or no impact on their availability for diversion.

Feeder Canal Modifications

As previously mentioned, neither the T-C diversion or GCID diversion presently have the capability of diverting the desired 2,000 cfs each during the winter, although the GCID canal is expected to have this capability by around 2001. During the summer, with the Red Bluff Diversion Dam gates lowered, a diversion of 3,000 cfs is possible into the T-C Canal. However, with the gates raised during eight months from mid-September through mid-May winter water would have to be pumped into the canal. The future pumping capacity into the GCID Canal is projected to only be around 500 cfs long term during the winter using Archimedes, or other fish passing pumps, which are now being tested. In order to increase the winter diversion capacity of the RBDD into the T-C Canal above 500 cfs, more pumps would have to be installed. Their installation and operating cost would be large and some opposition might be expressed by those who do not want the RBDD replaced entirely by pumps. Additional operational costs are incurred when pumping water into the canal because water must be lifted an additional 15 feet from the river into the canal.

The GCID Canal historically has not normally diverted large flows during the winter even though it has been capable of diverting 3,000 cfs in the summer. Present fishery restrictions limit diversions from August 1 to November 31 to approximately 1,500 cfs but allow diversions up to an average of 2,400 cfs the rest of the year. Also, separate from the screening issues, the GCID Canal would have to go through a "winterization" construction program estimated to cost around $16 million before it would be capable of routinely carrying large winter flows.

Potential Sacramento River Diversions to a Sites/Colusa Project. Above is the entrance to the Tehama-Colusa Canal at the Red Bluff Diversion Dam(RM 243). Below is the entrance to the Glenn-Colusa Irrigation District Canal (RM 206).



Intensive studies are under way to solve the fishery problems at both diversions but little emphasis is being placed on developing the capability to divert large winter flows. If a Sites/Colusa Project is studied in the near future, close coordination should be established with the existing teams developing solutions to fishery problems at the T-C and GCID canals. Adding large winter diversion capability at both canal intakes would be costly and a Sites/Colusa Project would logically be responsible for paying those additional costs. Such costs would be additive to any existing project cost estimate and could have a significant impact on project feasibility.

Roller Compacted Concrete

Roller compacted concrete construction, developed in the 1980s, is being used more frequently for dam construction because of its cost and time savings. Dam volumes can be reduced greatly from earthfill construction and time saved over conventional concrete techniques because RCC is rapidly placed using conventional construction equipment.

In 1993, a cost comparison between alternative RCC and earthfill dams at the Red Bank Project near Red Bluff showed RCC to be approximately half the cost of earthfill. Therefore, future studies of a Sites/Colusa Project should evaluate the use of RCC as a construction material.

Potential Alternative Water Sources

Other potential supplemental water supply sources could augment direct river diversions. Flood water originating in Colusa Basin collects in the Colusa Basin Drain from where it could be pumped into a Sites/Colusa Reservoir. A 1988 DWR flood flow frequency analysis of the Colusa Basin at the Highway 20 Gage west of Williams shows that the drain carries a peak flow of at least 3,000 cfs an average of once every two years and carries at least 6,500 cfs an average of once every five years. Also, during flood periods, the low land surrounding the drain periodically stores up to 100,000 af for several weeks until the Sacramento River at Knights Landing drops enough to allow the flood water to drain into the River. Part of the flows forming this periodic large inland lake could be pumped into a Sites/Colusa Project via a new 6-mile canal from the Maxwell Road/CBD crossing to the GCID Canal/Maxwell Road crossing. Once in the GCID Canal, this water could be pumped to Funks Reservoir and then to Sites Reservoir using the same pumping-generating plants that would convey Sacramento River water. The capacity of the GCID Canal at this location is around 1,800 cfs. Another potential method to deliver flood water to a Sites/Colusa Project would be through a westside flood control canal paralleling the T-C Canal. This flood control canal would intercept part of the flow of the numerous small westside tributaries such as Willows, Logan, and Hunters creeks and channel it to Funks Reservoir from where it would be pumped into a Sites/Colusa Reservoir. This alternative would likely be more expensive and environmentally significant than pumping directly from the CBD east of Maxwell. However, it would deliver water at a higher elevation and reduce pumping costs. A modification to a new flood conveyance canal could be to store flood

water from Wilson, Willow, and Walker creeks in old gravel extraction pits northeast of Willows from where it could be pumped 15 feet into the adjacent GCID Canal for conveyance to Funks and Sites reservoirs.

Other more elaborate and expensive alternatives which have been suggested are linking regional reservoirs with pipelines so surpluses that would normally spill from each of them could instead be stored in a Sites/Colusa Project. The most expansive concept, suggested by the engineering firm CH2M-Hill, is a 45-mile-long pipeline between Oroville and a Sites/Colusa Reservoir. Maximum water surface elevation in Oroville is 380 feet higher than a Sites/Colusa Project and Oroville frequently is forced to spill surplus water. Some of this surplus water could be transported by a gravity pipeline to a Sites/Colusa Reservoir where it would be conserved for drought year water supply. Pipeline connections with Black Butte and East Park Reservoirs to capture a portion of reservoir spills are also possible. Detailed studies are needed to determine the economic feasibility of these concepts.

Another concept which could be associated with a Sites/Colusa Project is extension of T-C Canal about 7 miles to the Cache Creek watershed. Some of the surplus winter water stored in a Sites/Colusa Reservoir could then be released in the spring making possible conjunctive water management with the Yolo groundwater subbasin. Conjunctive use with the nearer Colusa groundwater subbasin can be accomplished without constructing substantial additional facilities to a Sites/Colusa Project. Water could be released into Stone Corral, Funks, and Hunter's Creeks for groundwater recharge in the spring. During wet years, when filling of the Colusa groundwater basin is assured, some groundwater could be pumped in winter at numerous locations into T-C and GCID canals for storage in a Sites/Colusa Project and released during droughts. This would essentially increase the storage area for local groundwater.

Project Benefits

Numerous project benefits would result from the construction of a Sites/Colusa Project. At the cursory level of evaluation, most of these benefits can only be generally described and not accurately quantified.

The primary benefit would be development of a "new" water yield; water which is surplus to presently identified downstream water supply and environmental needs would be stored for future use. The quantity of this new yield would depend on many factors including reservoir size, capacity of river diversions to the project, future Delta standards, associated conjunctive use agreements, and environmental regulations.

Other potential project benefits are flood control for the lands around Maxwell and in the Colusa Basin Drain, increased recreation use around the reservoir, increased reliability of local agricultural water supplies, decreased spring through fall diversions by westside Sacramento River water users, and more reliable and adequate water supplies to federal refuges in the Colusa Basin.

Realization of all of these benefits as well as basic project feasibility depends on a high level of cooperation between agricultural, urban, and environmental water interests during project formulation.

Project Costs

Like project benefits, costs are difficult to accurately estimate at the cursory study level. All previous cost estimates were done at least 15 years ago. A couple of the primary project components - needed diversion structure modifications and environmental mitigation requirements - have not been determined. Minimum estimates are shown for each of the three project alternatives in Table 1. Colusa Reservoir has the most recent and detailed cost estimate as shown in Table 2. This table illustrates the relative cost of major components considered but does not include all the cost items that would be required by today's planning criteria.

Historic cost estimates for Large and Small Sites are not broken down into the basic components but are presented as a lump sum in old reports. The backup calculations are not available. As mentioned earlier, some cost reduction in these projects below the present indexed costs based on old reports may be possible by using RCC rather than earthfill for dam construction. Suitable natural construction materials must be available within a reasonable haul distance from the various dam locations for RCC to be a less expensive alternative. Additional geologic investigation will be required to determine the exact location of construction materials suitable for making RCC.

The true cost of environmental mitigation for a Sites/Colusa Project required for today's planning criteria can not be extrapolated from previous studies. Even though a Sites/Colusa Project may be relatively environmentally benign, substantial mitigation costs may be required to provide for the plant and animal life that will be displaced by the project. As an example, the Los Banos Grandes Project recently investigated by DWR was also thought to be relatively environmentally benign, but the latest report used approximately $10,000 per wetted acre as a rough estimate of mitigation cost. This figure was also used in the *1993 Red Bank Project Report*. Using this very rough unit mitigation value, the Sites/Colusa Project mitigation cost could range from around $120 to $280 million depending on the selected alternative. Hopefully, the actual required mitigation costs determined after detailed environmental studies will be much smaller than the above cursory estimates based on other projects.

ENVIRONMENTAL CONSIDERATIONS

Environmental legislation resulting from changing public priorities now requires that any public project mitigate for all adverse impacts to plant and animal life as well as cultural, economic, scenic, and other values the public feels are important. Only cursory study has been performed on the impacts that a Sites/Colusa Project would have on these values. Even so, most biologists who have briefly considered a project at this location have expressed the opinion that environmental impacts at the Reservoir would likely be moderate and could be fully mitigated. Field reconnaissance, literature review, and personal communication conducted for this evaluation do not indicate any significant fisheries, wildlife, or botanical constraints related to any of the lake elevations identified. No threatened or endangered species have been identified in the reservoir area; however, potential habitat exists at the site. Also, the listed winter run salmon would influence diversions from the Sacramento River.

In November and December 1995, DWR's Northern District performed a two-week investigation of available literature, reviewed aerial photographs of the Project, and conducted two days of field work at the project location. The following are the results of that effort, which covered only the Small and Large Sites and Funks Reservoir areas.

Fisheries

Four intermittent streams - Stone Corral, Funks, Grapevine, and Antelope creeks are within Sites Reservoir. These streams contain limited numbers of the following nongame species: Sacramento sucker, squawfish, blackfish, and hitch and green sunfish (introduced). No State or federally listed species are known to exist within the Sites Reservoir area.

Sites Reservoir would cover about 25 miles of intermittent stream habitat. However, all the impacted fish species are able to thrive in lakes. Sites would support both warm and cold water species such as bass, catfish, crappie, sunfish, bluegill, and trout. These species would create a large sport fishery where none presently exists.

Wildlife

Depending on reservoir size, a Sites Project would cover from 12,200 to 14,000 acres of terrestrial wildlife habitat composed primarily of annual grassland. The most significant loss of wildlife habitat would be 700 acres of oak woodland habitat, which is considered optimal breeding habitat for many species of reptiles, amphibians, birds, and mammals. The quantity of wetland and riparian habitats in the reservoir area is relatively small and the various other habitats (except for vernal lakes) are relatively common within this portion of the Coast Range. A seven-acre saline vernal lake, which could support listed invertebrate species, is present.

The extensive lake habitat that would be created could support waterfowl resting use because of nearby rice feeding areas. Few nesting areas would be created because the variable elevation shoreline would not support significant aquatic vegetation. Fish eating birds such as osprey, bald eagles, herons, grebes, mergansers, gulls, cormorants, egrets, pelicans, and king fishers should benefit from the proposed reservoir development.

The open grassland habitat and areas along intermittent drainages within the inundation zone provide limited yearling and winter deer use. However, these open habitats generally lack adequate cover for deer, and impacts are projected to be minimal. Impacts to resident and migratory deer populations rise with increasing loss of oak woodland habitat. Deer migration corridors should not be affected by reservoir development.

Local residents report that the reintroduced tule elk and pronghorn antelope populations in Colusa County have not been observed within Antelope Valley, although the elk herd may occasionally use the adjacent blue oak/foothill pine community.

Several State or federally listed wildlife species have the potential to occur within the proposed reservoir inundation zone including bald eagle, Swainson's hawk, bank swallow, valley elderberry longhorn beetle, and greater sandhill crane. A 1983 U.S. Fish and Wildlife Service assessment of the project area also identified the western yellow-billed cuckoo as a species that could be present. This species requires extensive (greater than 25 acres) deciduous riparian thickets or forests with a dense understory adjacent to slow-moving watercourses. This habitat is not present within the project area.

Vernal pool habitats, which are distinct from the previously mentioned vernal lake habitat, appear to be absent or extremely uncommon within the proposed inundation zone. These seasonal wetlands could, if present, provide habitat for the federally listed fairy and tadpole shrimp.

Sporadic wintering bald eagle use of the project area may occur. Reservoir construction would result in greatly increased biomass of both fish and waterfowl which are the principal bald eagle forage items. Lands surrounding the proposed reservoir would offer some potential to support nesting bald eagles. Bald eagle nesting on low elevation reservoirs in the blue oak/foothill pine community is uncommon and may be limited by the availability of suitable nest trees. The proposed reservoir would result in improved wintering habitat. No adverse impact to this State and federally listed endangered species is apparent.

Swainson's hawk, a State listed threatened species, could be present in the project area. This migrant uses open grassland or cropland habitats with scattered, large trees. Potentially suitable nesting and foraging habitat is present within the project area. Project construction would adversely impact this species by inundating nesting and foraging habitats.

The proposed project is outside of the known nesting range of the bank swallow, a State listed threatened species. This migratory species uses vertical silty banks for nesting. Banks suitable for nesting are present along the intermittent streams throughout the project area. However, this species is generally not associated with intermittent streams. Preproject surveys would determine if any bank swallows use the project area.

The valley elderberry longhorn beetle, a federally listed threatened species, could occur within the proposed reservoir area. Limited numbers of elderberry plants occur sporadically along the intermittent streams within the project area. However, this area is a transition zone between the federally listed subspecies of the beetle and the nonlisted coastal subspecies. In the absence of genetic information, U.S. Fish and Wildlife Service may attempt to extend regulatory protection to these elderberry longhorn beetles.

The greater sandhill crane, a State listed threatened species, is a common winter migrant to the eastern Sacramento Valley. This species does not currently nest in the project area. Wintering sandhill cranes are generally associated with wetland habitats but may use open grassland habitats for foraging. This species avoids alkaline wetlands like those present at Salt Lake within the project area. Limited, sporadic, winter use of the project area by sandhill cranes may currently occur. Project construction would eliminate any sandhill crane use of the impoundment area.

Preproject surveys of the proposed reservoir site would determine which, if any, of these State or federally listed species are present and would estimate current population levels. Offsite project-associated developments, including relocation of the Ladoga Road, downstream regulatory afterbay (Funks Reservoir), and Sacramento Valley water transportation structures, may impact additional State or federally listed species. State and federally listed giant garter snake habitat could potentially exist within the rice growing region of this portion of the Sacramento Valley. Water transfer between the T-C Canal and the project area should not result in modification of any giant garter snake habitats. Supporting habitats for this "threatened" reptile do not appear to be present within the reservoir inundation zone.

Several California species of special concern or federal candidate species are known to occur within or adjacent to the project area. These include San Joaquin pocket mouse, American badger, prairie falcon, Cooper's hawk, golden eagle, northern harrier, black-shouldered kite, California gull, burrowing owl, and tricolored blackbird. Others that could occur include little brown myotis, Townsend's big-eared bat, sharp-shinned hawk, long-billed curlew, western pond turtle, red-legged frog, and foothill yellow-legged frog.

Water development projects as large as Sites require long time frames to plan, design, permit, and construct. Several of the species identified above may become either State or federally listed before project construction is completed. It would be

prudent to identify those candidate species present and their population levels within the project area early in the planning process.

General Vegetation

Acreages of vegetation types within the proposed reservoir alternatives are listed in Table 3. Because the interpretation of vegetation types was based on 1958 aerial photos, there could be differences between these acreages and present acreages. During a brief field survey of the reservoir site in November 1995, it became apparent that much of the scrub riparian within smaller tributaries may no longer exist. Additionally, some areas of grassland may now be in dry land agriculture. Current stereo image photographs are necessary for an accurate acreage calculation.

Vegetation types which tend to occur within the lowest topography, such as vernal pools (Salt Lake) and wetlands, are inundated at identical acreages for each reservoir elevation. Both vernal pools and wetlands (especially alkaline wetlands) are considered "rare" vegetation types. Within this particular area, these habitat types support most of the potential sensitive plant species.

Both riparian and Valley Oak woodland habitats are found within the inundation area. These vegetation types have experienced severe declines in acreages in Northern California. Within the Sites Reservoir, both vegetation types are found adjacent to the watercourses.

Sensitive Plant Species

Sensitive plant species which are thought to possibly be found in the project area are discussed below. Because potential sensitive plant habitats associated with higher elevations (i.e., serpentine, and lodo shale) are not present within the reservoir site, there is a low probability of occurrence for many of the species known to occur in the region. No sensitive plants have been confirmed to exist within the project area, but no effort other than a literature search has been made to locate them. A plant survey of the proposed reservoir area should be conducted if this project is pursued further.

The presence of a large alkaline and vernal wetland at the northern end of the reservoir site could provide habitat for a number of sensitive plant species including Astragalus tener var. ferriseae, Atriplex cordulata, A. depressa, A. joaquiniana, Chamaesyce hooveri, Cordylanthus palmatus, Lepidium latipes var. heckardii, Orcuttia tenuis, Tuctoria greenei and Neostapfia colusana. Several of these species are either currently listed or proposed for listing. Much of the habitat at this site may be degraded due to heavy grazing activities.

Adobe lily Fritillaria pluriflora is likely to be found within the project area. Large amounts of potential habitat, that is, grassland habitat on clay soils, are present throughout the proposed reservoir site, but particularly north of the community of Sites.

Table 3

SITES RESERVOIR HABITAT TYPES

Habitat Type	Area (Acres) to be Inundated		
	440' Elevation	480' Elevation	520' Elevation
Alkaline Wetland	34	34	34
Wetland	30	30	30
Valley Oaks	16	28	33
Vernal Lake	7	7	7
Riparian	42	54	66
Oak Woodland/ Chaparral	28	34	40
Oak Woodland	122	351	766
Chaparral	12	28	65
Grassland	9,709	11,634	12,959
Total	10,000	12,200	14,000

Cultural Resources

At DWR's request the Historic Resources Information System located at Rohnert Park, California, reviewed its records to determine if the project area contains Native American cultural resources. The search located one listing indicating that homesteading and ranching took place in the project area during the historic period. Native American archaeological sites in this portion of Colusa County tend to be situated at the base of hills and on valley floors near sources of fresh water. Given the environmental setting of the project area and presence of one recorded archaeological site, the potential exists for Native American cultural resources and further archival and field study by an archaeologist is recommended.

FUTURE PROJECT INVESTIGATIONS

This evaluation of a Sites/Colusa offstream storage project indicates a potential for developing additional urban, environmental, and agricultural water supplies at this location. Several unresolved issues such as potential sources of water supply, environmental impacts, and seismic activity of the project area remain, but none presently appears serious enough to preclude project construction. If feasibility-level evaluations are favorable and the future economic and social-political climate is positive, a water supply, flood control, recreation, and fish and wildlife enhancement project is possible at this location.

The next logical step is a phased feasibility investigation. This would be a multiyear, staged, technical evaluation of all factors having a bearing on project justification. The first phase would include environmental and geologic evaluations to determine if the project has any fatal flaws which could prevent construction. The environmental evaluation would involve significant field work to determine the variety and numbers of fishery, wildlife, and vegetative species existing in the project impact area including the supply canals. Heavy emphasis would be placed upon identifying existing or potential threatened or endangered species inhabiting the project influence area. The level and cost of mitigation measures required to offset any project impacts would also be evaluated. The geologic investigation would focus on the damsite geology and seismicity of the area to determine dam design criteria and the type of dam best suited for the site. Along with the emphasis on environmental and geologic investigations, dam and reservoir planning evaluations would be conducted to determine an approximate cost for these physical features, estimate potential project water yields, and provide approximate cost-benefit results.

If no fatal flaws are found, the second phase of the feasibility and environmental evaluations would concentrate on refining the technical aspects of constructing and operating a project and would further evaluate costs and benefits which would result from the project. Application for required environmental, water right, and other permits would begin during this second phase. The main areas of intense technical investigation would be mapping, hydrology, dam and pumping plant design, damsite geology, availability of construction materials, project operation studies, energy analysis, and overall economic and financial evaluation.

Phase one feasibility and environmental investigations are estimated to take two years to complete. The second phase of the investigation is estimated to require a similar investment of time.

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