FINAL DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

July 2000

Integrated
Storage
Investigations

CALFED
BAY-DELTA
PROGRAM

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Chapter 1. Introduction

The California Department of Water Resources, in cooperation with CALFED, is studying the feasibility of four offstream storage sites in the Sacramento Valley, north of the Sacramento-San Joaquin Delta: (1) the Sites Project, (2) the Colusa Project, (3) the Thomes-Newville Project, and (4) the Red Bank Project. DWR received initial funding and authorization to study offstream storage projects upstream of the Delta when voters approved Proposition 204, the Safe, Clean, Reliable Water Supply Act, in 1996. Subsequent funding has been allocated to DWR's General Fund, as part of the Integrated Storage Investigations program. Concurrently, CALFED has developed a Water Management Strategy that includes surface storage as one of many available water resources management tools to achieve its water supply reliability objective. An initial listing of surface storage sites included 52 potential candidates. Preliminary screening narrowed the candidate list to twelve, including the four offstream storage projects indicated above. In addition to this North of the Delta Offstream Storage Investigation, other ISI investigations are studying the remaining 8 candidates.

This progress report summarizes the work conducted under the North of the Delta Offstream Storage Investigation since 1997. While the investigation continues, this status report has been prepared to document findings to date. This document provides information to CALFED agencies and the public about the projects under evaluation. Comments received from the agencies and other stakeholders on the direction of the work in progress and future program activities will help maintain a sound and balanced program.

The North of the Delta Offstream Storage Investigation consists of three phases, each including public involvement. Phase I studies include extensive field surveys of environmental resources; geological, seismic and foundation evaluations; potential environmental impacts; and preliminary engineering feasibility. Phase I has provided basic information on the costs, benefits, and potential impacts of north of the Delta offstream storage for consideration in CALFED's programmatic Environmental Impact Statement/Environmental Impact Report. Phase II will begin in mid-2000 after a federal Record of Decision is issued and the State certifies the Final Programmatic EIS/EIR, with a finding that north of the Delta offstream storage is consistent with CALFED's programmatic preferred alternative. Phase II will include preparation of a feasibility report, project environmental documentation, and the permits necessary to construct the most feasible project, if one is identified. Phase III would consist of final design, which would proceed contingent on findings during the Phase II investigation. Final design would precede construction.

Each of the four projects evaluated in this investigation includes a reservoir that is considered offstream, as well as optional diversion and conveyance facilities associated with various water supply sources. In addition, the projects will include facilities for delivery of the water stored in the offstream reservoir. Final decisions about the optimal water supply sources, and diversion and conveyance facilities for each project will be made based on current and forthcoming analyses.

CALFED Programs and Section 404 Screening Process

In 1995, the CALFED Bay-Delta Program was established 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 Estuary. Since then, CALFED agencies and stakeholders have been working to develop a balanced plan that will restore ecosystem health, improve levee stability in the Delta, and improve water quality and water supply reliability. After initial evaluations and extensive stakeholder input, the study to address supply reliability evolved into an all-inclusive analysis of water management tools: water use efficiency (conservation and recycling), water transfers, operational strategies (such as real-time diversion management), conveyance, and storage.

Early in the process, CALFED compiled a list of 52 potential surface storage projects in the Central Valley and began an initial screening to reduce the number of sites to a more manageable number for more detailed evaluation. CALFED was specifically looking for potential sites that could provide broad benefits for water supply, flood control, water quality, and the ecosystem. This initial screening of potential surface storage projects is consistent with the federal Clean Water Act Section 404 alternative analysis requirements.

The initial screening identified and eliminated those reservoir sites that were clearly impracticable. This screening was based on a minimum storage capacity of 200 taf, a determination of potential conflict with CALFED's restoration programs, and an assessment of consistency with CALFED's solution principles and policies. An interagency team of CALFED agencies cooperated in the initial screening, which was performed using available information. Forty surface storage sites were removed from the initial list. The remaining 12 storage sites are:

- Four north of the Delta offstream storage alternatives, including the Red Bank Project, Thomes-Newville Project, Colusa Project, and Sites Project.
- In-Delta storage and enlargement of Los Vaqueros Reservoir.
- Four south-of-the-Delta storage alternatives, including Ingram Canyon Reservoir, Quinto Creek Reservoir, Panoche Reservoir, and Montgomery Reservoir.
- Enlargement of Shasta Lake (Shasta Dam) and Millerton Lake (Friant Dam).

Figure 1-1 shows the location of the 12 remaining storage sites. For more detailed information about the initial screening, please refer to the *Draft Initial Surface Water Storage Screening*, CALFED Bay-Delta Program, December 22, 1999.

Figure 1-1. Integrated Storage Investigations Potential Surface Water Storage Alternatives

In addition to the initial screening, the CALFED reservoir screening process will also include an anticipated second stage screening. The second stage screening will be performed using more detailed information and will be based on more specific project purposes since not all potential sites can provide the same function. For example, a north of the Delta offstream storage project could help improve water quality in the Delta during drier years, but could not be used to regulate flows on the San Joaquin River. Montgomery Reservoir can improve regulation of San Joaquin River flows, but can not provide the flexibility for Delta pumping that in-Delta or off-aqueduct storage can provide. The second stage will evaluate the remaining reservoir sites based on detailed project purpose and environmental, engineering, and economic analyses. An extensive environmental inventory, detailed engineering analyses, and geological exploration are currently under way for the North of the Delta Offstream Storage Investigation. Information gathered will be used for the second stage screening as well as for environmental documentation, permits, and project feasibility evaluations. The second stage screening will lead to selection of a preferred alternative for the North of the Delta Offstream Storage Investigation.

Program Development and Funding

In 1996, voters approved Proposition 204—the Safe, Clean, Reliable Water Supply Act—which provided funding of feasibility and environmental investigations of regional water recycling, water transfer facilities, desalination, and offstream storage projects upstream of the Delta. In 1997, DWR began a two-year reconnaissance-level study of North of the Delta Offstream Storage Investigation under Proposition 204. In fiscal year 1997-98, DWR expended $3 million of Proposition 204 funds to start this investigation. The Budget Act of 1998 authorized DWR to spend up to $10 million of its General Fund appropriation in FY 1998-99 for feasibility and environmental studies pertaining to the Sites Reservoir site and alternatives. As a result, DWR expanded the 1997 reconnaissance study to a broader investigation that could eventually lead to feasibility reports, environmental documentation, and project permits. DWR expended $8.4 million on these studies during FY 1998-99.

In early 1999, CALFED consolidated all storage investigations under a comprehensive program called the Integrated Storage Investigations. The North of the Delta Offstream Storage Investigation was incorporated into one of seven original ISI program elements. For FY 1999-2000, $10 million of State general funds have been allocated to ISI, of which up to $4.2 million is available for the North of the Delta Offstream Storage Investigation.

Offstream Storage, Alternative Reservoir Sites, Water Supply Sources, and Conveyance Facilities

Traditionally, reservoirs have been created by constructing dams on major streams. These reservoirs are considered onstream storage. In contrast, an offstream storage reservoir is typically constructed on a small and generally seasonal stream that contributes a minor share of the water supply of the reservoir. Offstream storage involves diverting water out of a major stream and transporting the water through various conveyance systems to a reservoir that may be miles away from the point of diversion. Therefore, offstream storage investigations include extensive evaluation of diversion and conveyance facilities to carry the water to the reservoirs.

Storing water in offstream reservoirs can provide opportunities to increase dry year water supply reliability and improve the timing of its availability for multiple uses in an environmentally sensitive manner. Storing water during times of high flow may provide flood control benefits, improve water quality during dry periods, and increase water supplies for environmental, urban, and agricultural water uses.

Offstream storage north of the Delta would allow water to be diverted and stored during winter and early spring, when the Sacramento River and local streamflows are highest, which could reduce flood damage in some areas. Then, from May through October, water from the reservoir could be released for local agricultural irrigation and wetland water use in exchange for diversions that would have occurred from the Sacramento River. Such an exchange program would reduce diversion of water from the river during the irrigation season, therefore reducing diversion impacts to the Sacramento River fishery.

Water that would otherwise have been diverted from the Sacramento River for local irrigation in late spring and summer would be kept in the river or Shasta Lake for later downstream use. The exchange described here will result in increased storage and more cold water in Shasta Lake during the spring and early summers, which may benefit winter-run salmon habitat in the Sacramento River. Additional water supply in dry periods would also provide improved flexibility for agencies that own and operate or contract for offstream storage water supply. The exchange could also result in ecosystem benefits by reducing diversions from the river during the times when some fish species and the ecosystem are in their critical stages and diversions may have the greatest impacts on fish.

The four offstream storage sites investigated include the following:

- Sites Reservoir would be located about 10 miles west of Maxwell (Figure 1-1) and formed by constructing dams on Stone Corral Creek and Funks Creek. Evaluation of a Sites Project has focused on a 1.8 million acre-foot reservoir, although a 1.2 maf reservoir has been considered. A 1.8 maf Sites Reservoir would require construction of nine saddle dams along the southern edge of the Hunters Creek watershed. Floodflows from the Colusa Basin Drain, the Sacramento River, and local tributaries are potential sources of water supply for the Sites and Colusa Projects. These water supply sources have been studied with 14 optional conveyance facilities, including existing or enlarged Tehama-Colusa and Glenn-Colusa Irrigation District canals; two new diversion and conveyance systems from the Sacramento River; and two gravity flow conveyance alternatives that include tunnels for diverting floodflows from existing upper Stony Creek reservoirs.
- Colusa Reservoir is a 3.0 maf storage proposal that would include the area inundated by the 1.8 maf Sites Reservoir, plus the adjacent Logan Creek and Hunter Creek watersheds to the north, called the Colusa Cell. The Colusa Cell requires four additional dams along Logan Ridge. Colusa Reservoir requires seven saddle dams. Water supply source and conveyance

options are essentially the same for Sites and Colusa, although capacities would likely be greater for the Colusa Project.

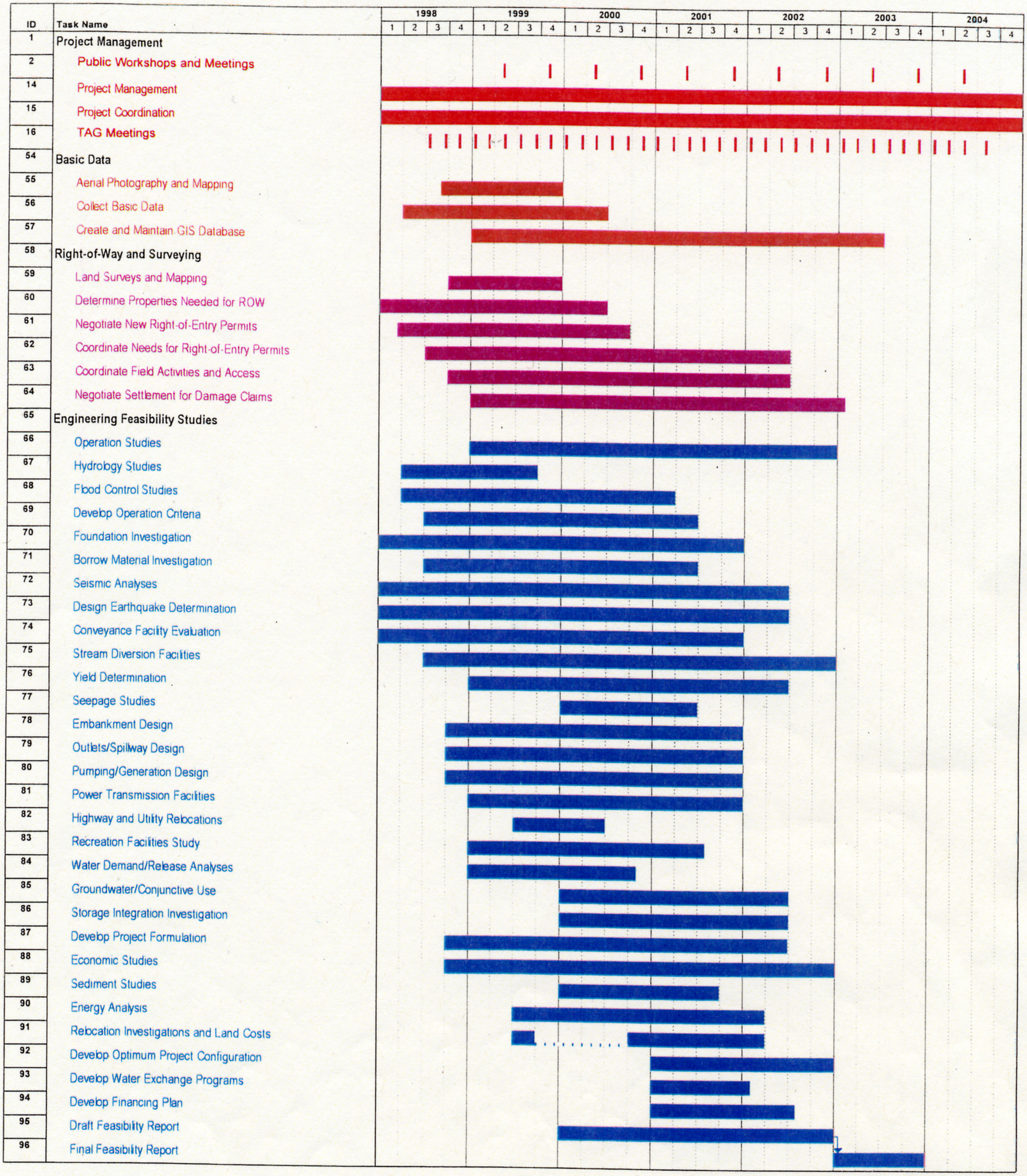
- The proposed Newville Reservoir, upstream of Black Butte Lake, is located about 18 miles west of Orland. Constructing a dam on North Fork Stony Creek and a small saddle dam at Burrows Gap would form Newville Reservoir. The alternative reservoir sizes being evaluated are 1.9 and 3.0 maf. Up to five additional saddle dams are required for the 3.0 maf reservoir alternative. Thomes Creek is the likely primary water supply source for the Thomes-Newville Project. However, conveyance alternatives to carry floodflows of Stony Creek (from Black Butte Lake) and the Sacramento River are also being considered. Prior Thomes-Newville Project studies included a diversion dam on Thomes Creek. Current planning challenges include investigating a diversion facility that would allow anadromous fish migration in Thomes Creek while allowing the creek's floodflows to be diverted to Newville Reservoir. Thomes-Newville conveyance facilities planning is not yet complete.
- The Red Bank Project would be located about 17 miles west of Red Bluff. This project was originally proposed with two major dams to create 350 thousand acre-feet of storage in Dippingvat Reservoir on South Fork Cottonwood Creek and Schoenfield Reservoir on Red Bank Creek. Two small dams and reservoirs, Lanyan and Bluedoor, would be part of the conveyance from Dippingvat to Schoenfield. Most of the water supply for this project would come from South Fork Cottonwood Creek. Floodflows would be diverted for short-term storage in Dippingvat, and then diverted to Schoenfield, the main storage reservoir.

Project Schedule

Figure 1-2 shows the schedule for Phase I and Phase II of the North of the Delta Offstream Storage Investigation. Phase II consists of an environmental documentation and permit process that will begin in mid-2000 after the Record of Decision for CALFED's Programmatic EIR/EIS is filed and if additional north of the Delta offstream storage is consistent with CALFED's preferred program alternative. The schedule is subject to several important constraints. CALFED has linked the implementation of surface storage projects with achieving specific objectives in other water management areas such as the water use efficiency program. Therefore, acquiring regulatory permits and construction of new surface storage projects can only take place after specific actions on water use efficiency are implemented and threshold levels for water use efficiency are satisfied. Water use efficiency is one of eight early implementation actions in Stage 1 of CALFED's Programmatic EIR/EIS. While Stage 1 actions are undertaken, the North of the Delta Offstream Storage Investigation will begin environmental documentation and feasibility evaluation for potential project alternatives, and will be prepared to move forward if the CALFED linkages and conditions are satisfied.

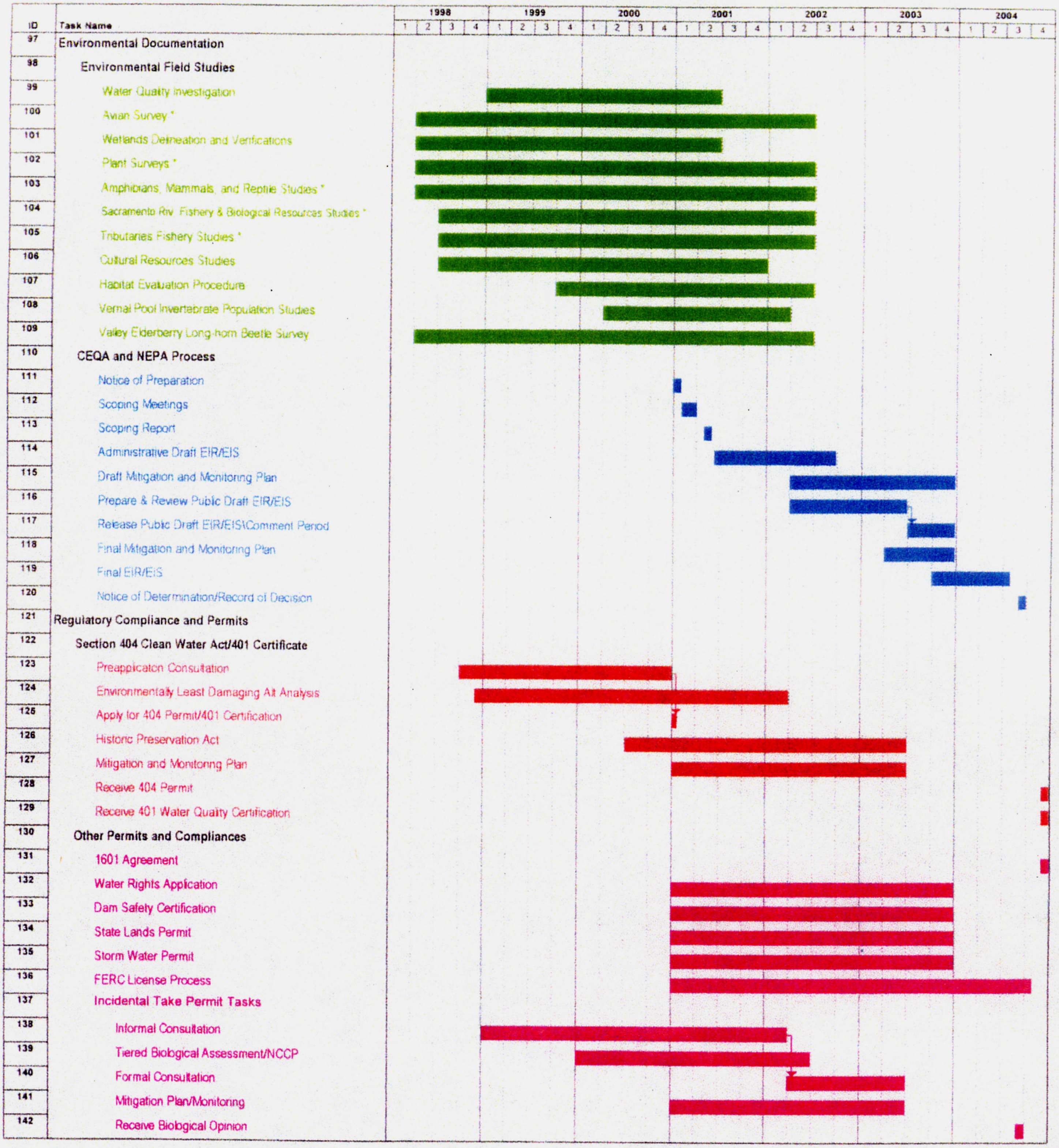
The Offstream Storage Investigation schedule is also subject to requirements imposed by the National Environmental Policy Act, California Environmental Quality Act, the Clean Water Act, and other laws and regulations

Figure 1.2
Offstream Storage Investigation -- Draft Workplan



Notes: 1998 = Fiscal Year 1997-98, etc.
1997-98 work was conducted under proposition 204 authorization.
* Includes both threaten, endangered, and general species.

Figure 1.2
Offstream Storage Investigation -- Draft Workplan



Notes: 1998 = Fiscal Year 1997-98, etc.
1997-98 work was conducted under proposition 204 authorization.
* Includes both threaten, endangered, and general species.

that pertain to surface storage projects. CEQA requires public agencies to prepare an EIR that addresses environmental impacts, mitigation measures, alternatives, and public comments and responses. Project-specific CEQA/NEPA processes for surface storage projects can be initiated after the Record of Decision for the CALFED Programmatic EIS/EIR is issued finding that offstream storage is consistent with the preferred program alternative.

Section 404 of the Clean Water Act has significant implications for proposed surface water storage projects, particularly the scope of alternative evaluations. Section 404 has been interpreted broadly and requires a reservoir project proponent to undertake an extensive evaluation of alternatives and to select the "least environmentally damaging practicable alternative." In addition to nonstructural alternative considerations such as water use efficiency, various storage sites should be evaluated to determine which alternative has the least environmental impacts. This evaluation includes detailed field surveys that follow multi-year protocols to identify the existence of threatened or endangered species or other species of concern in the project area. Botanical surveys require at least two consecutive years of detailed surveys within a given location. Fishery surveys must be conducted over the entire life cycle of the species of concern; for salmonids this requires a multi-year survey. The biological resources for each alternative reservoir site, conveyance facility, potential road relocation, and recreation facility must be surveyed in detail to provide a basis for comparison in selecting the least environmentally damaging alternative.

Past Studies

This section gives a brief description of the studies that have been conducted at the four alternative project sites prior to the current investigation.

Sites and Colusa Projects

The topographically attractive dam sites on Stone Corral and Funks Creeks appear suitable for dams. Both are deep narrow gorges with steep rock walls. The rock at Sites Dam site 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 then proposed Tehama-Colusa Canal.

DWR's Bulletin 109, *Colusa Basin Investigation 1964*, evaluated potential flood control projects and 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 economically unjustified for flood control alone. 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 that would impound 9,500 af in "Golden Gate Reservoir." Project benefits are listed as flood control and modest springtime irrigation yield.

Consideration of larger projects at the Sites location was first documented in December 1964 in the U.S. Bureau of Reclamation's *West Sacramento Canal*

Unit Report, which studied the feasibility of extending the TCC (via a new West Sacramento Valley Canal) into Solano County near Fairfield. To develop additional water supply to support 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. USBR unsuccessfully attempted to obtain funds for a full feasibility study of Sites in 1977 and documented its finding in a report published in 1981.

Throughout the 1960s and 1970s, DWR performed limited unpublished analyses of the larger Colusa Project's water supply potential in connection with regional investigations. Two unpublished office reports in 1967 and 1968 on potential Klamath-Trinity development projects include conveyance systems that would terminate at Colusa Reservoir. DWR's progress report titled *Major Surface Water Development Opportunities in the Sacramento Valley 1975* presented details of a Colusa Reservoir Offstream Storage Project. A slightly modified version of the Colusa Reservoir plan is shown in the DWR's Bulletin 76-81: *State Water Project - Status of Water Conservation and Water Supply Augmentation Plans November 1981.* This report states that cursory-level studies of Colusa Reservoir to date indicated that the incremental cost of storage would be excessive in comparison to storage costs of Sites Reservoir.

In March 1990, the engineering consulting firm CH2M-HilI, Inc. prepared a long-range plan for Glenn-Colusa Irrigation District that included an 870,000 af Sites Reservoir with normal water surface elevation of 460 feet. This project was based on USBR's 1964 report, but was judged non-implementable by GClD because of the financing needed to cover the estimated capital cost of $152 million. In 1993, CH2M-Hill published a report on *Meeting California's Water Needs in the 21st Century,* which presented a conceptual Westside Storage and Conveyance System. The report mentioned a Sites/Colusa Reservoir with a feeder pipeline from Lake Oroville.

In late 1995, DWR received numerous requests from water interests, including the Northern California Water Association, for information regarding the potential of an offstream storage reservoir at the Sites/Colusa site near Maxwell. In response to this renewed interest, DWR reviewed historic documents on a Sites/Colusa Project to assess its potential to augment local and statewide water supplies during drought periods. DWR conducted a brief investigation of current environmental literature, studies, project area aerial photos, and conducted limited field work in the project area. DWR published its findings in a July 1996 report entitled *Reconnaissance Survey – Sites Offstream Storage Project.*

DWR's 1996 report briefly summarized Sites/Colusa Project planning information and updated earlier cost estimates to 1995 cost levels. No insurmountable problems were identified that would prevent further evaluation of this project. Rather, DWR found that the project had several unique characteristics that make it an attractive candidate for further feasibility level investigations. It has a significantly lower cost per unit of storage than most sites and the area is sparsely populated. The geography of the site permits a range of storage options to be considered, from a minimum of approximately 1.2 maf to a maximum of 3.0 maf when it is combined with the Colusa Cell to form the Colusa Project.

Thomes-Newville Project

Newville Dam site was first examined by the U.S. Geological Survey sometime between 1901 and 1903. USGS noted that the natural runoff was quite limited and briefly considered the possibility of diverting Thomes Creek water to Newville Reservoir; the current Thomes-Newville Project is a direct descendant of this early USGS idea.

Newville Reservoir was again examined during the California Water Plan studies in 1947-57. The resulting framework plan, presented in DWR's Bulletin 3, suggested a 950,000 af Newville Reservoir that would be supported by gravity diversion of surplus flows from a Paskenta Reservoir on Thomes Creek and a 38-mile gravity diversion canal from upper Stony and Grindstone Creeks. This proposal is the closest ancestor of the current Thomes-Newville Project, since it would divert floodflows of the same sources.

The first intensive investigations of Newville Reservoir were conducted by DWR in the 1958-63 period as a part of the North Coastal Area Investigation. These studies indicated the dam site was suitable for the reservoir elevation of about 1,000 feet that was then being considered, but noted that more study of Rocky Ridge should be performed if the reservoir were to be higher than elevation 950 feet. Based on these studies, DWR's Bulletin 136 presented a plan for early construction of a Newville Reservoir at elevation 845 feet with a diversion from a Paskenta Reservoir on Thomes Creek. The bulletin envisioned later integration of the Paskenta-Newville facilities into a full-fledged Glenn Reservoir development for regulation of water imported from the north coastal area.

USBR conducted much more detailed studies of the Paskenta-Newville Plan in 1965-71. USBR also concluded that conditions were suitable for construction of a large Newville Reservoir. USBR's 1971 status report outlined a plan including a Newville Reservoir at elevation 975 feet, forming a 2,986,000 af reservoir. (The reservoir size was limited by hydrologic considerations, not geologic.) The feasibility design drawings presented in USBR's report showed both Newville Dam and Chrome Dike as rolled earth-fill structures.

While USBR's studies were in progress, DWR was conducting its own studies of the possible integration of a Newville Reservoir with an upper Eel River development. DWR's design criteria led to a Newville Dam design that incorporated substantial zones of quarried rock upstream of the central rolled-earth core. Preliminary designs and cost estimates for reservoir elevations up to 1,000 feet were prepared, but Newville Reservoir was eventually dropped from the Eel River plans in favor of the more favorably located Rancheria Reservoir.

In the early 1970s, DWR made additional planning studies of Newville Reservoir as a component of a Glenn Reservoir that would be used to store surplus water pumped from the Sacramento River. The 1975 report on these studies presented a 987 foot Newville Reservoir elevation as "near the maximum size feasible due to topographic and geologic limitations" of Rocky Ridge. No new geologic studies were conducted during this planning phase.

Additional field investigations of Rocky Ridge were undertaken in 1979 as a part of the next round of planning studies. These additional geologic studies addressed lingering concerns about the structural integrity and leakage potential of Rocky Ridge; the studies concluded that the suitability of the ridge for a reservoir elevation of up to at least 1,000 feet has been adequately established.

In November 1980, DWR published the *Thomes-Newville and Glenn Reservoir Plans – Engineering Feasibility*, which discussed the physical and operational feasibility of two potential plans for developing additional water supplies for the State Water Project. At that time, water supply and demand projections indicated that the smaller of these, the Thomes-Newville Plan to develop additional supplies from Stony and Thomes Creeks, could be needed in the mid-1990s. Subsequent studies concentrated on the Thomes-Newville Plan as a viable development in its own right. Larger offstream storage developments of the scale of the Glenn Reservoir Plan would not be needed until after the turn of the century. Further study of Glenn Reservoir was deferred.

Continuing studies showed that Thomes-Newville would fit well into a staged sequence. Accordingly, DWR elected to focus its planning efforts on the Thomes-Newville Plan to produce a plan formulation report and draft environmental impact report scheduled for release in June 1983. However, the project was deferred in June 1982 when the voters of California defeated Proposition 9, which was a referendum on the Peripheral Canal and related water projects. The Thomes-Newville Plan was included among the projects mentioned explicitly within the referendum.

Red Bank Project

Initial water development planning studies in the Cottonwood Creek Basin were conducted by USBR in the mid-1940s. USBR's staff deferred further action on the projects due to the State of California's initiation of a comprehensive study to develop "The California Water Plan." Bulletin 3 investigations of the Redding Stream Group and the Westside Stream Group concluded that the Cottonwood Creek tributary reservoirs—Hulen, Fiddlers, Rosewood, Dippingvat, and Schoenfield—should be developed primarily for local water supply, recreation, flood control, and streamflow enhancement to improve the anadromous fishery.

After the publication of Bulletin 3, DWR initiated more detailed studies of the upper Sacramento River and its tributaries between Shasta Dam and Red Bluff. This study focused on a large Iron Canyon Reservoir on the Sacramento River, but also investigated the tributary reservoirs as possible alternatives. Bulletin 150: *Upper Sacramento River Basin Investigation* (published in May 1965), concluded that the Iron Canyon Project was not economically justified, but that several of the tributary reservoirs, including Hulen and Dippingvat on Cottonwood Creek, were justified and should be considered for initial development of the upper Sacramento River Basin.

The U.S. Army Corps of Engineers, under authority of the Flood Control Act of 1962, conducted a survey "for flood control and allied purposes" of the Sacramento River drainage, including the Cottonwood Creek Basin. The Corps' survey report in December 1970 proposed two large reservoirs, (Tehama and Dutch Gulch) to provide 100-year flood control on lower Cottonwood Creek, reduce flood damages downstream along the Sacramento River and in Butte Basin, and develop a water supply that would be contracted for by the State Water Project.

The Corps' two-reservoir project was authorized by Congress in the Flood Control Act of 1970, but funding for Advanced Engineering and Design Studies did not begin until 1976. By the time the Corps completed their Phase I plan formulation in 1981, the 1970 project cost of $170 million had increased to almost $700 million due to inflation and more stringent design and safety criteria. The Corps' General Design Memorandum, dated May 1983, showed a total project cost of $802 million, which pushed the cost of water to about $400 per af. The SWP Contractors concluded that they could not afford the water supply at that price. Early in 1984, the Corps was asked to reanalyze the project, with the objective of reducing costs as much as possible. At the same time, DWR initiated a separate analysis of the upstream tributary reservoirs as possible alternative developments.

In May 1985, the Corps reanalysis estimated a total cost of $571 million for a reformulated Dutch Gulch-Tehama Project, with an allocated cost of water of about $216 per af. The DWR study, conducted concurrently with the Corps reanalysis and using the same design and economic criteria, showed that a combination of three tributary reservoirs – Hulen, Fiddlers, and Dippingvat – could be built for about $427 million. These three reservoirs would develop about two-thirds the water supply of the Corps project, at a combined cost of about $197 per af. DWR further concluded that the cost of the tributary reservoirs might be further reduced by:

1. Using the then-new roller-compacted concrete method of dam construction, which could provide substantial savings over standard concrete or earthfill construction.
2. Using Schoenfield Reservoir on Red Bank Creek to provide offstream storage for South Fork Cottonwood Creek water, thus reducing the size of Dippingvat Reservoir, the least cost-effective of the three reservoirs studied.

In May 1985, DWR announced the withdrawal of State Water Project participation in the authorized Corps project and expressed the intent to continue evaluation of the tributary projects as possible features of the SWP. In July 1985, DWR started the first of a series of studies to evaluate the engineering and economic feasibility of the tributary reservoirs. The Corps terminated their work on the project in October 1985.

In November 1987, DWR reported on a two-year pre-feasibility study of the Dippingvat-Schoenfield Project on South Fork Cottonwood Creek and Red Bank Creek in western Tehama County. The objective of the study was to develop information on the Dippingvat-Schoenfield alternative (Red Bank Project) comparable to that available on the other Cottonwood Creek tributary projects (i.e., Hulen Reservoir on the North Fork, Fiddlers Reservoir on the Middle Fork, and Rosewood Reservoir on Dry Creek) as a basis for selecting one project for further study at the feasibility level. Efforts on this study were centered primarily on geologic investigation of the project dam sites, sources of construction materials, and engineering analysis of project operations and cost estimates.

These studies, completed in 1993, recommended the roller-compacted concrete dam construction alternative. Further investigations were deferred until CALFED renewed interest in 1996.

Public Involvement

Extensive public involvement activities are an integral part of the North of the Delta Offstream Storage Investigation. Program participants have briefed local entities frequently during the course of the investigation. DWR, in cooperation with CALFED, has held public workshops and meetings to provide information about the proposed reservoir alternatives and to answer questions about the investigation. Public workshops will continue periodically throughout the duration of the program.

In November 1999, a technical briefing and tour of the Sacramento River and Sites Reservoir was given for Legislative and Governor's Office staff. During this tour, information was provided on Sacramento River ecosystem restoration, geomorphology, conveyance alternatives, biological field surveys, and geologic and seismic findings at Sites Reservoir.

In April 1998, DWR established a technical advisory group to assist DWR staff in developing study plans. Technical advisory group meetings are held bimonthly to review work in progress and comment on the content and adequacy of various elements of investigation. The TAG consists of interested parties from federal, State, and local agencies, as well as environmental groups, and property owners in the project area.

Special thanks go to the advisory group members. DWR is indebted to the members for providing critical feedback on the content and direction of the investigation. The committee members' comments and support contribute greatly to the process and to developing a balanced approach for the North of the Delta Offstream Storage Investigation. DWR gratefully acknowledges the input and advice from the members.

North of the Delta Offstream Storage Investigation Technical Advisory Group

Members	Organization
O. L. Van Tenney	Glenn-Colusa Irrigation District
Art Bullock	Tehama Colusa Canal Authority
Mark Cowin	CALFED
Terry Erlewine	State Water Project Contractors
Steve Evans	Friends of the River
Jerry Hemsted	California Cattlemens Association
Dan Keppen	Northern California Water Association
Gaye Lopez	Colusa Basin Drainage District
Jerry Maltby	County of Colusa
Rick Massa	Orland Unit Water Users' Association
John Merz	Sacramento River Preservation Trust
Jim Smith	U.S. Fish and Wildlife Service
Mike Vereschagin	Farm Bureau
Larry Vinzant	U.S. Army Corps of Engineers
Frank Wernette	Department of Fish and Game
Dick Whitson	U.S. Bureau of Reclamation

Chapter 2. Environmental Setting

This chapter contains a general description of the environmental setting of the watersheds draining the Coast Range eastward toward the northern Sacramento Valley as well as a more detailed description of the environmental setting for the area of the four reservoir project alternatives. The sections of the chapter are: physical location, topography, climate and hydrology, geology and soils, land use, vegetation, fish and wildlife resources, cultural resources, transportation, air quality, and recreation.

Physical Location

All four of the proposed reservoir projects are located within the Coast Range foothills along the western edge of the northern Sacramento Valley. The United States Geological Survey watersheds and subbasins containing the proposed offstream reservoirs are delineated in Figure 2-1. The acreage of the watersheds or subbasins associated with the reservoirs are shown in parentheses below. The drainage area of the watersheds upstream of the dams is shown in Table 3-1.

The proposed Sites Reservoir is in north-central Colusa County and south-central Glenn County, approximately 10 miles due west of the community of Maxwell. The proposed reservoir inundation area includes most of Antelope Valley and the small community of Sites. As shown in Figure 2-2, the reservoir is in the Funks Creek and Stone Corral Creek watersheds (59,700 acres), with the associated USGS subbasins. A mean full pool elevation of 520 feet would inundate 14,000 acres and could store a maximum of 1.8 maf.

The proposed Colusa Project would also be located in north-central Colusa County and south-central Glenn County, approximately 12 miles southwest of the community of Willows and 10 miles west of Maxwell. The Colusa Cell would be due north of the proposed Sites Reservoir and could be constructed with Sites Reservoir facilities to form a single 28,000 acre reservoir (Colusa Reservoir). The inundation area of the Colusa Cell is within Logan Creek and Hunter Creek watersheds (35,000 acres), which are shown in Figure 2-2, with the associated USGS subbasins. A mean full pool elevation of 520 feet would inundate about 14,000 acres within the Colusa Cell and could store an additional 1.2 maf. The maximum storage of the Colusa Project would be 3.0 maf.

The Thomes-Newville Project would be situated within north-central Glenn County and south-central Tehama County. Newville Reservoir would be approximately 18 miles west of the City of Orland and 23 miles west-southwest of the City of Corning. As shown in Figure 2-3, this proposed reservoir project would be within portions of the North Fork Stony Creek watershed (51,200 acres) and Thomes Creek watershed (123,500 acres), as well as the associated USGS subbasins. A small diversion along Thomes Creek would transfer water to Newville Reservoir in the North Fork Stony Creek watershed. Alternative reservoir sizes of 1.9 and 3.0 maf are being evaluated, with associated normal water surface elevations of 905 and 980 feet and corresponding reservoir surface areas of 14,500 and 17,000 acres. The proposed Red Bank Project is in northwest Tehama County, approximately 17 miles west of the City of Red Bluff. This project would include a diversion on South Fork Cottonwood Creek at Dippingvat Reservoir, two small reservoirs in the headwaters of North Fork Red Bank Creek (Blue Door and Lanyan Reservoirs), and a larger storage reservoir on Red Bank Creek (Schoenfield Reservoir). The South Fork Cottonwood Creek watershed is relatively large (81,900 acres), while the Red Bank Creek watershed is relatively small (27,300 acres). The reservoirs, watersheds, and subbasins are shown in Figure 2-4. Dippingvat Reservoir would have a normal pool elevation of 1,205 feet and an inundation area of 1,800 acres. Schoenfield Reservoir, with a normal pool elevation of 1,017 feet, would inundate 2,770 acres and have a storage capacity of 250 taf.

Topography

The physical topography of the watersheds draining the east side of the Coast Range toward the Sacramento Valley is diverse. The topography ranges from steep, rugged, mountainous terrain within the upper watersheds to rolling foothills in the project areas to relatively flat alluvial terrain as the watersheds enter the Sacramento Valley. Elevations range from less than 40 feet on the valley floor to over 8,000 feet along the Coast Range divide.

The Sites Project area is situated between the Sacramento Valley to the east and the mountainous portion of the Coast Range on the west. The Coast Range mountains are a series of rugged, north-south tending ridges dissected by narrow canyons containing steep gradients, and entrenched streams. A relatively narrow band of steep rolling foothills, approximately 2 to 3 miles wide, separates the proposed reservoir area from the Sacramento Valley. Antelope Valley, the primary inundation area of the proposed Sites Reservoir, lies between this narrow band of foothills and the more mountainous Coast Range. This relatively narrow north-south tending valley is approximately 13 miles long and up to 2 miles wide. Elevation of the Antelope Valley floor ranges from 320 to 400 feet above mean sea level, while the foothills separating the valley from the Sacramento Valley reach a maximum elevation of 1,300 feet. Elevations along the west side of Antelope Valley increase rapidly with several peaks within 2 miles of the valley margin above 2,000 feet.

The Colusa Cell area is also between the Sacramento Valley to the east and the mountainous portion of the Coast Range on the west. In addition to the inundation area of Sites Reservoir, the proposed Colusa Reservoir would also inundate the valleys associated with both Hunter and Logan Creeks upstream of Logan Ridge. Topographic relief within the inundation area of the Colusa Cell is more varied than within Sites Reservoir and numerous islands would be created from hills greater than 520 feet elevation. The Colusa Cell inundation area would be approximately 10 miles long and 3 miles wide, with a maximum depth of 260 feet. The foothills separating the Colusa Cell from the Sacramento Valley are substantially lower in elevation than those found near Sites, with only a single peak in excess of 1,000 feet elevation. Development of this project would require construction of numerous saddle dams, as a number of areas along the eastern edge of the project are less than the normal pool elevation of 520 feet.

FIGURE 2-1.
NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION WATERSHEDS

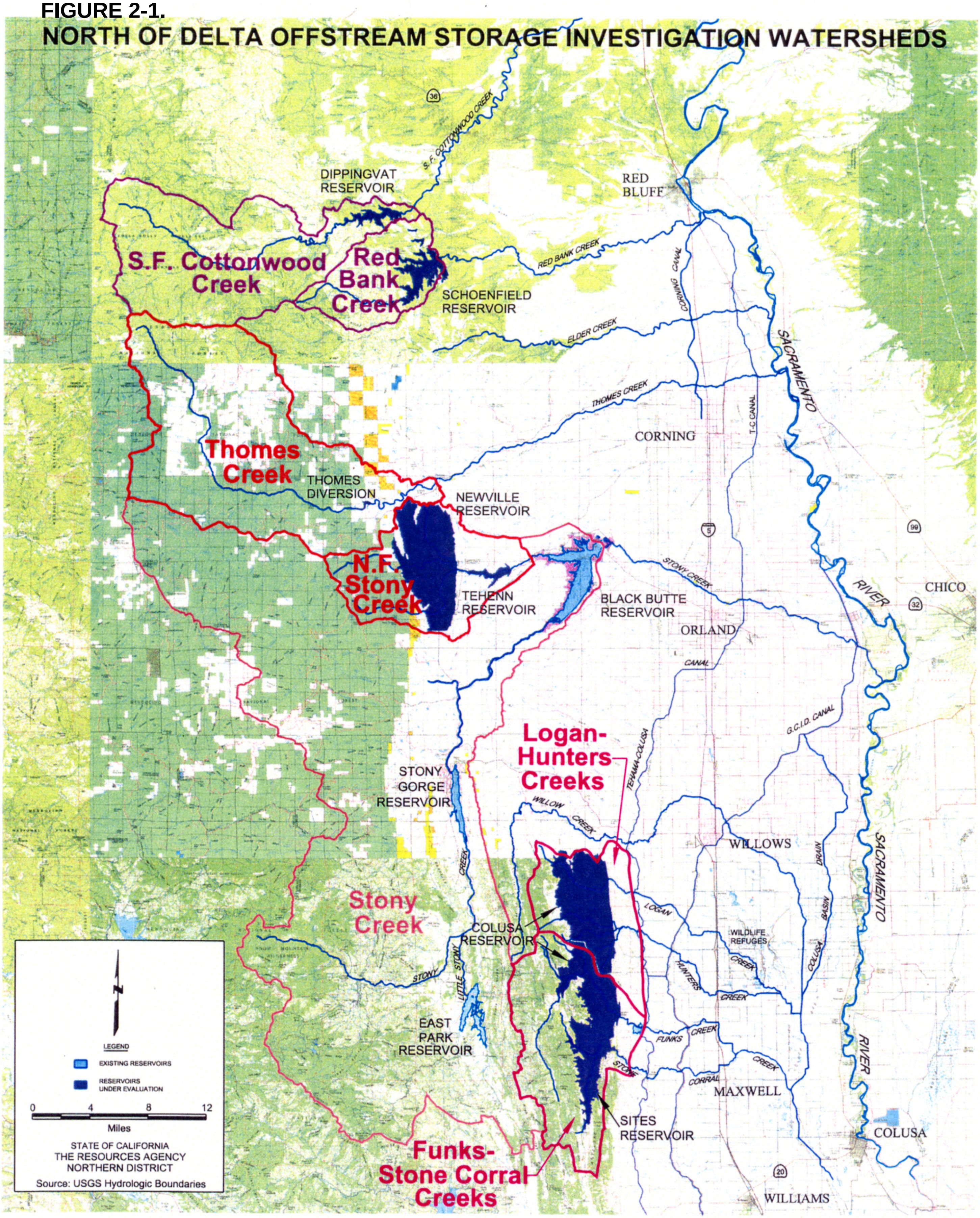


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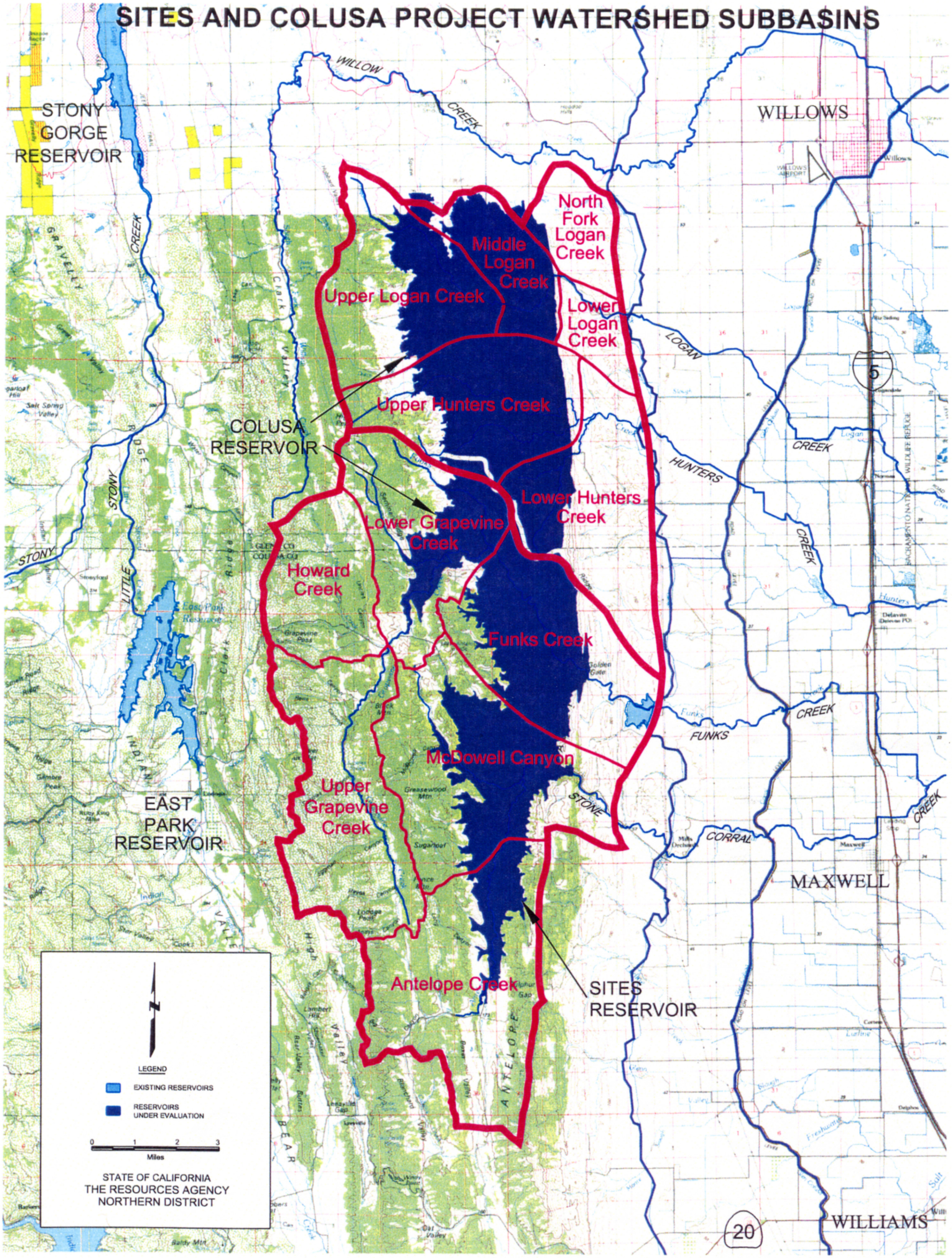
FIGURE 2-2



SITES AND COLUSA PROJECT WATERSHED SUBBASINS
STONY GORGE RESERVOIR
WILLOWS
North Fork Logan Creek
Middle Logan Creek
Upper Logan Creek
Lower Logan Creek
LOGAN
COLUSA RESERVOIR
Upper Hunters Creek
HUNTERS
Lower Hunters Creek
Lower Grapevine Creek
Howard Creek
Funks Creek
FUNKS
McDowell Canyon
STONE
CORRAL
Upper Grapevine Creek
EAST PARK RESERVOIR
MAXWELL
Antelope Creek
SITES RESERVOIR
WILLOW CREEK
STONY CREEK
LITTLE STONY
INDIAN
ANTELOPE
BEAR
5
20
WILLIAMS
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
0 1 2 3
Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT

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FIGURE 2-3

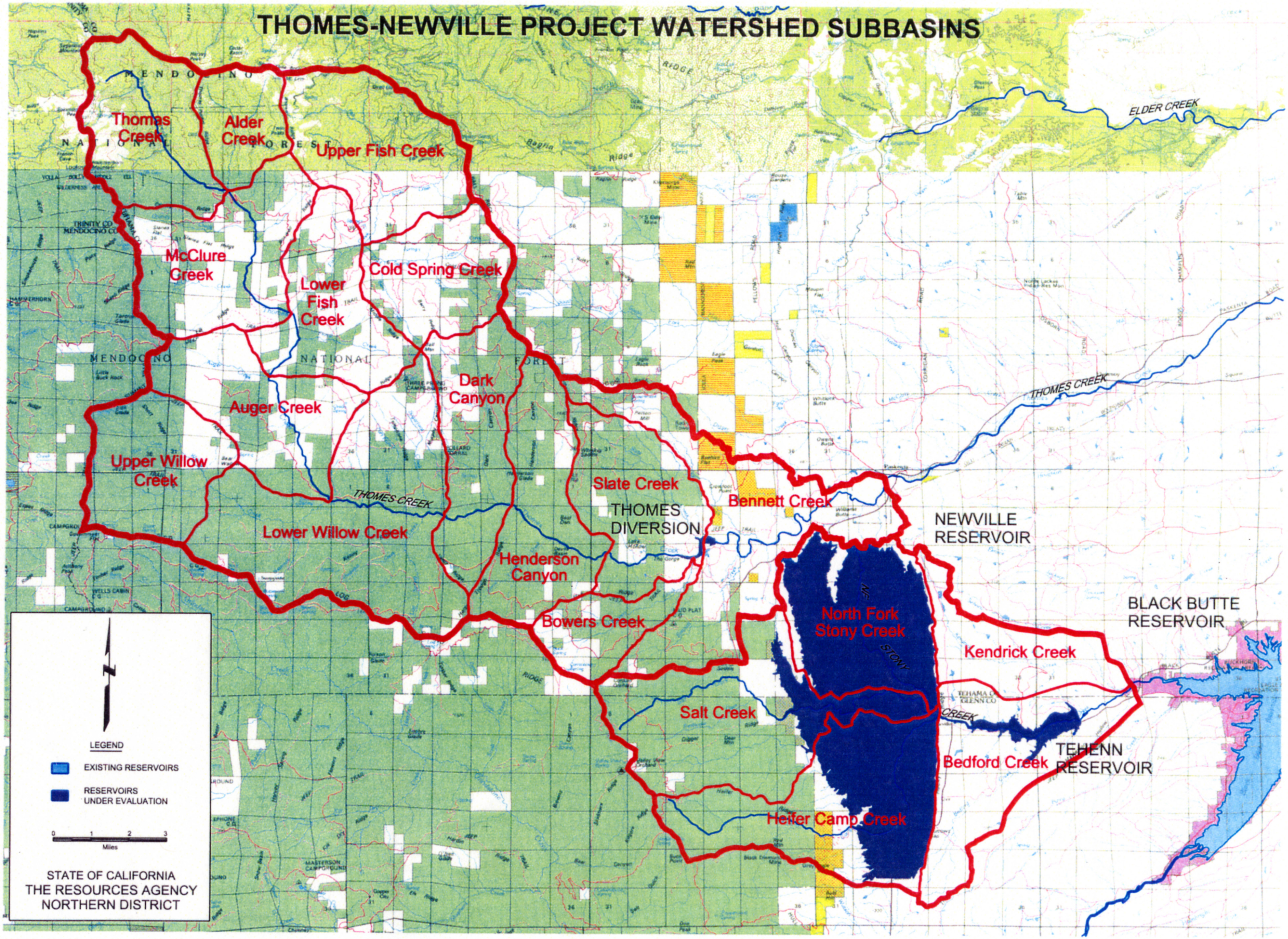
THOMES-NEWVILLE PROJECT WATERSHED SUBBASINS
Thomas Creek
Alder Creek
Upper Fish Creek
McClure Creek
Lower Fish Creek
Cold Spring Creek
Dark Canyon
Auger Creek
Upper Willow Creek
Lower Willow Creek
Henderson Canyon
Slate Creek
THOMES DIVERSION
Bennett Creek
Bowers Creek
NEWVILLE RESERVOIR
North Fork Stony Creek
Kendrick Creek
Salt Creek
Bedford Creek
Heifer Camp Creek
TEHENN RESERVOIR
BLACK BUTTE RESERVOIR
ELDER CREEK
THOMES CREEK
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
0 1 2 3
Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT

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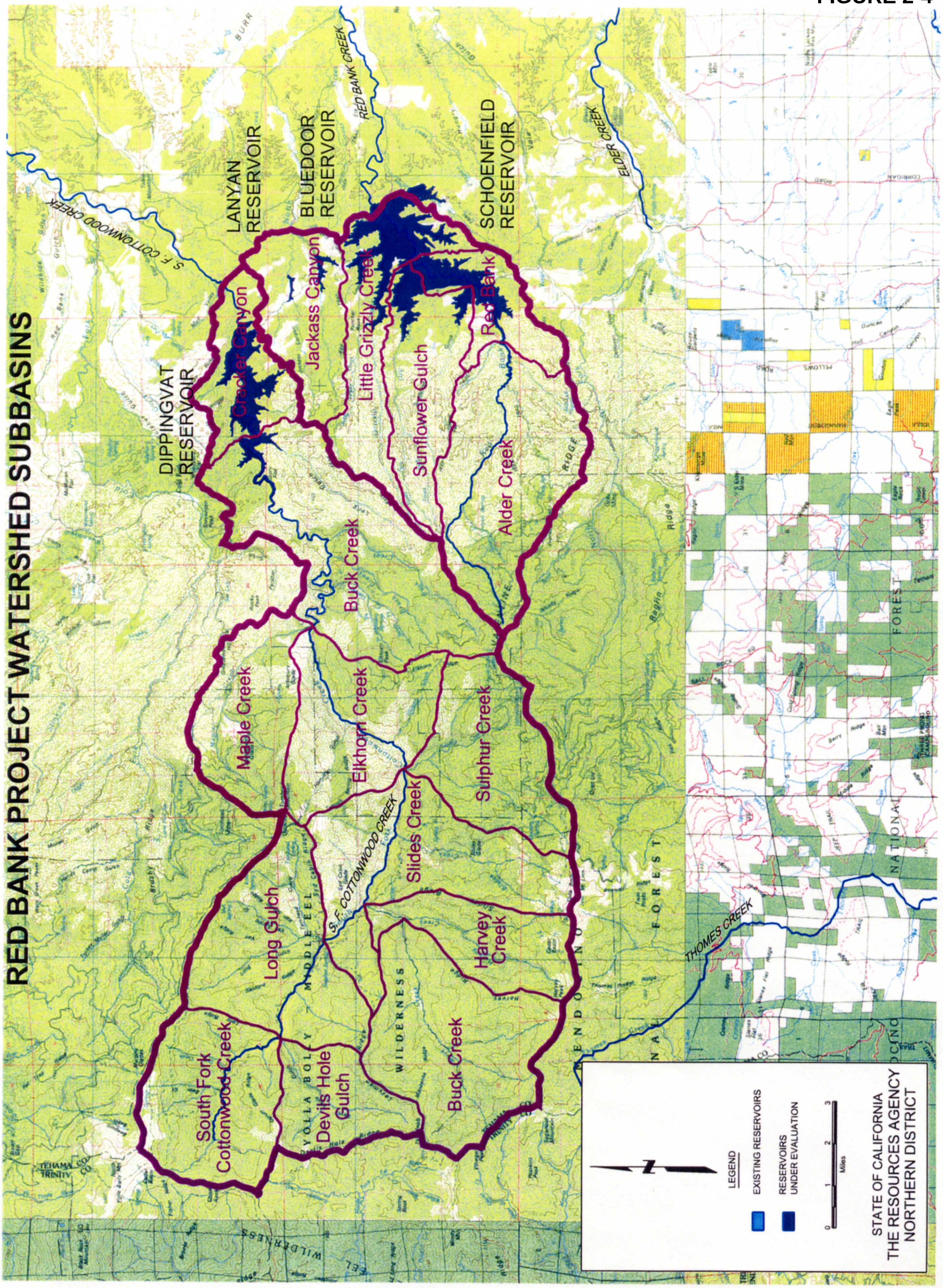
FIGURE 2-4


RED BANK PROJECT WATERSHED SUBBASINS
DIPPINGVAT RESERVOIR
LANYAN RESERVOIR
BLUEDOOR RESERVOIR
SCHOENFIELD RESERVOIR
S.F. COTTONWOOD CREEK
RED BANK CREEK
ELDER CREEK
THOMES CREEK
Crocker Canyon
Jackass Canyon
Little Grizzly Creek
Red Bank
Sunflower Gulch
Alder Creek
Buck Creek
Maple Creek
Elkhorn Creek
Sulphur Creek
Slides Creek
Long Gulch
Harvey Creek
South Fork Cottonwood Creek
Devils Hole Gulch
Buck Creek
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
Miles
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1
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3
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT

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Newville Reservoir would be located in a large circular valley surrounding the North Fork Stony Creek. Topographical relief within the inundation area of Newville Reservoir is that of gently rolling terrain ranging in elevation from 630 feet to 975 feet elevation. A single steep ridge (Rocky Ridge) separates the Newville Reservoir site from low, rolling foothill areas to the east. Rocky Ridge runs north and south with several peaks above 1,300 feet elevation. The western boundary of the reservoir area is formed by steep, rugged mountains, with elevations up to 3,000 feet within 2 miles of the reservoir inundation area. The currently preferred diversion on Thomes Creek would be made at a low dam in a steep, narrow, confined reach below Thomes Creek Canyon at approximately 1,035 feet above mean sea level.

The Red Bank Project area is highly dissected, rugged, mountainous terrain. The primary drainages (and associated valleys) run from west to east. Linear alluvial terraces are associated with the major drainages and stream gradients are much greater than those found in the other three proposed reservoirs. Topographical relief within the inundation area of the Red Bank Project varies from small areas of relatively flat alluvial terraces to gently rolling terrain to very steep hillslopes ranging in elevation from 780 to 1,200 feet.

Climate and Hydrology

The climate of the watersheds draining into the western Sacramento Valley is typical mediterranean. Winters are rainy and relatively mild with only occasional freezing temperatures at the lower elevations; summers are comparatively dry and hot. The rainy season normally begins in September and continues through March or April. Rains may continue for several days at a time, but are usually gentle. Summer rains are rare, as are thunderstorms and hailstorms. Thunderstorms occur about ten days per year in the Sacramento Valley, occasionally producing high intensity rainfall of short duration. Most precipitation is associated with migrant storms that move across the area during winter. Snow is the dominant form of precipitation above 5,000-foot elevation and persists on north- and east-facing slopes into the early summer.

High temperatures occur during July, August, and September, with temperature readings commonly in excess of 100 degrees Fahrenheit. Fog of varying density and duration is common within the Sacramento Valley during winter. However, due to the physical topography, dense or persistent fog is much less common in the project areas. Winds occur seasonally, with dry north winds common during the summer and fall, while winds from the south are frequently associated with winter storm events. Winds in excess of 60 miles per hour may occur; however, these events are relatively uncommon and of short duration. Average wind speed at Red Bluff is 8.8 miles per hour, with the strongest winds reported during the winter months. Gross evaporation, the depth of water lost to the atmosphere, averages approximately 70 inches per year in the foothill region.

Average annual precipitation within the Sites/Colusa project areas is approximately 18 inches and occurs almost exclusively in the form of rain. Average annual precipitation in the Colusa Cell area is slightly higher, with up to 22 inches per year. Snow occurs annually at higher elevations and occasionally within the reservoir areas. Some areas within western Glenn County that range in elevation from 5,000 to 7,000 feet frequently receive between 60 and 75 inches of precipitation per year, primarily in the form of snow. Mean annual temperature in the area of the proposed reservoirs is approximately 62 degrees Fahrenheit. Summer temperatures in excess of 115 degrees Fahrenheit have been documented. The project areas generally have about 220 frost-free days per year and nearby areas in the Sacramento Valley have about 260 frost-free days per year.

Average annual precipitation in the Thomes-Newville Project area ranges from 20 to 24 inches, primarily in the form of rain. Annual precipitation averages 23.5 inches at Paskenta. The wettest year on record at the Paskenta monitoring location (1982-1983) was 48.4 inches and the driest (1938-1939) was 8.6 inches. The project area generally has between 220 and 250 frost-free days per year. The average date of the last spring freeze is April 1 at Paskenta. Summer temperatures in excess of 90 degrees Fahrenheit occur approximately 97 days per year and summer temperatures in excess of 100 degrees Fahrenheit occur annually.

The average annual precipitation of the Red Bank Project area is 25 inches, due to the slightly higher elevation and more northern location. Snowfall occurs more frequently here than at the other proposed reservoir locations, but seldom persists for long or contributes significantly to the total annual precipitation. Approximately 175 to 200 frost-free days per year occur in the project area, with the last frost of the spring on or about May 1. Temperature ranges are similar to those described for the other three proposed reservoirs.

Streams draining the proposed Sites Reservoir, Colusa Cell, and Newville Reservoir are ephemeral with little or no flow from July through October. However, these streams tend to respond rapidly to significant rainfall events. Flash flooding with substantial overland flow has been observed. Flow recorded at the stream gage on Stone Corral Creek near Sites is representative of the flow variability in these small ephemeral streams. Annual discharge varied from zero in 1972, 1976, and 1977 to 39,930 af in 1963 and averages 6,500 af. Monthly flows in excess of 15,000 af have been documented.

Flows in the Thomes Creek watershed fluctuate seasonally. Summer low flows are frequently measured at less than 4 cfs, while winter flows often exceed 4,500 cfs. Flows recorded at Paskenta range from zero in 1977 to 37,800 cfs during December 1964. The December 1964 runoff event was triggered by a major rain-on-snow storm. Periodic large floods like the 1964 event can result in tremendous bedload movement.

Streamflows within Red Bank and South Fork Cottonwood creeks are generally greater than those creeks within the other three proposed reservoirs. Red Bank Creek stream gaging (measured near Red Bluff – near the confluence with the Sacramento River) indicates an average annual discharge of 35,377 af with annual extremes ranging from 988 af in 1976 to 138,775 af in 1983.

The surface water quality of streams draining eastward from the Coast Range is generally poor. These streams generally have very high suspended sediment loads due to the metavolcanic bedrock and schist formations which produce clays that stay in suspension during turbulent flow conditions. Soil disturbance within these watersheds can accelerate erosion and sedimentation processes and lead to increased metal and nutrient concentrations. High concentrations of metals and nutrients are commonly present during both low flow and storm runoff events. These concentrations frequently exceed water quality criteria established for the protection of beneficial use or the maintenance of aquatic life. Water is generally warm in streams flowing through the proposed reservoir sites. Total phosphorus concentrations are at stimulatory levels for algae.

The immediate area of the alternative projects has very few groundwater resources. The area is underlain by the Great Valley Sequence rocks and locally by Quaternary terrace deposits. Groundwater is found in fractures in the Great Valley Sequence and in the sands and gravels in the terrace deposits. Springs occur where the terrace deposits terminate or where water-bearing fractures encounter the surface. A number of springs also occur in the Great Valley Sequence rocks where faults create subsurface dams that cause groundwater to reach the surface. Not all fractures or faults contain groundwater. Nor do all terrace deposits have groundwater.

There are about 280 Well Completion Reports on file with DWR for the general area of the candidate offstream reservoir projects. Sixty percent of these wells are used for domestic purposes. Irrigation wells and stock watering wells make up 10 percent each. About 20 percent of the wells are classified as “other” and are used for monitoring, test wells, or the use is unknown. Most of the irrigation wells are just east of the Tehama-Colusa Canal outside the area of the Sites and Colusa Projects and have reported depths and yields of about 250 feet and 750 gallons per minute respectively. The few wells in or close to the reservoir inundation areas obtain their yield from the Great Valley Sequence rocks. These wells are typically about 50 feet deep and yield less than 10 gallons per minute.

Few of the 170 reported domestic wells are within any of the proposed reservoir inundation areas. Domestic wells in the general area average about 200 feet deep and yield an average of about 10 gallons per minute. These wells are only perforated down to about 150 feet and the rest of the hole depth is apparently used for water storage. The stock wells are shallower and average about 125 feet deep and also yield an average of about 10 gallons per minute. Most of the yield comes from fractures in the Great Valley Sequence rocks.

DWR's Bulletin 118 identifies only one groundwater basin within the immediate area of the proposed projects: the Chrome Town Area adjoining the Thomes-Newville Project. This is not a true groundwater basin, but a groundwater area. It consists of Quaternary terrace deposits up to about 50 feet in thickness, which is unusual because terrace deposit thickness in the range of 10 to 20 feet is more common. Most wells in the area obtain their water from either the gravels in the terrace deposits at the contact with the underlying Great Valley Sequence rocks or from the fractures in the Great Valley Sequence rocks. Well yields up to 10 gallons per minute are all that can be expected from this area. Dry wells are not uncommon.

Landowners within the northern portion of Sites Reservoir and the Colusa Cell report the presence of shallow salt-water deposits. Limited sampling of the springs that feed Salt Lake in the northeast portion of Sites Reservoir show elevated levels of various minerals and salts. The depth and extent of this highly mineralized groundwater is unknown. The flow from these springs is very limited.

Geology and Soils

The rocks underlying the proposed dam sites are part of the Great Valley geomorphic province, which is mostly sandstone, mudstone, and conglomerate. The Great Valley geomorphic province is bounded to the west by the Coast Ranges province, to the north by the Klamath Mountains province, to the northeast by the Cascade Range province, and to the east by the Sierra Nevada province.

Along the west side of the Sacramento Valley, rocks of the Great Valley province include: Upper Jurassic to Cretaceous marine sedimentary rocks of the Great Valley Sequence; fluvial deposits of the Tertiary Tehama Formation; Quaternary Red Bluff, Riverbank, and Modesto formations; and Recent alluvium.

Water gaps in the sandstone and conglomerate ridges form the dam sites for all four proposed projects. The Great Valley Sequence was formed from sediments deposited within a submarine fan along the continental edge. The sediment sources were the Klamath Mountains and Sierra Nevada to the north and east.

The mudstones of the Great Valley Sequence are typically dark gray to black. Generally the mudstones are thinly laminated and have closely spaced and pervasive joints. When fresh, the mudstones are hard, but exposed units weather and slake readily. Mudstones generally underlay the valleys.

Fresh sandstones are typically light green to gray; weathered sandstones are typically tan to brown. They are considered to be graywackes in some places because of the percentage of fine-grained interstitial material. Sandstone beds range from thinly laminated to massive. In many places, the sandstones are interlayered with beds of conglomerates, siltstones, and mudstones. Massive sandstones are indurated and hard with widely-spaced joints, forming the backbone of most of the ridges.

The conglomerates are closely associated with the massive sandstones and consist of lenticular and discontinuous beds varying in thickness from a few feet to more than 100 feet. Conglomerate clasts range in size from pebbles to boulders and are composed primarily of chert, volcanic rocks, granitic rocks, and sandstones set in a matrix of cemented sand and clay. The conglomerates are similar to the sandstones in hardness and jointing.

Tertiary and Quaternary fluvial sedimentary deposits unconformably overlie the Great Valley Sequence. The Pliocene Tehama Formation is the oldest. It is derived from erosion of the Coast Ranges and Klamath Mountains and consists of pale green to tan semiconsolidated silt, clay, sand, and gravel. Along the western margin of the valley, the Tehama Formation is generally thin, discontinuous, and deeply weathered.

The Quaternary Red Bluff Formation consists of reddish poorly sorted gravel with thin interbeds of reddish clay. The Red Bluff Formation is a broad erosional surface, or pediment, of low relief formed on the Tehama Formation between 0.45 and 1.0 million years ago. Thickness varies up to about 30 feet. The pediment is an excellent datum to assess Pleistocene deformation because of its original widespread occurrence and low relief. Red Bluff Formation outcrops occur just east of the dam sites.

Alluvium is a loose sedimentary deposit of clay, silt, sand, gravel, and boulders. Deposits include landslides, colluvium, stream channel deposits, floodplain deposits, and stream terraces. Quaternary alluvium is a major prospective source of construction materials. Colluvium, or slope wash, consisting mostly of soil and rock, occurs at the face and base of a hill. Landslide deposits are similar but more defined and generally deeper. Landslides occur along the reservoir rim but are generally small, shallow debris slides or debris flows. These deposits may be incorporated as random fill in dam construction.

Stream channel deposits generally consist of sand and gravel. Potential construction material uses include concrete aggregate, filters, and drains. Floodplain deposits are finer grained and consist of clay and silt. Floodplain deposits may be used for the impervious core and for random fill.

The stream terraces form flat benches adjacent to and above the active stream channel. Up to nine different stream terrace levels have been identified. Terrace deposits consist of several to 10 feet of clay, silt, and sand overlying a basal layer of coarser alluvium containing sand, gravel, cobbles, and boulders. Four terrace levels have been given formational names by the U.S. Geological Survey (Helley and Harwood 1985)—the Upper Modesto, Lower Modesto, Upper Riverbank, and Lower Riverbank—and they range in age from 10,000 to several hundred thousand years old.

Soils of the Coast Range and western Sacramento Valley are highly diverse. Mountain soils are generally shallow to deep, well drained to excessively well drained, and mostly steep to very steep. Foothill soils are formed from hard, unaltered sedimentary rock and poorly consolidated siltstone of the Tehama Formation. Soils of older alluvial fans and terraces are well drained to poorly drained and have moderate to low permeability. Interior valley basin soils are generally fine textured, poorly drained with very slow runoff.

Predominant soil associations within the Colusa and Sites Reservoir sites are the Altamont and Contra Costa clay loam series. These are young, eroded and shallow, well to excessively drained clay to clay loam soils that have developed in place over hard sandstone and shale. Runoff is slow to moderate. Erosion is slight to severe depending on slope and relief. Terrain is nearly level to steep and in many areas the surface yields many outcrops of the parent material.

The general soil associations of the Newville Reservoir area are the Millsholm and Lodo series. The Millsholm series are shallow, well drained, moderately coarse to moderately fine textured clay-loam soils that are formed from sandstone, mudstone, and shale. Terrain is hilly to steep with numerous outcrops found scattered throughout the landscape. In this area, outcrops occur on 30 to 50 percent slopes where runoff is medium to high, permeability is moderate, and erosion potential is severe. Lodo series are shallow, somewhat excessively drained, shaley-clay loam soils that formed in weathered, hard shale and fine-grained sandstone. In this area, the soils occur on mountainous terrain with slopes ranging from 30 to 65 percent. Runoff is medium to high, permeability is moderate, and erosion potential varies from moderate to severe depending on slope and relief.

Predominant soil associations within the Schoenfield Reservoir site are the Maymen-Los Gatos-Parrish series and to a lesser extent, the Sheetiron-Josephine association. The Maymen-Los Gatos-Parrish series are shallow to moderately deep, gravelly to rocky clay loam soils that are formed in hard sandstone and shale and in some areas, in hard mica schist. These soils occur on slopes ranging from five percent to nearly vertical. Terrain is steep with deep canyons and narrow ridges. Most soils are well drained to excessively drained, and runoff is rapid to very rapid. Permeability is moderately slow to slow in the Parrish component, moderate to moderately rapid in the Maymen component and moderate in the Los Gatos component. The Sheetiron Josephine associations are well drained, shallow, gravelly loam soils found in strongly sloping to very steep terrain and are formed in altered sedimentary and extrusive igneous rock. This series comprises a very small portion of the area.

The general soil associations within the Dippingvat Reservoir are the Millsholm and Lodo series. The Millsholm series are shallow, well drained, moderately coarse to moderately fine textured clay-loam soils that are formed from sandstone, mudstone, and shale. Terrain is hilly to steep with numerous outcrops found scattered throughout the landscape. In this area, they occur on 30 to 50 percent slopes where runoff is medium to high, permeability is moderate, and erosion potential is severe. Lodo series are shallow, somewhat excessively drained, shaley-clay loam soils that formed from weathered, hard shale and fine-grained sandstone. In this area, the soils occur on mountainous terrain with slopes ranging from 30 to 65 percent. Runoff is medium to high, permeability is moderate, and erosion potential varies from moderate to severe depending on slope and relief.

Land Use

The watersheds draining the east slope of the Coast Range are subject to a variety of land use practices. Upper elevations are primarily commercial forest lands and managed for timber production, outdoor recreation, and grazing. Foothill areas are currently managed primarily for livestock grazing. Some foothill valleys support dryland grain or orchard production. Extensive mineral extraction activities have historically occurred throughout foothill and mountain areas. Sacramento Valley portions of the watersheds support a wide variety of agricultural uses including livestock grazing, irrigated grain and truck-crops, and orchards.

Land use within the proposed Sites Reservoir area is dedicated primarily to livestock production. Both year-round and winter/spring cattle grazing is the dominant land use, while a small amount of both horse and sheep grazing also occurs. Other agricultural land uses include minor amounts (200 to 300 acres) of dryland grain production. Some residential land use also occurs within the small community of Sites (population 20) and on 10 to 14 scattered ranch sites. A small commercial rock quarry is present near the proposed Sites Dam site. Limited commercial firewood harvesting has occurred within and adjacent to the inundation area.

Land use within the proposed Colusa Cell area is almost exclusively dedicated to livestock production. Both year-round and winter/spring cattle grazing is the dominant land use. No other agricultural land use practices have been identified. Only one occupied ranch homesite has been identified within the inundation area and no other residential or commercial developments are present.

Land use within the Newville Reservoir area is dominated by seasonal and year-round livestock grazing. However, limited horse and sheep grazing also occurs. At least 20 occupied ranch sites are found within the reservoir area. Limited firewood harvest has occurred in some areas.

Land use within the Red Bank Project area is similar to that at the other three proposed reservoirs. Both year-round and winter/spring cattle grazing is the dominant land use. Other agricultural land uses include a small walnut orchard and a few acres of irrigated pasture. Several landowners operate hunting clubs and at least one landowner operates a fee-for-fishing business.

Vegetation

The watersheds of Sacramento Valley west-side streams contain a variety of vegetative communities. These include white fir, Klamath mixed conifer, Douglas fir, ponderosa pine, closed-cone pine-cypress, montane hardwood-conifer, montane hardwood, blue oak woodland, valley oak woodland, blue oak-foothill pine, montane riparian, valley foothill riparian, montane chaparral, mixed chaparral, chamise-redshank chaparral, annual grassland, and cropland.

Vegetation within the four proposed reservoir locations is varied due to the influence of local soils, geology, microclimate, hydrology, aspect, and elevation, as well as other physical and biological factors. All four reservoir sites contain at least some annual grassland habitat. This upland plant community of herbaceous annual grasses and herbs is characteristically composed of many non-native species and a limited number of native species. Species composition is highly variable among stands and throughout the growing season. Vernal pools and swales within the annual grassland community support unique assemblages of native wetland plant species.

Chaparral communities occur at or near each of the proposed reservoir locations in varying amounts. These stands frequently occur in a continuous canopy with little or no understory. Other shrub and tree species, including poison oak and manzanita, form a mosaic in some chaparral stands.

Riparian vegetation is associated with both intermittent and permanent streams. Common riparian overstory species include Fremont's cottonwood, willow, and Mexican elderberry.

Two types of oak woodland were identified within the four proposed reservoir locations: valley oak woodland and blue oak woodland. Valley oak woodlands are found along the major tributaries and valley bottoms in the reservoir sites. This vegetative community may include other native tree and shrub species. Blue oak woodland occurs at or near each of the proposed reservoirs. Blue oak is the dominant or sole canopy species in these woodlands. An annual grassland understory is common and a shrub layer comprised of manzanita and wedgeleaf ceanothus can occur. Blue oak woodlands primarily occur on moderately rocky to well-drained slopes. Limited amounts of wetlands occur within the proposed reservoirs. For additional information on wetland resources see Chapter 6.

Foothill pine woodland is the most common vegetative community (61 percent) within the Red Bank Project area. This woodland is dominated by foothill pine and frequently contains a well-developed blue oak understory. The foothill pine community is most common on well-drained uplands.

Annual grasslands (89 percent of the surface area) dominate the proposed Sites Reservoir. Blue oak woodland occurs around the fringe of the reservoir area. Approximately 923 acres (7 percent of the surface area) of blue oak woodland are present within the project area. Relatively small amounts of chaparral, riparian, wetlands, cultivated grain, and non-vegetated areas comprise the remaining 4 percent of the inundation area. As elevation increases above the western edge of the reservoir boundary, the foothill pine community becomes dominant with large chamise chaparral stands present on shallow soils and southern exposures.

Ninety-nine percent of the Colusa Cell area is dominated by an annual grasslands community. The remaining one percent of the land area is divided between blue oak woodland, riparian, emergent wetlands, and non-vegetated areas. No chaparral, blue oak/gray pine woodland, or cultivated grain is present within the project area. As elevation increases above the western edge of the reservoir boundary, the blue oak savanna community becomes dominant.

The Newville Reservoir area is dominated (85 percent) by annual grasslands. Oak woodland comprises an additional 11 percent of the inundation area. A limited amount of chaparral, emergent wetland, and riparian habitat were also mapped within Newville Reservoir. No foothill pine or cultivated grain was mapped within the reservoir footprint.

Foothill pine woodland comprises 61 percent of the Red Bank Project area. Oak woodland habitat was identified and mapped in about 20 percent of the area. Annual grasslands are present on about 12 percent. Limited amounts of chaparral, riparian, and wetlands are also present.

No State or federally threatened or endangered plants were found in the four potential reservoir areas during the two-year study. Populations of federal Species of Concern were identified in the Thomes-Newville and Red Bank alternatives. Several rare or limited distribution species were also found in all of the alternative reservoir areas. The Thomes-Newville and Red Bank sites yielded the greatest number of populations of sensitive plant species. A more detailed description of vegetative communities and rare plant survey methodologies and results can be found in Chapter 6.

Fish and Wildlife Resources

The watersheds of the North Coast Range draining east toward the Sacramento Valley contain native and non-native species, warm-water and cold-water species, and anadromous and resident fish species. At least 24 species of fish are present in these watersheds. Several State or federally listed fish species occur in the region including steelhead, and various runs of chinook salmon. Cold-water habitats are present in the upper watersheds of the major streams including Cottonwood Creek, Red Bank Creek, and Thomes Creek.

Fishery evaluations performed at Antelope, Stone Corral, and Funks Creeks within the footprint of Sites Reservoir indicated the presence of several native and non-native species. All of these streams are ephemeral within the reservoir area and do not provide cold-water habitat. Most are degraded with extensive downcutting and little riparian vegetation. However, a single adult spring-run chinook salmon was observed in Antelope Creek within the inundation area. Habitat surveys indicate that the stream reaches above the reservoir do not provide suitable rearing habitat for anadromous species.

Fishery evaluations were performed on three ephemeral streams within the Colusa Cell footprint (Logan, Hunters, and Minton Creeks). Survey results indicate the presence of only one native species and several introduced warm-water species. All of these streams are ephemeral upstream from the proposed dam sites and do not provide cold-water habitat. No State or federally listed fish species were identified within the reservoir area. Habitat surveys indicate that the stream reaches above the reservoir do not provide suitable rearing habitat for anadromous species.

Surveys from the 1980s of the ephemeral streams within the Newville Reservoir footprint resulted in capturing California roach, Sacramento pike minnow, Sacramento sucker, and green sunfish. Rainbow trout were present in the perennial headwater areas of Salt and Heifer Camp Creeks above the proposed reservoir inundation area. The lower Thomes Creek watershed contained a diverse fish assemblage that included runs of fall-run, late fall-run, and spring-run chinook salmon and steelhead.

DFG conducted studies in lower Cottonwood Creek (below the north fork confluence) and in South Fork Cottonwood Creek in 1976. They found ten resident game species and 13 nongame species of fishes. The 1976 DFG survey also found runs of fall-run, late fall-run, and spring-run chinook salmon in lower Cottonwood Creek and spring-run chinook salmon and steelhead in South Fork Cottonwood Creek. A more recent survey on South Fork Cottonwood Creek and Red Bank Creek within the Red Bank Project area located four species of resident game fishes and four species of non-resident game fishes. Steelhead were identified within the Red Bank Creek watershed. Additional information concerning fish survey methods and results can be found in Chapter 6.

A wide variety of wildlife species utilize areas in and around the four proposed reservoir areas either seasonally or year-round. Surveys are ongoing of the proposed reservoir sites for the presence of State and federally listed species. However, substantially less information has been collected on non-listed species density and distribution.

Some general statements about relative wildlife species' diversities can be made based on the variety of habitat types and successional stages present within each of the proposed reservoir locations. The Colusa Cell is strongly dominated by annual grasslands with little habitat or structural diversity. This monotypic habitat would not support the same diversity of wildlife species that would be expected at the other proposed reservoir locations where a greater diversity of habitats is present. Sites Reservoir contains a greater diversity of habitat types than found within the Colusa Cell. Thomes-Newville and Red Bank Project areas support a greater diversity of habitat type than the Sites and Colusa Cell areas. This increased habitat diversity should provide habitat for a number of wildlife species not found within the Colusa Cell. Although the Red Bank Project area is the smallest of the four proposed reservoir locations, it contains the greatest diversity of habitats and several stages of habitats and should support the highest diversity of vertebrate wildlife.

State or federally listed wildlife species have been studied and documented at or near each proposed reservoir location. Wintering bald eagles (State endangered, federal threatened) occur in low numbers at each proposed reservoir. Both wintering sandhill cranes (State threatened) and a migrating bank swallow (State threatened) have been detected at or near the proposed Colusa Cell. Extensive surveys of the proposed Sites and Colusa Cell project areas have failed to detect any California tiger salamanders, red-legged frogs, or giant garter snakes. Protocol for the field surveys requires that the study include areas around the proposed reservoirs where proposed facilities, roads, and utilities will be relocated. Surveys are not yet complete. One red-legged frog (federal threatened) has been reported within the Red Bank project area. Numerous federal species of concern, California Species of Special Concern, federal Migratory Nongame Birds of Management Concern, or candidate species occur within each of the proposed reservoirs. Additional information concerning these species' occurrence can be located in Chapter 6.

Several DFG harvest species occur within the proposed reservoirs. Upland game includes black-tailed deer, black bear, feral pig, gray squirrel, wild turkey, California and mountain quail, and mourning dove. Waterfowl use is limited within each of the proposed reservoirs and generally restricted to winter use of stock ponds and small lakes. Limited wood duck and mallard nesting also occurs within stock ponds and along the stream channels where adequate brooding water exists. Relatively high deer use of portions of the Thomes-Newville and Red Bank Project areas during winter has been reported. Substantially less deer use has been observed within the Sites Reservoir area and no use has been noted within the Colusa Cell area. Observations indicate that feral pigs occur in low to moderate numbers within each of the proposed reservoirs, with the greatest use within the Red Bank Project area. Wild turkeys are relatively common in portions of the Red Bank Project area and Newville Reservoir area.

According to the Natural Diversity Database, several federally listed invertebrate species may occur within the four proposed reservoir sites. These species include valley elderberry longhorn beetle, vernal pool fairy shrimp, Conservancy fairy shrimp, and vernal pool tadpole shrimp.

Elderberry bushes with stems greater than 1-inch diameter at ground level are considered habitat for the valley elderberry longhorn beetle. Survey of reservoir inundation areas identified mature elderberry bushes at each of the proposed reservoir locations. These bushes primarily occur adjacent to riparian habitat. However, several small stands of elderberry bushes were located in upland habitat within each of the proposed reservoir areas. A small number of beetle emergence holes were observed in elderberry stems at both Sites and Newville Reservoirs.

Surveys designed to detect federally listed fairy or tadpole shrimp have not yet been conducted. Potential vernal pool fairy and tadpole shrimp habitat is present within annual grassland habitat at Sites, Colusa Cell, and Newville Reservoir sites, but absent within the Red Bank Project area. For additional information on State or federally listed species see Chapter 6.

Cultural Resources

Surveys of cultural resources within the Sites Reservoir project area recorded a total of 41 historic and prehistoric sites. Seventeen sites appear to be significant because they provisionally meet the criteria for eligibility to the National Register of Historic Places. Prehistoric settlement in the project area was constrained by the limited food and fuel resources and the scarcity of water. However, the area would have been important for seasonal hunting and gathering forays. The larger and more permanent villages were situated along the lower reaches of the bigger streams and on the knolls and natural levees along the Sacramento River.

Historic sites, features, and standing structures are significantly underrepresented in the site totals. These resources were not recorded because they are associated with working ranches, occupied buildings, and the town site of Sites. A future survey of historic resources may yield other historic sites in addition to the Historic District of the Town of Sites. Moving the cemetery associated with Sites and several smaller cemeteries would present special consideration.

Results of the record search indicated that there were no site records in the files of the State database for the Colusa Cell. A field survey found greater scarcity of subsistence resources than in the Sites Reservoir area and the ephemeral nature of the water supply were not suitable for extensive use or habitation during the prehistoric past.

Three sites were recorded within the Colusa Cell, two historic ranches and one site with a prehistoric and an historic component. The significance of the sites is undetermined. The assessment of eligibility to the National Register could not be made on the basis of surface indications. Additional studies would be necessary to complete the evaluation.

A comprehensive survey of prehistoric sites within Thomes-Newville Project area was completed in 1983. A total of 117 sites was recorded within the footprint of the proposed reservoir, representing a more complete prehistoric settlement pattern that includes evidence of permanent or semi-permanent villages, seasonal campsites, and special resource procurement and use sites. The presence of perennial streams and availability of fuel and subsistence resources accounts for the more intensive use of the project area during prehistoric times. As with the Sites Reservoir, moving the historic cemeteries within the footprint of the Thomes-Newville Project would be necessary.

Results of the record search for the Red Bank Project indicated that the project area had not been surveyed for cultural resources and no site records were present in the State database. The surveys completed in 1994 for the Corps' Cottonwood Creek Project were downstream of the project described here, with no overlap of the footprints.

A total of 31 sites were recorded within the Red Bank Project. Twenty-eight sites are prehistoric and three are historic. The prehistoric sites in the Red Bank Project area were generally small and the artifact distribution relatively sparse. The sites were probably associated with seasonal upland hunting, fishing, and gathering activities. The larger permanent settlements were situated further downstream on the banks of the perennial streams and along the Sacramento River.

Transportation

The proposed Sites Reservoir is approximately 11 miles west of U.S. Interstate 5. East-to-west access through the project area is via the Maxwell/Sites Road. This Colusa County road receives relatively heavy volumes of traffic, especially on weekends, because it provides access to East Park Reservoir and the southwest portion of the Mendocino National Forest as well as the communities of Stonyford and Lodoga. Other Colusa County roads include Peterson Road, which extends approximately 4 miles north from the community of Sites, and Huffmeister Road, which extends south and west from the community of Sites to the community of Leesville. The closest airport is approximately 17 miles away at the City of Willows.

The Colusa Cell is approximately 7 miles west of Interstate 5. Access to the reservoir area is via Glenn County roads 60 and 69. These gravel/paved roads receive relatively little traffic. No public access currently exists within the reservoir footprint. Ranch roads within the reservoir inundation area are very limited and access is severely restricted during winter and spring due to a high number of unimproved stream crossings. The closest airport is approximately 12 miles away at the City of Willows.

The Thomes-Newville Project area is accessed via Newville Road west from Orland or Corning Road west from Corning. The project area is approximately 18 miles west of Interstate 5. Round Valley Road connects to both Newville and Corning Roads in the northern end of the proposed reservoir. Round Valley Road continues west from the reservoir and provides access to the central portions of the Mendocino National Forest. The southern part of the proposed reservoir area can be accessed via Elk Creek Road and State Highway 162. The closest airport is approximately 18 miles away at the City of Orland.

The Red Bank Project is approximately 18 miles west-southwest from Interstate 5 at Red Bluff. Access to the project area is provided by a variety of Tehama County roads that travel west from Red Bluff including Red Bank Road, Reeds Creek Road, Pettyjohn Road, Johnson Road, and Balis-Bell Road. Red Bank Road provides public access through the Schoenfield Reservoir area. Balis-Bell Road follows Clover Creek and provides public access into Blue Door Reservoir. No public access currently exists into the Lanyan or Dippingvat Reservoir areas. However, several private ranch roads provide some access into both of these proposed reservoirs. The closest airport is approximately 18 miles away at the City of Red Bluff.

Air Quality

The respective County Air Pollution Control Districts monitor air quality within Colusa, Glenn and Tehama Counties. Each county monitors similar contaminants, including ozone and particulate matter. Detailed site-specific air quality information is not available. Tehama County is considered a moderate non-attainment area for both ozone and particulates (PM10) under the California Clean Air Act. However, levels of both contaminates are within federal criteria. Glenn County air quality meets both State and federal air quality standards for ozone and PM10. Colusa County is a non-attainment area for both PM10 and ozone under both State and federal criteria.

Recreation

Recreational activities within watersheds of the streams flowing through the project areas include hiking, hunting, fishing, camping, boating, mountain biking, and off-road vehicle use. Most of these activities occur primarily on public lands on the Mendocino National Forest and associated private timberlands. Little public access into the foothill private grazing lands occurs. However, public recreation areas are present within the foothill portion of the Stony Creek watershed at Black Butte Lake and Stony Gorge and East Park Reservoirs. Waterfowl and upland game bird hunting are the primary recreational use activities within the Sacramento Valley portions of these watersheds.

Recreation use and opportunity are currently very limited within the proposed project areas. Almost all lands are privately owned and posted against trespass, thus preventing general public access. Recreational activities that do occur are primarily by landowner families, their friends, and employees. This level of recreation use probably amounts to only a few hundred recreation-hours per year per reservoir site. On these agricultural lands, hunting is the most common recreational activity. Upland game birds (dove, quail, and pheasant), black-tailed deer and feral pigs are the most commonly hunted species within the proposed reservoir areas. Commercial hunting operations for feral pig, black-tailed deer, wild turkey occur within the Red Bank Project area and may operate on individual landholdings within the other reservoirs as well. Fishing is an infrequent activity because of the intermittent nature of the streams in Sites, Colusa Cell, and Newville Reservoir areas. Numerous stock ponds within the project areas are large enough to support bass, catfish, and sunfish. Angling pressure for these ponds appears to be generally low. At least one fee-for-fishing recreational operation is currently in business on a small lake within the Red Bank Project area.

Chapter 3. Project Alternative Evaluation

As part of its Phase II evaluation, CALFED compiled a list of 52 potential surface storage project alternatives and associated engineering, cost estimate, and environmental information. An interagency team of specialists reviewed available data and screened out clearly impracticable alternatives. This initial screening was based on minimum storage capacity and potential for conflict with CALFED's restoration programs, solution principles, and policies. New onstream projects were excluded because of their greater potential for negative environmental impacts. During the initial screening, CALFED narrowed the number of potential sites for future consideration to twelve. Four of these are offstream storage projects located north of the Delta, namely Sites, Colusa, Thomes-Newville, and Red Bank. This chapter describes in detail each of these project alternatives and summarizes the evaluations conducted to date.

Evaluation of north of the Delta offstream storage alternatives is continuing. Information gathered during this investigation will be used for the second stage screening as well as for environmental documentation, permits, and project feasibility evaluations. The second stage screening will lead to selection of a preferred alternative for the North of the Delta Offstream Storage Investigation. In addition, information developed will be used in CALFED's Water Management Strategy Evaluation Framework. This long-term decision-making framework will allow comprehensive comparisons of surface storage projects with other strategies included in CALFED's initial list, including water use efficiency, recycling, and water transfers.

Alternative Projects Description

The four north of the Delta offstream projects provide a range of potential water supply reliability benefits, but would serve similar project purposes. Since all of the projects are upstream of the Delta and adjacent to the Sacramento River, the kinds of benefits, such as supplemental yield for various uses and reduced diversions from the Sacramento River during the peak local delivery period will vary primarily in scale. Comparative project statistics are shown on Table 3-1. All of these projects have been investigated to varying degrees in the past. Current studies have updated and augmented these past studies as needed to allow comparative evaluation of alternatives. Each of these projects is described individually in more detail below.

Sites Project

Consideration of major offstream storage at Sites was first documented in a December 1964 U.S. Bureau of Reclamation report titled *West Sacramento Canal Unit*. This study evaluated a planned extension of the Tehama-Colusa Canal south into Solano County and included a 1.2 maf Sites Reservoir as part of that plan. The potential to use Sites as a stand-alone project to help serve statewide multiple water needs was not considered until this current evaluation. The larger 1.8 maf Sites Reservoir was not considered by either DWR or USBR until the mid-1970s and was sized at the maximum elevation considered practicable at this location.

Table 3-1. Comparative Project Statistics for the Sites, Colusa, Thomes-Newville, and Red Bank Projects

Project Feature	Sites	Colusa	Small Thomes-Newville	Large Thomes-Newville	Red Bank	
					Dippingvat	Schoenfield
Storage (acre-feet)						
Gross	1,800,000	3,000,000	1,900,000	3,000,000	104,000	250,000
Dead	40,000	100,000	50,000	50,000		
Drainage Area (square miles)	85	115	63	63	132	39
Reservoir Surface Area (acres)	14,000	28,000	14,500	17,000	1,270	2,770
Dam Height/Volume (feet/1,000yd^3)						
Sites	290/3,800	290/3,800	325/16,000	400/33,000	250/367	300/467
Golden Gate	310/10,600	310/10,600	75/600	150/2,000	75/19	
Prohibition		230/11,300			115/55	
Owens		260/11,700				
Hunters		260/24,700				
Logan		270/30,600				
Newville						
Burrows Gap (largest saddle)						
Schoenfield (RCC)						
Dippingvat (RCC)						
Lanyan (RCC)						
Bluedoor (RCC)						
Saddle Dams (Number/Height)	9/130	7/140	None	4/75		4/85
Reservoir Elevation (feet)						
Normal	520	520	905	980	1,205	1,017
Minimum	320	320	685	685	1,103	830
Average Annual Natural Reservoir Inflow (acre-feet)	15,000	20,000	20,000	20,000	96,400	16,000
Reservoir Evaporation						
Average Annual	40,000	80,000	50,000	60,000		
Critical Period Total	220,000	440,000	300,000	360,000		
Pumping						
Static Lift from T-C Canal (feet)	320	320	655	730		
Maximum	120	120	435	435		
Minimum	5 - 8	5 - 8	2	2 - 5		
Capacity (1,000 ft^3/s)						

For Golden Gate Dam, statistics shown are for the downstream curved embankment alternative.

The Sites Project site is located about 8 miles west of Maxwell in Antelope Valley, which is drained by Stone Corral and Funks Creeks. The drainage area of these watersheds totals 85 square miles. Two sizes of reservoir were investigated in the past—1.2 maf at 480-foot normal water surface elevation and 1.8 maf at 520-foot normal water surface elevation. However, due to its greater water supply yield, Large Sites appears the more favorable project. Therefore, this investigation to date has focused mainly on Large Sites Reservoir and hereafter will be referred to simply as Sites Reservoir. Two main dams—Golden Gate on Funks Creek and Sites on Stone Corral Creek—and nine saddle dams along the northern edge of the project are required to form the reservoir. Sites Reservoir would occupy a maximum area of 14,000 acres.

Sites Reservoir would be formed by a 290-foot-high Sites Dam on Stone Corral Creek and a 300 or 310-foot-high Golden Gate Dam on Funks Creek. Nine saddle dams ranging up to 130-feet-high would also be built along the reservoir's northern boundary to prevent water from spilling over the ridge into Hunters Creek. Presently, 40-foot-high Funks Dam forms a 2,000 acre-foot reservoir 1 mile downstream of the Golden Gate Dam site. This reservoir was constructed by USBR and is part of the Tehama-Colusa Canal System. Funks serves as a surge reservoir to stabilize flows down the canal as diverters come on- and off-line. Either the existing or an enlarged Funks Reservoir would serve as a forebay/afterbay to the Sites or Colusa Project.

For most of the water source options, imported water entering Sites or Colusa Reservoir would pass through Funks Reservoir. More specifically, it is the terminal location for all of the optional water conveyance routes to these reservoirs derived from sources east of the proposed reservoirs. The exception is a potential water supply source developed from the upper Stony Creek watershed, west of Sites, by diverting water from existing reservoirs through a tunnel and conveying it by gravity via canals, tunnels, and streams directly into the reservoir. These upper Stony Creek water supply source and conveyance options are the only ones that do not convey water through Funks and then require a lift into Sites Reservoir. However, all water source options would flow through Funks Reservoir when water is released to meet downstream water demands.

If daily pumpback operations were incorporated into either project, then Funks Reservoir would probably need to be enlarged to around 8,000 af. A pumpback or pumped-storage operation would maximize power production by releasing water through hydroelectric generation facilities in excess of downstream requirements and then returning it to storage in the offstream reservoir during off-peak periods. This water is then available again for release and generation during peak power demand periods. This type of operation scenario will be evaluated further as the study progresses.

The Sites or Colusa Project water control features (appurtenances) include water intake and outlet structures, a pumping and generating plant, and emergency spillway located at the Golden Gate Dam site on Funks Creek. Sites Dam will have a low-level outlet structure to release stream maintenance flows into Stone Corral Creek.

The proposed operation of the Sites or Colusa Projects would be similar. Each of the water supply source and conveyance alternatives for Sites or Colusa includes water from the Sacramento River through existing, expanded, or new conveyance facilities. Water would be diverted to the offstream reservoir from the Sacramento River and possibly some tributaries, mainly in winter months. During the irrigation season, releases from the offstream reservoir would be made back to local irrigation canals to provide irrigation water in exchange for water that would otherwise have been released from Shasta and diverted downstream from the Sacramento River. The exchanged water would then remain in Shasta Lake for release later in the summer, partially to help cool the upper river for fishery maintenance purposes, and to be used downstream for agricultural, environmental, and urban purposes.

Development of a Sites or Colusa Project with diversion from the Sacramento River will either require modification of the Tehama-Colusa and/or Glenn-Colusa Canal intakes or construction of a new intake for new conveyance. These modified or new facilities will allow large-scale winter diversions of water from the river without adversely affecting the river fishery or other biologic resources. Total diversion capacity from the Sacramento River for the currently proposed source and conveyance alternatives does not exceed 5,000 cfs. A new canal diverting 5,000 cfs from the Sacramento River, east of Maxwell, is also being considered. Colusa Basin Drain floodflows could also be diverted to this new canal for conveyance to offstream storage. High winter flows diverted into these canals would be conveyed to Funks Reservoir and then pumped into Sites or Colusa Reservoirs. Other alternative locations and sources of water supply are being evaluated and will be discussed in greater detail later in this chapter.

When water is released from the reservoir, it would be routed through generators to generate power, which could help offset the power and costs associated with pumping. The economic value of power used to supply the reservoirs will be largely offset by the value of power generated, even though consumption would exceed generation. This is due to the project's ability to pump during periods of lower power costs and generate during periods of higher power costs.

Hydrology of Optional Water Supplies

Project formulation for the alternative offstream projects includes identification of water supply sources that will be diverted to storage. A list of optional water supply sources and conveyance has been developed and evaluation has been initiated to determine preferred sources for each project. The Red Bank Project has only one water supply source under consideration. The project formulation decisions have not yet been made and will require environmental, engineering, and economic evaluation of the water supply source options. The following discussion reflects the evaluation of the water supply sources to date.

Flows of various nearby streams were evaluated to determine the quantity of water that could be diverted to storage in the four alternative offstream reservoirs. In general, three steps were required in determining the hydrologic and water supply characteristics of the optional water supply sources. First, historical flows of the streams were reviewed to provide a preliminary assessment of the relative scale of available water in a given stream.

Second, the historical flows were subjected to local and downstream operational constraints to determine the divertible flow. Local operational constraints include instream flow requirements of the source stream, limitations related to the operations and water rights of existing local water supply projects, and existing or proposed diversion and conveyance facility capacities. Downstream operational constraints include lower Sacramento River flow requirements and requirements in the Sacramento–San Joaquin Delta.

Third, divertible flows of optional sources are combined to determine the water supply yield associated with alternative water supply projects by using a reservoir simulation (CALSIM) model. In this step, water supplies are subject to the offstream reservoir capacity and the system-wide operational constraints of the Central Valley Project and State Water Project. System-wide operational constraints include pumping limitations in the Delta, availability of other system-wide water supplies, and customer demands.

Optional Water Supply Sources

Table 3-2 shows the optional water supply sources considered for the alternative north of the Delta offstream storage projects. Sites, Colusa, and Thomes-Newville Projects each have a number of optional water supply sources. These sources may be packaged in various combinations to generate sufficient water supply for a specific project. The Red Bank Project is unique because there is only one major water supply source being considered for diversion and storage. The six optional sources are the same for Sites and Colusa. Thomes-Newville has three optional water supply sources. Local inflow sources are not shown, but each offstream project would receive some local inflow from the relatively smaller streams that flow directly to the offstream reservoirs.

Table 3-2. Optional Water Supply Sources for North of the Delta Offstream Projects

Sites / Colusa	Thomes-Newville	Red Bank
Colusa Basin Drain	Sacramento River	South Fork Cottonwood Creek
Grindstone Creek	Stony Creek	
Little Stony Creek	Thomes Creek	
Sacramento River		
Stony Creek		
Thomes Creek		

The optional water supply source streams evaluated for north of the Delta offstream storage are the Sacramento River, Stony Creek, Colusa Basin Drain, Thomes Creek, Grindstone Creek, Little Stony Creek, and South Fork Cottonwood Creek. Streamflow records were reviewed to determine the relative quantity of water that has historically flowed in various streams. Table 3-3 shows November through March streamflow volumes at representative locations for the period 1945-1994. The November through March period was chosen to avoid any operational conflicts with existing facilities and water rights. Local irrigation operations often begin in April and conveyance facilities are being used for deliveries. Most of the data shown are directly from gage station streamflow records. A number of the data records needed to be extended or adapted using basic hydrologic correlations. Correlations for the entire period of record were required for Grindstone Creek, inflow to East Park Reservoir, and South Fork Cottonwood Creek.

The Sacramento River is by far the largest water supply source of the options considered. With an average historical five-month flow volume at Butte City of almost 5.5 maf, the river's flow is over 23 times the size of the second largest option, Stony Creek. The three smallest optional water supply sources are Grindstone Creek, East Park Reservoir, and South Fork Cottonwood Creek, each with an average November through March runoff of less than 100 taf. The sources are not independent options. All of the tributary streams contribute to the flow of the Sacramento River. Outflow from East Park Reservoir becomes inflow to Stony Gorge and then ultimately contributes to the flow below Black Butte.

Table 3-3. November - March Streamflow Volumes, 1945-1994 of Optional Water Supply Source Streams

Source and Location	Minimum (taf)	Maximum (taf)	Average (taf)
Sacramento River at Butte City	1,613.4	14,414.6	5,460.7
Stony Creek below Black Butte Dam	1.0	1051.8	234.5
Colusa Basin Drain at Highway 20	38.8	759.2	208.9
Inflow to Stony Gorge Res.	3.6	508.6	151.3
Thomes Creek at Paskenta	7.3	359.1	150.9
Inflow to proposed Grindstone Res.	0.9	301.1	85.4
Inflow to East Park Res. w/ Rainbow Diversion	1.1	221.8	76.2
South Fork Cottonwood Creek at Dippingvat	4.8	259.3	75.4

Streamflow volumes are dependent upon diversion location. In general, volumes increase in the downstream direction. Optional diversion locations for the Sacramento River are at the existing Tehama-Colusa Canal diversion in Red Bluff, the existing Glenn-Colusa Irrigation District Canal diversion in Hamilton City, a new diversion at Chico Landing, and a new diversion opposite Moulton Weir. Diversion locations investigated for Stony Creek include Black Butte Lake, Stony Gorge Reservoir, East Park Reservoir with additional water from the Rainbow Diversion, and at the GCID Canal crossing. The diversion location investigated for Colusa Basin Drain is due west of Moulton Weir, almost 10 miles north of Highway 20. Thomes Creek diversion locations include a number of options west of Paskenta and at the Tehama-Colusa Canal crossing. The Grindstone Creek diversion location is from a potential Grindstone Reservoir. The Grindstone Dam site is approximately 2-1/2 miles upstream from the confluence with Stony Creek. The diversion location for South Fork Cottonwood Creek is at the proposed Dippingvat Reservoir.

Divertible Flow of Water Supply Sources

Divertible flow is computed by imposing local and downstream restrictions on the streamflow volume, including applicable instream flow requirements of tributary streams and the Sacramento River. Divertible flow is also limited by diversion and conveyance capacity of new or existing facilities. A representative divertible flow is shown in Table 3-4 for each of the water supply sources for comparison. The divertible flow value is used as input for the CALSIM operations model.

Table 3-4. November-March Average Divertible Flow

Stream and Location	Conveyance Capacity (cfs)	Divertible Flow (taf)
Sacramento River at Butte City	5,000	587.3
Stony Creek below Black Butte Dam	1,700	234.5
Colusa Basin Drain	3,000	136.5
Stony Gorge Reservoir	1,500	70.2
Thomes Creek	2,100	108.9
Grindstone Reservoir	750	67.9
East Park Reservoir w/ 300 cfs Rainbow Diversion	1,200	30.1
South Fork Cottonwood Creek at Dippingvat	800	52.9

Stony Creek Hydrology and Water Supply

Subsequent to the initial evaluations of optional water supply sources, members of the Technical Advisory Group requested that DWR refine its treatment of options from the upper watershed of Stony Creek. Based on input from TAG members and local project operators, some adjustments were made to the assumptions related to these optional sources. These adjustments did generate corresponding changes in available streamflow volume and the water supply characteristics of these sources. Following is a more comprehensive description of the Stony Creek options.

Stony Creek is a potential source of water supply for an offstream storage reservoir along the western edge of the Sacramento Valley. More specifically, water from Stony Creek could be conveyed to Sites, Colusa, or Thomes-Newville project alternatives for storage. Stony Creek diversion and conveyance options that take advantage of existing reservoirs or conveyance facilities were evaluated for this study.

The major surface water projects in the Stony Creek basin include the Orland Project and Black Butte Dam and Lake. The Orland Project is one of the oldest reclamation projects in the country and includes two main dams and reservoirs, East Park and Stony Gorge. The project is locally operated by the Orland Unit Water Users' Association and provides irrigation water for up to 20,000 acres near Orland, as well as residential, commercial and industrial water supply to about 2,500 residents. East Park Dam and Reservoir are located on Little Stony Creek, about 33 miles southwest of Orland. The capacity of East Park Reservoir is about 51,000 af. In addition to the inflow from Little Stony Creek, East Park receives water from Rainbow Diversion Dam on the mainstem. The Rainbow Feeder Canal is about 7 miles long with a design capacity of 300 cfs. Stony Gorge Dam and Reservoir are located about 18 miles downstream of East Park at the confluence of Little Stony and Stony Creeks. The capacity of Stony Gorge Reservoir is about 50,000 af.

The U.S. Army Corps of Engineers developed Black Butte Dam and Lake, approximately 22 miles downstream of Stony Gorge and 9 miles west of Orland, primarily for flood control in the early 1960s. Black Butte is operated in coordination with a number of other agencies including the OUWUA and USBR for water supply. In addition, the City of Santa Clara generates hydroelectric power. The lake's capacity is about 143,000 af.

Stony Creek Water Supply Source Options

A number of options have been considered for diverting Stony Creek winter flows to offstream storage including:

- Diversion from Black Butte Reservoir to Newville Reservoir;
- Diversion from lower Stony Creek into existing Tehama-Colusa and GCID canals for conveyance to Sites or Colusa Reservoirs;
- Diversion from East Park Reservoir to Sites or Colusa Reservoirs;
- Diversion from Stony Gorge Reservoir to Sites or Colusa Reservoirs; and
- Diversion from proposed Grindstone Reservoir to Stony Gorge Reservoir and rediversion to Sites or Colusa Reservoirs.

The Grindstone Reservoir water supply source option was evaluated at a cursory level. Ranges of reservoir and diversion capacities were considered. The cursory analysis of Grindstone Reservoir indicated a number of undesirable characteristics related to this option including susceptibility to large landslides, relatively large embankment quantities for the dam and saddles, relatively high sediment load in the creek, and close proximity to a fault. While these characteristics would not make the Grindstone Reservoir option technically infeasible, a number of other options appear to be more feasible at this stage of evaluation. Therefore, Grindstone Reservoir as an optional source has been set aside.

The following analysis has focused on the reservoir diversions to Sites or Colusa Reservoirs. Simplified operation simulations using the historic hydrology and current reservoir operations have been used to estimate potential water supply diversions from East Park and Stony Gorge Reservoirs. Potential water supply diversions are simply the amount of water that can be diverted from a source with given conveyance capacities, instream flow, and other operational requirements. Unimpaired inflow to Stony Gorge Reservoir was determined based on historic outflow and changes in storage in East Park and Stony Gorge. Inflow to East Park and Rainbow were estimated as a percentage of the unimpaired Stony Gorge inflow. The area of the watersheds above Stony Gorge, East Park, and Rainbow diversions was determined. Area/precipitation factors of 45 and 31 percent were used for Rainbow and East Park respectively. This means that 45 percent of the unimpaired inflow to Stony Gorge flows past the Rainbow location and 31 percent flows into East Park.

A review of available data and discussions with local project operators provided helpful information. For example, a review of monthly reservoir storage indicates that a significant shift in Orland Project reservoir operations occurred subsequent to construction of Black Butte Reservoir in 1963. After Black Butte Reservoir was built, water in storage at the end of the irrigation season in the Orland Project reservoirs increased an average of about 16,000 af. Local project operators helped refine current project operating criteria, including estimates of instream water releases below the dams.

Criteria were established to determine the potential water supply diversions from Orland Project reservoirs including:

- Instream flow requirements for the creeks below East Park, Stony Gorge, and Black Butte were set at 10, 10, and 30 cfs, respectively. These are based on operator's estimates of current operating practices.
- Diversion is limited to the November through April period to avoid potential impacts to existing projects. This diversion period is one month longer than for other options, but will not conflict with the rights of existing water users.
- Diversion is limited such that end of the month reservoir storage during the diversion period was equal to or greater than historic levels in all three reservoirs.
- A minimum diversion storage level of 20,000 af in East Park and Stony Gorge was established to provide adequate tunnel submersion.

A range of conveyance capacities to the offstream storage alternatives was evaluated to determine optimal sizing of diversion and conveyance facilities. For Stony Gorge, conveyance of 500, 1,000, 1,500, and 2,000 cfs were considered; for East Park, conveyance of 800, 1,000, and 1,200 cfs; the Rainbow Feeder Canal to East Park was sized at 300, 500, 750, and 1,000 cfs.

Potential water supply diversions were analyzed for the above range of facilities for the 1964 through 1994 period. This period was chosen based on the previously mentioned effect of Black Butte operations and the data requirements of CALSIM, the statewide operation simulation model. The potential water supply diversion data was then extended to the standard CALSIM period, 1922 through 1994, by correlation with the Sacramento River Index. Annual potential water supply diversions from Stony Creek sources are shown in Table 3-5 for the 1922-1994 period.

Table 3-5. Stony Creek Reservoir Options Average Potential Water Supply Diversions (taf)

Diversion and Conveyance(cfs)	Existing or Rainbow (300)	Rainbow (500)	Rainbow (750)	Rainbow (1,000)
Stony Gorge (500)	60			
Stony Gorge (1,000)	90			
Stony Gorge (1,500)	107			
Stony Gorge (2,000)	117			
East Park (800)	60	66	68	69
East Park (1,000)	62	70	74	76
East Park (1,200)	63	71	77	80

Water Supply Contribution

Water supply contribution (Table 3-6) is the amount of water actually diverted in an operation simulation to an offstream reservoir from a specific source and is an output from CALSIM. Water supply contribution to an offstream reservoir is dependent on potential water supply diversions and a number of other hydrologic and operational variables that are input to the

CALSIM model. These variables include capacity of the offstream reservoir, water supply diversions from other sources, instream flow requirements, Delta conditions, demands, and Delta diversion facilities.

Table 3-6. Water Supply Contribution (taf) From Sources to 1.8 maf Sites Reservoir (Typical operational studies)

Conveyance Package	Stony Creek	Sacramento River	Colusa Basin Drain	Total
2,000 cfs tunnel from Stony Gorge	117			117
2,100 cfs T-C canal 1,800 cfs GCID canal		143 159		302
2,100 cfs T-C canal 1,800 cfs GCID canal 2,000 cfs tunnel from SG	58	127 141		325
2,100 cfs T-C canal 1,800 cfs GCID canal 3,000 cfs canal from CBD		85 168	63	317

Yield is difficult to assign to a specific source for a project with multiple sources of water. The portion of total water supply contribution from a specific source is an indicator of the yield from a specific source using specific sources and conveyances for a project. Yield of a given offstream reservoir project can be determined by computing the difference between deliveries with and without the project and is discussed in the section describing CALSIM results.

Factors Related to the Upper Stony Creek Options

Factors other than potential water supply diversions, water supply contribution, and yield may be considered in evaluating the upper Stony Creek reservoir diversion options. Using Stony Creek as a water supply source may offer a number of unique advantages compared to other sources. Since the East Park and Stony Gorge diversions are from existing reservoirs, fishery impacts and their associated mitigation costs may be significantly less. While Stony Creek would not provide enough water for an offstream reservoir by itself, maximizing diversion from Stony Creek sources would provide opportunities to limit diversions from the Sacramento River, for example. Since potential Stony Creek diversions are at greater elevation than Colusa or Sites Reservoirs, no pumping is required and additional hydroelectric power may be generated. All of the other source options must be pumped up 120 to 320 feet from Funks Reservoir.

Finally, conveyance from these reservoirs to Sites or Colusa would be independent of existing conveyance systems. All of the other source options are dependent upon the Tehama-Colusa Canal, at least, to get water into Sites or Colusa. This independence described above means that water could continue to be conveyed to offstream storage after deliveries begin in the Tehama-Colusa and GCID service areas.

Project Operation Studies

Two important characteristics of a surface water project are the size of its increased water supply and the cost of the project. The new or additional yield that a proposed project could generate is predicted by conducting operation studies. This is an accounting process over a historic period using recorded or estimated streamflows. This accounting includes all water hypothetically supplied to, stored in, lost to seepage and evaporation, and released from the reservoir. Operation studies are performed using a computer-based hydrologic simulation model. DWR's model is titled CALSIM and allows an operation simulation of a project under investigation simultaneously with other major reservoir systems such as the Central Valley Project and the State Water Project over a historic period. The current operation simulation uses the 1922 through 1994 hydrologic sequence. CALSIM's predecessor DWRSIM was used extensively by CALFED in its programmatic evaluation of the water resources of the Delta and its tributaries.

For a project operation study, water is released on a schedule representing project water demands at some point in the future (in this investigation the year 2020). The difference between the total system water supply with and without the project under investigation is considered to be the water supply attributable to the proposed project. The model is run using average monthly flows; whereas the availability of water supplies from various streams is developed using average daily flow data. Although the model is running on monthly steps, the result is refined enough to determine water supply yield estimates that are acceptable for making comparisons between competing alternatives.

For this phase of the offstream storage investigation, 42 CALSIM operation studies were run. These studies include 3 base studies, 31 for the Sites Project, 4 for the Colusa Project, and 4 for the Thomes-Newville Project. These studies include various optional sources of water and conveyance facilities for filling the reservoirs to allow identification of a preferred source and conveyance alternative for each project. The 1993 operation studies for the Red Bank Project were considered adequate for this phase of evaluation.

For the Sites and Colusa Projects, seven possible diversion locations were considered as sources of water to fill the reservoir: the Sacramento River at Red Bluff Diversion Dam; the Sacramento River at the GCID pumps; the Sacramento River at Chico Landing; the Sacramento River at mile 158.5 (opposite Moulton Weir); the Colusa Basin Drain; Stony Gorge Reservoir; East Park Reservoir; Thomes Creek at the Tehama-Colusa Canal crossing; and lower Stony Creek at the Glenn-Colusa Canal crossing.

For the Thomes-Newville Project, five possible diversion locations were considered: Thomes Creek about 5 miles upstream from Paskenta; Stony Creek at Black Butte Lake; the Sacramento River at the Red Bluff Diversion Dam; the Sacramento River at the GCID pumps; and Thomes Creek at the Tehama-Colusa Canal crossing.

The general formulation of the CALSIM operation studies:

- Runs on a monthly basis for years 1922 through 1994.
- Uses estimated 2020 level of development.
- Uses a surrogate demand for project water supply. A surrogate demand is representative of currently unassigned project beneficiaries of the offstream

project yield. After project beneficiaries have been identified, an actual projected demand schedule will replace the surrogate in subsequent operation study runs.

- Models flows of both the Sacramento and San Joaquin River systems, with coordinated operation of CVP and SWP reservoirs.
- Generates data to estimate water supply, power use and power generation, fishery maintenance flows, recreation use, and Delta flow requirements.

The computation of project yield is one of the most useful outputs from an operation study. Yields are computed by comparing total system-wide deliveries for a proposed project to the deliveries under a base study. Table 3-7 summarizes the yields or increase in system deliveries for specific project formulations completed to date. Average and drought yields have been determined for each study. An average yield is the average annual increase in system deliveries from 1922 through 1994. Similarly, drought yield is the average annual increase in system deliveries during the 1928 through 1934 drought period.

Table 3-7. Increase in System Deliveries with Offstream Storage Project (taf)

Study #	T-C Canal	GCID Canal	New Canal	Chico Landing	Colusa Drain	East Park	Stony Gorge	Thomes Creek	Stony Creek	Assumptions	Avg Drought Yield (28-34)	Average Yield (22-94)
Base Studies:												
2												
6										Banks P.P.=10,300 cfs	79	184
7										Proposed Trinity flows	-134	-40
1.8 maf Sites Project:												
3	2100	1800									290	268
3b	2100										159	242
4	2100	1800			3000						310	277
5	2100	1800					1000				290	268
8	2100	1800					2000				296	282
8a							2000				36	98
9	2100	1800				800					292	275
9a	2100	1800				1000					293	277
10	2100	1800				1200					295	278
11	2100	1800								Banks P.P.=10,300 cfs	282	349
12	2100	1800					1000			Banks P.P.=10,300 cfs	299	354
13	2100	1800				800				Banks P.P.=10,300 cfs	295	351
14	2100	1800			3000					Banks P.P.=10,300 cfs	315	370

Table 3-7. Increase in System Deliveries with Offstream Storage Project (continued)

Study #	T-C Canal	GCID Canal	New Canal	Chico Landing	Colusa Drain	East Park	Stony Gorge	Thomes Creek	Stony Creek	Assumptions	Avg Drought Yield (28-34)	Average Yield (22-94)
15	2500	2500									294	282
16	2500	2500			3000						336	284
17			5000		3000						365	284
24	2100	2900									294	279
25	2100	2900			3000						336	286
38		5000			3000						331	286
1.8 maf Sites Project (cont'd):												
39		2900		2100	3000						349	285
40	2100		2900		3000						342	284
41	3200	1800			3000						339	287
42	5000				3000						338	288
43				5000	3000						360	284
44	2100	1800					1500				293	269
Sacramento River Flow Requirement:												
18	2100	1800			3000					Diversion Min=7,000 cfs	314	266
19	2100	1800			3000					Diversion Min=10,000 cfs	277	254
20	2100	1800			3000					Diversion Min=13,000 cfs	227	251
21	2100	1800			3000					Trigger=40,000 cfs	192	228
22	2100	1800			3000					Trigger=60,000 cfs	160	200
23	2100	1800			3000					Proposed Trinity	335	274
3.0 maf Colusa Project:												
30	2100	1800			3000					Diversion Min=10,000 cfs	277	313
31	2100	1800			3000					Trigger=60,000 cfs	159	236
32	2100	1800			3000					Proposed Trinity flows	398	328
33	2100	1800			3000					Banks P.P. =10,300 cfs	412	428
1.9 maf Thomes-Newville Project:												
34								5000	3000		146	213
35	2200							5000	3000		319	275
3.0 maf Thomes-Newville Project:												
36								5000	3000		146	248
37	2200							5000	3000		377	315

Three base studies were used in this set of modeling studies. In addition to the general formulation of the studies described above, Base Study 2 assumes the existing Banks Pumping Plant capacity restrictions per the Corps' 1981 Criteria, existing Trinity River instream flow requirements, and existing Sacramento River operating guidelines for flows. Base Studies 6 and 7 model the effect of increased Banks Pumping Plant capacity and proposed instream flow requirements for the Trinity River, respectively.

The proposed instream flow requirements for the Trinity River would reduce the average system yield by about 40 taf. The remaining studies that model these proposed flow requirements are compared against this lesser system yield indicated in Study 7. Other sensitivity analyses performed in this study set are related to potential flow requirements for the Sacramento River. The sensitivity analyses conducted for Sacramento River Diversion include trigger flows of 40,000 and 60,000 cfs and minimum downstream flows of 7,000, 10,000, and 13,000 cfs. A trigger flow is a minimum required flow that must be met once in a water year before diversion can be made to an offstream project. Once the trigger is achieved, only current restrictions related to Sacramento River flow would limit diversion. A minimum downstream flow is a continuing requirement that must be met at all times for diversion to offstream storage to be allowed.

The average project yields for North of the Delta Offstream Storage range from 98 to 428 taf. The 98 taf yield is associated with a 2,000 cfs conveyance from Stony Gorge Reservoir for the 1.8 maf Sites Project. This study formulation is not an actual alternative, but indicates the maximum amount of yield associated with the Stony Gorge source since no other sources would fill up storage space in the reservoir. The 428 taf yield is associated with the 3.0 maf Colusa Project with increased capacity at Banks Pumping Plant.

In addition to project yield, the operation studies also enable an assessment of impacts to Sacramento River flow and storage in existing reservoirs. By comparing "with project" flows and "without project" flows in specific reaches of the river, an estimate of streamflow changes related to project operation can be made. A comparison of storage in Shasta Lake and Lake Oroville with and without an offstream project indicates the potential change in storage levels in these existing reservoirs associated with project operation.

In general, the timing of flows in the Sacramento River is shifted a few months later in a given year. The shift in flows is mainly related to the exchange, where water that would have been released from Shasta Lake and delivered locally in the Tehama-Colusa and GCID service areas would instead be served by an offstream project. Water that is held in Shasta would then be released for other uses according to a demand schedule that generally requires water later in the year.

This flow information will be evaluated more thoroughly in the next phase of the investigation. In addition to general overview of flow impacts for the Sacramento River, scientists from the University of California will be assessing potential impacts of the flow changes in the river related to operation of an offstream reservoir project. Two studies will focus on river meander migration impacts and associated habitat evolution impacts. These studies are described in greater detail in Chapter 6.

The operation of an offstream project would also impact storage levels in existing reservoirs. Again, changes in the end-of-month storage in Shasta Lake are likely related to the exchange described above. Another factor that appears to affect both Shasta and Oroville is related to the additional storage that would be created by an offstream project and adjustments needed to operate that additional storage with the existing projects. More evaluation of end-of-month storage impacts is anticipated during the next phase of the investigation.

Water Conveyance Alternatives

This study investigated alternative conveyance systems designed to move water from sources including the Sacramento River and its tributary streams as well as offstream storage projects. For the Sites and Colusa Projects, the optional conveyances considered are identical and consist of the following: existing or expanded Tehama-Colusa and Glenn-Colusa Canals; a new canal from the Colusa Basin Drain and/or the Sacramento River near Moulton Weir; a new diversion on the river near Chico Landing; and a canal intertie to the Tehama-Colusa or Glenn-Colusa Canals. These primary options were combined in different ways with supplemental conveyance from river tributaries and resulted in the variations described below and shown on Figure 3-1. Descriptions and approximate cost estimates for the conveyance system alternatives investigated for Sites and Colusa are given below:

Alternative

I. Would use the existing Tehama-Colusa and Glenn-Colusa Canals from their diversions near Red Bluff and Hamilton City, respectively, to a terminal location near Funks Reservoir. A short section of new canal and pumping plant would connect the Glenn-Colusa Canal to Funks Reservoir. The cost of this alternative is estimated at $110 million, mostly for the new canal section and pumping plant. This alternative could deliver a maximum of 3,900 cfs from the Sacramento River to Funks Reservoir. Operation studies 3 and 11 reflect this alternative, with average yields for Sites of 268 and 349 taf for existing and enlarged pumps at Banks, respectively.

II. Is the same as alternative I except that both canals would be enlarged slightly to carry 2,500 cfs each for a total of 5,000 cfs from the river to Funks. The total cost would double to around $220 million, while the carrying capacity would increase 28 percent. Under this alternative, the costs of pumping plants and other conveyance facilities would be approximately equal to that of Alternative I. This alternative is reflected in operation study 15, with a Sites Project average yield of 282 taf.

III. This alternative would use the existing 2,100 cfs capacity in the Tehama-Colusa Canal and 2,900 cfs capacity in an enlarged Glenn-Colusa Canal, combined with 3,000 cfs from the Colusa Basin Drain. The drain water would be conveyed via a new canal and two pumping plants to the Glenn-Colusa Canal for transfer to Funks Reservoir by way of the same connector used in alternatives I and II. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated cost would be about $490 million. This alternative is modeled in operation study 25 and would have an average yield of 286 taf for Sites Project.

IVA. This alternative would use the enlarged Glenn-Colusa Canal to carry 5,000 cfs plus 3,000 cfs from the Colusa Basin Drain via the new canal. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated cost around $550 million. Operation study 38 reflects this alternative conveyance for the Sites Project, with an associated average yield of 286 taf.

IVB. Same as Alternative IVA, but with a new 2,100 cfs diversion near Chico Landing connecting to the Glenn-Colusa Canal instead of an increase in pumping capacity at the existing Hamilton City pumping plant. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated cost is approximately $500 million. This alternative is shown in operation study 39, with an average yield of 285 taf for Sites Project.

V. Would consist of a new 5,000 cfs river diversion opposite Moulton Weir combined with a 3,000 cfs diversion from the Colusa Basin Drain. Both sources of water would be conveyed to Funks Reservoir via the new canal. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated cost $580 million. See operation study 17, with an average yield of 284 taf for Sites.

VIA. Would use existing 2,100 cfs Tehama-Colusa Canal combined with new 2,900 cfs Sacramento River diversion and canal opposite Moulton Weir, plus 3,000 cfs from the Colusa Basin Drain. Total diversion capacity to Funks Reservoir is 8,000 cfs and the estimated cost would be around $470 million. This alternative is shown in operation study 40, with an average Sites yield of 284 taf.

VIB. Same as Alternative VIA except with the capacity of the Glenn-Colusa Canal reduced to the existing 1,800 cfs and the new Sacramento River diversion increased to 3,200 cfs. Total diversion capacity would remain the same at 8,000 cfs and the total costs would be reduced to about $450 million.

VIIA. New 5,000 cfs Tehama-Colusa Canal diversion and canal expansion to Funks Reservoir plus 3,000 cfs from the Colusa Basin Drain via the new canal. Total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated cost would be around $870 million. Operation study 42 shows an associated average yield of 288 taf.

VIIB. Same as Alternative VIIA except that the Tehama-Colusa Canal water would be diverted at Chico Landing via new diversion. Diversion capacity would be the same and estimated cost around $730 million. Operation study 43 indicates an average yield of 284 taf for Sites.

VIIIA. Includes 1,500 cfs tunnel diversion from Stony Gorge Reservoir combined with the existing 2,100 and 1,800 cfs diversions via the Tehama-Colusa and Glenn-Colusa Canals, respectively. The total diversion capacity to Sites or Colusa Reservoirs would be 5,400 cfs and the estimated cost around $420 million. Operation study 44 shows an average yield of 269 taf for Sites.

VIIIB. Same as Alternative VIIIA except that Stony Creek water would be diverted from East Park Reservoir via a 1,200 cfs tunnel. Total diversion capacity to Sites or Colusa Reservoirs would be 5,100 cfs and the estimated cost approximately $230 million. Operation study 10 indicates an average yield of 278 taf for Sites.

In addition to the above conveyances, new or enlarged river diversion and canal pumping plants would be required in all of the conveyance alternatives.

Pumping plant capacities would range from approximately 1,100 to 6,100 cfs, with pumping heads of approximately 20 to 110 feet (excluding the final Funks to Sites Reservoirs lift). These pumping costs were not included in the comparative cost estimates above.

No decision on the preferred conveyance alternative has been made yet. Future investigation of the environmental impacts associated with these alternatives must be completed before a preferred source and conveyance alternative can be selected.

Figure 3-1. Sites Reservoir Conveyance Alternatives

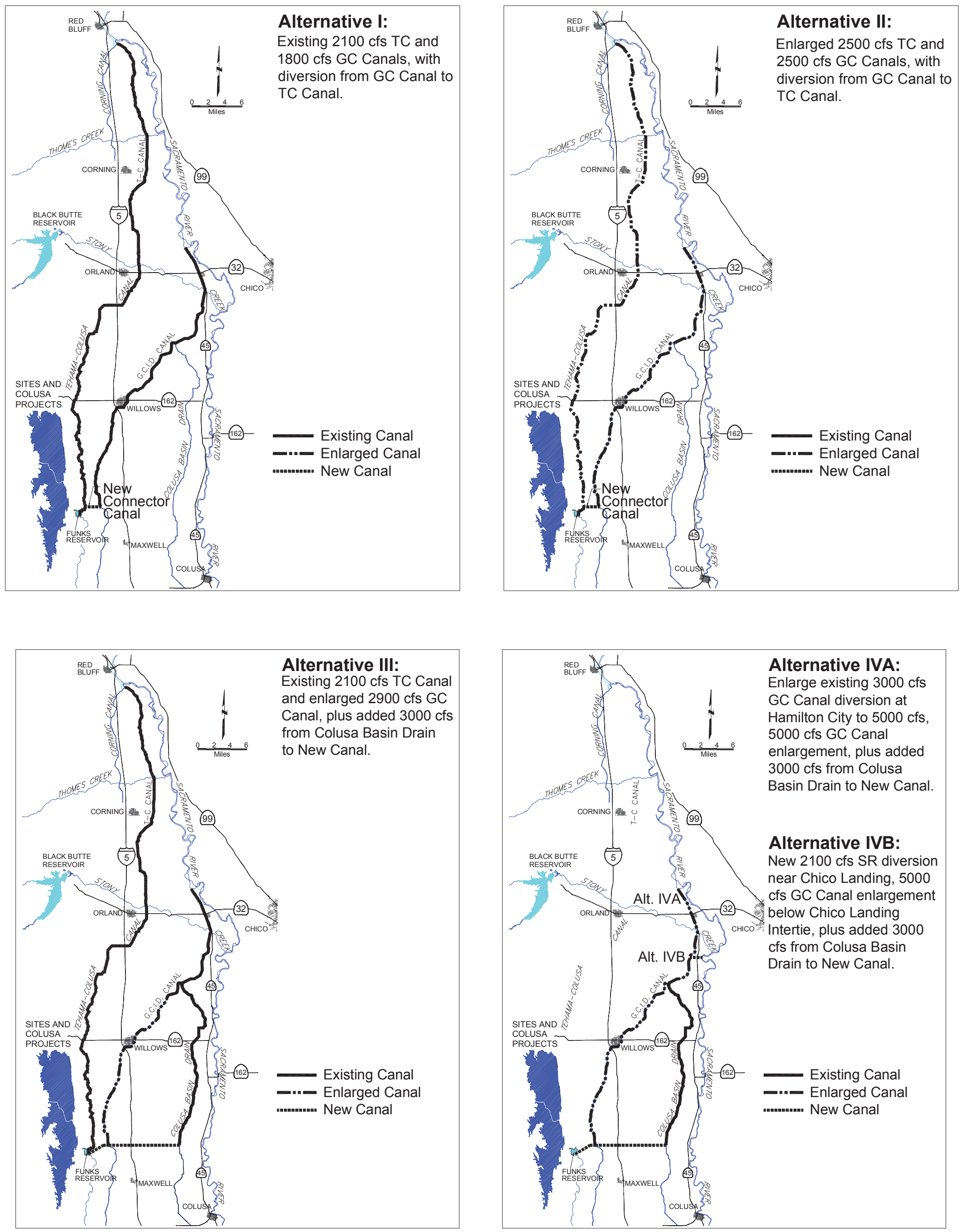

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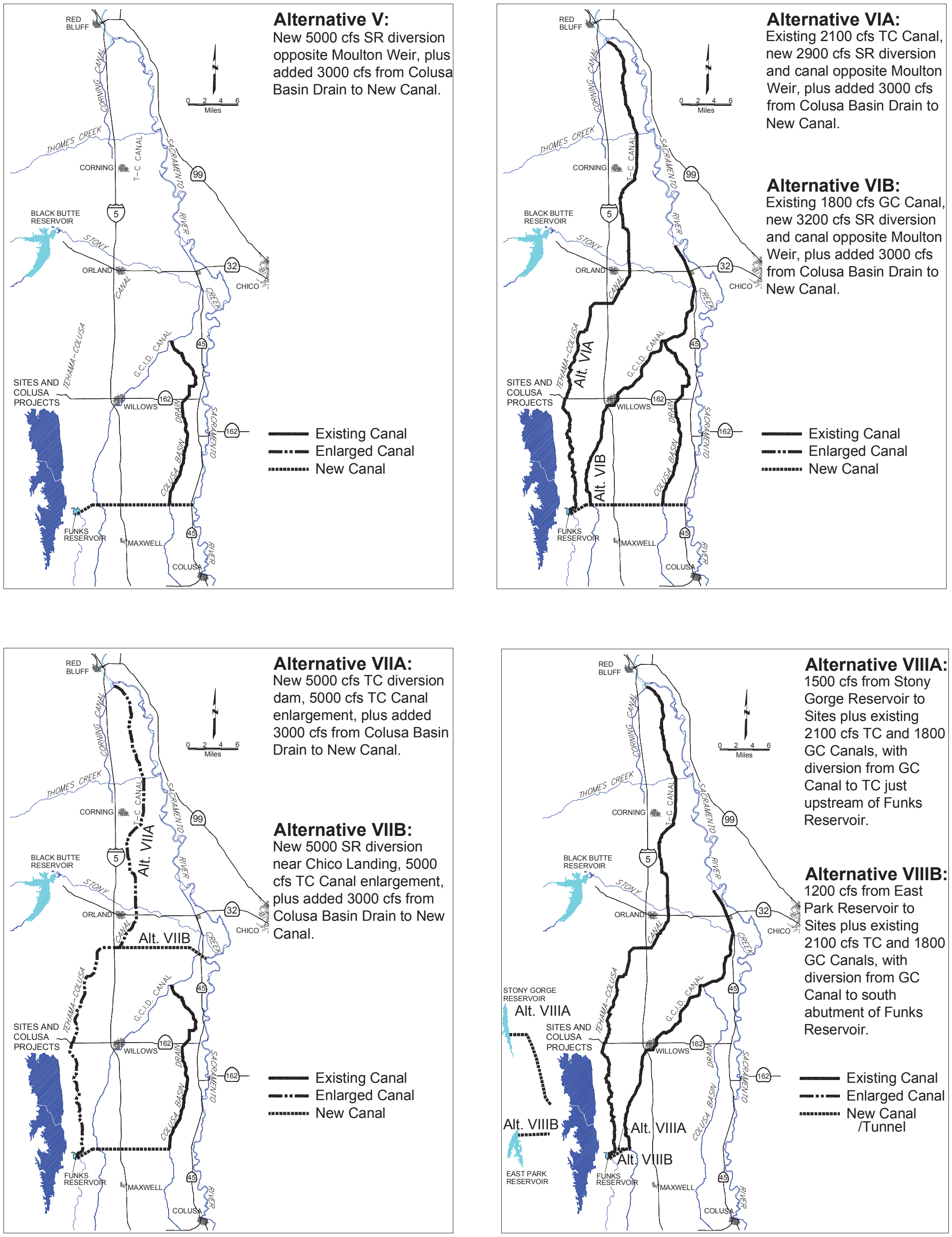
Figure 3-1. Sites Reservoir Conveyance Alternatives (continued)



Power Generation/Consumption and Potential Pumpback Operation

DWR's State Water Project Analysis Office performed a cursory study of power consumption, generation (including potential pumpback hydropower operation), related costs, and revenues associated with operation of the Sites

Project. The pumpback power generation potential of other projects will be evaluated later.

This study estimated power costs associated only with the transfer of water between existing or enlarged Funks Reservoir and a 1.8 maf Sites Reservoir. It did not include costs associated with any additional pumping/generating plants required to transport water from the river or other water supply sources to Funks Reservoir. Nor does the study include the cost of energy required to initially fill Sites Reservoir.

Two alternative operations were considered:

1. Operation with no increased storage at Funks Reservoir, referred to as minimal operation.
2. Operation with an enlarged Funks Reservoir of around 8,000 af capacity to maximize power operations referred to as optimized operation.

For these two categories, the following alternative operation modes were evaluated as summarized in Table 3-8.

- **Minimal Seasonal Operation.** No additional forebay storage beyond that in existing Funks Reservoir would be required for this operating option. It would simply pump water into the Sites Reservoir for storage on a 24-hour per day schedule as required during the winter and release water through Funks Reservoir for irrigation on the same continuous schedule during the summer. Pumping and generation would occur on a 24-hour basis regardless of hourly or daily power cost fluctuations. The average annual net power cost (cost of power consumed minus revenue from sale of power produced) resulting from this operation is estimated at around $723,000, or approximately $11.4 million in present worth net power cost over the life of the project (50 year period of analysis, 6 percent discount rate).
- **Optimum Seasonal and Pumpback Operation combined.** This option would require construction of a larger Funks or similar forebay (to around 8,000 af) and another pumping plant to raise water from the Tehama-Colusa Canal into the enlarged forebay. It would take advantage of pumpback opportunities whenever economically advantageous by pumping at night when power costs are lowest, and generating (by releasing reservoir water) during the day when power values are highest. After the project pumped or released the desired amount of water for seasonal operation, any remaining time could be used for full pumpback operation. This operation just transfers water back and forth between Sites and Funks Reservoirs for the sole purpose of generating power revenues. This would only be done when the difference between peak and off-peak power rates was large enough to more than offset the cost of power consumed by system inefficiencies and the operation, maintenance, and replacement costs. In other words, pumpback would only be implemented at times when substantial net revenues would be realized. The average net power revenue benefits which could result from this operation were estimated at around $2,481,000 per year or approximately $39 million in equivalent present worth over the life of the project.

Net revenues from pumpback operation must be balanced against major additional pumpback storage costs such as: (1) constructing and maintaining an 8,000 af forebay; (2) constructing and maintaining an additional pumping plant to lift water from the Tehama-Colusa Canal to the new enlarged forebay; and (3) increased pumping/generating capacity, maintenance, and replacement. Although precise estimates have not been made, these costs would be substantial, possibly exceeding the $39 million present worth of pumpback storage power benefits. More work will be performed on this potential project feature as the OSI continues. However, it does not appear that pumpback storage offers a major advantage to a project whose overall cost will substantially exceed $1 billion. Therefore, pumpback power operations appears to be a relatively inconsequential factor in determining project feasibility, and may not be justified.

Table 3-8. Summary of Pumpback Operation Cost and Revenues

(Only pertains to water conveyed between Funks and Sites Reservoirs)

MINIMAL OPERATION (No Enlargement of Funks Reservoir)

Mode of Operation	72-Year Period	Annual Operation: Energy Consumption (1,000 MWH)	Energy Production (1,000 MWH)	Energy Cost ($1,000)	Energy Revenue ($1,000)	Revenue Minus Cost ($1,000)
Seasonal	Max	350	261	8,991	6,331	-2,660
	Min	0	0	0	0	0
	Avg	107	75	2,657	1,925	-732

OPTIMIZED OPERATION (Enlargement of Funks Reservoir to around 8,000 af)

Mode of Operation	72-Year Period	Energy Consumption (1,000 MWH)	Energy Production (1,000 MWH)	Energy Cost ($1,000)	Energy Revenue ($1,000)	Revenue Minus Cost ($1,000)
Combined Seasonal pumpback	Max	800	625	15,032	18,363	3,331
	Min	223	167	3,771	4,861	1,090
	Avg	554	418	9,892	12,373	2,481

(a) The study this table summarizes was based upon assumption of a very efficient schedule with no environmental restrictions. This cannot be achieved in actual operation; therefore, this table represents the maximum power revenues potentially available.

(b) Costs of maintenance and wear on the units and replacement costs are considerable and may affect the decision to use pumpback operation when the on-peak/off-peak price differential is small.

Sites Reservoir Recreation

The recreation use potential of Sites Reservoir is substantial, though limited somewhat by steep terrain and potential, widely varying, reservoir elevations due to operation. The nearby, but much smaller, Black Butte Lake received an average of 335,000 recreation user days annually since 1985. Visitation at Sites Reservoir is anticipated to be higher because of its attractive larger size and proximity to population centers. There are several potential developable recreation areas around Sites Reservoir.

Five major potential recreation areas around Sites Reservoir were identified in this investigation and are described below:

- Stone Corral Recreation Area (225 acres) is located immediately north of Sites Dam. It could support approximately 50 campsites and possibly a two-lane boat ramp. Shoreline fishing would be good due to deep water and the area offers excellent views because of its higher elevation. A trail system and interpretive displays would be suitable.
- Saddle Dam Boat Ramp (600 acres) is located at the north end of the reservoir adjacent to several of the project saddle dams. This area is mildly sloping and suitable for boat ramp construction and associated parking. Also, this area would be readily accessible if the Maxwell-Lodoga Road was relocated around the north end of the reservoir. Day-use facilities such as a swim beach and picnic area could be located on the slopes surrounding a boat ramp. No campsites are proposed at this location due to its lack of vegetation and exposed character.
- Peninsula Hills Recreation Area (325 acres) is located on the west shore of Sites Reservoir on what would be a large peninsula. This area contains a series of small coves that would be excellent for fishing and hiking. It is suitable for a large campground of around 200 sites that could be completed in stages. There are two potential boat ramp locations. Access would be from the relocated Sites-Lodoga Road, but about 2 miles of additional new road would have to be constructed.
- Lurline Headwaters Recreation Area (200 acres) is located on the ridge forming the southeast shore of Sites Reservoir and is characterized by an open meadow surrounded by oak grassland and steep hills overlooking the reservoir. This area could support both camping and day-use activities such as hiking to a nearby 1,282-foot-high peak with outstanding views. Approximately 50 campsites, one or two group sites, and numerous picnic sites could be constructed on the 50 acres of relatively level land in this area. However, this area would not have vehicle access to the shoreline or a boat ramp, because of the steep terrain. About 2 miles of rough existing road would need to be upgraded to access this area.
- Dunlap Island Boat-In Facilities (50 acres) could be located near the southwestern shore across from the Sites townsite. This island would provide boaters a camping area near a secluded bay. Enough suitable land exists to support construction of approximately a dozen primitive campsites with sanitation facilities, but with no treated water supply.

Other recreation features that have been considered could also become a part of the Sites Project include:

- Sites Reservoir Loop Trail for hiking, biking, and equestrians extending around the reservoir and connecting all the shoreline recreation areas. Much of the trail would run along the crest of Logan Ridge that provides outstanding views of the Sacramento Valley and surrounding mountain ranges.
- Fishing access points could be constructed at numerous locations along the relocated Sites-Lodoga Road.
- Pre-project fishing enhancement could be accomplished by stocking the numerous existing ponds in the reservoir area with brood-stock fish to accelerate development of a reservoir recreational fishery.

- A Stone Corral Creek coldwater fishery could be developed immediately below Sites Dam.

Colusa Project

DWR's interest in the Colusa Project began in the 1960s as part of a Klamath-Trinity River Development alternative conveyance system that would terminate at Colusa Reservoir. The November 1981 Bulletin 76-81 concluded “data indicates that the incremental cost of storage at Colusa would be excessive in comparison to the storage costs of Sites Reservoir."

The Colusa Cell, at the maximum water surface elevation of 520 feet, occupies all of the 14,000 acres immediately north of Sites Reservoir. The Colusa Cell adds 1.2 maf of storage to Sites, for a total of 3.0 maf for Colusa Reservoir. However, four more major dams along Logan Ridge—Prohibition, Owens, Hunters, and Logan Dams—and seven saddle dams are required to form the reservoir. There is approximately a four to one ratio between the dam volume of Colusa compared to Sites at the maximum 520-foot water surface elevation.

The Colusa Project, like Sites, would be filled by winter water, surplus to downstream needs from the Sacramento River and/or tributaries. Project appurtenances including inlet, outlet, spillway, pumping/generating plants, and forebay at Golden Gate Dam would be the same as for the Sites Project. However, with the larger Colusa Reservoir capacity, the size of most of these appurtenances would be increased proportionately. Considerable engineering and geologic work has been performed at Sites; Colusa is not as well defined and requires additional work to bring it up to an equivalent status. This work would be performed in the near future, subject to continuing screening.

There are no State or county roads and only one known permanent resident within the additional area required to form Colusa Reservoir. Also, the only known utilities are those that service the residents; therefore, the relocation of people and structures for Colusa will be essentially the same as for Sites. Colusa would flood a primary road relocation route for Sites. This would probably result in the Maxwell-Lodoga Road being located around the south end of Colusa Reservoir.

Alternative Sources of Water

Colusa at 3.0 maf can take advantage of a greater water supply and produce a larger yield than Sites at 1.8 maf. However, the potential sources of supply for Colusa are the same as those for Sites. The size of the diversion and conveyance system can be increased to expand the supply. Determination of the near optimum match between reservoir capacity and conveyance size is made by comparing water yields (from operation studies) with the estimated project costs to generate these yields. This sizing selection process will be emphasized later in this investigation. More operation studies covering numerous sizing options and feasibility-level cost estimates are needed to determine optimum project size. At this point in the investigation, the same alternative sources and sizes of water conveyances are under consideration for both the Sites and Colusa Projects. Continued project formulation studies will evaluate the optimum conveyance sizing compared to reservoir size.

Project Operation Studies

The results of the four Colusa Project Operation Studies run to date are shown in Table 3-7. The 1922 through 1994 period average annual project yield estimated by studies ranged from 236 to 428 taf, depending on assumptions related to potential operations. All of the studies run were for a source and conveyance alternative including existing Tehama-Colusa and GCID canals and a 3,000 cfs diversion and conveyance from Colusa Basin Drain. Yields associated with alternative Colusa Project formulations can be estimated based on Sites Project studies and the four Colusa studies. In general, yields are diminished when potential instream requirements for the Sacramento River are included and a smaller reduction occurs when proposed Trinity River requirements are included. Comparison of Sites and Colusa using the same assumption sets indicates an average yield increase of 16 to 23 percent. The largest improvement is for critical years with expanded Banks Pumping Plant capacity, where the yield improves from 315 taf for Sites to 412 taf for Colusa, a 31 percent increase. This correlates with the fact that Colusa Reservoir is 66 percent larger than Sites. Additional operation studies will be run if the study of Colusa continues, using the CALSIM model and more detailed operational criteria.

Water Conveyance Alternatives

The potential Colusa Project water conveyance alternatives are identical to those for Sites but the higher capacity options may be a better match for Colusa due to its larger capacity. Future operation studies and cost comparisons would more clearly identify the water supply needs of the Colusa Project. Earlier studies of Colusa located the inlet/outlet and pumping/generating facilities at Logan Dam instead of Golden Gate Dam. This was done to shorten the conveyance system distance from the Tehama-Colusa and Glenn-Colusa canals Sacramento River diversions. However, for this comparative study to determine relative project feasibility, Golden Gate Dam has been designated as the water inlet/outlet location for both projects based on the following:

- The Tehama-Colusa and GCID canals are much closer together near the Golden Gate Dam site and a connector canal between them would be less expensive to construct.
- Golden Gate is a superior input location for water from the Colusa Basin Drain and the Sacramento River below Chico Landing because it would collect more water farther down the basin and the canal alignment would not pass through sensitive public waterfowl areas.
- Considerably more study effort would be required to evaluate another inlet/outlet location and the probability that it would significantly impact project feasibility is small.
- If after further study the Colusa Project is determined to be superior to Sites, further consideration can be given to the relative merits of locating inflow/outflow facilities at Logan Dam instead of Golden Gate Dam.

Recreation Opportunities

Recreation opportunities for the Colusa Project are similar to those for Sites. A more detailed investigation of these opportunities would be initiated if study of the Colusa Project continues.

Comparison of the Sites and Colusa Projects

The Offstream Storage Investigation frequently confirms conclusions from older studies that evaluated similar projects. Despite the fact that many of the facilities for the Sites and Colusa projects would be the same or similar, the DWR investigation of the projects around 1980, as reported in Bulletin 76-81, indicated that the unit cost of storage (dollars per acre foot of storage) and yield (dollars per acre foot of yield) for Colusa is considerably higher than for Sites. These relatively high unit costs were primarily due to the very large embankments required by the additional dams and seven saddle dams that are required to expand Sites Reservoir to the larger Colusa Reservoir. This current investigation estimates the embankment volumes required for Sites and Colusa reservoirs at about 24 and 100 million cubic yards respectively so that Colusa requires about four times the embankment volume as Sites. Preliminary estimates indicated the total unit cost of yield for Colusa is approximately double the unit cost of water yield of Sites.

Although feasibility level determination of these project's costs requires further evaluation, comparable historic cost estimates updated to the present confirms the findings of earlier work. Supporting information and additional factors relevant to a comparison of the Sites and Colusa projects are listed below:

- Assuming a basic formulation for source and conveyance – where the preferred conveyance includes a new canal from Colusa Basin Drain and existing GCID and Tehama-Colusa canals, with the expanded Banks Pumping Plant—the unit cost of the Colusa Project would be approximately double that of Sites and the average annual water yield would only increase by around 30 percent.
- The Colusa Reservoir inundation area would approximately double the inundation area of Sites. If the associated environmental impacts and mitigation costs also double, then a 100 percent increase in impacts would again be associated with a 30 percent increase in yield as compared to Sites.
- The additional dams required to form Colusa Reservoir are extremely long and located in an area with less sandstone than at the Sites and Golden Gate dam sites. This will increase the haul distance for sandstone to Colusa in comparison with Sites by as many as ten miles. Sandstone, in large volumes, is required for dam shell and slope protection material.
- The foundation geology of the Colusa Project dam sites in comparison to the Sites Project dam sites is generally weaker, more deeply weathered, fractured, and permeable. Colusa dam sites will require more corrective actions to the foundations such as additional overburden stripping and grouting, which will increase the cost of construction.
- Reservoir evaporation at Colusa would be approximately double that at Sites. The estimated average annual evaporation from Colusa Reservoir would be around 90 taf. This is water that must be pumped into the reservoir, but is not available for water supply or power recovery purposes when reservoir releases are made during the irrigation season.

Thomes-Newville Project

The Thomes-Newville Project would include a 1.9 to 3.0 maf offstream reservoir located on North Fork Stony Creek. It is about 18 miles west of Orland and 6 miles upstream of existing Black Butte Lake. The water supply for this project could come from Stony Creek, Thomes Creek, and the Sacramento River. The Thomes-Newville Project received extensive study by DWR from 1976 through 1982 and a major DWR document titled *Thomes-Newville and Glenn Reservoir Plans: Engineering Feasibility* reported on this work. The long and interesting history of water project planning in the Stony and Thomes Creek basins is summarized in an appendix of this report. The current Offstream Storage Investigation is using this past work as a basis, but is incorporating substantial changes in water project planning criteria that have occurred since then. Because of the large amount of past engineering studies at this site and our concentration to date with investigation of the Sites and Colusa Projects, most Thomes-Newville Project information presented here is based on historic work.

The basic components of the Thomes-Newville Project are: (1) a 300-foot to 400-foot Newville Dam at the historic Newville Townsite; (2) an 80-foot to 180-foot high saddle dam at Burrows Gap; (3) a southern saddle dam at Chrome for normal water surface elevations exceeding 920 feet; (4) a pumped diversion and conveyance system from Black Butte Lake; 5) a small diversion dam and gravity diversion from Thomes Creek; and 6) a pumped diversion and conveyance system from the Tehama-Colusa and/or Glenn-Colusa Canals if needed for larger reservoir sizes.

More stringent fishery requirements will likely be applied on Thomes Creek, which may require a fish passage at the diversion location. In view of Thomes Creek's heavy sediment load, construction and operation of these structures may be difficult and expensive. Future study would address these issues in greater detail if required.

In addition, several low saddle dams may need to be constructed along Rocky Ridge, the eastern boundary of the reservoir, depending on the selected reservoir elevation. The roads through the reservoir inundation area to Paskenta, Round Valley, and Elk Creek would be rerouted around the eastern and northern boundary of the reservoir.

Topographically, Newville Reservoir is very efficient. It requires a relatively small volume of dam embankment material per unit of water stored. Also, the reservoir bottom is relatively wide, long, and flat so that the reservoir area only increases around 20 percent (14,000 to 17,000 acres) between the capacities of 1.8 and 3.0 maf. In comparison, the Colusa Project at 3 maf capacity occupies 28,000 acres, or 65 percent more area.

The main challenges of the Thomes-Newville Project are providing an adequate water supply from nearby streams and mitigating for environmental impacts which have not all been evaluated yet.

Alternative Reservoir Capacities

The most recent (1980) DWR report on the Thomes-Newville Project examined three sizes: 1.4 maf at normal water surface elevation of 868 feet; 1.7 maf at 887 feet; and 1.9 maf at 905 feet. For the CALFED Offstream Storage Investigation, a reservoir size up to 3 maf is also included. This larger reservoir size analysis is based on studies performed by DWR around 1966. A 3.0 maf Newville Reservoir would be created at a normal water surface elevation of 980 feet. These older studies will be updated and modified in the future along with feasibility-level engineering analysis at the Sites Project.

The primary sources of water for a Thomes-Newville Project up to 2 maf capacity are Stony Creek at Black Butte Lake, and Thomes Creek above Paskenta. For a reservoir size above 2 maf or if fishery-related facilities are too costly for the Thomes Creek diversion, additional water from the Sacramento River would be needed to fill the reservoir in a reasonable period (less than 10 years).

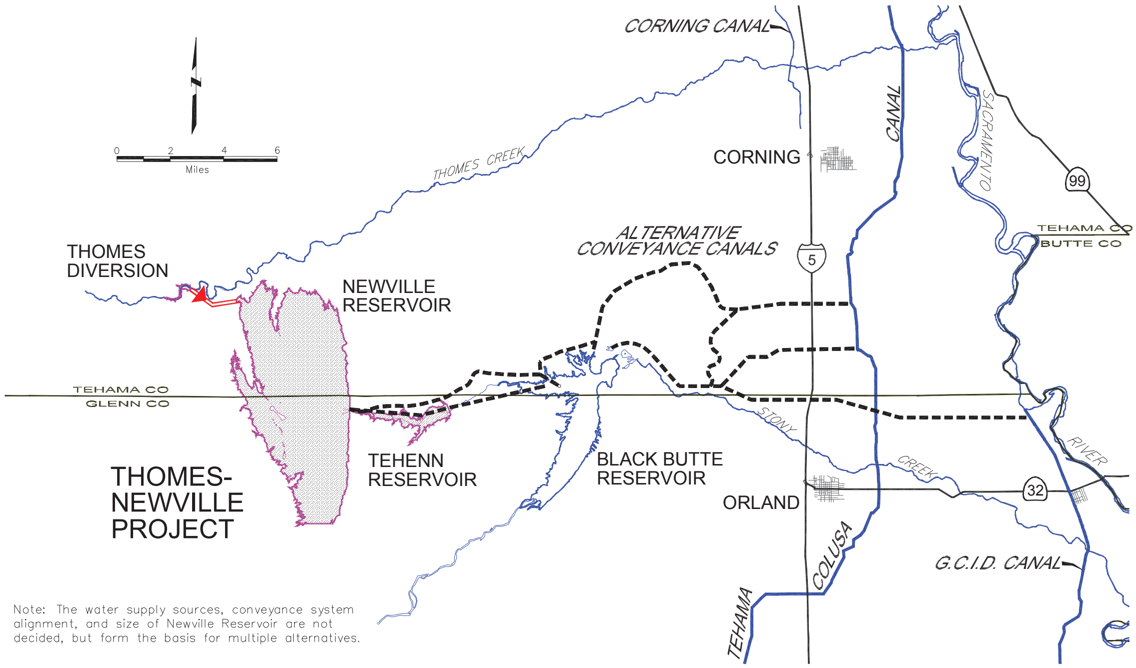
Diversions from Stony and Thomes Creeks for reservoir sizes less than 2 maf are evaluated in the 1980 Engineering Feasibility Report. Stony Creek water from Black Butte Lake would be conveyed westward via an excavated deepening of the channel of North Fork Stony Creek and pumped into a small reservoir named Tehenn. This small dam and reservoir was planned for location on the north fork about midway between Black Butte Lake and Newville Dam site. A small dam 112 feet high and 2,500 feet long would form the 32,500 af Tehenn Reservoir at elevation 610 feet. Because this reservoir would flood a cemetery of historic importance, future studies will evaluate other conveyance alternatives.

Three potential diversion dam locations on Thomes Creek to convey water through the low divide to Newville Reservoir were investigated in studies around 1980. Because the lower sites required taller dams and flooded more land area critical to migratory deer herds, the upper dam was considered most desirable. In addition to typically lower costs, a low dam is more favorable to migrating fish. Therefore, the dam site farthest upstream is still the favored alternative for a Thomes Creek diversion. Further investigation will determine whether a ladder and screen would be required for fish. The economic and environmental feasibility of these facilities has not been determined. After diversion, the Thomes Creek water (minus required instream flows) would be conveyed to Newville Reservoir via a 2-1/2 mile canal.

If additional water is needed due to larger reservoir sizes or an inability to divert water from Thomes Creek, it could be obtained from the Sacramento River by diverting from Tehama-Colusa and/or Glenn-Colusa Canals. This water could be conveyed via new facilities shown on Figure 3-2. Lift pumps would be required. Several alternative conveyance system alignments have been investigated at an initial level and the results are contained in the report titled *Sites Reservoir Conveyance Study*. Considerable additional design and cost estimating work needs to be done on the Thomes-Newville Project facilities.

Optional sources of water supply for the Thomes-Newville Project are similar to those for Sites and Colusa. Local sources potentially have a more significant role for Thomes-Newville. In the original project formulations, water from the Sacramento River is included in all of the Sites and Colusa alternatives. For Thomes-Newville, Sacramento River water would be imported only if water from Stony and Thomes Creeks is not feasible or adequate to fill the reservoir. The streamflow volumes and divertible flows associated these streams are shown in Tables 3-3 and 3-4.

Figure 3-2. Thomes-Newville Project Alternatives



Operation Studies

Four operation studies have been run for the Thomes-Newville Project: two at the 1.9 maf size and two at the 3.0 maf size as shown on Table 3-7. The average annual yield of these projects for the 1922 through 1994 period ranges from 213 taf to 275 taf for the 1.9 maf size, and 248 taf to 315 taf for the 3.0 maf size. These yield estimates are based on project formulations that include 5,000 cfs conveyance from Thomes Creek and 3,000 cfs conveyance from Black Butte Lake. The larger yields are for adding 2,200 cfs conveyance associated with Tehama-Colusa Canal diversion to Black Butte and increased diversion to Newville Reservoir. Drought year yields are generally less for the alternatives that only include the local sources and greater when the Sacramento River is included as a source. More operation studies will have to be run in the future as project sizing and conveyance features become more defined. For the present, these operation studies indicate that the Thomes-Newville Project has roughly the same new water supply capability as comparable sizes of the Sites and Colusa Projects.

Operation of the Thomes-Newville Project would be similar to that of Sites and Colusa, in that winter water surplus to needs and rights in the watershed would be diverted and stored for release mainly during the irrigation season. The water released would be used entirely within the Colusa Basin in exchange for Sacramento River water that would otherwise have been diverted to serve this area. This undiverted river water would remain as storage in Shasta Lake until it is released on a different schedule designed to serve a combination of urban, environmental, and agricultural purposes.

Recreation Opportunities

Major recreational attributes of Newville Reservoir would include a large water surface that would be desirable for large motorboats, sailboats, and houseboats. The west shore islands would attract boat anglers and boat-in campers and would provide ideal houseboat anchorage. A hiking and riding trail would follow the crest of Rocky Ridge along the eastern shore of the reservoir and offer attractive vistas and secluded fishing spots. Boat-in, hike-in, or ride-in camps on the west shore could provide access to the reservoir or the backcountry of the Mendocino National Forest.

Fourteen recreation sites were identified around the reservoir that could accommodate up to 13 boat ramp lanes, 150 to 200 picnic sites, more than 100 camp sites, more than 1 mile of beach, and 5 to 10 miles of trail. If these areas are developed, they could support 500,000 to 1,000,000 recreation days annually, a typical level of use for this size project.

Red Bank Project

The Red Bank Project would be located on the South Fork of Cottonwood Creek and on Red Bank Creek approximately 17 miles west of Red Bluff. Two main dams—Dippingvat on Cottonwood Creek and Schoenfield on Red Bank Creek—and two smaller dams—Lanyan and Bluedoor on small tributaries of Red Bank Creek—would form this project. The smaller dams facilitate conveyance of water from Cottonwood Creek to Schoenfield Reservoir.

With a total storage of about 350 taf, the Red Bank Project is by far the smallest of four alternatives evaluated. Its main potential benefit is its ability to supply water directly to the entrance to the Tehama-Colusa Canal instead of diverting this water from the Sacramento River. This operational feature could allow the Red Bluff Diversion Dam gates to be raised for a longer period; thus reducing the dam's impact on the fishery.

The Red Bank Project was investigated by DWR in the late 1980s through the early 1990s and is documented in several DWR reports. The Red Bank Project is not a typical offstream storage project because one of the two major dams blocks access to approximately 132 square miles of South Fork Cottonwood Creek watershed which contains anadromous fishery habitat. Also, the estimated cost of the project steadily increased as the study progressed and the water supply decreased as downstream fishery flow needs were identified.

DWR recently investigated the possibility of lowering and modifying Dippingvat Dam to allow fish passage around it, but this cursory evaluation indicated that the required actions would increase costs and decrease yield without ensuring unhindered fish passage. Even though the size and cost of Dippingvat Dam would be reduced, savings would likely be more than offset by greater conveyance system costs, fish ladder and screen construction costs, and the large reduction in reservoir capacity which also reduced flood control and water supply benefits.

Because the Red Bank Project was intensively studied around 1993 and because of its small size, and potential for adverse fishery impacts, little additional engineering work on this project has been conducted. At this point, it seems likely that CALFED may defer additional work on this project in favor of emphasis on the Sites and Thomes-Newville Projects. However, an inventory of environmental resources is being completed which will help determine the environmental feasibility of this project.

Alternative Sources of Water

Unlike the other three alternative projects, the Red Bank Project's only sources of water are the watersheds above the two main dams. More than 70 percent of its 135 taf/yr average annual water supply comes from South Fork Cottonwood Creek, and the remainder comes from Red Bank Creek. In contrast, Schoenfield Reservoir on Red Bank Creek would provide around 70 percent of the reservoir storage. South Fork Cottonwood Creek provides the main water supply and Red Bank Creek provides the main storage area. No water would be conveyed from any other sources.

Operation Studies

Operation studies for the Red Bank Project run in 1993 were considered sufficient for this phase of investigation. These studies were for a stand-alone project that was not dependent on other existing water supply projects, as the previously described CALSIM studies are. A coordinated study should be performed at a later date if the project survives screening analysis. Instream fishery flow needs in South Fork Cottonwood Creek are estimated to range from 30 cfs in the summer to 60 cfs in the winter with a couple of 120 cfs flushing flows of eight days duration each. These flow needs were incorporated into the 1993 study. A 70 taf flood control reservation in Dippingvat Reservoir was also included. The firm new water supply for an agricultural demand schedule estimated by this operation study is 43 taf/yr. This yield estimate could change considerably if different assumptions were made concerning fish releases, flood control reservation, water demand schedule, or other project criteria. No water from this project would be released directly to the Sacramento River because of concerns over the potential impacts of its warm summer temperature.

One significant issue that past studies have not addressed is percolation to groundwater along 16 miles of Red Bank Creek of water released from Schoenfield Reservoir. This percolation loss could be substantial and should be addressed if study of the Red Bank Project continues.

Recreation Opportunities

The recreation potential at Schoenfield Reservoir is much greater than at Dippingvat due to the flatter terrain around the reservoir and the less severe drawdowns required for flood control. Schoenfield Reservoir could be developed for fishing, camping, picnicking, boating, hiking, and hunting. Earlier estimates indicated that the entire Red Bank Project has the potential to support an average of around 100,000 recreation user days annually.

Offstream Storage Project Formulation

Project formulation is a critical component of surface water storage investigations. The objective of project formulation is to 1) select a project which will have the least environmental impacts, and 2) optimize project benefits by selecting the most feasible location, size, and configuration for the various project features such as storage, conveyance, and diversion structures. Many combinations of these separate facilities are possible, but the cost effectiveness of different configurations varies widely.

At its heart, the project formulation process is technically rigorous and requires the analysis of numerous options. However, in practice the complexity of the process is reduced by making simplifying assumptions and developing reasonable criteria, and by the limitation of practical realities. Some of these potentially limiting factors include environmental considerations, hydrology and water supply availability, water demand projections, projected energy demands and costs, and the level of development in and around the project. Evaluating these and other factors requires as much art (subjective analysis) as science and, therefore, the process may rely heavily on historic project operations and experiences. For example, many reservoirs have different operating rules applied to them over their life. The trend today is to operate most major water projects as a unit in order to maximize total combined water supply benefits, whereas most projects were planned using a stand-alone operating strategy. This tendency for water management operations to change over time is considered beneficial and is known as adaptive management. It is a strong motivator for building maximum flexibility into current project formulations. Current project formulation studies attempt to combine engineering possibilities with cost and financial considerations, biological impacts (environmental), and public acceptability.

The first step in project formulation is to identify reservoir site alternatives, water supply sources, and possible conveyance facilities. Alternatives that are not practicable or are environmentally harmful are then screened out. The next step of the project formulation is to perform a series of initial project operation studies for remaining alternatives. These operation studies estimate the relative level of water supply, or yield of various sized reservoirs, water conveyance systems, and water supply sources for various project alternatives. After feasibility-level cost estimates are made, formulation studies combining various sizes of reservoirs and water supply systems will be made. Also, opportunities for maximizing power revenues will be explored in greater detail. Increasingly refined project formulation studies will continue to be performed throughout the entire duration of these studies.

At this point in the study, the project formulation analysis has just begun and much work remains to be done on two levels. First the project formulation of alternatives must be refined concurrently until a preferred alternative is selected. Then the preferred alternative must be evaluated at a higher level to optimize reservoir storage and conveyance capacities to reduce the cost per acre-foot of water as much as possible. This requires that additional iterative operation studies be run to test each revised project formulation to determine its yield for comparison to the reformulated project cost. This process continues throughout the entire study period until the final feasibility-level report on the preferred project is finalized.

Chapter 4. Geology and Geotechnical Studies

Regional Geology

The four proposed projects are in the western foothills along the edge of the Sacramento Valley. The rocks underlying the dam sites are part of the Great Valley geomorphic province and are comprised of mostly sandstone, mudstone, and conglomerate. The Great Valley geomorphic province is bounded to the west by the Coast Ranges province, to the north by the Klamath Mountains province, to the northeast by the Cascade Range province, and to the east by the Sierra Nevada province.

Along the west side of the Sacramento Valley, rocks of the Great Valley province include Upper Jurassic to Cretaceous marine sedimentary rocks of the Great Valley Sequence, fluvial deposits of the Tertiary Tehama Formation, Quaternary Red Bluff Formation, Quaternary terrace deposits, Recent alluvium, and colluvium.

Rocks of the Great Valley Sequence form a series of northwest-trending, east-dipping ridges of sandstone and conglomerate separated by valleys underlain by siltstone and mudstone. Notches in the sandstone and conglomerate ridges, called water gaps, were formed by seasonal creeks. The dam sites for all four proposed projects would be founded on the ridges at these water gaps.

Fresh mudstones of the GVS are typically dark gray to black, but weathered mudstones are mostly light brown. In general, the mudstones are thinly laminated and have closely spaced and pervasive joints. When fresh, the mudstones are hard and moderately strong. Exposed units are fragile, weak, and weather and slake readily. Mudstones generally underlay the valleys because of the rocks' susceptibility to weathering and erosion.

Fresh sandstones are light green to gray; weathered sandstones are tan to brown. Sandstone beds range from thinly laminated to massive. The sandstones are often interlayered with beds of conglomerates, siltstones, and mudstones. Massive sandstones are indurated, strong and hard, with widely-spaced joints, and form the backbone of most of the ridges.

The conglomerates are closely associated with the massive sandstones and consist of lenticular and discontinuous beds varying in thickness from a few feet to more than 100 feet. Conglomerate clasts range in size from pebbles to boulders and are composed primarily of chert, volcanic rocks, granitic rocks, and sandstones set in a matrix of cemented sand and clay. The conglomerates are similar to the sandstones in hardness and jointing.

Tertiary and Quaternary fluvial sedimentary deposits unconformably overlie the GVS. The Pliocene Tehama Formation is the oldest. It is derived from erosion of the Coast Ranges and Klamath Mountains and consists of pale green to tan, semi-consolidated silt, clay, sand, and gravel. The Nomlaki tuff member occurs near the bottom of the Tehama Formation and has been age-dated at about 3.3 million years. The Nomlaki is a slightly pink to gray pumice deposit forming a single massive bed about 30 feet thick. Along the western margin of the valley, the Tehama Formation is generally thin, discontinuous, and deeply weathered.

The Quaternary Red Bluff Formation consists of reddish, poorly sorted gravel with thin interbeds of reddish clay. The Red Bluff Formation is a broad relatively flat deposit that covered much of the Tehama Formation between 0.45 and 1.0 million years ago. Thickness varies up to about 30 feet. The surface of the Red Bluff Formation is an excellent datum to assess Pleistocene deformation because of its original widespread occurrence and low relief. Red Bluff Formation outcrops occur just northeast of the dam sites.

Terrace deposits form flat benches adjacent to and above the active stream channels. Nine different stream terrace levels have been identified. Terrace deposits consist of several to 10 feet of clay, silt, and sand overlying a basal layer of coarser alluvium containing sand, gravel, cobbles, and boulders. Four terrace levels have been given formational names by the U.S. Geological Survey (Helley and Harwood 1985): the Upper Modesto, Lower Modesto, Upper Riverbank, and Lower Riverbank. These levels range in age from 10,000 to several hundred thousand years old. Terrace deposits may be suitable for the impervious core and random fill for the embankment of the proposed dams.

Terrace deposits are also valuable for evaluating the age and activity of faults that trend across them. A number of investigators have applied different types of age dating techniques, together with geomorphic analysis, to date and correlate terrace deposits. Lack of evidence of faulting across the terrace deposits constrains the time of last movement.

Recent alluvium is a loose sedimentary deposit of clay, silt, sand, gravel, and boulders. These include both stream channel and floodplain deposits. Stream channel deposits generally consist of sand and gravel and may be useful as construction material for concrete aggregate, filters, and drains. Floodplain deposits are finer grained and consist of clay and silt. Floodplain deposits may be used for the impervious core of a dam and for random fill.

Colluvium, or slope wash, occurs at the face and base of a hill and consists mostly of soil and rock. Landslide deposits are similar, but are more defined and generally deeper. Landslides often occur along a reservoir rim, but are generally small, shallow debris slides or debris flows. Landslide deposits may be incorporated as random fill in dam construction.

Faulting and Seismicity

Recent work by numerous researchers indicates that an active tectonic boundary between the Sierra Nevadan basement and the Coast Ranges lies buried beneath the entire western edge of the Great Central Valley from Bakersfield to Red Bluff. This system of faults is generally referred to as the Great Valley thrust fault system or the Great Valley fault. The boundary is not a line but a complex geologic region, and the exact location of this fault in the study area is not known.

Activity along this complex zone is characterized by a number of types of faulting, and is considered to be the source of the two 1892 Winters-Vacaville earthquakes (Magnitude 6-7), the 1983 Coalinga earthquake (Magnitude 6.7), and the 1985 Kettleman Hills events (Magnitude 5.5 or 6.1). Many small to moderate earthquakes have also occurred along the full length of the boundary.

These include a Magnitude 5.8 in 1866, a Magnitude 5.9 in 1881 west of Modesto, and a Magnitude 6.0 in 1889 near Antioch. The deeper faulting manifests itself on the surface as low hills on the west side of the valley like those near Corning and the Dunnigan Hills.

Since no definitive surface faulting exists, the analysis of microseismic data becomes an important tool to define the extent of the fault and its seismic potential. Wong et al. (1988) believes that a Magnitude 7 earthquake could possibly occur anywhere along the boundary.

The Working Group on Northern California Earthquake Potential and other workers have divided the Great Valley fault into a number of segments that act independently of each other. The segments of interest to this study are designated by the working group as GV01, with the source near the Salt Lake fault and Sites anticline, and GV02 outside the project area to the south, centered on the Cortina thrust. GV01 has been assigned a magnitude of 6.7 with a recurrence interval of 8,300 years and a slip rate of 0.1 mm per year (USGS 1996).

In the Phase I Fault and Seismic Hazards Investigation (Appendix O), DWR concluded that the design earthquake was a maximum credible earthquake of Magnitude 7.0 occurring directly under the Sites, Golden Gate, Hunters, Logan, or Newville Dam sites at a depth of about 6 miles on the Great Valley fault. This earthquake would have a duration of about 26 seconds, a peak horizontal acceleration of 0.7 gravity, and a predominant period of 0.32 seconds. This is assumed to be a conservative estimate. DWR's fault and seismic consultant, William Lettis and Associates, also considers this conservative, with a Magnitude 6.5 to 6.75 more likely.

Earth Sciences Associates (1980) concluded that all the faults near the Thomes-Newville Project's principal engineering structures are pre-Quaternary in age (over 1 million years old) and surface offsets need not be considered in project feasibility studies. DWR will revisit this conclusion during the Phase II Fault and Seismic Investigation.

The Salt Lake fault and the associated Sites anticline and adjacent Fruto syncline extend from near Sites about 40 miles north to near Newville. The anticline is a tight fold with steeply dipping and locally overturned strata on both limbs. Based on analysis of seismic reflection data, William Lettis and Associates (1997) interprets the anticline as a fault-propagation fold developed above one or more blind thrust faults. The faults are truncated by a sub-horizontal detachment at a depth of about 3 miles.

The Salt Lake fault is a high-angle thrust fault that developed adjacent to the axis of the doubly plunging Sites anticline (DWR 1978). Salt water springs and gas seeps along the fault trace are suggestive of recent fault activity. In several locations, however, the fault is concealed by unbroken Pliocene Tehama Formation suggesting that the latest movement occurred over one million years ago.

Based on the work done by the consultant and the Working Group on earthquake potential, it is probable that the Salt Lake fault, the Sites anticline, and the Fruto syncline are features related to the Great Valley fault. The fault trends within 1 mile of most of the Thomes-Newville and Colusa project dam sites, and possibly crosses the upstream edge of the Sites dam site. The Sites anticline (Kirby 1943) and the Fruto syncline (Chuber 1961) are flexures extending in the northwest direction from the general area of Sites possibly as far north as Newville. Table 4-1 shows the preliminary seismic design parameters, except for the Gorda plate at Newville, which has not yet been evaluated.

Table 4-1. Draft Preliminary Seismic Design Parameters for the Proposed Projects

Project	Maximum Credible Earthquake Magnitude	Distance (km)	Depth (km)	Peak Acceleration (g)	Duration (seconds)	Period (seconds)
Sites and Colusa	7.0	0	10	0.70	26	0.32
Thomes-Newville	7.0	0	10	0.70	26	0.32
Red Bank	8.3	0	35	0.72	28.5	0.42

Note: Preliminary design parameters subject to change as new information becomes available.

William Lettis and Associates is currently working on the Phase II investigation, which includes trenching and detailed seismic analysis of the dam sites. Their results are preliminary and incomplete at this time. They have found that the faults are typically expressed within bedrock as well-defined, narrow (2 to 5 feet wide) zones of moderately to highly fractured rock with less than 1 to 2 feet of fault gouge.

The Quaternary stream, terrace, and slope deposits provide preliminary constraints on the activity of these faults. Detailed soil profiles in the trenches suggest that deposits within all trenches are roughly correlative and probably early Holocene to latest Pleistocene in age, or 8,000 to 15,000 years old (WLA 2000). No surface rupturing events have occurred on these faults during this time. Geologists continue to look for deposits that have been disturbed by faulting. This will help determine the actual age of the most recent fault movement.

Sites Project

Both DWR and the U.S. Bureau of Reclamation have conducted geologic studies for Golden Gate and Sites Dam sites. Geologic data gathered to date suggest that the foundations are adequate for the proposed structures. The majority of the construction material is readily available locally, but riprap, filter, transition, and concrete aggregate may have to be imported from distances up to 50 miles.

Golden Gate Dam Site Geotechnical Studies and Findings

Currently, there are three axial alignments for Golden Gate Dam being considered. These are the upstream straight alignment, the downstream curved alignment, and the downstream straight alignment. Only the downstream straight alignment has been investigated as part of this study to date.

Bedrock

The Golden Gate Dam site consists of northwest trending and moderately to steeply northeast dipping interbedded sandstone and mudstone of the Boxer and Cortina formations. The overall composition is about 65 percent sandstone and 35 percent mudstone.

Rock Strength

DWR (Appendix Q) has measured compressive strengths of foundation rocks. Compressive strengths of the sandstone and conglomerate generally range from 9,000 to 12,000 pounds per square inch. The mudstone generally varies from 3,000 to 6,000 psi. However, these samples are not fractured or jointed. Overall strength of the foundation rock will vary depending on the amount of jointing, fracturing, and faulting. For comparison purposes, general purpose concrete has compressive strengths from 3,000 to 5,000 psi.

Surficial Deposits

Quaternary to Recent deposits include colluvium, alluvium, landslide, and terrace. Stream gravel deposits are minor and range in thickness to about 5 feet. Colluvium typically ranges from 5 feet to about 15 feet at the base of slopes. Two minor landslides have been identified, a small recent slide on the right abutment and a larger and older slide deposit on the left abutment. Terrace deposits are the most extensive, mostly Upper Modesto and possibly Lower Riverbank Formations. These average 15 to 20 feet thick, but may reach a thickness in excess of 25 feet. The composition is variable, but generally consists of an upper layer of silt and soil, and a thin lower layer of clayey gravel and cobbles.

Structure

Two faults, GG-1 and GG-2, traverse through the foundations of the proposed axes. Faults GG-1 and GG-2 were mapped by Brown and Rich (1961). GG-2 extends from the right abutment, crosses the channel slightly downstream of the axis, crosses the left abutment, and then extends an additional 2 miles in a northeast direction before it terminates or cannot be traced in the mudstones to the east. Apparent right lateral displacement is estimated to be in the range of 600 to 1,200 feet. Fault GG-1 is shorter and extends across the left abutment of the upstream dam axis, then trends northeast and misses the left abutment of the downstream dam axis. Apparent right lateral displacement is estimated to be about 50 feet.

GG-3, which does not trend through any of the proposed foundations, was also mapped by Brown and Rich (1961). It is parallel to GG-2 but about 4,000 feet further to the south. William Lettis and Associates, the Phase II Fault and Seismic contractor, excavated trenches across all three faults. Their preliminary findings indicate no evidence of faulting within the surficial deposits.

The Salt Lake fault is less than 1 mile to the west. Although the fault is considered potentially active at this time, it does not cross any of the proposed dam foundations. The fault may be one of several expressions of the deep-seated Great Valley fault.

Exploration

USBR drilled and water pressure tested three diamond core drill holes at the upstream straight axial alignment and one hole at the proposed powerhouse location. DWR drilled an additional four diamond core holes and three auger holes near the downstream straight alignment foundation. Three of the core holes were drilled downstream of the axis and the fourth was an angle hole drilled near the channel and oriented to intercept fault GG-2. Seven seismic refraction lines were surveyed at the dam site and outlet structure, totaling 1,000 feet in length. William Lettis and Associates excavated three trenches across fault GG-1, three trenches across GG-2, and two trenches and three test pits across GG-3.

At the proposed Golden Gate inlet and outlet facilities, DWR drilled five holes. Two diamond core holes were drilled along the tunnel alignment; two holes along alternative spillway alignments; and one hole at the pumping plant.

Three shallow (up to 34 feet deep) auger holes were drilled along the proposed canal from Funks Reservoir to the pumping plant. In addition, eight holes were augered to facilitate trench locations for the regional fault investigations.

Permeability and Grouting Requirements

Preliminary analysis of the water pressure test data indicates that grout takes should be mostly low to moderate, with some areas of high take. Abutment holes at the Golden Gate Dam site have permeabilities averaging 0.26 feet per day, with higher values and grouting requirements on the right abutment. Channel hole permeabilities are lower, averaging 0.15 feet per day.

Foundation Preparation, Clearing, and Stripping

Both abutments and the channel are covered by grass with no brush or trees and require no clearing. About 20 feet of alluvium and terrace deposits in the channel should be easily stripped using common methods. Up to 20 feet of moderately weathered bedrock may require some blasting and removal by common methods.

About 5 feet of soil, colluvium, and intensely weathered bedrock on both abutments may be stripped using common methods. Another 5 to 20 feet of moderately weathered bedrock may require blasting for abutment shaping and then material removal.

Construction Materials

More information about construction materials required for Golden Gate Dam can be found in Appendix P. Impervious core material is available from terrace deposits within 1 mile of the dam site, in the reservoir inundation area. Excavation for the spillway, powerhouse, tunnel, and canal will provide much of the required random and rock fill. Additional material is available directly upstream or downstream, depending on which dam alignment is selected. Concrete aggregate, riprap, and filter material sources are the same as for Sites.

Sites Dam Site Geotechnical Studies and Findings

The dam alignments proposed by DWR and USBR for Sites Dam are basically the same. The major design difference is that the DWR embankment crest elevation would be higher.

Bedrock

The Sites Dam foundation consists of northeast-dipping interbedded sandstones and mudstones of the Upper Cretaceous Boxer and Cortina Formations. The Sites Dam site area consists of about 50 percent sandstone and 50 percent mudstone, mostly interlayered, with beds typically ranging from less than 1 inch to tens of feet.

Surficial Deposits

Quaternary to Recent deposits include colluvium, alluvium, terrace deposits, and landslide deposits. Minor alluvium consisting mostly of sand, gravel, and some slabs of sandstone occurs in the stream channel. Terrace deposits are the most abundant, occurring both upstream and downstream of the dam axis. The terrace deposits typically range in depth from 15 to 30 feet and consist mostly of silt, sand, and clay. Colluvium averages about 5 feet on the abutments but may reach depths of 15 feet at the base of slopes. Several small landslides occur on the left abutment and a larger slide occurs on the right abutment. This landslide deposit is probably about 30 feet thick at the base but thinner at the top. It is approximately 200 feet high and 75 feet wide at the base.

Structure

Possible faults at the Sites Dam site include Lineament S-1 and Fault S-2. S-2 was mapped by Brown and Rich (1961) and extends from near the vicinity of the town of Sites. Then it trends northeast through the right abutment, crosses the channel near the downstream toe and extends downstream of the left abutment beyond the footprint of the dam. The fault is about 5 miles long and has a right lateral displacement of about 100 feet. S-2 was trenched fall 1999. The trenches showed no disturbance in the overlying alluvial deposits. The age of the alluvial deposits is presently uncertain, but is believed to be 8,000 to 15,000 years old.

Lineament S-1 was not mapped by Brown and Rich (1961) or by USBR (1969). This lineament, or suspected fault, may trend from the left abutment, then across the channel near the axis, and through the right abutment. Drill hole LC-3 intersected gouge and fractured rock apparently associated with a fault. There is a possibility that the lineament is a southward extension of the Salt Lake fault, which is shown by Brown and Rich (1961) to terminate about 2 miles north of the dam site. This lineament will be considered further in the Phase II field investigation.

Bedding of the bedrock units generally trend northerly and dip 50 to 70 degrees to the east. Joints generally trend parallel and perpendicular to the bedding. Both joint sets are of concern on the abutments because of a tendency for the joints parallel to the creek to be open within the ridge. This condition may require some abutment shaping and more grouting.

Exploration

USBR investigated Sites Dam site in the 1960s and 1980s and drilled three diamond core holes in the foundation. DWR has recently completed mapping, trenching, augering, diamond core drilling, and geophysical surveys. Four holes totaling 740 feet were drilled during the summer of 1998. Two holes, LC-1 and LC-3, were diamond core drilled in the channel downstream of the dam footprint to intercept Fault S-2. Two additional holes, LC-2 and LC-4, were drilled to intercept Lineament S-1. Two of the four holes were water pressure tested. Three auger holes, totaling 41 feet, were drilled to estimate overburden and depth to bedrock. William Lettis and Associates excavated three trenches across Fault S-2, several miles northeast of the dam site.

Permeability and Grouting Requirements

Preliminary analysis of water pressure test data indicates that grout takes should be mostly low to moderate, with some high. The average permeability of the four channel holes is a relatively low 0.15 feet per day. USBR drilled the abutments in 1979 and 1980. Review of this data shows that the left abutment has an average permeability of 0.54 feet per day. The right abutment has a higher average permeability of 1.29 feet per day, possibly due to the S-2 fault crossing the right abutment.

Foundation Preparation

The channel section has a sparsely vegetated riparian zone with scattered fig trees, willows, cottonwoods, and other trees. Vegetation is mostly grass with a few blue oaks on the left abutment. The right abutment is mostly blue oaks and grass. The tree density is higher on the right abutment because of the north-facing slopes and the colluvial and landslide deposits near the base of slopes.

The 15 feet of alluvium and terrace deposits in the channel area can be removed by common methods. An additional 3 to 10 feet of weathered bedrock may need to be blasted and removed. Soil, loose boulders, and weathered bedrock may be removed by common methods on the abutments to depths ranging from 1 to 10 feet. Landslides and colluvium at the base of the slopes probably range in thickness from a few feet up to 30 feet. These deposits must also be removed during foundation excavation. An additional 10 to 15 feet of weathered and fractured bedrock will probably have to be removed by common methods. Some blasting may be required to shape the abutments.

Construction Material

Construction materials for the proposed embankment dam include impervious fill for the core, random or rock fill for the shell with riprap at the surface, filter and drain material, and aggregate for concrete structures. Construction materials for Sites Dam are described in Appendix P.

The sources of the impervious core material are terraces along Antelope and Stone Corral Creeks. The field classification of this material is silty clay to clayey silt with a slight amount of gravel in the stream channel, and appears to be suitable for the impervious fill zone. In spring 1998, terrace samples were collected and analyzed at seven different locations where the terrace is exposed along Funks and Stone Corral Creeks. Fifteen test pits were excavated into the terrace deposits in the Sites Reservoir area. Generally, three samples were collected from each test pit for laboratory analysis.

One source of rockfill and random fill is the existing Sites quarry in the Venado sandstone downstream of the dam site. Material stripped from the foundation excavation can be used in this zone. Preliminary testing indicates that the crushed quarried rock would probably not be suitable for the filter and drain material because of low durability. During spring 1998, Bryte Laboratory analyzed ten 3-inch cube samples of the quarry rock. During March 1999, approximately 5 cubic yard samples of the weathered and fresh sandstone were crushed and taken to the Bryte Laboratory for further testing. During May 1999, ten rock cores each of the weathered and fresh sandstone from the Sites quarry were collected and analyzed.

A study has been initiated to identify replacement filter and drain material sources. Various sources will be evaluated to determine the most feasible source with the least environmental impacts. Possibilities include the commercial gravel pits near Willows and Orland, and Stony Creek upstream of Black Butte. Construction material investigations are continuing to better define these sources.

Crushed quarried sandstone also may not be suitable for use as concrete aggregate. The commercial gravel pits near Willows and Orland are possible sources for concrete aggregate. Quarried sandstone has been considered marginal for the use as rock riprap on the dam shell. Riprap is available on the east side of the Sacramento Valley near Deer Creek, a distance of about 70 miles.

Sites Reservoir Saddle Dam Sites, Geotechnical Studies and Findings

The proposed DWR Sites Reservoir saddle dam configuration and alignments follow the USBR proposal and consists of nine separate saddle dams (SSD-1 through SSD-9) for a reservoir elevation of 520 feet. The saddle dam sites have been mapped by USBR and DWR.

Bedrock

The Boxer Formation underlies the foundations. It consists mostly of mudstone with some interbedded sandstone and conglomerate. SSD-1 is underlain by mostly mudstone. SSD-2 is underlain by the Salt Lake fault, an 800-foot-wide zone of fractured, folded, and faulted Boxer mudstone with interbedded sandstone. The SSD-3 area is underlain by stream alluvium and colluvium in the channel area, and Boxer on the abutments. SSD-4, -5,-7,-8, and -9 are all underlain by Boxer mudstone with some interbedded sandstone. SSD-6 is underlain by conglomerate. The rock strengths of these units are described under the Sites Dam site description above. It is expected that the rock strength within the Salt Lake fault zone will be less.

Surficial Deposits

Surficial deposits consist of stream channel alluvium and terrace deposits, mostly at SSD-3. Colluvium covers the slopes and collects at the slope base at most of the dam sites.

Structure

The upturned Upper Cretaceous sedimentary rocks consist of north-south trending mudstone, sandstone, and conglomerate. The degree of dip and direction is variable because of deformation along the Salt Lake fault and the Sites anticline.

The Salt Lake fault trends north through the saddle dam alignment at SSD-2. The fault zone is locally about 800 feet wide, mostly consisting of folded and fractured mudstone. Numerous springs, gas seeps, and small mudflows mark the trace of the fault.

The Sites anticline trends normal to the saddle dams roughly parallel to and directly west of the Salt Lake fault. The anticline trends north from the town of Sites along Antelope Valley for about 24 miles. The folding is believed to be a result of movement on buried blind thrusts related to the Great Valley fault. The Fruto syncline is near the western part of the saddle dam alignment, where the beds dip at a shallow angle to the west and to the east.

Exploration

Only preliminary geologic mapping has been completed at the saddle dam sites. Additional evaluation, including subsurface geological exploration, is needed to investigate overall formation permeabilities. USBR drilled and water pressure-tested 13 diamond core drill holes along the saddle dam alignments, generally in the wind gap portions of the saddle dams. In 1999, DWR's Northern District drilled two angle holes at SSD-3 and one vertical hole at SSD-6.

Permeability

DWR has not conducted any water pressure testing to date. USBR conducted water pressure testing in most of their 13 shallow drill holes. The data shows that permeability is generally low to moderate.

Foundation Preparation

The saddle dam areas are covered by closely cropped non-native grasses and only minor clearing is required. Rough estimates range from several feet up to 25 feet of colluvial overburden in the channel that needs to be stripped and removed. An average stripping estimate for the saddle dam sites includes 11 feet of overburden and several feet of weathered bedrock. Grouting requirements have not been developed, but a preliminary review of USBR permeability data indicates that the amount of grouting needed will be minor.

Construction Materials

The saddle dams will be embankment-type structures, either earthfill or rockfill. The same sources as for Golden Gate Dam are available. Terrace deposits for the impervious core can be found within several miles of each of the saddle dams. The random fill or rockfill parts of the embankment may include material stripped from the foundation, quarried sandstone, and terrace deposits. The source of the rockfill would be the sandstone ridge north of Golden Gate Dam site.

Colusa Project

Sites Reservoir geology and geotechnical analyses are applicable for the Colusa Project, with the exception of the discussion related to the saddle dams. These are the only structures that will not be part of both projects. The following section will focus on the geology and geotechnical analyses related to the Colusa Cell.

Limited geologic data have been gathered at the Hunters and Logan Dam sites. At the present reconnaissance-level of study, the foundations appear suitable for the proposed structures. The Colusa saddle dams have not been investigated. No studies of fault activity have been conducted. Sources of impervious core construction materials are available in the reservoir area. Sources of filter, transition, rockfill, concrete aggregate, and riprap material have not been identified.

Hunters Dam Site Geotechnical Studies and Findings

The Hunters Dam site consists of a single dominant ridge along the entire alignment and is made up of four dam sections including the saddle CSD-2, Prohibition, Owens, and Hunters. The total crest length of the proposed dam exceeds 14,000 feet. The dam would mantle the ridge and cross three water gaps formed by the North, Middle, and South Forks of Hunters Creek.

Bedrock

Hunters Dam site foundation consists of northwest trending and moderately to steeply northeast dipping interbedded sandstones and mudstones of the Upper Cretaceous Boxer and Cortina Formations. In general, the bedrock units consist of 40 percent sandstone with 60 percent interbedded mudstone and some minor conglomerate.

Laboratory results from the drill holes at Middle Fork Hunters Creek water gap show a variation in rock compressive strength from less than 1,000 to over 17,000 psi. The results are shown in Appendix Q.

Surficial Deposits

Only limited preliminary mapping has been done at this dam site. Alluvial deposits occur in all three water gaps, consisting of stream channel deposits and terrace deposits. Alluvial deposits are less extensive than at Golden Gate Dam site. Several shallow mudflows and debris slides occur in the water gaps and along the ridge.

Structure

The sandstone, mudstone, and conglomerate strike approximately north-south and dip 55 to 75 degrees east. The Salt Lake fault and the Sites anticline, described previously, are less than 1 mile to the west.

Two northeast trending vertical faults cross the ridge, one just north of the south fork and one about a quarter mile north of the north fork. Estimated offsets are 75 to 100 feet; recent movement is not apparent. As the studies progress, these faults will be evaluated in more detail.

Water pressure data indicate mostly low to moderate grout takes with some high takes. This is caused by open joints both parallel and perpendicular to the bedding.

Exploration

Reconnaissance mapping at the dam site has been completed. Four diamond core holes were drilled and water pressure tested in the middle fork water gap. No subsurface exploration has occurred at the south or north fork water gaps.

Permeability

The abutment holes on the middle fork have higher permeabilities than the abutments at Golden Gate, averaging 0.63 feet per day. Weathering, jointing, and fracturing account for the higher permeabilities and associated high water takes during the drilling.

Foundation Preparation

The dam site is covered by closely cropped non-native grasses. A limited number of trees (2 to 10) grow in each water gap. Clearing requirements are minimal.

Rough estimates of stripping range from 5 to 10 feet of colluvial overburden on the abutments, and 10 to 20 feet of alluvium and terrace deposits in the channel. It is estimated that grouting requirements will be low in the channel areas, but moderate to high on the ridges and abutments.

Construction Materials

The geologic investigation of construction materials is described in Appendix P. Terrace deposits were mapped in the Hunters, Logan, and Minton Creeks and other unnamed drainages. The mapped area of the valley floors occupied by the deposit is 960 acres with an estimated volume of 15,550,000 cubic yards. The terrace deposits along the drainages in the Colusa Reservoir area are not as extensive as along Funks and Antelope Creeks. The field classification of the terrace material exposed in the incised stream channels is silty clay to clayey silt with some gravel.

The volume of impervious fill required for the Hunters and Logan Dams and the Colusa saddle dams is 13,200,000 cubic yards, or about 8,200 acre-feet. Some quality material may have to be imported from the Sites Reservoir area. Haul distances of 3 or more miles would be required to transport this material to the dam sites. Nearly all of the terrace deposits inside the reservoir footprint would be utilized. The deposits of intensely weathered Boxer Formation mudstones that occur in the area are another potential source of impervious fill material. Some of these deposits have been observed with thicknesses of 12 or more feet. As studies proceed, laboratory analyses of these deposits will be required.

A source for the random or rockfill material has not yet been identified. The required volume is approximately 60,000,000 cubic yards. This volume of Venado sandstone is not available within the reservoir footprint. The ridges of

Venado sandstone upon which the Hunters and Logan Dams are based are single ridges, not double ridges like the Golden Gate and Sites Dam sites. Using the analogy of a ridge quarry of 300 by 300 feet, a ridge over 3 miles long would be required to supply the required volume of material. Some of the rockfill may have to be brought in from the Golden Gate quarry and some may be available from spillway excavation.

Transition, drain, filter, and rock riprap construction material sources have not been identified but probably would be the same as for Sites and Golden Gate dam sites.

Logan Dam Site Geotechnical Studies and Findings

The dam site consists of a single dominant ridge along the entire alignment. The total length of the dam axis would be about 7,200 feet.

Bedrock

In general, the bedrock consists of tilted Upper Cretaceous sedimentary rocks made up of 45 percent sandstone and 55 percent interbedded silty mudstone with some conglomerate. The beds trend north-northwest and dip about 60 degrees to the east. The foundation consists of about 45 percent sandstone and 55 percent mudstone.

Surficial Deposits

Surficial deposits of stream channel alluvium and terrace deposits occur in the channel area. Landslide deposits and colluvium occur along the bases and sides of the ridge.

Structure

The conglomerate, sandstone, and mudstone strike north-south, and dip from 55 to 75 degrees to the east. Two tentative northeast-trending, vertical faults occur across the left abutment with estimated offsets of 50 to 75 feet; the occurrence or amount of recent movement has not been determined. The Logan Creek water gap does not exhibit evidence of faulting.

Exploration

Preliminary mapping has been completed at Logan Dam site, but no subsurface investigations have been performed.

Foundation Preparation

Closely cropped non-native grasses cover the dam site. A limited number of trees (less than 30) grow in the Logan Creek water gap. Clearing requirements are minimal. Rough stripping estimates range from 5 to 20 feet of colluvial overburden on the abutments, and up to 20 feet of alluvium and terrace deposits in the channel.

No drilling or water pressure testing has been done. Drilling at dam sites to the south suggests that similar values are likely at Logan Dam site and that the channel area will have low grouting requirements. The abutments may have moderate to high requirements. This is because open joints may be present on the ridges and abutments.

Construction Material

Construction materials available for Logan Dam site are the same as for Hunters Dam site.

Thomes-Newville Project

DWR and USBR have conducted geologic studies for the Thomes-Newville Project. Geologic data gathered to date suggest that the foundations are adequate for the proposed structures. The majority of the construction material is readily available locally, but riprap, filter, transition, and concrete aggregate may have to be imported from distances up to 50 miles.

Newville Dam Site Geotechnical Studies and Findings

USBR's "Paskenta-Newville Unit, Engineering Geology for Feasibility Estimates, Lower Trinity River Diversion, North Coast Project, California," was the first major work done at Newville Dam site. This was followed by DWR's work from 1978-1982. Most of DWR's work is documented in three reports:

1. "Thomes-Newville and Glenn Reservoir Plans Engineering Feasibility Report," November 1980
2. "Engineering Geology of the Newville Dam and Burrows Gap Saddle Dam Sites, Glenn County, California," December 1982
3. "Thomes-Newville Unit – The 1980-1982 Construction Materials Investigations," December 1982

Bedrock

Newville Dam would be founded on sandstone, mudstone, and conglomerate of the Jurassic to Cretaceous Stony Creek Formation and Cretaceous mudstones of the Lodoga Formation. Both of these formations are part of the Great Valley Sequence.

Rock Strength

The sandstone and conglomerate are massive and strong, but in places have open fractures near the ground surface. The conglomerates and sandstones have unconfined compressive strengths that range from 5,000 to 26,000 psi. The mudstone slakes readily when exposed, and ranges from weak to moderately strong and hard depending on freshness, bedding, and fracturing.

Surficial Deposits

Colluvium, stream channel deposits, and terrace deposits cover about 20 percent of the foundation area. Alluvial depths in the active stream channel average 5 feet and consist of silt, sand, and gravel. The colluvium consists of gravelly clay averaging about 5 feet thick. Terrace deposits occur upstream and downstream, and cover part of the foundation in the channel. These consist of 5 to 20 feet of sandy clay overlying 3 to 15 feet of silty, clayey sand and gravel.

Small areas of older terrace deposits occur near the lower portions of the abutments.

Structure

Conglomerate, sandstone, and mudstone beds strike north-south and dip 50-80 degrees to the east.

There are five faults crossing the foundation area. They are roughly parallel, striking N50E across the regional bedding. Mapping and drilling show that the faults dip steeply and offset bedrock units. The faults range in width from a few feet to over 40 feet and typically consist of highly fractured rock with seams of gouge. Some faults have been partially cemented with calcium carbonate.

Two sets of joints are prevalent. One set strikes northeast and dips near vertical; the second set strikes parallel (north-south) to the ridge and dips east or west at zero to 45 degrees. Joint spacing is widest in the conglomerate beds (2 to 7 feet) and somewhat more closely spaced in the sandstone (less than 1 to more than 5 feet). Joints in the mudstone are generally closely spaced.

Exploration

USBR mapped the dam site, drilled and water pressure tested 10 core holes, and drilled 12 bucket auger holes near the dam site to investigate construction materials. DWR drilled and water pressure tested 11 core holes and excavated 10 trenches to explore the foundation. DWR also ran 18 geophysical survey lines to explore the subsurface.

Permeability

The foundation rocks are mostly low permeability, but faults, fractures, and joints contribute to local seepage. Water pressure testing of ten channel holes showed low water takes. Grout takes should be generally low, but higher locally where fractures are present.

Foundation Preparation

Clearing will be minimal at Newville Dam site. Scattered oaks and brush occur on both abutments. Some riparian growth occurs in the channel area.

Exploration drilling, trenching, and geologic mapping indicate that the rock on both abutments is intensely weathered to a depth of about 5 feet and fresh rock is found at about 15 feet. Soil depth is generally less than 3 feet. Alluvium depths in the channel average 5 feet and an additional 20 feet of weathered rock overlie fresh rock.

Average depths of stripping under the outer shells are estimated to be about 10 feet on the right abutment, 20 feet in the channel area, and 10 feet on the left abutment. Under the impervious core, the average stripping depth would be about 15 feet on the abutments and 40 feet in the channel. Additional excavation may be required in more weathered areas, along faults, and in lenses of poorly cemented conglomerate.

Construction Materials

Materials are available nearby for construction of the various features, but additional work is needed to evaluate alternative sources and their quantity and quality. Local sandstone and conglomerate appear to be weaker and less durable than the usual quarried rock for use in dams. The dam could be designed to accommodate this, but it would probably prove more economical to use stream gravel for transition zones and basalt for riprap. The stream gravel would probably come from upper Stony Creek and the basalt from the east side of the Sacramento Valley.

There are several adequate and tested sources of construction materials for an embankment-type Newville Dam. These are:

- Good quality impervious material for Newville Dam and Burrows Gap Saddle Dam is found within the reservoir area. About 90 percent of the needed pervious material can be found in Stony Creek between Julian Rocks and the Grindstone Indian Rancheria and in Grindstone Creek east of the Coast Range front. The environmental impact and acceptability of removing stream channel deposits should be evaluated. Dewatering will be required for some of the impervious deposits and all of the pervious.
- Tehama Formation deposits for the impervious core are located 5 miles east of the dam site.
- Terrace and slopewash deposits for the core and random fill portions of the embankment are located in the reservoir area and adjacent to the dam site.
- Stream gravel for filters and concrete structure is located within 7 to 12 miles of the dam site along Stony Creek between Black Butte Lake and Stony Gorge Dam. The use of stream gravel from streams with anadromous fisheries such as Thomes and lower Stony Creeks is not being considered at this time.
- Quarried sandstone and conglomerate from the Great Valley Sequence may be used for the rockfill and random zones of the embankment. The potential borrow sites nearest the dam site are of limited extent and contain large percentages of weathered rock. The most promising borrow area, with 21 million cubic yards of material, lies 3 miles north of the dam site. Preliminary laboratory tests show that the low strength and durability would require more conservative embankment slopes than are customary in high rockfill dams. The quarry source may also be used for riprap, but laboratory tests show that the rock is marginal for this use. Additional sources occur on the east side of the Sacramento Valley.

Several potential quarry sites have been identified and some drilling and laboratory testing have been completed on sandstone and conglomerate deposits from Rocky Ridge north of Newville Dam site. At the conclusion of the studies in 1982, a test fill was recommended to evaluate the conglomerate from Rocky Ridge as a rock source.

Burrows Gap Dam Site Geotechnical Studies and Findings

The Burrows Gap Saddle Dam would be an earth or rock embankment with an internal filter and drain. It would function as a saddle dam for reservoir levels above 780 feet. This saddle dam for the 1.9 maf Newville Reservoir would be about 75 feet high and 450 feet long and would span a low saddle in Rocky Ridge 3 miles south of the Newville Dam site.

Bedrock

The rock units at Burrows Gap are part of the Stony Creek Formation. They are nearly identical to the conglomerate, sandstone, and mudstone units found at Newville. The main section of the dam would be founded on conglomerate and sandstone. The upstream section of the embankment would be founded partially on mudstone.

Structure

The conglomerate and sandstone beds strike north-south and dip about 60 degrees toward the east. Burrows Gap is a faulted saddle in Rocky Ridge. The northeast-trending fault zone that passes through the gap is considered to be inactive (ESA 1980). The fault appears to be 3 to 10 feet wide.

Exploration

The geology at the site was mapped by DWR in 1961 and by USBR in 1966 (DWR 1980). This mapping was field-checked and revised by DWR in 1982. One angled core hole, drilled to a depth of 275 feet, and two geophysical survey lines provide the only subsurface information at the site.

Foundation Preparation

Stripping the foundation will consist of removing soil and weather rock under the embankment area and excavating a key trench. Soil, colluvium, and intensely weathered rock should be about 5 feet deep on the left abutment. In the saddle and on the right abutment, it will average 10 to 12 feet.

The rocks that make up the foundation are essentially impervious below 50 feet. However, the east-west-trending joints and fractures related to the fault zone could contribute to seepage beneath the dam. There is a seep near the downstream embankment toe, which is probably related to the presence of the fault. Seepage should be controllable with a grout curtain under the foundation and a filter drain.

Construction Materials

The same sources of construction materials as the Newville Dam are available.

Red Bank Project

The geologic studies conducted at the dam sites and along the conveyance routes indicate that the foundations are suitable for the proposed structures. The dams would be constructed from roller-compacted concrete (RCC) using quarried and crushed sandstone. The Red Bank Project was initially envisioned as two large embankment structures—Dippingvat Dam on South Fork Cottonwood Creek and Schoenfield Dam on Red Bank Creek—but were switched to RCC structures. The geology of the Red Bank Project was documented in the 1980 DWR report, “Engineering Geology of the Red Bank Project, Tehama County, California.”

Reevaluation of the seismic conditions (Appendix O) has resulted in an increase of the Maximum Credible Earthquake that could occur for the project. The reevaluation could also impact the proposed design. William Lettis and Associates are presently conducting additional studies related to the seismic characteristics associated with the project.

Dippingvat Dam Site Geotechnical Studies and Findings

Dippingvat Dam site is located on South Fork Cottonwood Creek and would be an RCC structure.

Bedrock

The dam site lies within the Great Valley Sequence along the west boundary of the Sacramento Valley. The foundation bedrock consists mostly of Upper Cretaceous sandstone, with lesser amounts of interbedded mudstone and minor conglomerate, and with bedding thickness varying from less than 1 inch to tens of feet. The sandstone forms prominent ridges in the area.

The sandstone is medium green, hard, and well indurated. The mudstone is dark gray to gray, and generally finely laminated to thinly bedded. It is generally closely fractured and slakes where exposed to air and moisture. The conglomerate only occurs in one layer interbedded with the sandstone. It is also hard and well indurated.

Surficial Deposits

Colluvium and stream channel deposits are at the dam site. Terrace deposits occur 150 feet upstream of the proposed dam axis. The colluvium, stream channels, and terrace deposits cover bedrock locally up to 10 feet.

Structure

The conglomerate, sandstone, and mudstone beds trend northwest and dip about 60 degrees to the east.

Three faults are in the foundation. All were intersected during the drilling. Associated with the faults are zones of gouge and sheared bedrock from 2 to 10 feet wide. Trenching to determine receny of faulting has not been conducted.

Exploration

The geology was investigated by DWR between 1987 and 1990. Six diamond core holes were drilled and water pressure tested at the dam site. No additional geologic field work has been completed.

Permeability

A grout curtain to about 150 feet deep in the abutments and 70 feet under the channel should be sufficient to control foundation seepage. There is some concern that open joints and fractures in the right abutment conglomerates may require treatment. Grout takes are expected to be low, except for some zones with moderate to high takes.

Foundation Preparation

Foundation preparation should include the stripping of about 24 feet of colluvium, soil, and loose weathered bedrock from the left abutment, 13 feet from the right abutment, and several feet from the channel. Another 10 feet of fractured and moderately weathered bedrock may have to be removed. Some dental work along the fault crossing the axis may be required.

Construction Materials

Aggregate construction material for the RCC dam is available about one-half mile downstream. The sandstone is interbedded with some mudstone, which will be removed before crushing.

Schoenfield Dam Site Geotechnical Studies and Findings

The geology is similar to Dippingvat Dam site. The dam site would be founded on the Great Valley Sequence of mudstone, conglomerate, and sandstone.

Surficial Deposits

Patches of Quaternary stream alluvium cover the channel locally to depths up to 9 feet. Several levels of scattered terrace deposits occur upstream within 600 feet of the dam axis. The terraces consist of 1 to 3 feet of clayey silt overlying 3 to 5 feet of gravel and cobbles perched on a bedrock bench about 5 feet above the present channel level. Colluvium wedges occur at the base of the slopes in depths approaching 10 feet or more. The colluvium consists of a mixture of soil and angular rock fragments.

Structure

The major structural feature is the northwest-trending, homoclinally east-dipping bedding of the Cretaceous Great Valley Sequence. Bedding attitudes trend northwest and dip northeast about 45 degrees and joints are common.

There are two mapped faults and several shears that are present in the foundation. Both faults are roughly perpendicular to the regional strike of bedding. Trenching to determine recency of faulting has not been conducted.

Permeability

In general, the rocks in the foundation were hard, well indurated, and of sufficient strength for the proposed dam. Water pressure data showed that water takes were generally low to moderate, with some zones of higher takes. The rocks have little primary permeability. Instead, zones of high water take are associated with extensive fractures or jointing. The conglomerate has the highest take due to open fractures. The zones of fractured rock associated with faulting may act as seepage paths.

Foundation Preparation

Foundation preparation of the abutments will consist of the removal of brush interspersed with oak and pine. About 10 to 16 feet of soil, colluvium, and intensively weathered bedrock can be removed with common methods. An additional 5 to 10 feet of moderately weathered bedrock may require some blasting. An average of about 5 feet of stream alluvium and up to about 10 feet of weathered bedrock needs to be removed from the channel. The two fault zones crossing the dam site may require some treatment. Grout take, based on water pressure testing, is expected to be moderate overall, but with zones of high grout take in places.

Construction Material

The construction material initially selected for RCC structures is from a sandstone quarry site located one-half mile downstream. The quarry consists of one sandstone bed about 100 feet thick and a number of thinner beds. Two diamond core holes were drilled and samples sent to the laboratory for analyses. In addition, a series of mixes of sandstone aggregate, cement, and pozzolan were tested for compressive strength. The testing showed that the sandstone aggregate was adequate for the previously-proposed, seismic loading criteria.

Bluedoor and Lanyan Dam Sites Geotechnical Studies and Findings

The geology, seismic considerations, construction materials, and foundation preparation for Bluedoor and Lanyan Dam sites are similar to Schoenfield Dam site. These two proposed RCC dams are small and less than 100 feet high. Four diamond core holes were drilled at Lanyan and five at Bluedoor. The drill holes intersected minor gouge and fractured rock at both dam sites. Each hole was then water pressure tested. Grout takes are expected to be low except for some zones of high grout takes.

Chapter 5. Engineering Analysis

As summarized in preceding chapters, considerable engineering and related studies of the four north of the Delta offstream storage projects have been previously conducted. This past work has been incorporated into this investigation to the extent possible. However, most of these previous studies were performed at less than feasibility level and under planning guidelines that have changed substantially. Therefore, much additional engineering work remains to be done on each alternative, subject to continuing screening. This chapter summarizes the engineering work completed to date.

In addition to differing years of engineering analysis, studies have been performed at differing levels of detail and precision. Many of the design characteristics shown are for comparative purposes. As studies progress and more site-specific information is developed, some of these characteristics may change.

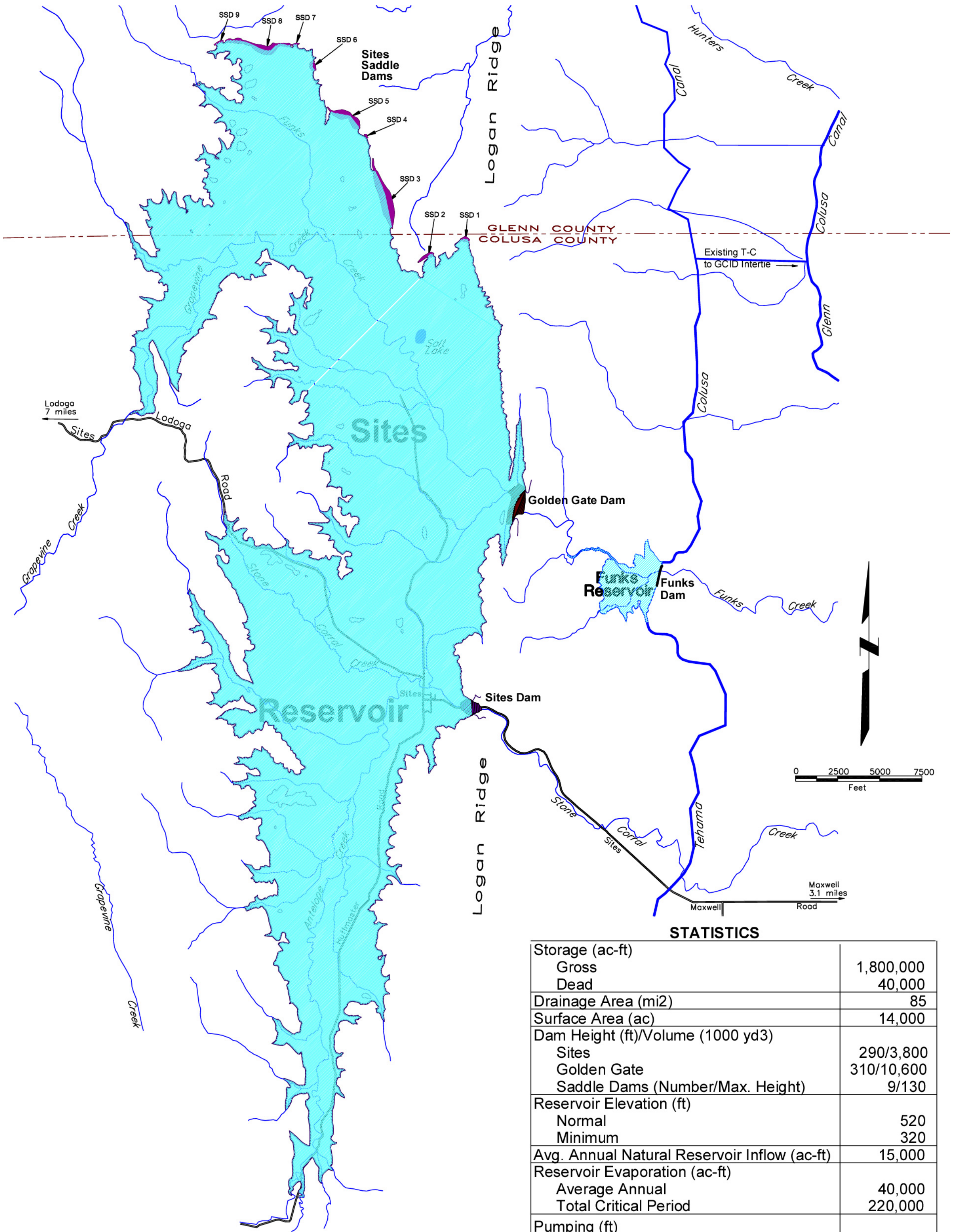
Sites Project

Sites Reservoir would be formed by Golden Gate Dam on Funks Creek, Sites Dam on Stone Corral Creek, and nine saddle dams along the ridge between Funks and Hunters Creeks. Figure 5-1 shows the dams and reservoir for the Sites Project, with dam statistics based on initial designs of the dam embankments. Statistics shown for Golden Gate Dam are for a downstream embankment alternative. An area-capacity curve for Sites Reservoir is shown in Figure 5-2. The normal water surface elevation of the reservoir would be 520 feet, inundating 14,000 acres for a total capacity of 1.8 maf. The minimum operating water surface elevation would be 320 feet. Dead storage at that elevation would be approximately 40 taf.

Much of the Sites Project engineering work is being conducted by DWR's Division of Engineering in Sacramento, while most of the geology work has been performed by DWR's Northern District Geology Section. Northern District's Offstream Storage Investigation Branch directed the overall planning effort.

Since the two small watersheds above the reservoir produce only around 15 taf of average annual runoff, Sites Reservoir would serve as offstream storage for other sources of water. The reservoir would be filled almost entirely by diversions from the Sacramento River and local tributaries using existing, new, or enlarged conveyance and diversion facilities. A number of water supply source and conveyance options have been considered for the Sites Project. The source and conveyance options have been packaged in various combinations to create eight unique source and conveyance alternatives and an additional six that are variations. All of the supply and conveyance alternatives being considered include multiple conveyance options; all but one include multiple sources. Decisions related to optional water supply sources and conveyance have not been made.

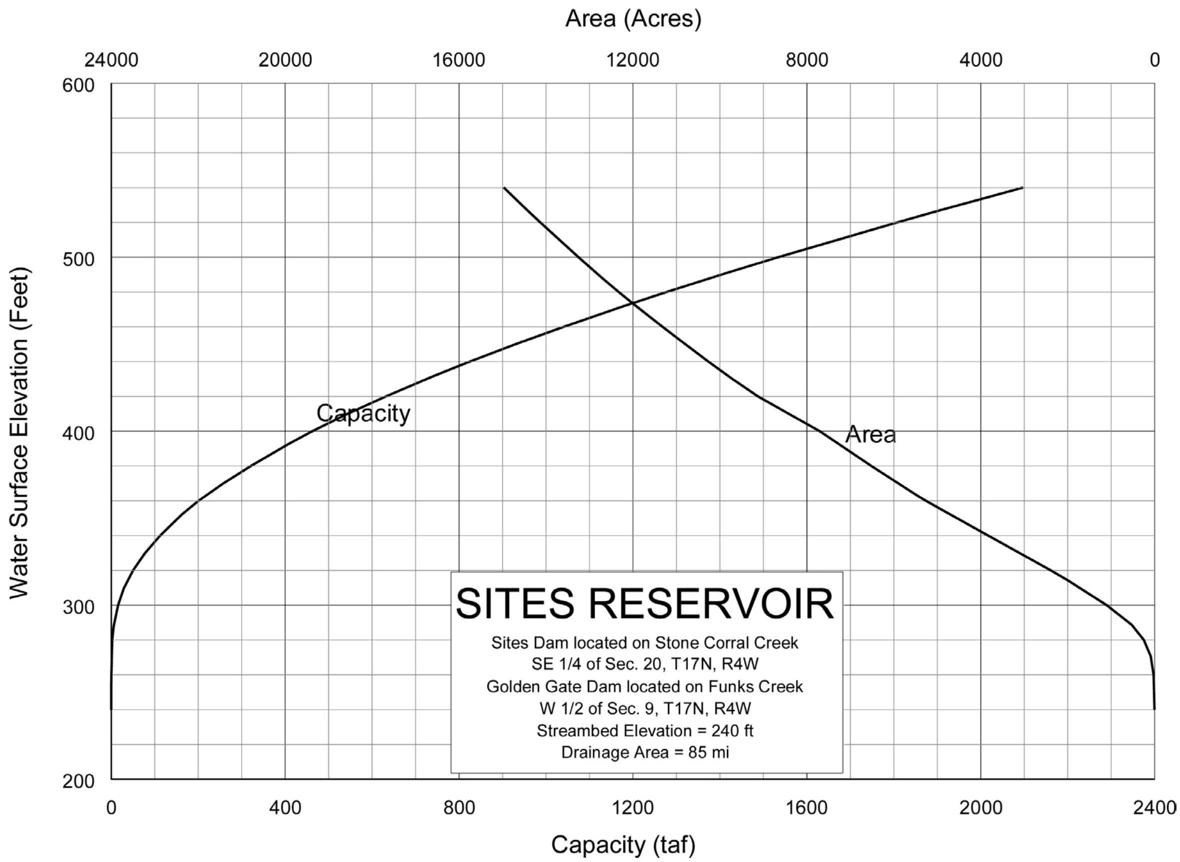
Figure 5-1. Sites Project and Statistics



STATISTICS

Storage (ac-ft)	
Gross	1,800,000
Dead	40,000
Drainage Area (mi2)	85
Surface Area (ac)	14,000
Dam Height (ft)/Volume (1000 yd3)	
Sites	290/3,800
Golden Gate	310/10,600
Saddle Dams (Number/Max. Height)	9/130
Reservoir Elevation (ft)	
Normal	520
Minimum	320
Avg. Annual Natural Reservoir Inflow (ac-ft)	15,000
Reservoir Evaporation (ac-ft)	
Average Annual	40,000
Total Critical Period	220,000
Pumping (ft)	
Static Lift from T-C Canal	
Maximum	320
Minimum	120
Capacity	
Maximum (1000 ft^3/s)	5 to 8

Figure 5-2. Sites Reservoir Area-Capacity Curves



Funks Reservoir, approximately 2 miles downstream from the Golden Gate Dam site, is a convenient forebay/afterbay for the Sites Project. All of the water supply source and conveyance options propose to use Funks Reservoir as a forebay, with the exception of the upper Stony Creek water supply options. The existing 40-foot-high dam that impounds Funks Reservoir might be used as is or might be replaced with a larger dam to regulate the inflow and outflow from Sites Reservoir. For this investigation, it was assumed that no additional forebay or afterbay storage would be required to meet project inflow or outflow regulation needs.

Tehama-Colusa Canal and Glenn-Colusa Canal are existing conduits that could convey water to Sites Reservoir from the Sacramento River. Tehama-Colusa Canal runs through Funks Reservoir, which currently serves as a surge reservoir for canal operations. The Glenn-Colusa Canal runs approximately 3 miles east of and 80 feet below Funks Reservoir. Water from this canal could be pumped into Funks Reservoir through a new connector canal and pumping plant. Another conveyance option is a new canal running west from a new diversion point on the Sacramento River that also could convey water from the Colusa Basin Drain. Water from this new canal would be pumped into Funks Reservoir through the same connector canal mentioned previously.

Reservoir inflow from the alternatives considered ranges from 3,900 up to 8,000 cubic feet per second. A pumping/generating plant located at the base of

Golden Gate Dam would lift water up to 320 feet from Funks Reservoir into Sites Reservoir. During scheduled releases, the plant would be used to generate power. The plant would have maximum pumping and discharge capacities of around 8,000 cfs.

Contour maps of Sites Reservoir were scanned and digitized in 1997 by DWR. USBR prepared the original contour maps from 1:25000 photography BR-SVC-2, dated April 8, 1978. Ten-foot contours were interpolated from 5-meter contours. This digitized information was used for determining the most efficient facilities layout and the area-capacity curve.

Golden Gate Dam

Golden Gate Dam, including its inlet/outlet works and pumping/ generating plant, is the most complex structure necessary to form either Sites or Colusa Reservoirs. The dam site is located on Funks Creek along Logan Ridge approximately 8 miles northwest of Maxwell. For Sites and Colusa Reservoirs, the normal reservoir elevation would be 520 feet.

Embankment Design

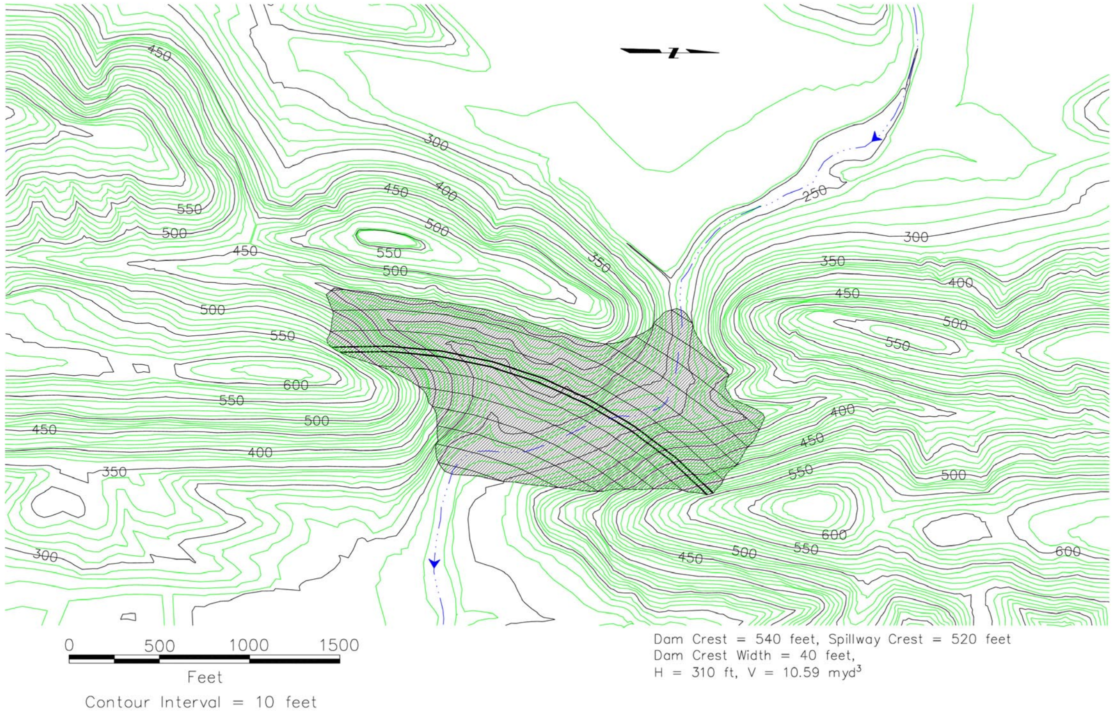
Golden Gate Dam would most likely be constructed as a zoned rockfill embankment dam. A roller-compacted concrete (RCC) dam is being evaluated as an alternative, but appears to be more expensive. The following discussion concentrates on embankment alternatives. Design characteristics shown allow for comparative evaluation. As studies progress and more site-specific information becomes available, some of these characteristics may be adjusted.

Because of complex topographic and geologic conditions at the Golden Gate Dam site, two representative dam axis alignments have been investigated and are shown on Figure 5-3. For the downstream curved alternative, Golden Gate Dam would rise 310 feet above the streambed, with a crest 2,000 feet long and 30 feet wide, and require 10.6 million cubic yards of embankment material. An upstream straight alignment would be 300 feet high, with a crest length of 5,000 feet and crest width of 40 feet, and require 17.3 mcy of embankment material. The crest elevation is the same for all embankment alternatives and would be 540 feet, providing 20 feet of freeboard.

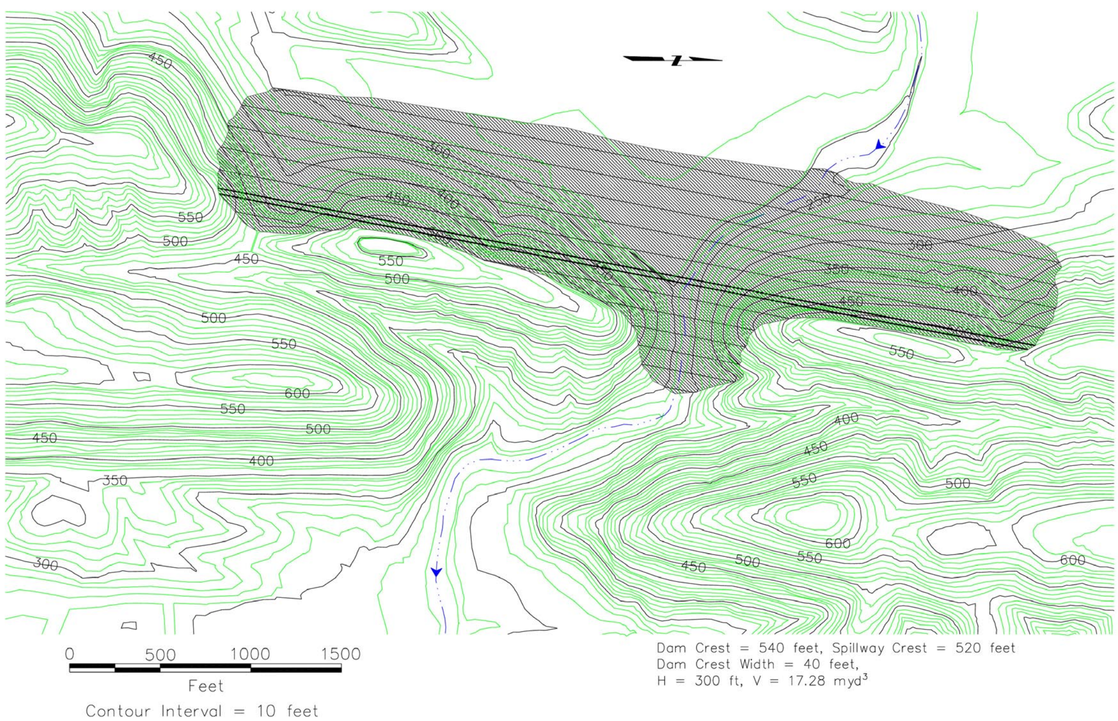
The dam foundation is composed of sandstone and mudstone, which is strong and tight enough to provide an adequate foundation for either an embankment or RCC dam. Stripping will be required to remove softer surface deposits in depths up to 20 feet. Also, extensive grouting in some foundation areas will be required to reduce reservoir seepage.

The zoned embankment alternative would have an impervious clay core with upstream filter and downstream drain zones. Materials testing indicates that adequate clay mixture soils exist in the reservoir area to supply the quantity of material required for the dam’s impervious core. Sandstone is available locally for dam rockfill and shell material. Filter, drain, and concrete aggregate material may need to be imported. Additional materials testing work will have to be performed to verify the location and quantity of suitable construction materials.

Figure 5-3. Golden Gate Dam Alternative Alignments



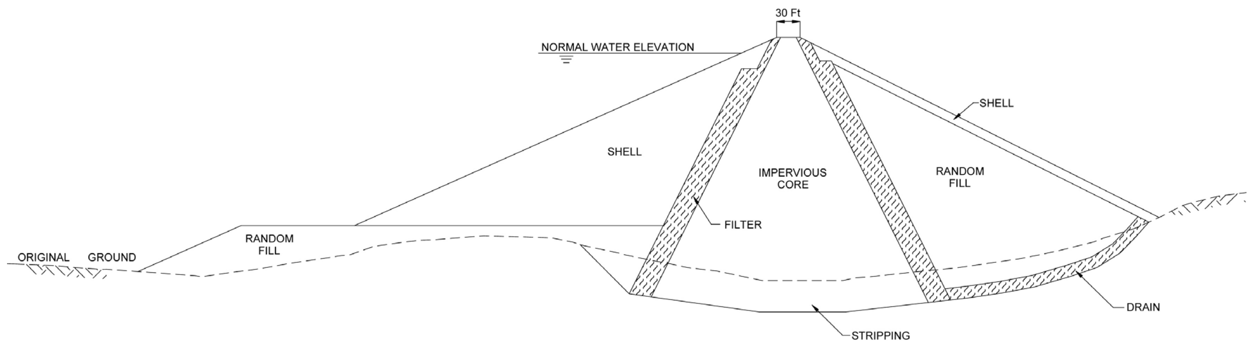
Downstream Curved



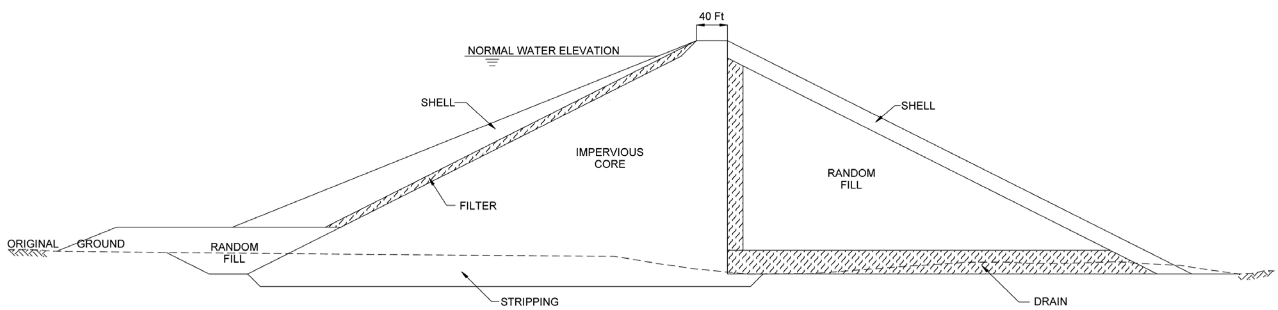
Upstream Straight

The typical cross sections of potential embankment dams at the Golden Gate and Sites locations are shown on Figure 5-4. The results from preliminary stability analyses using assumed strengths are considered adequate for the purpose of developing feasibility-level designs and cost estimates. A significantly different embankment cross section was proposed for the upstream alignment.

Figure 5-4. Golden Gate and Sites Embankment Dam Cross Sections



Golden Gate Downstream Alignment and Sites Dam



Golden Gate Upstream Alignment

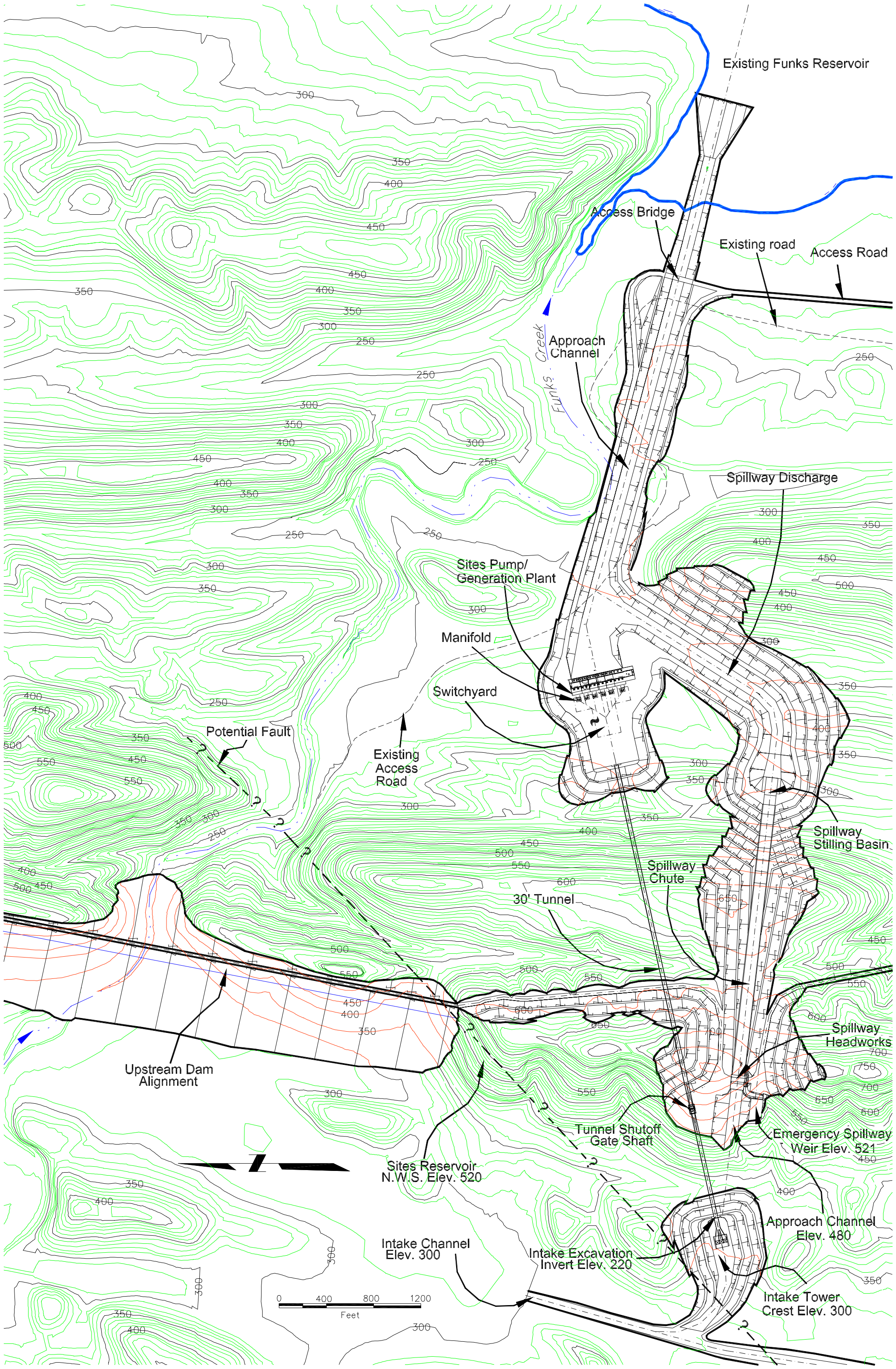
Spillways

Several alternatives are under evaluation for spillway and outlet appurtenant works. A spillway is necessary to convey water around the dam to prevent overtopping from extreme floods. An outlet is necessary to reduce reservoir head in case of an emergency. The emergency spillway is designed to spill the probable maximum flood storm, or 5,000 cfs. The initial alternative considered a high-level outlet consisting of six radial gates that release water into a concrete spillway chute. This spillway can be controlled by a mechanical headgate structure. Other alternatives are being considered.

The emergency spillway is designed as an ungated weir. One option is to have these spillways combined into a single structure as shown in Figure 5-5.

Figure 5-5. Golden Gate Dam Upstream Alignment and Appurtenances

Note: Other alternative dam alignments are still under consideration.



Excavation of this option would produce approximately 6.5 mcy of construction materials that could be incorporated into the Golden Gate Dam embankment. To date, only one of several potential types of outlets has been investigated in this study. Others should be considered and an economical analysis should be completed to determine the ideal size, type, and location of the structure.

Pumping/Generating Plant and Inlet/Outlet Works

Much of the following discussion is applicable for Sites and Colusa Reservoirs. Most of the water entering Sites or Colusa Reservoirs would be diverted from the Sacramento River or its tributaries. The average annual natural inflow from the watersheds upstream of Sites Reservoir is 15 taf; Colusa Reservoir is 20 taf. These natural inflows comprise less than half the water annually evaporated from the respective proposed reservoir. Diverted water would be conveyed to the existing or enlarged Funks Reservoir, in most cases, where it would be pumped into Sites or Colusa Reservoirs. In order to recover much of the power required for pumping, generators would be included for recapturing power when reservoir releases are made.

Initial design and cost estimate studies of the facilities at Golden Gate Dam include facilities to convey water between existing Funks and potential Sites or Colusa Reservoirs. Figure 5-5 shows an alternative location of the pumping/generating plant and other appurtenances. This facility would pump up to 8,000 cfs using from 10-to-15 pumping/generating units. For initial design and cost estimating purposes, ten 680 cfs and three 350 cfs units were used. This facility would be a conventional indoor-type plant with an inline arrangement of 13 vertical pumping/generating units. The total power output would be around 220 MW. Once a dam alignment is selected, the final plant location can be established.

For this initial design, the plant would be located on a relatively low, flat bench immediately south of Funks Creek and less than a mile southeast of the Golden Gate Dam site. If the existing Funks Reservoir were used as a forebay, the maximum excavation depth for the pumping/generating plant would be approximately 130 feet. This compares favorably with pumping plant excavations along the California Aqueduct, which frequently exceeded 140 feet. Much of the large quantity of material excavated to reach the required approach channel and plant depth may be usable in constructing the embankment dam.

The inlet-outlet structure would convey up to 8,000 cfs between Sites Reservoir and the pumping/generating plant. This preliminary design set the reservoir intake tower crest at elevation 300 feet. The intake structure would need to be redesigned to allow water to be drawn from different elevations in the reservoir water column if this feature is required.

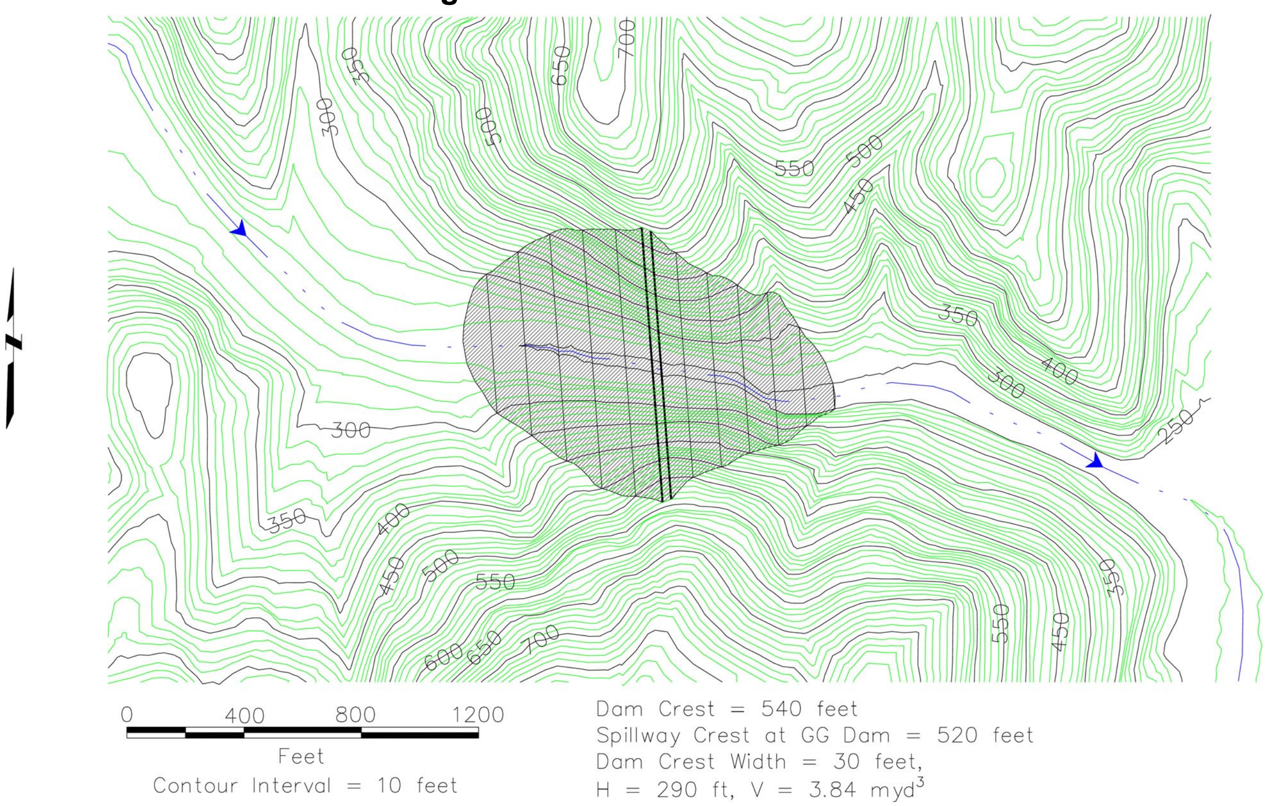
The preliminary design intake structure would connect to a 30-foot inside diameter pressure tunnel that would be 4,000 feet long. This tunnel would be connected to the pumping/generating plant, concrete lined for 3,000 feet and then steel lined for 1,000 feet at the pump/generating plant end. The tunnel is designed to convey water with a maximum velocity not to exceed approximately 10 feet per second. A 30-foot-by 20-foot control gate would be located in the tunnel approximately 1,000 feet from the intake tower and would allow dewatering of the lower tunnel for inspection. Tunnel inspection upstream of the gate shaft could be accomplished by covering the intake openings with bulkhead gates lowered from barges. Other design options are being considered.

A steel penstock would extend approximately 400 feet from the east tunnel portal and connect to a manifold feeding or receiving inflow from the pumping/generating plant. The penstock and manifold would be encased in concrete with anchor blocks to resist thrust forces at bends. The various branch diameters within the manifold were determined by setting maximum water velocity at approximately 10 feet per second. The connecting channel between Funks Reservoir and the pumping/generating plant would be a concrete-lined trapezoidal section with a 100-foot bottom width and 2:1 side slopes.

Sites Dam

The second major dam required to form Sites Reservoir is the 290-foot-high Sites Dam (shown in Figure 5-6) at the Stone Corral Creek water gap through Logan Ridge, approximately 2 miles south of the Golden Gate Dam site. This dam could be constructed either as an RCC or an embankment structure. At this point, it appears that an embankment structure alternative may be less expensive. Further study will be required to allow selection of a preferred alternative. Sites Dam would rise 290 feet above the streambed, with a crest elevation of 540 feet, crest width of 30 feet, and tentatively would require at least 3.8 mcy of embankment material.

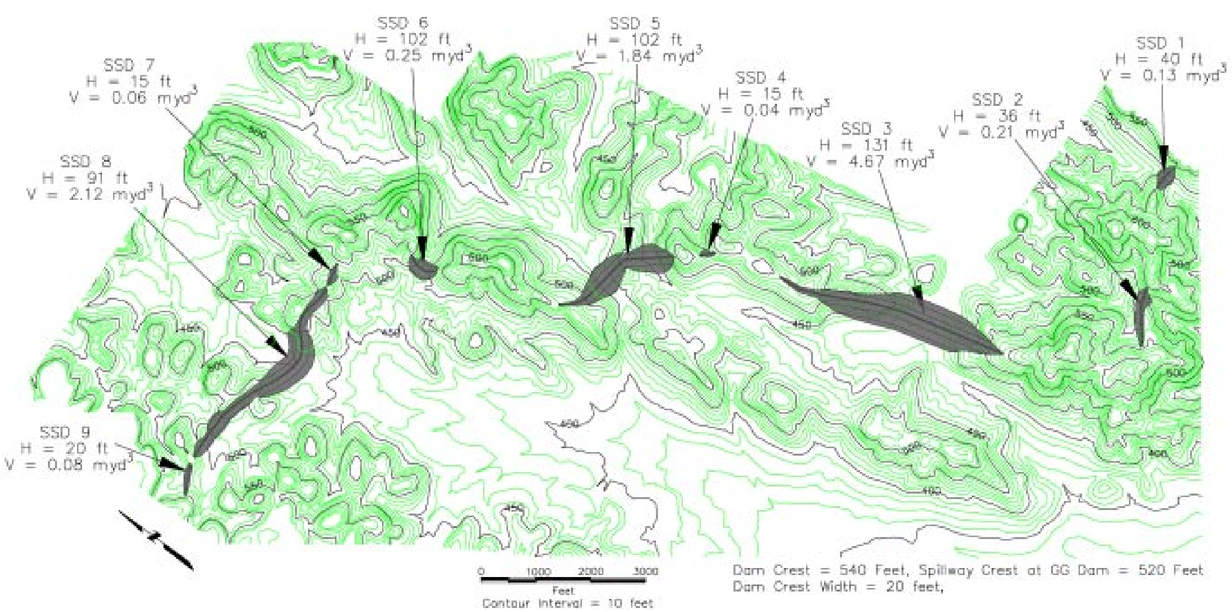
Figure 5-6. Sites Dam Plan View



Saddle Dams

The Sites Project will require the construction of nine saddle dams along the northern ridge dividing the Funks Creek and Hunters Creek drainages, as shown in Figure 5-7. The total embankment volume of these saddle dams is estimated to be about 9.4 mcy; there would be no appurtenances associated with them.

Figure 5-7. Sites Project – Saddle Dams

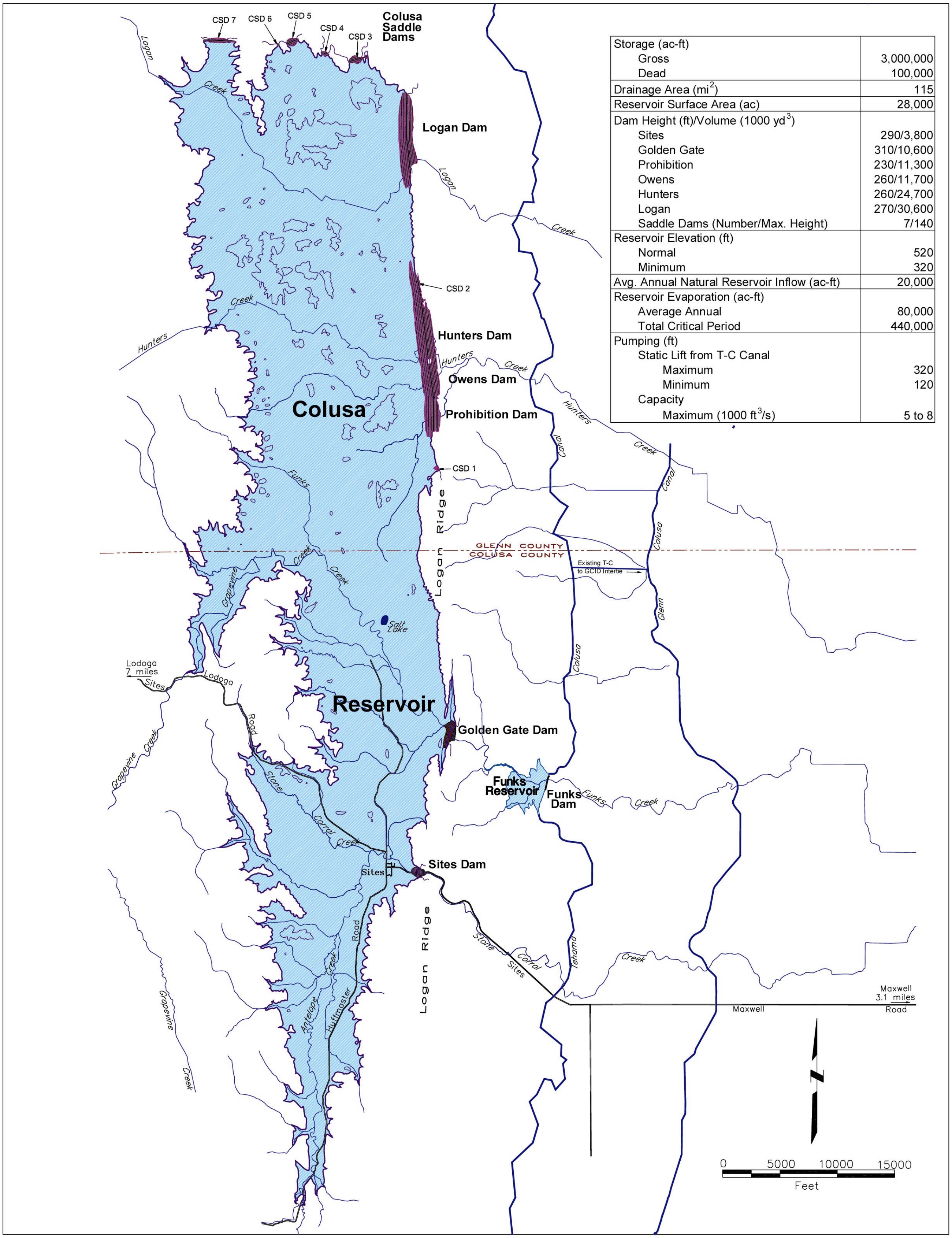


Colusa Project

The Colusa Project (Figure 5-8) would be an expansion of the Sites Project to include the Hunters and Logan Creek drainages to the north. All of the Sites Project facilities, except the saddle dams, would be constructed. Colusa Reservoir requires seven saddle dams along its northern boundary, with total embankment volume estimated to be 7.6 mcy. In addition, large dams would be built along Northern Logan Ridge at the Hunters and Logan Creeks water gaps, forming a 3.0 maf reservoir with a normal water surface elevation of 520 feet.

A large cut or tunnel would be required between Funks and Hunters Creek watersheds, upstream of Logan Ridge, to allow free water transfer between the Sites and Colusa portions of the reservoir at all elevations above dead storage elevation of 320 feet. Colusa Reservoir at a water surface elevation of 520 feet would contain 3.0 maf, or 67 percent more water than the 1.8 maf Sites Reservoir at the same level. However, fill material for Colusa Reservoir is 300 percent greater than Sites Reservoir — 100 mcy versus 24 mcy (for the Golden Gate downstream embankment alternative). This difference in embankment volume required will make the Colusa Project significantly more expensive than the Sites Project.

Figure 5-8. Colusa Project and Statistics



Storage (ac-ft)	
Gross	3,000,000
Dead	100,000
Drainage Area (mi^2)	115
Reservoir Surface Area (ac)	28,000
Dam Height (ft)/Volume (1000 yd^3)	
Sites	290/3,800
Golden Gate	310/10,600
Prohibition	230/11,300
Owens	260/11,700
Hunters	260/24,700
Logan	270/30,600
Saddle Dams (Number/Max. Height)	7/140
Reservoir Elevation (ft)	
Normal	520
Minimum	320
Avg. Annual Natural Reservoir Inflow (ac-ft)	20,000
Reservoir Evaporation (ac-ft)	
Average Annual	80,000
Total Critical Period	440,000
Pumping (ft)	
Static Lift from T-C Canal	
Maximum	320
Minimum	120
Capacity	
Maximum (1000 ft^3/s)	5 to 8

Figure 5-9 is the area-capacity curve for Colusa Reservoir. The plan views of the saddle dams, Hunters Dam, and Logan Dam are shown in Figures 5-10, 5-11, and 5-12 respectively.

Figure 5-9. Colusa Reservoir Area-Capacity Curves

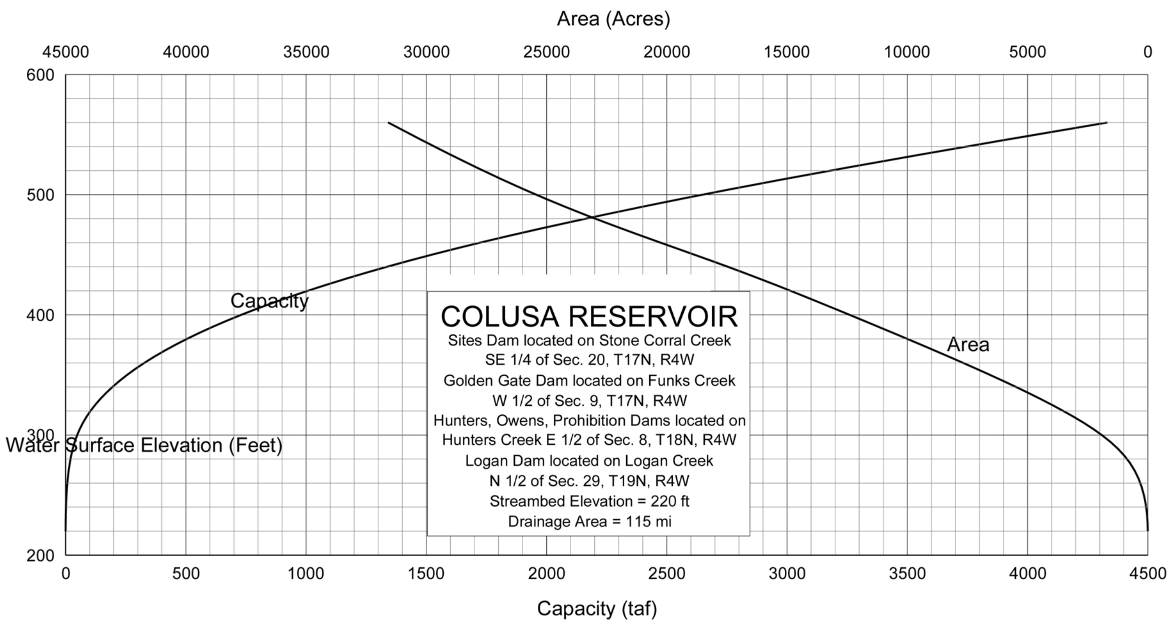


Figure 5-10. Colusa Reservoir – North Saddle Dams

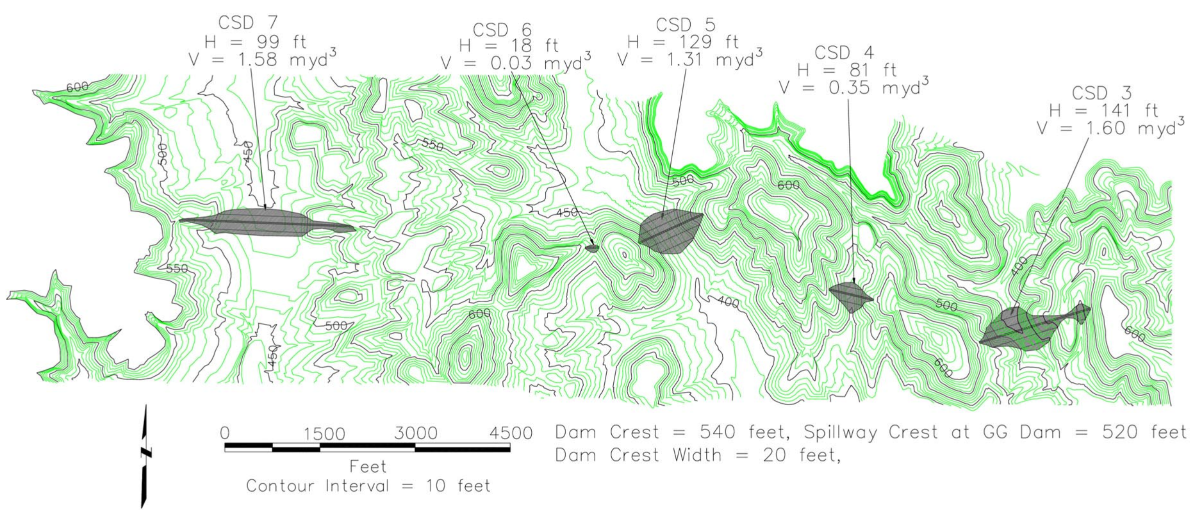


Figure 5-11. Colusa Reservoir – Hunters, Owens, and Prohibition Dams

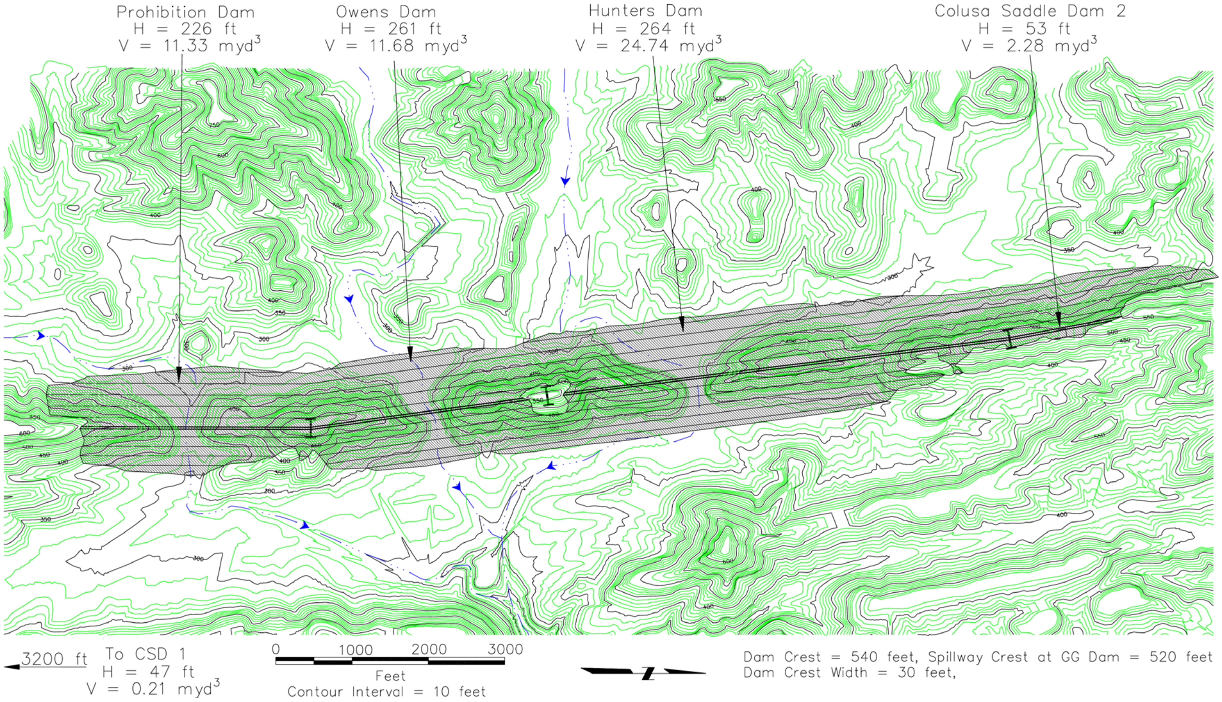
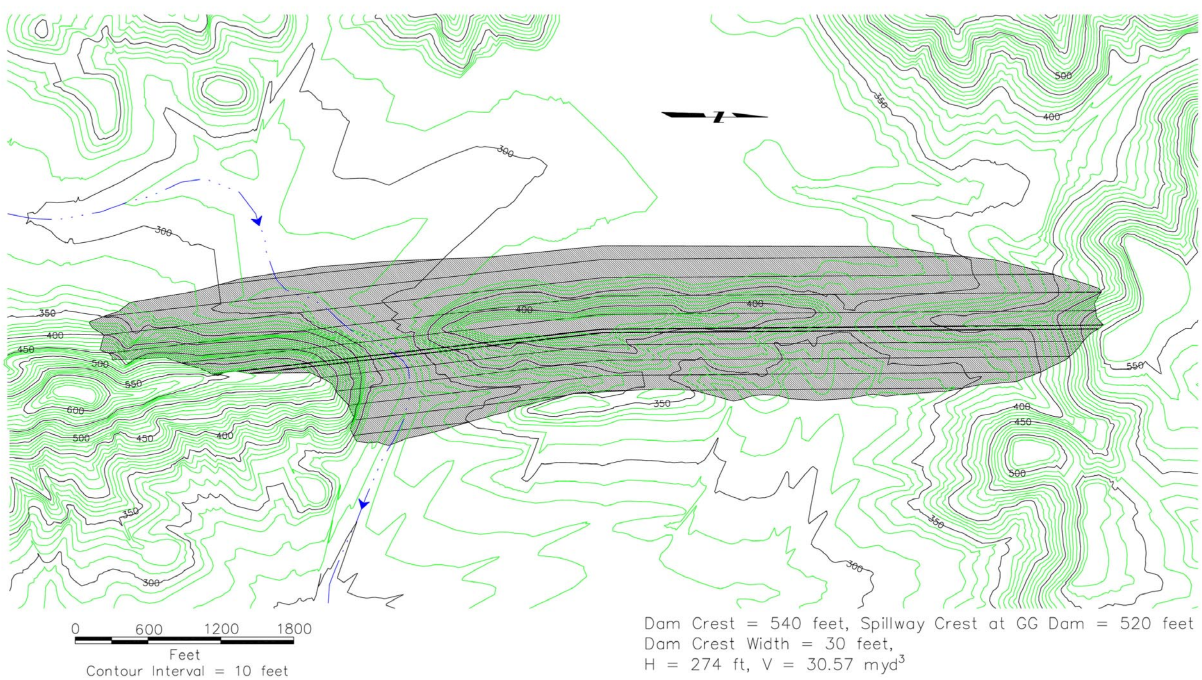


Figure 5-12. Colusa Reservoir – Logan Dam



Investigations conducted for the Colusa Project under the Offstream Storage Investigation have focused on geotechnical studies. Additional analysis of embankment design and materials will be needed if the Colusa Project is retained for continued study. As presently configured, there would be no major appurtenances located at the Colusa Cell dams. The dams at Hunters and Logan Creeks would require low-level outlet works to allow release of stream maintenance flows. This project characteristic and the fact that the Sites Project dams and appurtenances would be significantly similar will simplify the engineering evaluations required for this project. The water supply conveyance options are essentially the same as for Sites, although larger conveyance capacity would likely be required to support Colusa's larger storage capacity.

Road and Utilities Relocations

Sites and Colusa Reservoirs would inundate a portion of the Maxwell to Lodoga Road, which must be relocated. Alternative potential relocation routes under consideration are shown in Figure 5-13. Basically, the relocated road must go either north or south of the reservoir. A north route around Sites and a south route around Colusa appear most practicable, but considerably more investigation and public input is required before a preferred alternative can be identified.

Thomes-Newville Project

A feasibility-level evaluation of the Thomes-Newville Project was conducted by DWR in the late 1970s and reported in November 1980. This work was based on earlier studies conducted in the mid-1960s. Because of the extensive level of past studies, compared to the Sites and Colusa Projects, the Thomes-Newville engineering reevaluation was judged to be of a lower priority for this initial study effort. One of the goals of this study is to bring all the alternative projects up to an equivalent level of knowledge for screening purposes. Therefore, few recent engineering studies have been conducted for the Thomes-Newville Project and most of what is known about it is derived from the historic studies. However, this project will probably receive extensive additional study during the next couple of years.

The Thomes-Newville Project map and area-capacity curve are shown on Figures 5-14 and 5-15, respectively. Reservoir sizes under consideration are 1.9 and 3.0 maf. Newville Dam and at least one saddle dam at Burrows Gap 3 miles south would create Newville Reservoir on North Fork Stony Creek. However, North Fork Stony Creek has a limited drainage area and little surplus water. Therefore, most of the water supply for Newville Reservoir is proposed to be diverted from the mainstem of Stony Creek, Thomes Creek, or the Sacramento River.

Diversion of surplus flows from the mainstem of Stony Creek would involve pumping from the existing Black Butte Lake to either a proposed Tehenn Reservoir forebay/afterbay on North Fork Stony Creek or a canal that would convey water to the toe of Newville Dam. Since Tehenn would flood a locally-important cemetery, dating from the mid-1880s, future studies will emphasize the canal over the reservoir as a conveyance facility. Two pump lifts would be required with either the Tehenn Reservoir or canal conveyance alternative to transport water from Black Butte to Newville Reservoir. During reservoir releases, generators would recapture most of the energy required for

Figure 5-13. Potential Road Relocations for Sites and Colusa Reservoirs

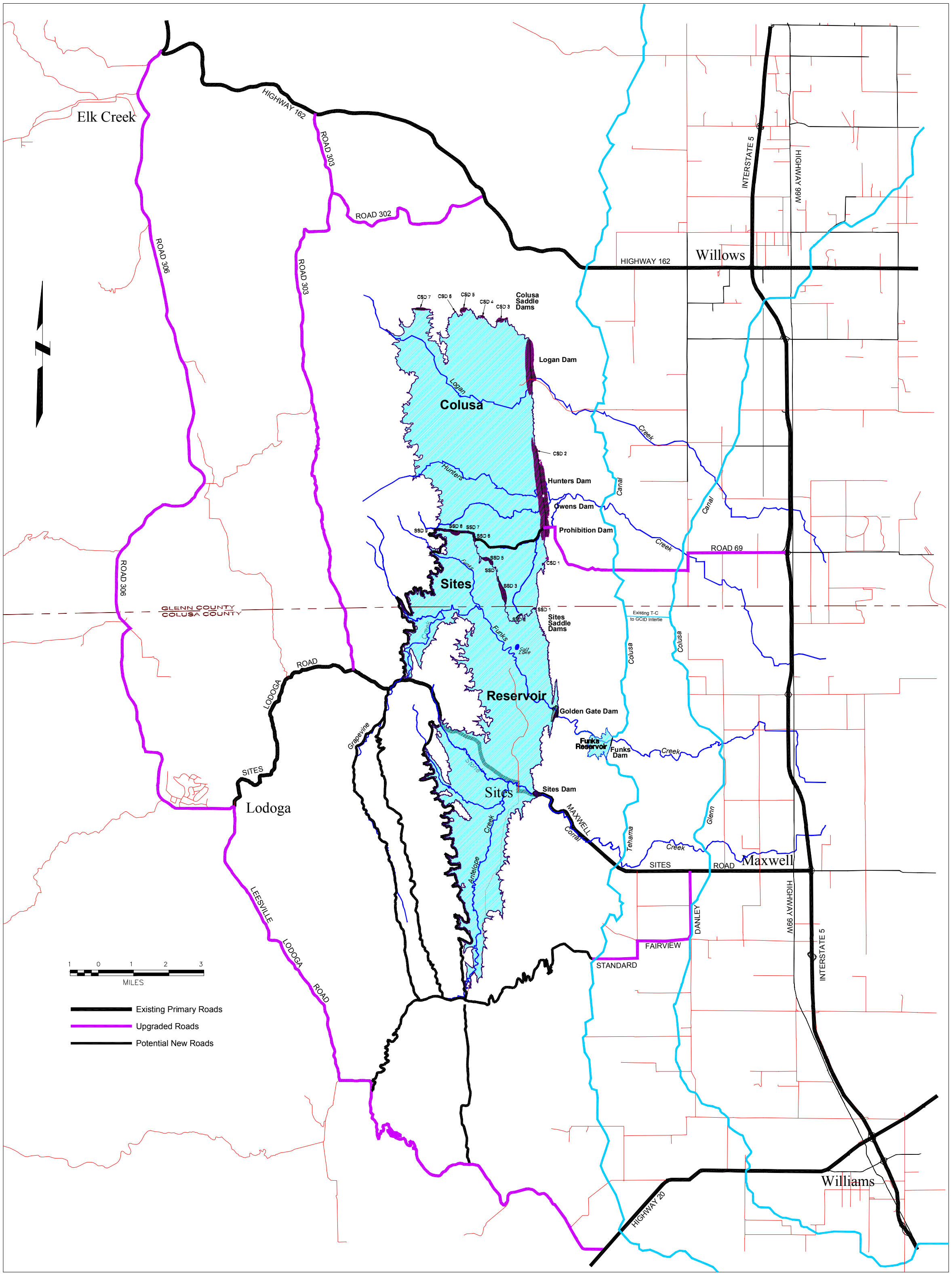
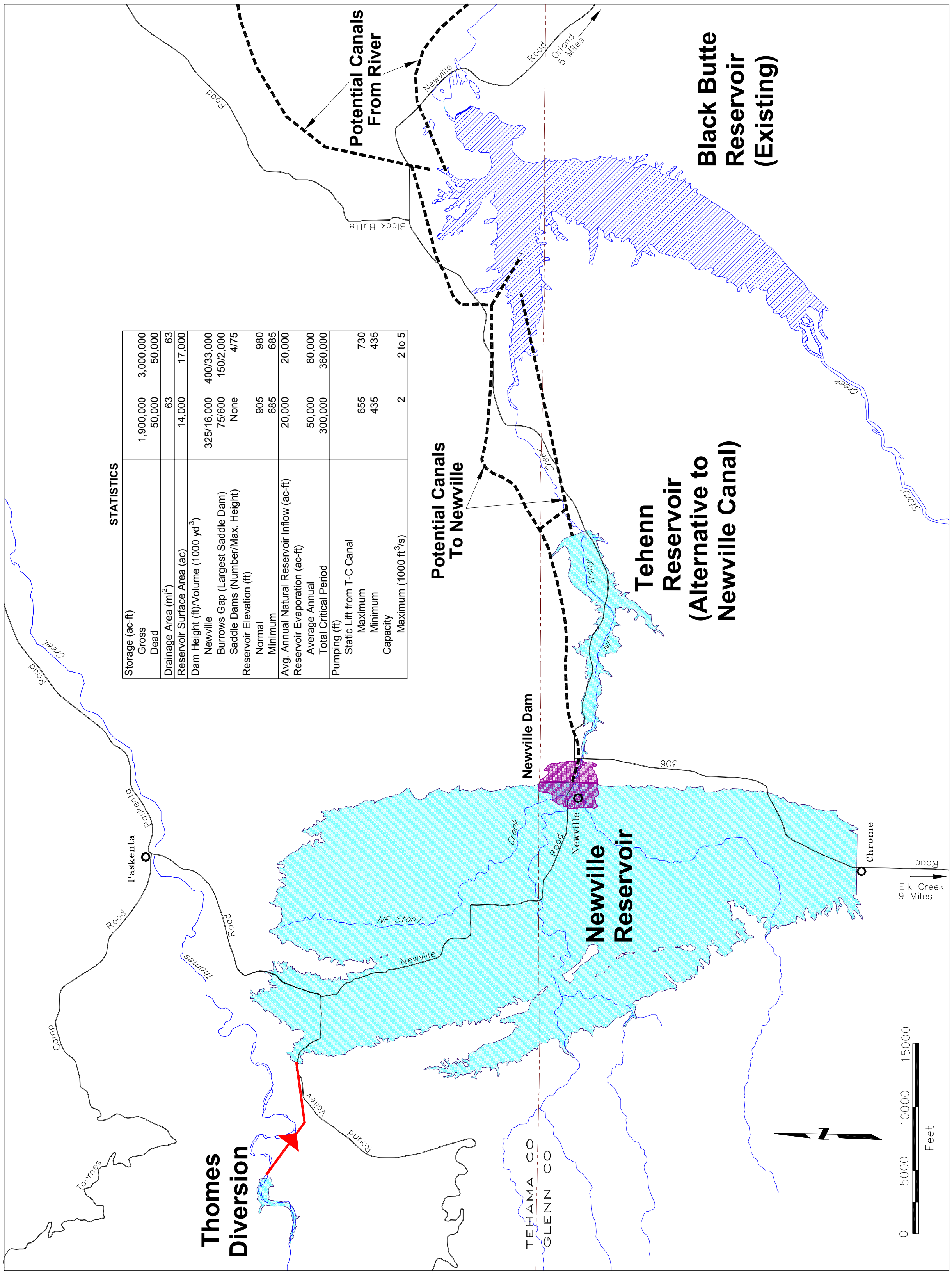


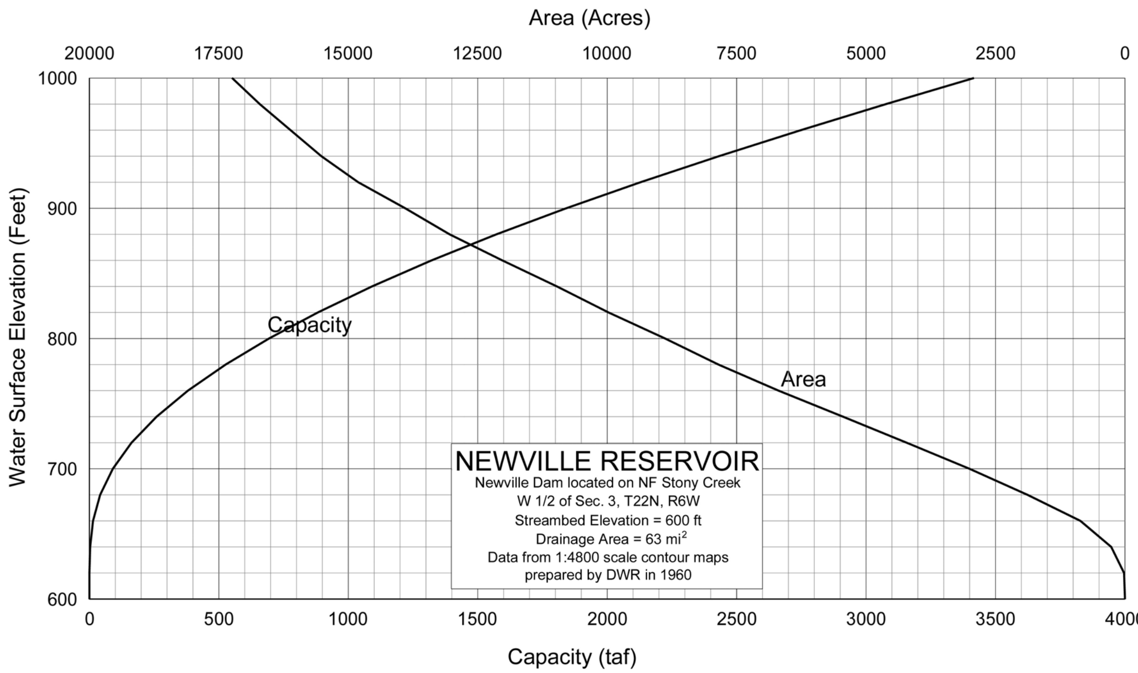
Figure 5-14. Thomes-Newville Project and Statistics



STATISTICS

Storage (ac-ft)		
Gross	1,900,000	3,000,000
Dead	50,000	50,000
Drainage Area (mi²)	63	63
Reservoir Surface Area (ac)	14,000	17,000
Dam Height (ft)/Volume (1000 yd³)		
Newville	325/16,000	400/33,000
Burrows Gap (Largest Saddle Dam)	75/600	150/2,000
Saddle Dams (Number/Max. Height)	None	4/75
Reservoir Elevation (ft)		
Normal	905	980
Minimum	685	685
Avg. Annual Natural Reservoir Inflow (ac-ft)	20,000	20,000
Reservoir Evaporation (ac-ft)		
Average Annual	50,000	60,000
Total Critical Period	300,000	360,000
Pumping (ft)		
Static Lift from T-C Canal		
Maximum	655	730
Minimum	435	435
Capacity		
Maximum (1000 ft³/s)	2	2 to 5

Figure 5-15. Newville Reservoir Area-Capacity Curves



pumping. Reservoir releases would either flow down Stony Creek or the proposed conveyance from Tehama-Colusa Canal and be diverted, under an exchange agreement, to the Glenn-Colusa and Tehama-Colusa Canals. Because of water temperature concerns, no water would be released directly to the Sacramento River.

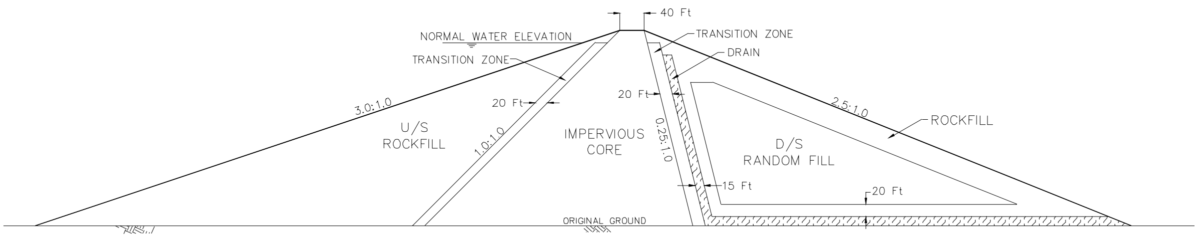
Surplus winter flows from Thomes Creek could be conveyed by gravity from a low diversion dam. A short diversion canal would pass through a saddle on the drainage divide and discharge to the northwest corner of Newville Reservoir. When investigated in the 1970s, this appeared to be a rather conventional diversion, but current requirements to pass fish around diversion dams and screen fish away from the diversion facilities will greatly complicate this structure. Another challenging design issue is Thomes Creek's extremely large sediment load. It is possible that further investigation may reveal that this diversion is no longer practicable. Under those circumstances, a Sacramento River source may be required for all Thomes-Newville Project alternatives.

An investigation to identify Sacramento River diversion and conveyance options for the Thomes-Newville Project is continuing. Likely options would use conveyance in the existing Tehama-Colusa and/or Glenn-Colusa Canals.

Newville Dam

Newville Dam would most likely be a conventional zoned earth-rock embankment dam with a cross section as shown on Figure 5-16. For the reservoir capacities of 1.9 and 3.0 maf under consideration, the dam heights above the streambed are 325 and 400 feet, respectively, and the dam volumes are 16 and 33 mcy, respectively. The dam would have conservative upstream and downstream slopes of 3 to 1 and 2.5 to 1, respectively, a crest width of 40 feet, and a freeboard of 20 feet. Newville Dam would fill the gap in the north-south trending Rocky Ridge through which North Fork Stony Creek flows.

Figure 5-16. Newville Reservoir – Earthfill Dam Section



Embankment Design

The dam would be composed of four major material zones as shown on Figure 5-16 and listed below:

- Impervious core using Tehama Formation clay mixture soils;
- Transition and drain material composed of processed sands and gravels (transition zones prevent mixing of material in different zones);
- Compacted processed rockfill; and
- Random fill.

The material for the impervious zone would come from the Tehama Formation soils located in the reservoir area. Stream gravels for concrete and filter zones are available from streambed sources. Sandstone for rockfill is available from nearby Rocky Ridge. Most of the sand and gravel may have to be obtained from sources up to 50 miles from the dam site. This is because sand and gravel availability near the dam site is limited and crushed sandstone from Rocky Ridge may not meet concrete and drain material specifications.

The relative volume of each type of material composing the dam is approximately 25 percent impervious, 10 percent transition and drain, 55 percent rockfill, and 10 percent random fill. The embankment section was checked for stability under a range of static and seismic loading conditions and the resulting safety factors meet the relevant criteria for large dams.

When the dam height is increased beyond 325 feet (corresponding with a 1.9 maf reservoir capacity), some additional design problems are encountered because of the limited thickness of Rocky Ridge. Since the Newville Dam abutments would be founded on Rocky Ridge, a dam axis must be selected that protects the upstream face of the abutments without excess embankment spillover on the downstream side. Also, as the normal water surface elevation increases, additional saddle dams are required along Rocky Ridge. These issues will need to be addressed during feasibility-level studies. The previous dam design will be modified using current design criteria as the study continues.

Inlet/Outlet Structure

A single structure can convey water into the reservoir from the pumping plant and out of the reservoir to meet water supply demands. The outlet structure must also provide adequate capacity to meet emergency drawdown requirements. The outlet works should be able to selectively withdraw water from different reservoir levels to ensure high quality releases into Black Butte Lake. This structure would serve to divert creek flows around the dam site during construction.

Additional studies will be required to refine plans for this structure and modifications will have to be made depending on the reservoir size ultimately selected. However, this preliminary design revealed no unusual design or construction problems with this structure.

Spillway

A conventional, gated spillway with a concrete-lined chute and a stilling basin on the right abutment was selected for planning purposes. Deep gates were incorporated to let the spillway help meet the emergency reservoir evacuation flow of around 33,000 cfs. This flow estimate is for the 1.9 maf reservoir and would increase substantially if the capacity of the reservoir were increased to 3.0 maf.

Stony Creek Diversion Facilities

One-third to one-half of the inflow to Newville Reservoir could be derived from the mainstem of Stony Creek. Two plans are under consideration for conveying this water from Black Butte Lake to Newville Reservoir. The 32,500 af Tehenn Reservoir would be formed by a 112-foot-high earthfill dam that is 2,500 feet long. A gravity canal would convey water from Black Butte Lake to the base of Tehenn Dam, where the water would be pumped into Tehenn Reservoir, whose upper end terminates at the Newville Dam Pumping Plant. The total pumping lift from Black Butte Lake to Newville Reservoir would range from 210-to-470 feet, depending on the levels of the reservoirs. The possibility of stabilizing the operation of Black Butte Lake so that the water surface elevation varied within a narrow range to facilitate pumping will also be investigated.

A second alternative was developed in response to local concerns that Tehenn Reservoir would flood a historically significant cemetery. This alternative proposes a canal and pumping plants to convey water directly from Black Butte Lake to the Newville Pumping Plant. This alternative is only conceptual at present and design and cost-estimating work will be performed later. The 1980 Thomes-Newville Feasibility Report contains an extensive discussion of the Tehenn alternative.

Tehenn and Newville Pumping/Generating Facilities

The Tehenn plant would have to operate under variable level extremes of between 430 and 474-foot elevation for incoming water from Black Butte Lake. Water elevation in Tehenn Reservoir would normally be held at the spillway crest elevation of 610 feet. The plant would be located 2,000 feet downstream of

Tehenn Dam in a 120-foot deep bowl on the north side of the creek. The plant would connect to the reservoir through a 16-foot diameter welded-steel penstock.

The Newville pumping/generating plant at the toe of Newville Dam would lift water up to 370 feet from Tehenn to Newville Reservoir. The plant would be an 80 x 200-foot indoor facility with two pumping units, one pumping/ generating unit, and a service bay.

Thomes-Creek Diversion Facilities

The nearly 200-square mile Thomes Creek watershed produces an average annual runoff of around 200 taf. West of Paskenta, Thomes Creek passes within a half mile of a low saddle ridge separating its watershed from the Newville Reservoir drainage area. At this point, it would be relatively easy to divert the floodflows of Thomes Creek to Newville Reservoir. However, under today's stringent environmental requirements, there are several major obstacles associated with such a diversion: (1) preventing the diversion of fish; (2) allowing the free passage of fish around a diversion dam; (3) passing the creek's extremely large sediment load; and (4) minimizing interference with the migration of the large deer herd that winters in this area. Any one of these problems in isolation would probably be manageable, but combined, they present a formidable design challenge. Therefore, considerable future work remains to be completed. These obstacles may make this diversion option unfeasible and an alternative source of water would need to be developed.

Saddle Dams and Dikes

For a Newville Reservoir of less than 2 maf capacity, only one saddle dam at Burrows Gap would be required. This saddle dam would be located approximately 3 miles south of Newville Dam and would fill a saddle along Rocky Ridge. A 75-foot-high earth-rockfill embankment dam containing approximately 600,000 cubic yards of material and patterned after the Newville Dam section would likely be used. No unusual problems are anticipated in the design and construction of this relatively low dam.

If the capacity of Newville Reservoir were increased to 3 maf, Burrows Gap Saddle Dam would increase to a height of 150 feet and would require approximately 2.0 mcy of embankment material. Also, as the maximum reservoir capacity increases, within the range of 2.5 to 3.0 maf, two to five additional small saddle dams are required along Rocky Ridge. The total volume of these additional saddle dams would be less than 1 mcy. No appurtenances are proposed at any of the saddle dam locations. Similarly, as the maximum reservoir capacity varies between about 2.5 and 3.0 maf, a 30 to 70-foot-high Chrome Dike would be required at the southern end of the reservoir. This dike would require from 0.25 up to 1.7 mcy of fill material.

Potential Diversions from the Sacramento River

Earlier work on the Thomes-Newville Project, with reservoir capacities less than 2 maf, concentrated entirely on diversions from Stony and Thomes Creeks. However, as larger reservoir sizes up to 3 maf are considered, or if diversion problems are encountered on Thomes Creek, a diversion from the Sacramento River may be required.

Initial investigation of potential diversions from the Sacramento River using existing canals has been conducted, but much work remains to be done before specific design and cost estimates can be developed. Several potential alignments have been identified and initial reconnaissance-level evaluations have been made. More exact estimates will be completed after environmental analysis of comparative alignments has progressed.

Road and Utilities Relocations

There are about 8 miles of public roads within the prospective Newville Reservoir. The Paskenta-Round Valley route, a paved two-lane county road, passes through the north end of the reservoir for a distance of about 2 miles; another county road crosses northwest through the reservoir footprint from the dam site to connect with the Paskenta-Round Valley Road. The Glenn County portion of the road within the reservoir is about 2 miles long and is paved; the 4-mile portion within Tehama County is unpaved.

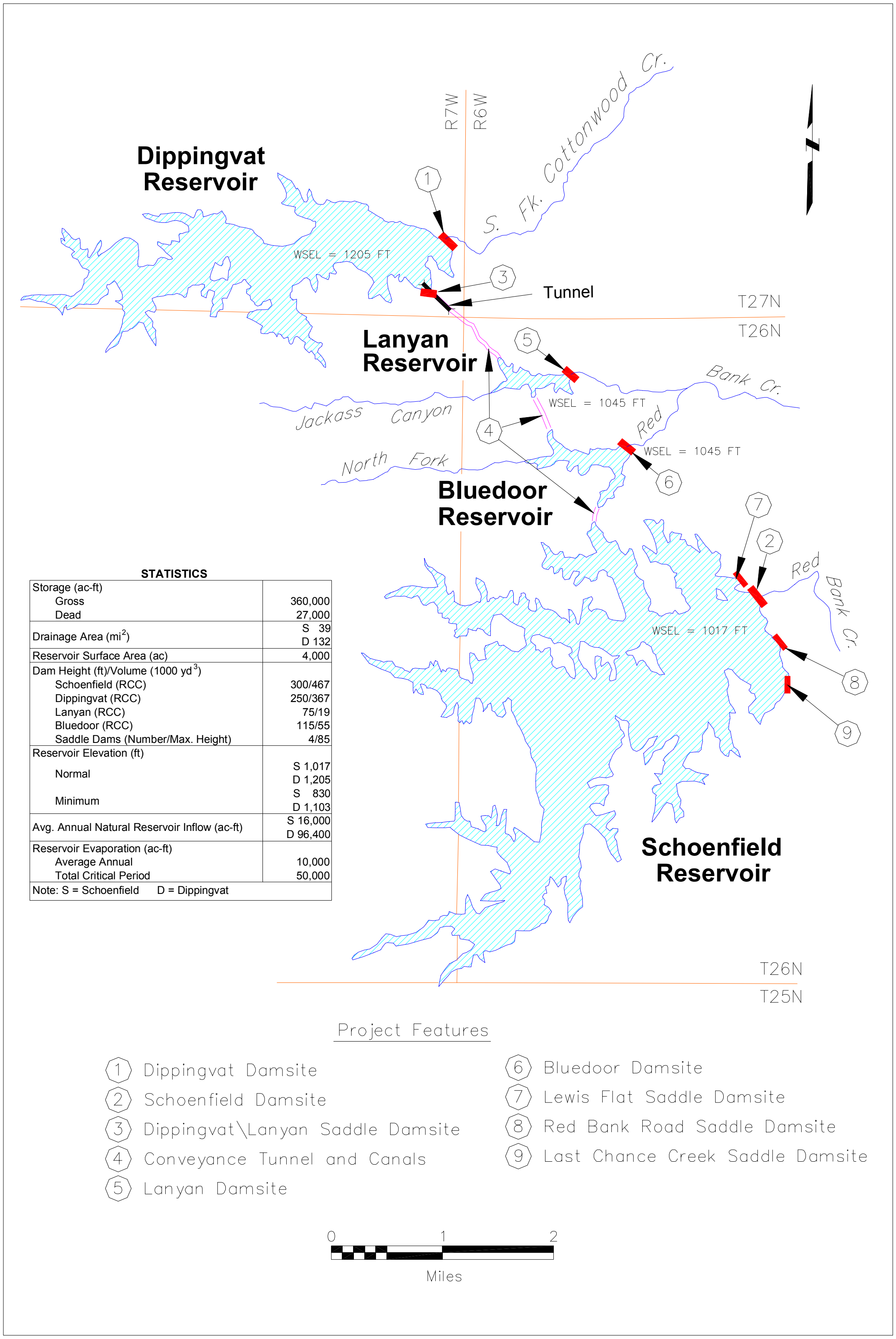
These roads would be relocated and upgraded to current county paved-road standards. The Paskenta-Round Valley Road would be realigned around the north end of the reservoir and the other road would be routed along the east side of Rocky Ridge to link Newville Dam site to the town of Paskenta. The length of new road construction would be about 10 miles. Any power lines or other utilities requiring relocation would follow the new road alignment whenever possible.

Red Bank Project

The Cottonwood Creek basin has been the subject of water development planning studies for more than 50 years. Located within the 927-square-mile watershed are two lower basin sites for large reservoirs, Tehama and Dutch Gulch, which were extensively investigated by the Corps in the late 1970s and early 1980s for flood control and water supply. Higher in the watershed are four smaller potential projects—Hulen, Fiddlers, Rosewood, and Dippingvat—that have been extensively investigated. Of these numerous potential projects, only Dippingvat appeared economically feasible in studies conducted in the late 1980s. It received continued low-level investigation until 1993, when study was suspended because of escalating project cost estimates.

Interest in Dippingvat Reservoir in combination with Schoenfield Reservoir on Red Bank Creek, known as the Red Bank Project (Figure 5-17), was renewed by CALFED around 1996. This renewed interest was motivated by the project's ability to supply water to the entrance of the Tehama-Colusa Canal. This would allow the Red Bluff Diversion Dam gates to remain raised for a longer period. As a result, the Red Bank Project was included as one of the four projects evaluated under the present Offstream Storage Investigation even though it is significantly smaller than the alternative projects. The pre-feasibility design alternatives report completed on the Red Bank Project in 1993 determined that RCC dams would be less expensive than equivalent earthfill dams at this location. Therefore, this progress report discusses only the RCC alternative. Additional future geologic

Figure 5-17. Red Bank Project Features and Statistics



STATISTICS

Storage (ac-ft)	
Gross	360,000
Dead	27,000
Drainage Area (mi^2)	S 39 D 132
Reservoir Surface Area (ac)	4,000
Dam Height (ft)/Volume (1000 yd^3)	
Schoenfield (RCC)	300/467
Dippingvat (RCC)	250/367
Lanyan (RCC)	75/19
Bluedoor (RCC)	115/55
Saddle Dams (Number/Max. Height)	4/85
Reservoir Elevation (ft)	
Normal	S 1,017 D 1,205
Minimum	S 830 D 1,103
Avg. Annual Natural Reservoir Inflow (ac-ft)	S 16,000 D 96,400
Reservoir Evaporation (ac-ft)	
Average Annual	10,000
Total Critical Period	50,000
Note: S = Schoenfield D = Dippingvat	

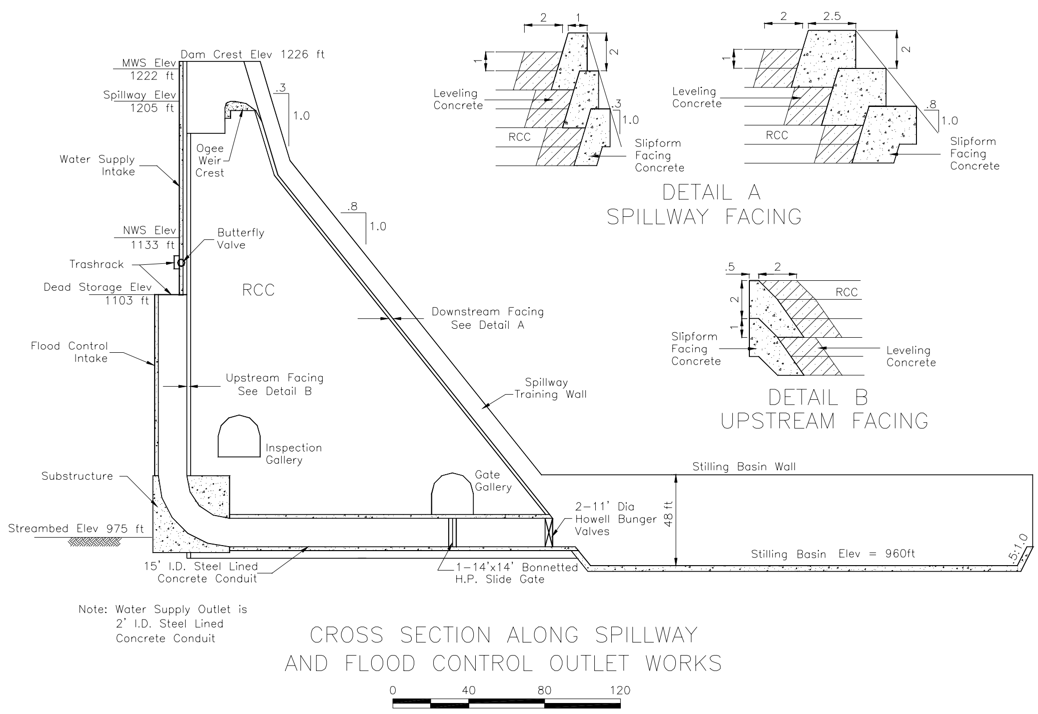
investigations will be required to determine the ultimate suitability of this type of dam at the project location.

Dippingvat Dam

Dippingvat Dam site is located on South Fork Cottonwood Creek, in a deep narrow canyon one-half mile downstream of Dippingvat Flat, Section 36, T27N, R7W. The proposed dam would be 250-feet high and would create a 104 taf reservoir. The average annual inflow to Dippingvat Reservoir is 96 taf captured by the 132 square mile upstream watershed. Dippingvat is an excellent dam site and Cottonwood Creek produces a substantial water supply. However, the reservoir's capacity is too small to capture the majority of the available runoff and also provide downstream flood control benefits. Therefore, a larger reservoir on nearby Red Bank Creek to help store excess Cottonwood Creek flows was thought desirable as part of the project.

Dippingvat Dam would be a 250-foot high RCC structure with a crest length of about 1,000 feet. The upstream face of the dam would be vertical and the downstream face would be sloped as shown in Figure 5-18. An earthfill dam was also evaluated at this location, but appears to be much more expensive than the RCC alternative. However, seismic investigations may determine that this site is not suitable for a RCC dam.

Figure 5-18. Dippingvat RCC Dam, Cross Section



Outlet and Spillway

The outlet works at Dippingvat Dam would be located through the dam near the center, at approximately streambed elevation. The outlet would be used to pass creek flows during construction. Discharge would be controlled by a dissipater valve at the end of each outlet as it transitions into a stilling basin. Maximum design velocity in the outlet pipe would be 35 feet per second.

Dippingvat Dam would have two outlets, a 15-foot diameter flood control outlet and a 2-foot diameter pipe to carry 60 feet per second for stream maintenance purposes. This stream maintenance outlet would draw from any of seven butterfly valves located along the upstream face of the dam to control outlet water temperatures.

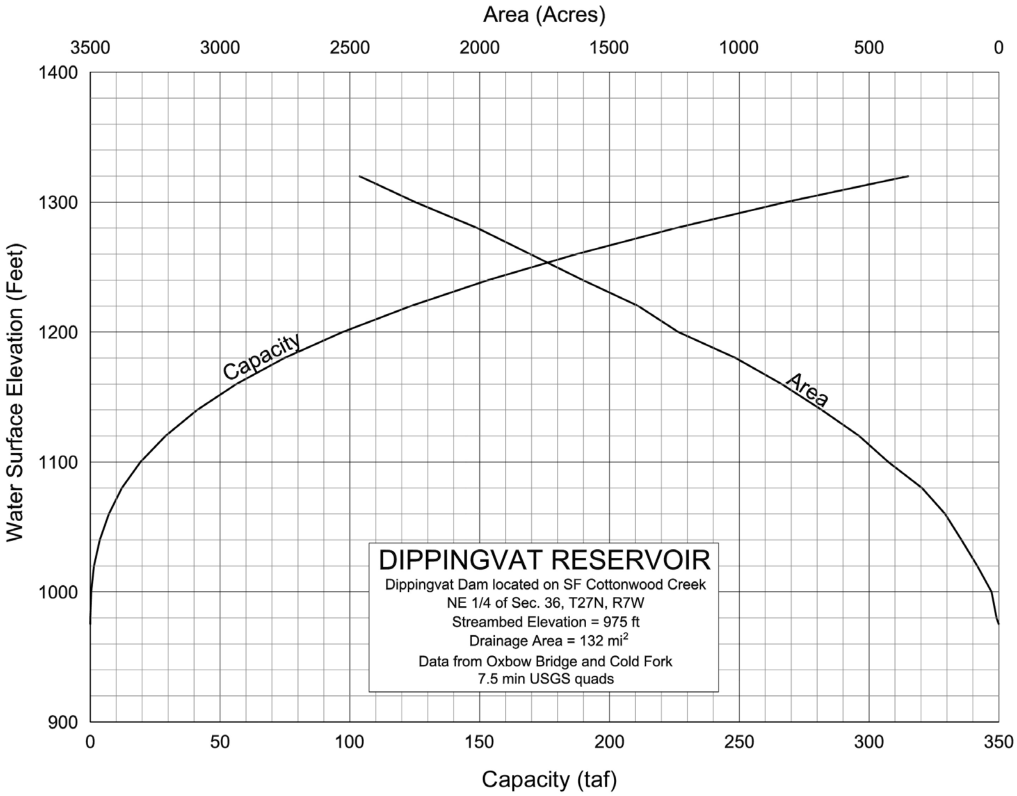
The spillway (Figure 5-19) at Dippingvat would be constructed as an integral part of the RCC dam face. Stepped concrete facing would line the spillway and help dissipate energy. The spillway would have a crest length of 200 feet and would be controlled by an uncontrolled ogee-type weir.

Figure 5-19. Dippingvat RCC Dam

Dippingvat Reservoir

At the spillway crest level, Dippingvat Reservoir would have a total storage of 104 taf and cover 1,270 acres. The area-capacity curves for Dippingvat Reservoir are shown in Figure 5-20. As planned in 1993, the reservoir would reach the spillway level only during major floods. Normally, the reservoir storage would be held at around 32 taf to maintain a 72 taf flood control reservation. These operating criteria could easily be modified in future studies if the level of flood control was changed.

Figure 5-20. Dippingvat Reservoir Area-Capacity Curves



Schoenfield Dam

Schoenfield Dam site is located on Red Bank Creek in a deep, narrow canyon known as the Narrows. This dam would form a 250 taf reservoir to store runoff primarily diverted from South Fork Cottonwood Creek. Water would be conveyed from Dippingvat to Schoenfield Reservoir through three short canals and two low dam reservoirs, Lanyan and Bluedoor.

Schoenfield Dam would be a 300-foot high RCC structure approximately 900 feet long. About 540,000 cubic yards of concrete would be required to build the dam and the cross section would be similar to that for Dippingvat Dam. An earthfill dam at this location is still a potential alternative if seismic investigations determine that the less expensive RCC dam is unsuitable.

Outlet Structure and Spillway

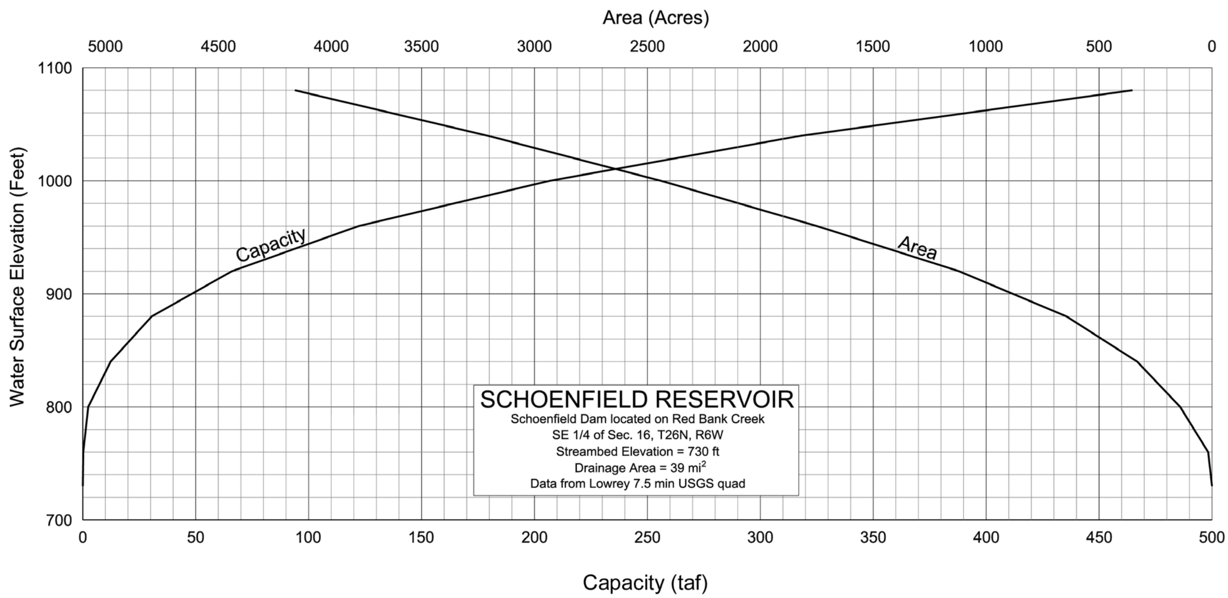
Schoenfield Dam would have a central overflow spillway constructed as part of the dam. The spillway crest length is limited to about 200 feet because of the narrow canyon floor at the downstream toe of the dam, which limits the width of the stilling basin. The maximum flow down the spillway resulting from the probable maximum flood is estimated at around 25,000 cfs.

Schoenfield Reservoir

At the spillway crest, Schoenfield Reservoir would store 250 taf of water and have a surface area of 2,770 acres. . The area-capacity curves Schoenfield

Reservoir are shown in Figure 5-21. The natural average inflow into the reservoir is around 16,000 af per year and the releases would be made down Red Bank Creek to the Tehama-Colusa Canal. Only low-level creek fishery maintenance releases would flow into the Sacramento River.

Figure 5-21. Schoenfield Reservoir Area-Capacity Curves



Conveyance System

Much of the Cottonwood Creek water captured by Dippingvat Reservoir would be conveyed to the larger Schoenfield Reservoir for long-term storage and ultimate release down Red Bank Creek. This water would be transported approximately 4 miles through three low ridges that separate the reservoirs. The conveyance system to accomplish this would consist of two small earthfill dams, a short linked tunnel/canal, and two other short canals. No fish screen is planned for placement at the entrance of the conveyance system because anadromous fish could not pass Dippingvat Dam.

Water would be diverted from Dippingvat Reservoir into an 8-foot diameter, one-half-mile long concrete-lined tunnel, capable of carrying 800 cfs. A one-mile unlined canal would carry the water to 1,200 af Lanyan Reservoir, formed by a 70-foot-high dam on Lanyan Creek. The water would then flow by gravity through a one-half mile canal from Lanyan Reservoir to 3,500 af Bluedoor Reservoir, formed by 90-foot-high Bluedoor Dam on the upper North Fork Red Bank Creek. From Bluedoor, a short canal would convey water to Schoenfield Reservoir. Lanyan and Bluedoor Reservoirs would normally be held at their maximum storage level to facilitate conveyance by gravity. Due to the gravity conveyance, water could only flow south through this system. The Lanyan and Bluedoor Dams were originally designed as conventional earthfill structures, but they could also be built as RCC structures.

Potential Future Studies

If study of the Red Bank Project continues, a canal-only conveyance alternative between the two major dams should be investigated. This would eliminate the need for Lanyan and Bluedoor Dams.

Also, a high dam on Cottonwood Creek would block salmon migration to suitable habitat on areas upstream of the dam. This has raised recent interest in investigating a low dam on Cottonwood Creek, which could divert surplus flows to Schoenfield Reservoir while still allowing fish passage. While the low dam alternative may be feasible, there would be significant impacts to the project's water supply yield and flood control and recreation benefits that would require considerable additional investigation to evaluate.

If interest in the Red Bank Project continues, the effect of potentially large flow reductions along Red Bank Creek should also be investigated. The amount of water diminished by percolation to groundwater and consumptive use by adjacent vegetation in the approximately 30 stream miles between Schoenfield Dam and the Tehama-Colusa Canal entrance would need to be determined. This flow reduction could be considerable, particularly during the summer months.

Chapter 6. Environmental Studies

Potential environmental impacts associated with the storage, allocation, distribution, and use of water in California are complex. These actions must be carefully evaluated to document adverse impacts and identify mitigation measures to avoid or reduce impact to less than significant levels. Many environmental laws affect the State's major water supply programs and environmental concerns play a major role in water policy and planning.

In order to comply with the myriad of environmental laws and regulations, extensive data on natural and cultural resources that could be affected by a proposed project must be compiled. To document fish, wildlife, and plant resources that could be affected by north of the Delta offstream storage projects, environmental field surveys have been initiated. To date, surveys have focused on the footprint of the reservoirs. Future evaluations will target completing surveys within the reservoir footprints and on areas outside the reservoirs where conveyance facilities, roads, recreation facilities, and other structures would be located.

This chapter summarizes the major laws influencing water supply facility planning, construction, and operation, and includes a summary of results of the environmental surveys conducted to date. The data from these field surveys will be used to evaluate potential impacts of proposed program alternatives. Detailed information on the environmental surveys can be found in separate appendices.

Major Laws Affecting Water Project Planning

In the late 1960s and the 1970s, State and federal lawmakers and natural resources managers began enacting laws and developing programs to address environmental and ecosystem problems associated with water supply development. This section discusses some of the major environmental laws affecting water project planning.

Endangered Species Act

Under the federal ESA, an endangered species is one that is deemed to be in danger of extinction in all or a significant part of its range, and a threatened species is one that is considered likely to become endangered in the near future. The ESA is designed to preserve endangered and threatened species by protecting individuals of the species and their habitat, and by implementing measures that promote their recovery.

The ESA sets forth a procedure for listing species as threatened or endangered. Final decisions on listings are made by USFWS and NMFS. Presently more than 650 species have been listed in the United States, of which 110 are native to California—the largest number in any state.

Once a species is listed, Section 7 of the act requires that federal agencies, in consultation with USFWS or NMFS, ensure that their actions do not jeopardize the continued existence of the species or habitat critical for the survival of that species. The federal fish and wildlife agencies are required to provide an opinion as to whether a proposed federal action would jeopardize the species. The opinion must consider reasonable and prudent alternatives to the action that would avoid jeopardizing the species' existence. Federal actions subject to Section 7 include issuance of federal permits such as the dredge and fill permit required under Section 404 of the federal Clean Water Act.

State and local agencies and private parties are subject to the ESA if their proposed projects require a federal permit. In addition, Section 9 of the ESA prohibits the "take" of an endangered or threatened species for which protective regulations have been adopted. "Take" has been broadly defined to include actions that harm or harass listed species or that cause significant loss of their habitat. Agencies and private parties are generally required to obtain a permit from USFWS or NMFS under Section 10(a) of the ESA before carrying out activities that may incidentally result in taking a listed species. The permit normally establishes conditions to avoid take of listed species and to compensate for habitat adversely impacted by the activities.

The ESA has been interpreted to apply not just to new projects, but also to ongoing project operation and maintenance. For example, maintenance activities along the California Aqueduct right-of-way may impact the San Joaquin kit fox, the blunt-nose leopard lizard, and the Tipton kangaroo rat, all species that have been listed as endangered. DWR initiated the Section 10(a) process to obtain a permit for the incidental take of species resulting from maintenance activities along the California Aqueduct. Another example is federal, State, and local operations in the Delta and upstream along the Sacramento River that are affected by biological opinions to protect winter-run salmon and Delta smelt.

California Endangered Species Act

The California Endangered Species Act requires that a project proponent obtain a Section 2081(b) permit to authorize the incidental take of State listed species. Should the project proponent already have a Federal Biological Opinion for species also listed by the State, DFG may authorize, under Section 2080.1, a statement of concurrence with the Federal Opinion as long as it is consistent with CESA. If additional State listed species may be affected by the project or should the State require additional conditions for State listed species, DFG may authorize, by a permit issued under Section 2081(b), the take of endangered, threatened, or candidate species. Under CESA, the project impacts must be fully mitigated and the applicant must provide assurances of adequate funding for implementation, compliance monitoring, and effectiveness of the measures identified and required for full mitigation.

Dredge and Fill Permits

Section 404 of the federal Clean Water Act regulates the discharge of dredged and fill materials into waters of the United States, including wetlands. The term "discharge of dredged and fill material" has been defined broadly to include the building of any structure involving rock, sand, soil, or other construction material in waters of the United States. No discharge may occur unless a permit is obtained from the Corps. Generally, the project proponent must agree to mitigate or have plans to mitigate environmental impacts caused by the project before a permit is issued. EPA has the authority to veto permits issued by the Corps for projects that EPA believes will have unacceptable adverse effects on municipal water supplies, fisheries, or recreational areas.

Section 404 requires that the project proponent demonstrate that a proposed project is the least environmentally damaging practicable alternative for meeting the project purposes. This requires an extensive and exhaustive evaluation of alternatives that may include non-structural alternatives. Mitigation of the proposed project is not even considered until this hurdle is passed.

Section 404 provides for the issuance of a general permit on a State, regional, or nationwide basis for certain categories of activities that will cause only minimal environmental effects. Such activities are allowed without an individual permit. Installation of a stream gaging station along a river levee is one example of an activity which falls within a nationwide permit.

The Corps also administers a permitting program under Section 10 of the 1899 Rivers and Harbors Act. Section 10 generally requires a permit for obstruction to navigable water. The scope of the permit under Section 10 is narrower than under Section 404 since the term “navigable waters” is more limited than “waters of the United States."

The majority of water development projects must comply with Section 404, Section 10, or both. For example, proposed facilities for orth of the Delta offstream storage, Phase II of the Coastal Branch for the SWP, Los Vaqueros for the Contra Costa Water District, as well as activities within Delta channels, are all subject to 404 jurisdiction and regulation.

New offstream storage facilities would probably require some type of authorization under Section 404 of the Clean Water Act (33 U.S.C. Section 1344). Section 404 regulates the placement of dredged or fill materials into the waters of the United States. The term “waters of the United States” includes any waters capable of use in interstate commerce, including use by migratory waterfowl. The term “dredged or fill material” includes virtually any material that could be used to create new storage. The Corps has the primary authority to regulate activities under Section 404. EPA has veto authority over any permit approvals of the Corps.

There are four ways that a new storage facility could achieve compliance with Section 404. First, a State or local implementing entity could obtain an individual permit under existing Section 404 authority, including implementing regulations promulgated by the Corps and the EPA. Second, a CALFED-implementing agency could proceed under a Memorandum of Understanding that is being drafted and negotiated and that outlines a process for compliance with the Section 404 (b)(1) Guidelines and other permitting issues. Third, the Corps could be the constructing entity, in which case there would be no Section 404 permit, but substantive compliance with Section 404 and the Section 404 (b)(1) Guidelines would be necessary. Fourth, an exemption could be pursued pursuant to Section 404 (r). Each of these options is explained in greater detail below.

1. **State or Local Implementing Entity Obtains Individual Permit**. Under this scenario, the implementing entity would proceed under the conventional individual permit process. This would entail completion of an alternative analysis and an analysis under the Section 404 (b)(1) Guidelines. The primary issue in this approach is the analysis of the least environmentally damaging practicable alternative (LEDPA) that achieves the project purpose. Under this analysis, a project proponent needs to

demonstrate that there are not other alternatives, such as water conservation measures, which would result in achieving the needed water supply. This approach would be the same if a federal entity (other than the Corps) were the project sponsor.

2. **CALFED-implementing Agency Proceeds under a Memorandum of Understanding.** Over the last several months, various CALFED entities have been attempting to negotiate an MOU regarding Section 404 compliance for the Stage 1 implementation. The parties which have been primarily involved in this effort include the EPA, the Corps, USBR, DWR, and CALFED staff. The draft MOU focuses on a path through the LEDPA analysis. For any proposed new surface water storage facility, the draft MOU specifies that as long as the overall CALFED program was "substantially attaining the performance measures for each of the water management tools" (all of which are part of the Stage 1 implementation), it would provide support for the Corps' LEDPA analysis that reasonable alternatives were being implemented to the maximum extent practical. The draft MOU reserves the Corps' authority to include new information in the record. The Corps would be free to analyze alternative locations for the proposed new surface storage facility. At present, negotiation efforts on the MOU have shifted to an executive level.
3. **Corps of Engineers as the Constructing Entity.** When the Corps constructs water facilities pursuant to its civil works or other authority, it does not obtain a permit for those features of a project which could be characterized as the placement of dredged or fill material. Instead, the Corps, through its Planning Branch (as opposed to the Regulatory Branch), analyzes the potential impacts and performs a Section 404 (b)(1) Guidelines analysis. This approach has the potential of streamlining the permitting process for new surface water storage facilities.
4. **Section 404 (r) Exemption.** Federal projects specifically authorized by Congress may be exempt under Section 404. Section 404 (r) states that a discharge of dredged or fill material is not prohibited if information on the effects of the discharge, including a consideration of the Section 404 (b)(1) Guidelines, is included in an EIS which has been submitted to Congress before any discharge and prior to either the authorization of the project or an appropriation of construction funds. There are few, if any, projects which have proceeded under this authorization. For this exemption to apply, the project must be a federal project. Second, there must be an EIS that includes the analysis of the impacts of the facility, including an analysis under the Section 404 (b)(1) Guidelines. Finally, Congress must authorize the project or appropriate the construction funds before any placement of dredged or fill material.

Migratory Bird Treaty Act

This federal act implements various treaties for the protection of migratory birds and prohibits the taking of birds protected by those treaties without a permit. The Secretary of the Interior is directed to determine conditions under which a taking may occur, and criminal penalties are imposed for unlawful taking or transportation of birds. Liability imposed by this act was one of several factors leading to the decision to close the Kesterson Wildlife Refuge.

National Environmental Policy Act

NEPA directs federal agencies to prepare environmental impact statements for all major federal actions that may have a significant effect on the human environment. It states that it is the goal of the federal government to use all practicable means, consistent with other considerations of national policy, to protect and enhance the quality of the environment. It is a procedural law requiring all federal agencies to consider the environmental impacts of their proposed actions during the planning and decision-making processes. The content of an EIS is very similar to that required by the California Environmental Quality Act for a State environmental impact report.

California Environmental Quality Act

CEQA, modeled after NEPA, requires California public agency decision-makers to document and consider the environmental impacts of their actions. It requires an agency to identify ways to avoid or reduce environmental damage and to implement those measures where feasible. It also serves as a means to encourage public participation in the decision-making process. CEQA applies to all levels of California government, including the State, counties, cities, and local districts.

CEQA requires that a public agency carrying out a project with significant environmental effects prepare an environmental impact report. An EIR contains a description of the project; a discussion of the project's environmental impacts, mitigation measures, and alternatives; public comments; and the agency's responses to the comments.

NEPA does not generally require federal agencies to adopt mitigation measures or alternatives provided in the EIS. CEQA, on the other hand, does impose substantive duties on all California governmental agencies approving projects with significant environmental impacts to adopt feasible alternatives or mitigation measures that substantially lessen these impacts, unless there are overriding reasons why they cannot. When a project is subject to CEQA and NEPA, both laws encourage the agencies to cooperate in planning the project and to prepare joint environmental documents.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act and related acts express the policy of Congress to protect the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources. Under this act, any federal agency that proposes to control or modify any body of water, or to issue a permit allowing control or modification of a body of water, must first consult with USFWS and State Fish and Game officials. This requires coordination early in the project planning and environmental review processes.

Public Interest Terms and Conditions

The California Water Code authorizes the State Water Resources Control Board to impose public interest terms and conditions to conserve the public interest, specifically the consideration of instream beneficial uses, when it issues permits to appropriate water. Frequently, SWRCB reserves jurisdiction to consider new instream uses and to modify permits accordingly.

Water Releases for Fish

California Fish and Game Code Section 5937 protects fisheries by requiring that the owner of any dam allow sufficient water at all times to pass the dam to keep in good condition any fisheries that may be planted or exist below the dam. In *California Trout, Inc. v. the State Water Resources Control Board* (1989), the court determined that Fish and Game Code Sections 5937 and 5946 require the SWRCB to modify the permits and licenses to the City of Los Angeles to appropriate water from Mono Lake tributaries to ensure sufficient water flows for fisheries purposes. In a subsequent case, the court of appeal ordered the Superior Court to set interim flow standards for the four tributaries that Los Angeles diverts. The Alpine County Superior Court entered a preliminary injunction prohibiting Los Angeles from diverting water whenever the Mono Lake level falls below 6,377 feet.

Streambed Alteration Agreements

Fish and Game Code Sections 1601 and 1603 require that any governmental entity or private party altering a river, stream, or lake bed, bottom or channel enter into an agreement with DFG. Where the project may substantially impact an existing fish or wildlife resource, DFG may require that the agreement include provisions designed to protect riparian habitat, fisheries, and wildlife. New water development projects and on-going maintenance activities are often subject to these sections.

Natural Community Conservation Planning

Adopted in 1991, California's Natural Community Conversation Planning Act established a program to identify the habitat needs of species before they become listed as threatened or endangered, and to develop appropriate voluntary conservation methods compatible with development and growth. This program is designed to preserve habitat for the variety of species that are dependent upon each other.

Participants in the program develop plans to protect certain habitat and will ultimately enter into agreements with DFG to ensure that the plans will be carried out. Plans must be consistent with endangered species laws. A pilot program has been established in Riverside, Orange, and San Bernardino Counties for the Coastal Sage Scrub, which exists in a habitat that has been diminishing. A number of endangered species, including the gnatcatcher, depend on this habitat. The Secretary of the Interior has endorsed this process, which may evolve into the approach of the future. Participation in these plans is not mandatory.

The Natural Community Conservation Planning Act is likely to play an important role in water development in the future. Water suppliers may participate in plans for habitat impacted directly by new water projects and indirectly in the areas that receive water supplies.

Need for Environmental Field Studies

Taken together, all of these environmental laws require that any agency proposing a major action such as construction of a large water project must conduct an extensive field evaluation of potentially affected natural and cultural resources.

The federal Endangered Species Act requires consultation with either USFWS or NMFS when any action threatens the continued existence of a species or its critical habitat. The State Endangered Species Act requires that a project proponent obtain a Section 2081(b) permit to authorize the incidental take of a State listed species. The Fish and Wildlife Coordination Act also requires consultation with USFWS and DFG to avoid damage to fish and wildlife resources. The federal Clean Water Act requires that a permit be obtained from the Corps, which can be obtained only after the affected resources are documented and plans are developed to mitigate any impacts. A complex set of federal and State laws and policies regulate preservation of historic and cultural resources, including cemeteries. Finally, NEPA and CEQA require disclosure of affected resources, potential environmental impacts, proposed mitigation measures, and alternatives.

At least 20 environmental permits would be required before a major water storage project could proceed. Each permit requires a detailed description of the potentially affected resources as the first step in determining what is affected, identifying measures to avoid impacts, and defining measures to mitigate for unavoidable impacts. The delineation of wetlands (identifying and mapping) is the first step of discussions with the Corps regarding the Clean Water Act and in consulting with the administering agencies regarding wetland species and the Endangered Species Acts.

This initial phase of the North of Delta Offstream Storage Investigation environmental evaluation focused on listed species. These are species that are listed as threatened or endangered by the federal and State Endangered Species Acts. It also evaluated sensitive species; those that could become listed as threatened or endangered in the near future. In future studies, the potential impacts on more common species, such as migratory deer or resident fish, will be evaluated.

The following sections describe the surveys and inventories undertaken to identify the sensitive plants, fish, animals, and their potential habitats, and the cultural resources that could be affected by the water diversion and storage projects under consideration. For some species, the regulatory agencies have defined guidelines, or protocols, that describe how the surveys should be conducted. When protocols have been defined, they were followed in conducting these surveys.

Table 6-45, at the end of this chapter, lists species that could occur in the counties in the west side of the Sacramento Valley where the proposed offstream storage reservoirs are located. The lists were based on a review of the California Natural Diversity Database and other references. The purpose of environmental field data collections and surveys is to verify the existence of these species in specific locations where offstream storage project facilities may be located. These are the species that determined the design of the various surveys and the species the survey teams were looking for in the field. Table 6-45 also shows the species that have been observed during two years of survey effort, and also the probability of other species that may be present in the area (based on preliminary habitat evaluations), but have not been observed to date.

Sacramento River Impact Analyses

An important element of the Offstream Storage Investigation is to evaluate the impact of diversions from the Sacramento River on the ecosystem. A common element of north of the Delta offstream storage alternatives is diversion from the Sacramento River during relatively higher flow periods. Options for Sacramento River diversion facilities extend from the existing Tehama-Colusa Canal intake at Red Bluff to a proposed new diversion opposite Moulton Weir, approximately 8 miles north of Colusa.

CALFED is developing a list of long- and short-term studies to address potential flow impacts of diversions for offstream storage between Colusa and Red Bluff. Short-term recommendations may include:

- Developing a daily time-step operations model to improve analysis of environmental effects of water management alternatives and operational constraints.
- Establishing new and improving existing data collection and analysis programs related to bed mobility, sediment transport, bank erosion, and channel migration.
- Completing detailed mapping of the current and historic distribution of riparian vegetation.
- Developing more detailed information on the relationship between riparian vegetation establishment and hydrologic factors that impact establishment.
- Developing a riparian establishment-geomorphic process model.

Long-term efforts should address the need for improved understanding of regulated flows on both physical and ecological processes related to maintaining riparian vegetation through adaptive management and targeted research. Several of the recommended efforts, such as data collection and analysis, updated mapping and surveys, and riparian-geomorphic process model development have been planned or are already being pursued.

Two University of California scientists, under contract with DWR, are developing tools to evaluate these impacts related to flow changes associated with offstream storage diversions. Two integrated computer-modeling efforts will quantify and assess geomorphic impacts related to meander migration patterns, and determine the associated evolution of the riverine-riparian habitat. Results from the models will be used to develop guidelines related to diversions for offstream storage.

Meander Migration Model

Eric Larsen, Ph.D., Geology Department, UC Davis, is extending the capabilities of an existing model designed to predict channel migration for a reach of river. Implementation of the mathematical model is expected to occur in five phases:

1. Further development and calibration of an existing meander migration model.
2. Quantification of the effect of flow changes on bank erosion within two study reaches of the Sacramento River. The study reaches are at Woodson Bridge and Bidwell River State Park and are approximately 8 and 10 miles, respectively.
3. Development of an interactive model for visualization of the model results using ortho-photo overlays.
4. Coupling the model with the habitat evolution model by providing compatible output from the meander model.
5. Extending the model to the remaining reaches of the river from Red Bluff to Colusa.

Vegetation Evolution Model

Steven Greco, Ph.D., Department of Environmental Design, UC Davis, is developing a model to predict the effects of changes in flows and flood regimes on the riparian ecosystem and habitats of several indicator species. The habitat evolution model will specifically use the results from the meander migration model as input. A number of additional models will be integrated including a Land Cover Classification Model, a Riparian Vegetation Succession Model, and a Habitat Model that will focus on specific indicator species.

Aquatic Resource Assessment

Understanding how changes in hydraulics and hydrology may influence aquatic resources is integral to evaluating impacts of diversion alternatives to the Sacramento River ecosystem. Tools to evaluate the impacts of different alternative diversion scenarios on fish and food web organisms in the Sacramento River between Keswick Dam and the Delta should be identified through a proposed two-phase approach conducted over a two-year period.

Phase I: ISI has developed a Request for Qualifications, will conduct interviews, and award a contract to the selected consultant. The contractor will be responsible for coordinating and conducting interagency and stakeholder scientific review team meetings and workshops. The function of the workshops and panels will be to develop the approach or framework to create an acceptable fisheries-hydraulics relationship. Conceptual models may be discussed and developed in conjunction with developing the approach to create working and acceptable tools for impact analyses. Tools used for fishery impact analyses may consider implications of concurrent developments in fluvial-geomorphology and riparian vegetation model results, and other population dynamics or hydraulic models available. Stakeholders will be consulted on a framework for fishery impact analyses, data applications, and identification of data required to complete the work.

Phase II: ISI will contract to develop working fisheries-hydraulics tools based on the results of the scientific review team recommendations. The contractor will continue to conduct review workshops to provide progress updates on tool development and receive feedback on specifics and application. The final product will be functional tools acceptable to agencies and stakeholders. The tools will be used to evaluate impacts on fisheries population as a result of changes in hydrology and hydraulics in the upper Sacramento River.

Wetlands Delineation

This section summarizes a two-year survey of wetlands and other "waters of the United States" within the reservoir footprints of the four potential offstream storage projects. Detailed information about the wetlands delineation can be found in Appendix B.

Stereo pairs of 1:12000 and 1:6000 scale color aerial photos were reviewed to identify wetlands and wetland vegetation prior to field studies. The aerial photography used in the wetland identifications was done in late spring 1998 to differentiate seasonal wetlands from annual grassland cover. Wetland types were identified on the photographs and representative types were selected throughout each reservoir area for field verification. Wetland delineations were made using the "routine method" as described in the 1987 *U.S. Army Corps of Engineers Wetland Delineation Manual*. Results of the wetland delineations and field verifications were used to produce a draft map of jurisdictional wetlands.

Sites Reservoir

Only 1.4 percent of the reservoir area was identified as jurisdictional wetlands. Of these jurisdictional wetlands identified within the Sites Reservoir footprint (Table 6-1), more than 76 percent are seasonal wetlands. Most of the alkaline wetlands are also "seasonal," but are vastly different in the plant species composition. The alkaline wetlands within the Sites Reservoir are located along a linear zone of deformation potentially associated with Salt Lake Fault. A small quantity (2 acres) of emergent wetland was identified within the Sites Reservoir.

The riparian areas found in the Sites Reservoir area are rarely well developed or large. The largest concentration of riparian habitat is located within the southern portion of the Sites Reservoir.

Many of the vernal pools found within the Sites and Colusa Reservoir areas are manmade (e.g., drainages blocked by roads, stock ponds, or disturbed areas within heavy clay soils) and have very low plant species diversities. Pools occurring along the northeastern edge of the Sites Reservoir tended to be larger in size and higher in plant species diversity than elsewhere.

Colusa Cell

Seasonal wetlands account for more than 84 percent of the Colusa Cell wetlands (Table 6-1). Most of the alkaline wetlands are also "seasonal" but are vastly different in the plant species composition. The alkaline wetlands within the Colusa Cell are located along a linear zone of deformation potentially associated with Salt Lake Fault. Emergent wetlands were present within the Colusa Cell in several small areas but these were not measurable using aerial photo interpretation.

The riparian areas found in the Colusa Cell were not well developed nor large. One large pool with higher plant species diversity occurs within the Colusa Cell.

Table 6-1. Jurisdictional Wetlands and Waters of the U.S. Delineation

Wetlands Type	Acreage by Reservoir			
	Sites Reservoir	Colusa Cell	Newville Reservoir	Red Bank Project
Alkaline	19	35	3	0
Emergent	2	0	6	included with seasonal
Riparian	22	11	77	76
Seasonal	153	263	304	7
Total Jurisdictional Wetlands	196	309	390	83
Streams	159	111	165	118
Ponds	16	24	66	34
Other Waters	175	135	231	152
Total Waters of U.S.	371	444	621	235
Reservoir Area	14,162	13,664	17,073	4,905

Newville Reservoir

Seasonal wetlands dominate (74 percent) the wetlands of the Newville Reservoir site (Table 6-1). Some of the wetland areas are very large in size and may form complexes with other types of wetlands including riparian areas. This site also has significant quantities of other wetland types.

Riparian areas account for more than 18 percent of the Newville Reservoir wetlands. Well-developed riparian habitat occurs along a number of the main tributaries, although patches of the invasive non-native *Ailanthus altissima* (tree of heaven) occur within some of these stands. Construction of the Newville Reservoir would result in the loss of 77 acres of good quality riparian habitat.

One small area of alkaline wetland was identified within the Salt Creek drainage. Other areas adjacent to Salt Creek and some of its tributaries supported alkaline species but were too narrow to map.

Vernal pool complexes, that is areas of concentrated pools and connecting swales, were found in several locations within the reservoir site. The pools of this reservoir alternative were of an overall higher quality when compared to the Sites and Colusa Reservoir areas.

Red Bank Project

Seasonal and emergent wetlands make up less than 9 percent of the wetland total for the Red Bank Project (Table 6-1). Many of these wetlands are located within or adjacent to small stockponds or are associated with saturated spring-fed areas. Clay soils are relatively rare within the steep terrain that dominates both the Schoenfield and Dippingvat Reservoirs.

Riparian areas dominate (92 percent) the wetlands of this area. Riparian areas can be found throughout the two reservoirs but are best developed along South Fork Cottonwood Creek and South Fork Red Bank Creek.

Special Status Shrimp Habitat Surveys

This section describes the methods and results of the mapping of potential special status shrimp habitat at the proposed Sites, Colusa, Thomes-Newville, and Red Bank Project areas.

Under contract with DWR, Jones & Stokes Associates ecologists performed surveys of potential special status shrimp habitat at the potential reservoir sites in 1998 and 1999. The 1999 surveys were conducted to verify potential special status shrimp habitat mapped in 1998 and to survey in areas where access was unavailable in the previous surveys because of flooded creeks, washed-out roads, and issues with property owners.

Special status shrimp include species in the following categories:

- Shrimp listed or proposed for listing as threatened or endangered under the federal Endangered Species Act (50 CFR 17.11 for listed animals and various Federal Register notices for proposed species)
- Other shrimp species meeting the definition of rare, threatened, or endangered species under the California Environmental Quality Act (State CEQA Guidelines, Section 15380).

The surveys focused on identifying potential habitat for the federally listed threatened vernal pool fairy shrimp (*Branchinecta lynchi*); the federally listed endangered Conservancy fairy shrimp (*Branchinecta conservatio*); the federally listed endangered vernal pool tadpole shrimp (*Lepidurus packardi*); and the rare, non-listed "Mid-Valley" fairy shrimp. Three fairy shrimp species, which are not special status species but are found in the same types of habitat, also have the potential to occur within the proposed project areas: *Branchinecta coloradensis, Branchinecta lindahli,* and *Linderiella occidentalis*.

The 1999 surveys were conducted between April 5 and May 21. Twenty-eight days (56 person days) were spent in the field. Aerial photographs and existing data from DWR and the 1998 survey results were used to select areas most likely to support special status shrimp habitat. Potential habitat was mapped conservatively in an effort to be as inclusive as possible. Potential habitat surveyed included vernal pools, alkali flats, clay flats, ephemeral stock ponds, pools, and salt lakes. Therefore, it is likely that the results of this study represent a high estimate of habitat extent. In certain instances, such as clay flats and non-vegetated artificial habitats that had dried for the season, precise boundaries were difficult to define and were estimated using best professional judgment. Future surveys conducted using the approved, more detailed USFWS protocol could result in identification of a lesser amount of actual special status shrimp habitat.

Typical habitat for special status fairy and tadpole shrimp in California include vernal pools, ponded areas within vernal swales, rock outcrop ephemeral pools, playas, alkali flats, and salt lakes. Other kinds of depressions that hold water of a similar volume, depth and area, and for a similar duration and seasonality, such as vernal pools and swales, also may be potential habitat. These other depressions, however, are typically artificial habitats and are unvegetated, yet bear an equal potential for supporting special status shrimp.

Pool volume is important in determining potential shrimp habitat. Deeper pools with a large surface area can more easily maintain their dissolved oxygen levels. Deep pools will also pond long enough to allow the shrimp to complete their life cycle.

Common wetland plant species that typically occur with special status shrimp species generally need the same hydrologic conditions (i.e., ponding depth, ponded surface area, ponding duration). Therefore, the presence of these plant species within a potential habitat would imply a greater potential for a population of these shrimp to be present. Conversely, pools that are dominated by vernal pool plant species that tolerate only short inundation periods will have hydrology that cannot support shrimp species (i.e., ponding duration too short, pool area too shallow). Similarly, wetland habitats that support plant species that need water year round cannot support special status shrimp species because the shrimp's cysts must dry out before they can hatch.

Therefore, potential special status shrimp habitat is defined as seasonal wetlands and other temporarily ponded areas of sufficient size (depth and area) and seasonality that may support specific vegetation. This vegetation indicates the potential for ponding for a sufficient duration to allow special status shrimp species to complete their life cycles and to maintain cool water temperatures conducive to special status shrimp species.

Unvegetated potential shrimp habitats (e.g., clay flats, road ruts, and alkali flats) were mapped to the perimeter (i.e., where the vegetation begins) or to high-water mark indicators such as drift lines or dams.

All habitats mapped during the 1998 survey effort were revisited, plus areas previously inaccessible were surveyed for additional potential special status shrimp habitat. Habitats fulfilling these criteria were mapped on U.S. Geological Survey 7.5-minute quadrangle maps. The shape and dimensions of the habitat sites were drawn and described in field notes and used to calculate habitat extent in acres.

A summary of potential special status shrimp habitat mapped in the 1998 and 1999 surveys is presented in Table 6-2. Potential habitat was mapped conservatively and the results represent a high estimate of habitat acreage. The highest quality, contiguous, potential special status shrimp habitat occurs at the Thomes-Newville Project site. A greater extent of habitat occurs at the Sites Project site area; however, this habitat is degraded by cattle activity, erosion, and debris from cattle feeding areas. The potential special status shrimp habitat at the Colusa Project site is similarly degraded by the activity of cattle, although not to the extent of the Sites Project site. Implementation of the proposed Red Bank Project would not result in impacts on special status shrimp or special status shrimp habitat.

Table 6-2. Total Acreage of Potential Special Status Shrimp Habitat

Potential Reservoir Site	Total Extent of Potential Special Status Shrimp Habitat (Acres)		
	1998 Survey	1999 Survey	Difference
Red Bank	0.0	0.0	0.0
Thomes-Newville	26	26	0
Sites	73	71	-2
Colusa Cell	12	12	0

Sites Reservoir

Grasslands and vernal pools on heavy clay soils in basin terrain characterize the Sites Reservoir area, with low ridge lines near the valley margins. Clay slumps are common along the ridges and clay flats occur in low-lying areas. The land is currently used for cattle and sheep grazing. During the 1999 surveys, 1.5 acres of potential special status shrimp habitat was determined to be incapable of supporting special status shrimp species based upon the dominant vegetation within those habitats. The revised total, potential, special status shrimp habitat is 71 acres.

Colusa Cell

The terrain within the Colusa Cell is characterized by grassland and vernal pools on heavy clay soils in basin terrain with low ridge lines near the valley margins. Clay slumps are common along the ridges and clay flats occur in low-lying areas. Cattle grazing is the main agricultural practice in the area. During the 1998 surveys, 11.8 acres of potential special status shrimp habitat were mapped within the Colusa Cell. Potential habitat was predominantly vernal pools, clay flats, and ephemeral stock ponds. During 1999, surveys identified an additional 0.3 acres of potential special status shrimp habitat.

Thomes-Newville Project

The Thomes-Newville Project site is characterized by grassland and vernal pools on clay soils and Lodo shale in foothill-type terrain. Cattle grazing is the primary agricultural practice in this area.

Potential habitat consisted predominantly of vernal pools and ephemeral stock ponds. During the 1999 surveys, an additional 0.3 acre of potential habitat was identified, making a total of 26 acres of potential special status shrimp habitat.

Red Bank Project

The Red Bank Project consists of two main components: Schoenfield Reservoir on Red Bank Creek and Dippingvat Reservoir on South Fork Cottonwood Creek. Two smaller components include Lanyan Dam and Bluedoor Reservoir on North Fork Red Bank Creek. The terrain at this site is generally too sloped to support habitat suitable for special status shrimp species. DWR staff conducting the botanical, wetlands, wildlife, and geological studies all indicated that the soils are well drained and there was very little to no potential habitat in any of the component cells of this project area.

The Red Bank potential offstream reservoir site does not support suitable habitat for special status shrimp species and is considered outside of the range of special status shrimp species.

Botanical Surveys

Plant communities were mapped and quantified within each reservoir site for broad scale resource inventory and assessment. See Appendix A for more information about botanical resources.

Rare plant surveys were conducted in the reservoir inundation areas according to established regulatory agency guidelines and protocols. Under these guidelines, focused habitat-specific surveys were conducted, using wandering transect methodology, between February and October in 1998 and 1999.

Sites Reservoir

Acreage estimates of mapped dominant vegetation types are presented in Table 6-3. California annual grassland was dominant at Sites Reservoir. Less than 10 percent of the vegetation in this reservoir is woodland (*Quercus* sp. or *Pinus sabiniana*), chaparral, riparian or vegetated wetland (*Eleocharis* sp.). Only six percent (923 acres) of the total inundation area of the Sites Reservoir supports oak woodland, which would be lost if the project is constructed.

Table 6-3. Acreage Estimates of the Dominant Vegetation Communities Mapped Within the Four Offstream Storage Reservoir Alternatives

Vegetation[1]	Acreage By Reservoir			
	Sites	Colusa Cell	Thomes-Newville	Red Bank
Grassland	12,602	13,540	14,492	565
Woodland (oak)	923	20	1,839	899
Woodland (foothill pine)	0	0	0	2,826
Chaparral	5	0	363	98
Riparian	52	37	64	73
Vegetated wetland	23	15	0	1
Cultivated grain	277	0	0	0
Vegetation Subtotal	13,882	13,612	16,758	4,462
Other	280	51	315	142
Total reservoir acreage	14,162	13,663	17,073	4,604

[1] Other classification refers to disturbed/developed acreage within the inundation elevations.

Colusa Cell

California annual grassland was dominant in the Colusa Cell (Table 6-3). Twenty acres of oak woodland was mapped at the Colusa Cell, which would be lost if the project is constructed.

Newville Reservoir

Acreage estimates of mapped dominant vegetation types are presented in Table 6-3. California annual grassland was dominant at the proposed Newville Reservoir site. The Newville Reservoir site supports valley and blue oak woodland vegetation more than 11 percent (1,839 acres) of the inundation area. There are good quality vernal pools with representation of common vernal pool flora; however, all the pools were grazed. No high priority species were found in any of the vernal pool habitat.

Thirty-one total occurrences of 4 low priority species and 23 occurrences of 5 priority species were identified in the Newville Reservoir site (Table 6-4).

Red Bank Project

Foothill pine woodland is the dominant vegetation in the proposed Red Bank Reservoir area. Oak woodland represents approximately 20 percent (899 acres) of the project area. The total amount of woodland habitat including foothill pine woodland and oak woodland comprises 83 percent of the vegetative cover. At this site, only 2 percent of the cover is chaparral scrub, and 12 percent (565 acres) is annual grassland. Potential habitat exists at this site for the chaparral, valley and foothill woodland, and valley and foothill grassland prioritized species. No vernal pool or alkaline wetland habitat was observed in the Red Bank Reservoir site. Ten prioritized plant species and 73 populations were found in this project area, including 39 priority species populations and 34 populations of low priority species (Table 6-4).

Table 6-4. Summary of Prioritized Plant Species Found in the Offstream Storage Reservoir Project, 1998-1999

Reservoir	Common Name (scientific name)[1]	Number of Occurrences[2]	Status[3] USFWS / CNPS
Sites	Fairy candelabra (*Androsace elongata* ssp. acuta)	3	– / List 4
	Hogwallow evax (*Hesperevax caulescens*)	3	-- / List 4
	Hoary navarretia (*Navarretia eriocephala*)	1	-- / List 4
	Tehama navarretia (*Navarretia heterandra)*	3	-- / List 4
Colusa Cell	Fairy candelabra (*Androsace elongata* ssp. acuta)	2	– / List 4
	Hogwallow evax (*Hesperevax caulescens*)	2	-- / List 4
	Hoary navarretia (*Navarretia eriocephala*)	1	-- / List 4
	Tehama navarretia (*Navarretia heterandra)*	1	-- / List 4
Thomes-Newville	Fairy candelabra (*Androsace elongata* ssp. acuta)	13	– / List 4
	Dimorphic snapdragon *(Antirrhinum subcordatum*)	7	—- / 1B
	Jepson's milk-vetch *(Astragalus rattanii* var. *Jepsonianus)*	1	-- / 1B
	Stony Creek spurge (*Chamaesyce ocellata* ssp *rattanii)*	7	-- / List 4
	Adobe lily (*Fritillaria pluriflora)*	12	SC / 1B
	Hogwallow evax (*Hesperevax caulescens*)	4	-- / List 4
	Tehama dwarf flax (*Hesperolinon tehamense)*	2	SC / 1B
	N.California black walnut (Juglans californica var. hindsii)	1	SC / 1B
	Tehama navarretia (Navarretia heterandra)	7	-- / List 4
Red Bank	Fairy candelabra (*Androsace elongata* ssp.acuta)	1	– / List 4
	Dimorphic snapdragon (*Antirrhinum subcordatum)*	23	-- / 1B
	Jepson's milkvetch (*Astragalus rattanii* var. *jepsonianus*)	*8*	-- / 1B
	Stony Creek spurge (*Chamaesyce ocellata* ssp *rattanii)*	9	-- / List 4
	Brandegee's eriastrum (*Eriastrum brandegeae)*	3	SC / 1B
	Adobe lily (*Fritillaria pluriflora)*	5	SC / 1B
	Woolly meadowfoam *(Limnanthes floccosa* ssp. *floccosa*)	1	--/ List 4
	Jepson's navarretia (*Navarretia jepsonii)*	8	– / List 4
	Tehama navarretia (*Navarretia heterandra)*	11	-- / List 4
	Sickle-fruit jewel-flower *(Streptanthus drepanoides*)	4	– / List 4

[1] Nomenclature corresponds to Skinner and Pavlik 1994;
[2] Occurrences are defined per California Native Plant Society 1999 as population findings separated by at least 0.25 miles;
[3] USFWS 1998: SC (Species of Concern); Skinner and Pavlik 1994; CNPS IB; (Plants rare, threatened or endangered in California and elsewhere); CNPS List 4 (Plants of limited distribution).

Valley Elderberry Longhorn Beetle Surveys

The valley elderberry longhorn beetle (VELB), *Desmocerus californicus dimorphus* Fisher, was listed by USFWS as threatened, with Critical Habitat on August 10, 1980 (Federal Register 45:52803-52807). Although there were no known VELB sites within the proposed reservoirs, habitat was known to exist within the project areas and known VELB locations were recorded nearby. The purpose of this survey was to identify and record the presence of VELB and its habitat (see Appendix C for more detail).

Surveys focused on identifying potential habitat for VELB, the number of elderberry stems found measuring one inch or more, and the presence of exit holes. All drainages and adjacent savannas were checked first with aerial photographs and then by field surveying all potential habitat.

Habitat for VELB occurs at each of the four proposed reservoir sites. VELB emergence holes were found within the proposed Sites and Newville Reservoir areas. No emergence holes were found within the proposed Colusa and Red Bank Project areas. No adult beetles were observed at any of the proposed reservoir sites. Six hundred seventy-two elderberry stems were counted within the Sites Project area. Emergence holes were found on 18 individual stems. Only one stand of elderberry (consisting of 38 stems) was found within the Colusa Cell. Five hundred fifty-two stems have been counted in the Newville Reservoir area. Emergence holes have been found in 42 stems. A total of 1,001 elderberry stems were found within the proposed Red Bank Project area. Two hundred ten elderberry stems were found at the Dippingvat Reservoir site. Seven hundred ninety-one individual stems were counted at the Schoenfield Reservoir site. No emergence holes were found at either proposed reservoir area. No elderberry plants were found at either the Bluedoor or Lanyan Reservoir sites, however, potential elderberry habitat does exist at both.

Areas not surveyed prior to this report, such as areas with restricted access, conveyance facility locations, and road relocations, will need to be surveyed. Analyses will also be needed to predict how possible changes in water regimes within the channels and associated savannas downstream will affect elderberry survival and distribution.

Avian Surveys

The purpose of the avian survey effort was to identify the occurrence, density, and distribution of State and federally listed species of birds that may occur within the proposed project areas. These data provide information to help evaluate and compare the potential project effects on State and federally listed avian species and their habitats at the four proposed reservoir locations. (See Appendix K for more detail).

A compilation of State and federal listed species, California Species of Special Concern, and federal Species of Management Concern which could potentially occur within the proposed reservoirs was developed from several sources including: Natural Diversity Database, California Wildlife Habitat Relationships Program, literature review, landowner interviews, USFWS lists, and consultation with species experts.

Three methodologies were used to determine presence, density, and distribution of State and federally listed bird species at the proposed reservoir locations including monthly avian line-transects, annual bank swallow surveys, and annual owl surveys using pre-recorded calls. The avian studies were primarily confined to the area of the reservoir footprint. However, line transects extended up to 2.5 miles from the reservoir footprints along key drainages. Surveys were initiated at the existing Funks Reservoir to document which State or federally listed avian species would use a reservoir within low elevation grassland habitats.

Line transects were established in representative habitat within proposed reservoir locations as access allowed, using standard avian line transect methodology (Emlen 1971). Transect length and initiation dates are identified in Table 6-5. Initial access for the transect surveys was obtained at different points in time, resulting in different numbers of transect repetition for each season at the four proposed project locations. Sites Reservoir data are most comprehensive as the 12.5-mile transect has been surveyed monthly since March 1997. DFG conducted avian surveys between 1980 and 1983 within the Stony and Thomes Creek watersheds as part of the fish and wildlife studies of the proposed Thomes-Newville Project.

Table 6-5. Avian Transect Lengths and Initiation Date

Reservoir Location	Transect Length	Date Initiated
Sites Reservoir	12.5 miles	March 1997
Colusa Cell	11.0 miles	October 1997
Newville Reservoir	19.5 miles	December 1998
Red Bank Project	16.0 miles	April 1998
Funks Reservoir (existing)	2.5 miles	October 1997

Line transects were surveyed either by foot or from a vehicle at a rate of two to three miles per hour. All State and federally listed avian species, California Species of Special Concern, and federal Migratory Nongame Birds of Management Concern detected were recorded. The distance from the transect line at the point of detection was recorded using a Tasco Lasersite Rangefinder. Detections were recorded on to field data sheets in 100-yard increments. Maximum range of the rangefinder of 800 yards (either side of the transect line) was used as the outer limit of the transect. State and federally listed species detected outside of the 800-yard limit were noted (presence), but not included in density estimates. Both 10X40 binoculars and a 15X60 spotting scope were used for field identification.

Information recorded included species, number of individuals, and lateral distance from the transect line at the point of first sighting. Data analyses followed methods of Balph et al. (1977). This method of line transect data analyses allows the field data to be used to determine differences in detectability between species and within the same species at different points in their life cycle, resulting in greater precision in density estimates.

Monthly transect results were consolidated into seasonal groups for density analyses. Seasons were defined based on the dates used by the California Wildlife Habitat Relationships Program for seasonal bird reports (Zeiner et. al. 1990). These seasonal breakdowns are based on documented migration and residency patterns of California species. Avian surveys were not conducted during periods of precipitation, high wind, or reduced visibility (fog or smoke).

Bank swallow surveys involved walking all permanent and ephemeral stream reaches with downcut channels during the bank swallow breeding season (May through July). All vertical banks were inspected for the presence of bank swallow burrows. All foraging swallows species were identified. All detections of burrows or foraging bank swallows were recorded.

Owl surveys were conducted at night along the previously identified line transect routes during May or June. Sampling was initiated at dusk. Methodology involved broadcasting pre-recorded calls using a tape recorder with external speaker at half-mile intervals. Each species call (burrowing owl, short-eared owl, and long-eared owl) was broadcast for 30 seconds followed by 30 seconds of silence to detect return calls. Three repetitions of each call/listen cycle were conducted for each species at each one-half mile interval along the line transects. All owl detections were logged. Owl surveys were not conducted during periods of high wind or precipitation.

Review of existing databases indicated that nine State or federally listed avian species may occur within Tehama, Glenn, or Colusa Counties. Three of these species were identified during avian transect sampling at or near the proposed reservoir locations: southern bald eagle, bank swallow, and greater sandhill crane (Table 6-6).

Sporadic wintering use by both adult and immature bald eagles has been documented at each of the four proposed reservoir locations. Wintering use was nearly an order of magnitude greater at Funks Reservoir than at any of the proposed reservoir locations. Fish and a large concentration of waterfowl are available as prey for bald eagles wintering at Funks Reservoir. Up to five bald eagles have been observed perched around the reservoir on one date. Extensive, winter, bald eagle surveys were conducted along Thomes Creek as part of the Thomes Reservoir studies in the 1980s. These studies confirmed extensive use of Thomes Creek by wintering bald eagles. No suitable nesting habitat is present in the vicinity of Sites, Colusa, or Newville Reservoirs. An adult and an immature bald eagle were observed together within the Red Bank Project area during late April 1998. No indication of nesting, other than these two sightings during the breeding season, has been observed.

A single sighting of a bank swallow was made near the proposed Colusa Reservoir Cell during avian transect sampling. This sighting was made during late September 1998 approximately 2.5 miles east of the proposed Colusa Reservoir Cell. This sighting represents a transient or migrating bank swallow rather than a breeding season use. DFG surveys conducted at the proposed Thomes-Newville Reservoir in the early 1980s identified two small bank swallow colonies along Thomes Creek downstream from the project area. Both of these historic colony locations appear to be outside the footprint of the proposed reservoir.

Five sandhill cranes were observed flying over the Colusa Reservoir site during November 1997. No actual habitat use was observed. This observation occurred on a date when the Sacramento Valley was fogged in while the adjacent foothill areas were fog free. Under these conditions sandhill cranes may set down and use foothill annual grasslands. No other sandhill crane observations at any of the other three reservoir locations were made during the sampling effort. No sandhill crane use was recorded during the three years of intensive study conducted at Thomes-Newville Reservoir during the early 1980s.

Table 6-6. State and Federal Listed and Special Concern Avian Species Which May Occur At North of the Delta Offstream Storage Reservoirs

Species	Status	Sites	Colusa	Newville	Red Bank	Funks
Aleutian Canada Goose	FT					
American bittern	MNBMC					X
American white pelican	CSSC					X
Bank swallow	ST		X			
Barrow's goldeneye	CSSC					
Bell's sage sparrow	MNBMC					
Burrowing owl	CSSC, MNBMC	X	X	X		
California gull	CSSC	X				X
California horned lark	CSSC, MNBMC	X	X	X	X	
Common loon	CSSC, MNBMC					X
Cooper's hawk	CSSC	X	X	X	X	
Double-crested cormorant	CSSC		X			X
Ferruginous hawk	CSSC, MNBMC	X				X
Golden eagle	CSSC	X	X	X	X	X
Grasshopper sparrow	MNBMC		X			X
Greater sandhill crane	ST		X			
Hermit warbler	MNBMC					
Lark sparrow	MNBMC	X	X	X	X	
Lawrence's goldfinch	MNBMC		X		X	X
Least bittern	MNBMC					
Loggerhead shrike	CSSC, MNBMC	X	X	X	X	X
Long-billed curlew	CSSC, MNBMC	X	X	X		X
Long-eared owl	CSSC	X	X	X	X	
Merlin	CSSC	X		X	X	
Mountain plover	CSSC, MNBMC					
Northern goshawk	CSSC, MNBMC					
Northern harrier	CSSC	X	X	X	X	X
Northern spotted owl	FE, SE					
Osprey	CSSC				X	
Peregrine falcon	SE					
Prairie falcon	CSSC	X	X	X	X	X
Purple martin	CSSC					
Sharp-shinned hawk	CSSC	X	X		X	X
Short-eared owl	CSSC, MNBMC					X
Southern bald eagle	SE, FT	X	X	X	X	X

Table 6-6. continued	Status	Sites	Colusa	Newville	Red Bank	Funks
Swainson's hawk	ST					
Tri-colored blackbird	CSSC, MNBMC	X	X	X		
Vaux's swift	CSSC, MNBMC					
Western snowy plover	CSSC, MNBMC					
Western yellow-billed cuckoo	SE, MNBMC					
White-faced ibis	CSSC, MNBMC					
White-tailed kite	MNBMC	X				X
Willow flycatcher	SE					
Yellow warbler	CSSC	X				
Yellow-breasted chat	CSSC					

KEY

CSSC=California Species of Special Concern
MNBMC=Migratory Nongame Birds of Management Concern (USFWS)
SE=State Endangered
ST=State Threatened
FE=Federal Endangered
FT=Federal Threatened
FPT = Federal Proposed Threatened
X=Observed at reservoir site indicated.

Nesting habitat for peregrine falcon, northern spotted owl, yellow-billed cuckoo, greater sandhill crane, and willow flycatcher is absent from the proposed reservoir sites. Marginal Swainson's hawk nesting/foraging habitat is present at Sites, Colusa, and Newville Reservoir locations and absent at the Red Bank Project area. Habitats within the proposed reservoirs offer very limited opportunity for wintering or migration use by Aleutian Canada goose, mountain plover, peregrine falcon, greater sandhill crane, and willow flycatcher.

Thirty-six avian species classified as either California Species of Special Concern or Migratory Nongame Birds of Management Concern may occur within Tehama, Glenn, or Colusa Counties. Twenty-five of these species have been observed at or near one or more of the proposed reservoir locations including: American bittern, American white pelican, burrowing owl, California gull, California horned lark, common loon, Cooper's hawk, double-crested cormorant, ferruginous hawk, golden eagle, grasshopper sparrow, lark sparrow, Lawrence's goldfinch, loggerhead shrike, long-billed curlew, long-eared owl, merlin, northern harrier, osprey, prairie falcon, sharp-shinned hawk, short-eared owl, tri-colored blackbird, white-tailed kite, and yellow warbler (Table 6-6).

Seasonal avian density estimates developed from line transect data for each of the four proposed reservoir locations are presented in Tables 6-7 through 6-10. Seasonal avian density estimates for the existing Funks Reservoir are shown in Table 6-11.

Table 6-7. Sites Reservoir Avian Transect Results (Density in Birds/Square mile)

Species	Summer	Fall	Winter	Spring
Burrowing owl	0.24	0.05		
California horned lark	4.83	1.58	2.90	6.57
Cooper's hawk		0.03		0.06
Ferruginous hawk			0.12	
Golden eagle	0.23	0.20	0.26	0.32
Lark sparrow	NS	NS	0.47	1.46
Loggerhead shrike	0.93	1.60	1.17	0.47
Long-billed curlew			14.59	1.26
Northern harrier	0.05	0.50	1.53	0.58
Sharp-shinned hawk		0.40		0.03
Southern bald eagle			0.07	
Tri-colored blackbird				5.38
White-tailed kite	0.12			0.12
Miles of transect per season	37.5	88.0	75.0	150.5

NS=Not Sampled

Table 6-8. Colusa Cell Avian Transect Results (Density in Birds/Square Mile)

Species	Summer	Fall	Winter	Spring
Bank swallow		0.14		
Burrowing owl		0.14		0.03
California horned lark	85.00	7.38	22.63	36.66
Cooper's hawk		0.14	0.27	
Double-crested cormorant				0.10
Golden eagle	0.22	0.32	0.24	0.30
Lark sparrow	NS	NS		0.80
Loggerhead shrike	0.89	2.15	1.84	2.82
Long-billed curlew				4.53
Northern harrier	1.00	0.67	0.87	0.50
Prairie falcon		0.14		
Sandhill crane		0.67		
Sharp-shinned hawk		0.14		
Southern bald eagle		0.04	0.03	0.10
Tri-colored blackbird	41.50			20.32
Miles of transect per season	20.0	74.5	38.0	87.5

NS=Not Sampled

Table 6-9. Newville Reservoir Avian Transect Results (Density in Birds/Square Mile)

Species	Summer	Fall	Winter	Spring
California horned lark	NS	NS	0.52	0.75
Cooper's hawk	NS	NS	0.17	
Golden eagle	NS	NS	0.10	0.13
Lark sparrow	NS	NS	7.64	1.50
Loggerhead shrike	NS	NS	2.05	0.90
Merlin	NS	NS	0.04	
Northern harrier	NS	NS	0.15	0.06
Prairie falcon	NS	NS	0.05	0.12
Southern bald eagle	NS	NS	0.08	
Tri-colored blackbird	NS	NS	0.69	2.41
Miles of transect per season			58.5	58.5

NS=Not Sampled

Table 6-10. Red Bank Project Avian Transect Results (Density in Birds/Square Mile)

Species	Summer	Fall	Winter	Spring
Cooper's hawk		0.07	0.16	0.26
Golden eagle	0.09	0.25	0.30	0.32
Lark sparrow	NS	NS	0.18	4.79
Lawrence's goldfinch			0.36	0.78
Merlin				0.07
Northern harrier		0.08	1.07	0.26
Osprey				0.13
Prairie falcon			0.00	0.13
Sharp-shinned hawk		0.19	0.40	0.06
Southern bald eagle		0.11	0.05	0.26
Miles of transect per season	25.5	53.0	55.0	68.0

NS=Not Sampled

Table 6-11. Funks Reservoir Avian Transect Results (Existing Reservoir) (Density in Birds/Square Mile)

Species	Summer	Fall	Winter	Spring
American bittern	0.84			
American white pelican		0.16	0.10	
California gull		0.32	1.84	0.43
Common loon				0.21
Cooper's hawk		0.48		
Double-crested cormorant	0.37	1.43	1.11	0.33
Golden eagle			0.13	0.05
Lark sparrow	NS	NS	8.18	
Loggerhead shrike		1.43	0.49	1.07
Long-billed curlew		4.20	17.73	
Northern harrier		0.53	3.89	0.75
Prairie falcon		0.09		
Sharp-shinned hawk			0.48	
Short-eared owl				0.43
Southern bald eagle			0.82	0.21
White-tailed kite			1.14	0.14
Miles of transect per season	6.0	21.5	18.0	20.5

NS=Not Sampled

Mammal Studies

A variety of field survey methods were used to sample the mammal populations at the four alternative sites. Preliminary research included general literature searches, consultation with agency and species experts, aerial photo habitat interpretations, and landowner interviews. In addition, DFG biologists reviewed the Natural Diversity Database; Wildlife Habitat Relationship System; the Federal Register of Threatened, Endangered, and Special Status Species; the 1983 *Thomes/Newville Status Report*; and the 1987 *Final Report on Reconnaissance Level Studies of the Fish and Wildlife Resources at the Dippingvat and Schoenfield Reservoir sites* to gather additional species information for each project area. A list was then compiled which included the following potentially occurring Special Status species of mammals. While the species listed below remain the focus of survey efforts, sampling has been designed to include the detection and assessment of all mammal species. (See Appendix E for detailed information).

Table 6-12. Mammal Species Surveyed at Proposed North of the Delta Offstream Storage Reservoirs

Species	Status
American badger *(Taxidea taxus)*	CSSC
Fringed myotis *(Myotis thysanodes)*	FSCS
Long-eared myotis *(Myotis evotis)*	FSCS
Long-legged myotis *(Myotis volans)*	FSCS
Pacific fisher *(Martes pennanti pacificus)*	FSCS, CSSC, SS
Pacific western big-eared bat *(Corynorhinus townsendii townsendii)*	FSCS, CSSC, SS
Pale big-eared bat *(Corynorhinus townsendii pallescens)*	FSCS, CSSC, SS
Pallid bat *(Antrozous pallidus)*	CSSC, SS
Pine marten *(Martes americana)*	SS
Ringtail *(Bassariscus astutus)*	CFPS
San Joaquin pocket mouse *(Perognathus inornatus inornatus)*	FSCS
Small-footed myotis *(Myotis ciliolabrum)*	FSCS
Spotted bat *(Euderma maculatum)*	FSCS, CSSC
Western mastiff bat *(Eumops perotis californicus)*	FSCS, CSSC
Western red bat *(Lasiurus blossivillii)*	SS
Yuma myotis *(Myotis yumanensis)*	FSCS, CSSC

Key

CSSC = California Species of Special Concern
CFPS = California Fully Protected Species
FSCS = Federal Special Concern Species
SS = Sensitive Species

After the development of the species list, field surveys were designed to assess the presence, distribution, and, where possible, the relative abundance of the mammal species at the four alternative project sites. Field investigation methods included small mammal live trapping, mist netting, acoustical surveys, roost and hibernacula searches, track plates, photo stations, spotlighting, general habitat measurements, walking transects, road transects, and incidental observations.

Small Mammal Trapping

H.B. Sherman live traps were used by DFG staff to inventory the small mammal (rodent) populations. The trap size used was 3 x 3.5 x 9 inches, the standard for conducting small mammal inventories. Traps were set for three consecutive nights and checked and closed at sunrise. All captures were identified, measured, marked, recorded on data sheets, and released back in the field. Traps were baited with a mixture of birdseed and crushed walnuts each afternoon approximately one-half hour before sunset. The initial surveys specifically targeted habitat areas identified from aerial photo habitat interpretations that appeared to have the greatest suitability for the target species. Those areas were ground checked and extensively surveyed with high densities of traps in an attempt to maximize capture success of Special Status species such as the San Joaquin pocket mouse.

During the current efforts, trapping grids were implemented for larger sampling areas. Trapping locations, or grids, were randomly selected from each of the habitat types and designed so that the number of samples represented the amount and coverage area for each of the habitat types on the alternatives, a technique known as stratified sampling.

The trapping grids consisted of 200 traps within a 100 X 100-meter square. The grids were established by field crews using a compass and 100-meter tape. Various colors of pin flags were used to mark the grids. One pin flag was placed every ten meters on the grid and two traps were set within two meters of each point (pin flag) on the grid.

Mist nets were the primary method of inventorying bat species. Nets were set over water sources (i.e., ponds, creeks, or water troughs), across draws or narrow canyons, in front of entrances of old buildings, in woodland or forest edges, and in small clearings within a woodland or forest. Various net sizes and configurations were used. Net configurations were primarily as simple as a single net, but often involved several single nets spaced throughout an area. Other net configurations included “joining” several nets together and arranging them to form V, L, and T shapes. These configurations were used primarily in areas where there was a lot of known bat activity, but where previous capture efforts failed.

All captures were removed from the nets immediately upon capture and placed in a handling bag for later processing. Processing was conducted at the conclusion of netting efforts or when bat activity became slow. This reduced the potential for counting individuals of any particular species multiple times. Captures were all identified, measured, recorded on data sheets, recorded on the Anabat Detector, and released back into the field.

The Anabat Detector and software (Anabat) with a laptop computer or tape recorder was used to conduct acoustical surveys for free-flying bat species. It is known that free flying bats can be difficult to survey and capture and the use of acoustical surveys can greatly increase the detection of bat species in a survey area (O’Farrell and Gannon 1999). The Anabat was primarily used to record free-flying bats at the net sites during the initial efforts. As the studies progressed, other survey techniques were implemented. These techniques included recording while night driving and/or walking and at stationary points. Walking and driving surveys helped field crews identify potential trapping sites. When bats were detected, crews stopped for one minute and continued recording. If bat activity continued, an additional five minutes of recording was conducted. Those areas with a great amount of bat activity were mapped for future trapping efforts since long periods of activity probably indicates either a foraging area or a roost location.

Visual surveys were conducted during the daytime hours in rock outcroppings, out buildings, tree cavities, woodlands, and snags for evidence of bat presence. Visual inspections with the aid of a flashlight, if needed, in a rock crevice or tree cavity enabled field personnel to locate potential and existing roosts. The location of the site was recorded and if the bat could be identified without disturbing the bat, the species was recorded. No bats were removed from the roost because it could cause them to abandon their roost.

Track plates were used to identify the presence of carnivores such as the marten and fisher. Track plates were set up in 3- to 4-foot square areas. The site was prepared by raking a relatively flat surface and placing an aluminum plate on the ground. The bait included chicken parts or pieces or approximately one and one half ounces of canned mackerel.

Track plates were placed at intervals of approximately 1,000 meters. They were checked every morning by DFG field staff. Any tracks were measured, identified, photographed, and recorded on data sheets. In addition, clear tape was used to lift the tracks from the plates and transfer to data sheets.

Trailmaster Camera set-ups were used to survey for carnivores in a method similar to the track plates. Two types of Trailmaster sensors were used, infrared and motion sensors. When triggered, the sensors sent a signal to the camera, which then took a photograph. The area was baited with canned mackerel, commercial baits or scents, chicken, road-kill deer, or fish.

Each event (detection by the sensor) was recorded in the sensor's memory, which also differentiated which events were photographed. The camera setups were checked each morning by field personnel and recorded on data sheets.

Spotlight surveys were conducted by two or three person crews using hand-held Q-beam spotlights (250,000 to 1,000,000 candle power) from a vehicle traveling between 10 and 15 miles per hour. When eye shine was detected, the vehicle was stopped and DFG personnel identified the species with the aid of binoculars or a spotting scope when possible. Eye shine characteristics such as color, body size, and general behavior of the animal were useful in identifying species (Morrel 1972). Information such as location, habitat, species, time, distance traveled on the route, and weather was recorded on data sheets each night. All accessible roads in the study areas were included in spotlight surveys. Surveys began approximately one-half hour after sunset and concluded at approximately midnight.

Field personnel conducted walking transects throughout the different habitat types on the project areas. This effort was designed and implemented specifically to detect badger denning sites and rodent burrow areas. Field personnel performed walking transects between 10 and 50 meters (33 and 164 feet) apart depending on terrain and ground cover. All potential denning sites and burrow areas were measured, mapped, counted, and recorded.

Road transects were used along with small mammal trapping to determine the prey base available to carnivores and raptors using the project areas. The main prey species sampled was the California ground squirrel (*Spermophilus beecheyi*). The technique involved driving the roads throughout the project areas at approximately 10 miles per hour and counting ground squirrels within 50 meters of the travel route.

Incidental observations were recorded by field personnel while conducting other, more formal, surveys. Observations from field personnel conducting surveys for other disciplines such as botany, birds, fish, and herps were also reported to DFG and recorded. Reports from other field personnel were verified where possible.

Initial field investigations were designed and focused to detect the presence and distribution of Special Status species in the proposed reservoir areas in order to provide decision-makers with some baseline information that might assist with assessing potential mitigation requirements. As the studies progressed, modifications were made to determine the presence and distribution of all mammal species in the alternative reservoir areas in an attempt to assess the cumulative potential impacts that would result from project construction.

General habitat measurements were made to assist with future efforts to conduct a Habitat Evaluation Procedure. Detailed vegetative inventories were conducted by DWR staff. DFG staff focused primarily on identifying habitat features such as snags, logs, burrows, and basic vegetation measurements such as plant heights and canopy cover while conducting other surveys such as trapping. This information was recorded and will be used in the future when the HEP Team is developed and begins the Habitat Suitability Index Model selection process.

As of August 13, 1999, six mammal species of Special Concern were documented at the four project areas (Table 6-13). The pallid bat (*Antrozous pallidus*) is the only species documented in all four of the project areas thus far in our efforts. The American badger (*Taxidea taxus*) and Yuma myotis (*Myotis yumanensis*) were documented in three of the sites. The western red bat (*Lasiurus blossivillii*) and ringtail (*Bassariscus astutus*) were documented in two of the sites, while the San Joaquin pocket mouse (*Perognathus inormatus inornatus*) was documented in only one of the sites.

Table 6-13. Sensitive Mammal Species by Project Area

Species	Sites	Colusa	Thomes-Newville	Red Bank
American badger	X	X	X	
Pallid bat	X	X	X	X
Ringtail	X		X	
San Joaquin pocket mouse			X	
Western red bat	X			X
Yuma myotis	X		X	X

Studies designed to evaluate the potential impacts of each of the alternatives on small mammals are not complete. Some areas have been surveyed lightly or not at all because of lack of vehicular access. Future surveys will require access to all areas throughout the year to allow a uniform effort at each of the alternative reservoir sites, which will be needed to make comparisons between the alternatives.

Fish Surveys

DFG initiated fish studies in 1997. Fish studies were conducted in the tributaries that flow through each of the four proposed project areas. Past studies were also reviewed and evaluated as part of this effort. Results and discussions of findings in past fishery studies and recently conducted surveys of fishery resources in the four proposed project areas are summarized in this section and included in Appendix D. Fishery studies conducted for the Sacramento River will be presented in a separate report.

Sites and Colusa Reservoir Projects

Fish studies for the Sites and Colusa Projects include three basic areas of study, fish resources in streams within the proposed reservoirs and in the Colusa Basin Drain, and habitat typing of the dominant streams in the proposed reservoirs (see Appendix D).

Studies of fish in streams that flow through the proposed Sites and Colusa Projects were conducted in 1998 and 1999. Thirty-six sample stations within the footprint of the project areas were seined to determine fish species composition. The stations were spread out among Hunter, Minton, Logan, Antelope, and particularly Stone Corral and Funks Creeks. Seven farm impoundment ponds in the area were also seined for fish.

Twelve species of fishes were caught in the Sites and Colusa study area in 1998 and 1999. Five species were game fishes and seven species were nongame fishes (Table 6-14).

Table 6-14. Fish Caught in the Sites Study Area in 1998 and 1999

Common Name	Scientific Name
Bluegill	*Lepomis macrochirus*
California roach	*Hesperoleucus symmetricus*
Chinook salmon	*Oncorhynchus tschawtscha*
Green sunfish	*Lepomis cyanellus*
Hitch	*Lavinia exilicauda*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Red-eared sunfish	*Lepomis microlophus*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento pike minnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentalis*
Sculpin sp.	*Cottus sp.*

Hitch were found in all the creeks in the Sites and Colusa Project areas. Hitch were also present in the greatest numbers. Stone Corral Creek had the greatest diversity of fishes throughout the year, eight species, including two species of introduced game fish, bluegill and green sunfish. However, fish densities were lower, particularly for Hitch in Stone Corral than in other creeks. The next most diverse creek, Funks Creek, had only five species of fish, including one introduced game fish, largemouth bass.

Most fish captured during seining were minnows, members of the Cyprinid family. California roach are the only fish present that are adapted to spending summers in the remaining pools of intermittent streams (Moyle 1976). Very few fish found while seining, including game fish, were above 5.9 inches long, suggesting that only juvenile fish rear in these areas. Adult fish typically ascend seasonal creeks in the study area in winter and spawn there in early spring. Most of the adults migrate downstream after they spawn.

Three game fish species were found in the seven ponds that were seined: red-eared sunfish, bluegill, and largemouth bass. Red-eared sunfish were found in one pond, bluegill were found in abundance in two ponds, and largemouth bass were found in three ponds out of the seven seined.

No species of concern or threatened or endangered species were found in this study. The species caught during the study are common in California.

Sites Reservoir

Stone Corral Creek. Eleven stations were sampled on Stone Corral Creek between July 15, 1998, and January 6, 1999. Eight species of fish were found in Stone Corral Creek, including two species of game fish, green sunfish and bluegill.

The fish that occurred at the most stations was the Sacramento pike minnow, followed by the hitch (Table 6-15). The density of fish on Stone Corral was relatively low for all species at all stations. Hitch were the dominant species in terms of density 0.8 fish/yd^2.

Table 6-15. Species Caught at Each Station and Relative Abundance in Stone Corral Creek

Species	Station Sampled											Fish/yd^2
	1	2	3	4	5	6	7	8	9	10	11	
Bluegill				X								0.002
California roach		X		X								0.02
Green sunfish			X					X	X	X	X	0.03
Hitch		X	X					X	X	X	X	0.8
Mosquitofish				X								0.002
Sacramento blackfish											X	0.2
Sacramento pike minnow			X	X	X	X		X	X		X	0.2
Sacramento sucker			X	X		X					X	0.02

Antelope Creek. Five stations were sampled on Antelope Creek between July 14, 1998, and November 25, 1998. Three species of fish were captured on Antelope Creek: green sunfish, hitch, and Sacramento pike minnow (Table 6-16). Hitch were the most abundant fish with an average density of 3.8 fish/yd^2. The Sacramento pike minnow and the green sunfish both had a relative abundance of 0.2 fish/yd^2. A single spring-run chinook salmon swam up Antelope Creek in the spring and died in a pool in early summer. Habitat in Antelope Creek does not support salmon because the creek nearly dries up each summer. The remaining water is too hot to allow salmon to survive there.

Table 6-16. Species Caught at Each Station and Relative Abundance in Antelope Creek

Species	Station Sampled					Fish/yd^2
	1	2	3	4	5	
Green sunfish		X		X	X	0.2
Hitch	X	X	X	X	X	3.8
Sacramento pike minnow				X	X	0.2

Funks Creek. A total of fifteen stations were sampled on Funks Creek between July 22, 1998, and January 8, 1999. Funks Creek had five species of fish, including one introduced game fish, largemouth bass. The most common fish in Funks Creek was the hitch, with an average density of 3.1 fish/yd^2 (Table 6-17). Hitch were caught in 11 out of 15 stations seined.

Table 6-17. Species Caught at Each Sample Station And Relative Abundance in Funks Creek

Species	Station Sampled															Fish/yd^2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Hitch			X	X	X	X	X	X	X	X	X	X	X			3.1
Largemouth bass									X			X				0.001
Sacramento pike minnow					X	X			X				X			0.06
Sacramento Sucker					X	X			X	X			X			0.02
Sculpin														X		---

The most diverse sections of Funks Creek that were sampled were in the lower reaches, stations 5, 6, 9, 10, 12, and 13. The upper reaches of Funks Creek that were sampled either lacked fish or only one species was found. Hitch densities varied widely throughout the creek, and no one area seemed to maintain a higher population.

Colusa Cell

Hunters Creek. Three stations were seined on Hunters Creek between July 22, 1998, and August 3, 1998. Only two species of fish were found on Hunters Creek, mosquitofish and green sunfish. Both species were found in two of the three stations (Table 6-18). Mosquitofish were found in a relative abundance of 3.8 fish/yd^2, but they only occurred in abundance at one station. Green sunfish were found to have an average density of 2.3 fish/yd^2.

Table 6-18. Relative Abundance of Fish Caught in Hunters Creek

Species	Fish/yd^2
Green sunfish	2.3
Mosquitofish	3.8

Minton Creek. Minton Creek was sampled in two locations in August 1998. Hitch were found in one of those stations, at a density of 0.5 fish/yd^2.

Logan Creek. Four stations were sampled on Logan Creek in August 1998. Hitch were caught in stations 1 and 2. The average density of hitch on Logan Creek was 0.4 fish/yd^2.

Colusa Basin Drain

The Colusa Basin Drain is a natural channel that historically transported water from west side tributaries such as Willow, Funks, Stone Corral, and Freshwater Creeks to the Sacramento River. It also carried overflowing floodwater from the Sacramento River. With the advent of agriculture in the Sacramento Valley, the CBD was channelized and dredged to carry agricultural runoff in addition to natural flows.

The CBD provides little bank cover for fish; however, some instream cover is provided by large and small woody debris. Its banks are scoured by periodic high flows and roads often run along the dikes that contain the waters of the CBD. The bottom of the CBD is largely mud. Water in the CBD is turbid and warm in the summer, and turbid and cool during the winter. The proposed diversion from the CBD for Sites and Colusa Reservoirs will be east of the town of Maxwell along the CBD.

Two fyke nets were placed in the Colusa Basin Drain, one upstream of the diversion point and one downstream, to sample fish. Periodic seining, seine and hook, and line sampling were also used to sample the fish of the CBD at the upper net location.

A total of 9 game fish and 17 nongame fish were caught (Table 6-19). The warmouth (*Lepomis gulosus*) and the largemouth bass *(Micropterus salmoides*), which were caught by USGS in 1996, were not observed in the recent surveys.

Table 6-19. Resident Fish of the Colusa Basin Drain.

Common Name	Scientific Name
Game Fish	
Black bullhead	*Ictalurus melas*
Black Crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tschawtscha*
Green sunfish	*Lepomis cyanellus*
White catfish	*Ictalurus catus*
White Crappie	*Pomoxis annularis*
Nongame Fish	
Big scale logperch	*Percina macrolepida*
California roach	*Hesperoleucus symmetricus*
Carp	*Cyprinus carpio*
Fathead minnow	*Pimephales promelas*
Goldfish	*Carassius auratus*
Hitch	*Lavinia exilicauda*
Inland silversides	*Menidia beryllina*
Mosquitofish	*Gambusia affinis*
Pacific lamprey	*Lampetra tridentata*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento pike minnow	*Ptycholcheilus grandis*
Sacramento splittail	*Pogonichthys macrolepidotus*
Sacramento sucker	*Catostomus occidentalis*
Sculpin sp.	*Cottus sp.*
Threadfin shad	*Dorosoma pretenense*
Tui chub	*Gila bicolor*
Tule perch	*Hysterocarpus traski*

Thomes-Newville Project

DFG initiated studies of the impacts on fish and wildlife of a Thomes-Newville Project in 1979 as part of DWR's Thomes-Newville Reservoir planning studies. However, the planning studies were halted in 1982. DFG completed a report of its abbreviated studies in 1983 (Brown et al. 1983). In 1998, DFG initiated studies of fish and wildlife resources of a Thomes-Newville Project as part of the North of Delta Offstream Storage Program. A brief survey of spring-run chinook salmon was conducted during the recent investigations. This section discusses recent findings and recapitulates the effort and results of the 1982 study (Brown et al. 1983).

Seining for juvenile chinook salmon in Stony and Thomes Creeks was done over three years, 1980 to 1982. Carcasses of chinook salmon were counted to estimate the number of adult salmon in Stony and Thomes Creeks. On June 13, 1979, August 18, 1980, and August 12, 1998, Thomes Creek was surveyed to enumerate spring-run chinook salmon and summer-steelhead. A fyke net was placed in the creek near the mouth of Thomes Creek to capture juvenile and larval Sacramento sucker and Sacramento pike minnows migrating to the Sacramento River. Streams in the footprint of proposed Newville Reservoir were sampled by electrofishing 1981 and 1982.

Thomes Creek

Juvenile Chinook Salmon and Steelhead

Thirteen juvenile chinook salmon were captured by seining during the 1980 sampling period (Table 6-20). These fish were caught in lower Thomes Creek from March 20 to May 24, 1980. Six juvenile chinook salmon were captured by seining during the 1981 sampling period. One of these fish was from Coleman National Fish Hatchery.

Table 6-20. Juvenile Chinook Salmon Seined from Thomes Creek in 1980 and 1981 (Brown et al. 1983).

Sample Period	Number of Weekly Seinings	Number of Fish	Average Length of Fish (in)
1980			
March	4	5	2.8
April	5	8	2.8
Total	9	13	
1981			
March	2	5	4.1
April	1	1	2.3
Total	3	6	

Seven juvenile steelhead were captured by seining in Thomes Creek in 1981. Four of these fish were probably from Coleman National Fish Hatchery. They had rounded fins and deformed dorsal fins, which are a characteristic of hatchery-grown fish.

In 1981, 206 juvenile chinook salmon were captured by fyke netting in Thomes Creek, 20 from the main stem, and 186 from the Tehama-Colusa Canal discharge canal (Tables 6-21 and 6-22).

Table 6-21. Fyke Net Catches of Juvenile Chinook Salmon from Main Stem of Thomes Creek in 1981 (Brown et al. 1983)

Sample Period	Hours Fished	Number of Salmon	Average Length of Fish (in)
February	672	0	0
March	744	9	2.7
April	648	10	3.1
May	336	1	2.7
Total	2,400	20	

Table 6-22. Fyke Net Catches of Juvenile Chinook Salmon from the Tehama-Colusa Canal Discharge Channel in Thomes Creek in 1981 and 1982 (Brown et al. 1983)

Sample Period	Number of Fish	Average Length of Fish (in)
1981		
January	1	1.4
February	126	1.3
March	59	1.3
Total	186	
1982		
January	2	1.4
February	45	1.4
March	337	1.5
Total	384	

No juvenile chinook salmon or steelhead were captured by seining or fyke netting in the main stem of Thomes Creek during the 1982 sampling period. However, 384 juvenile chinook salmon were captured by fyke netting in the Tehama-Colusa Canal discharge channel. The first fish was captured during the first week of January, but the bulk of the emigration did not occur until the third week of February.

Adult Chinook Salmon

1980-81 Fall-Run Estimate. Fifty-nine chinook salmon carcasses were tagged during 12 surveys of Thomes Creek. Twenty-three of these carcasses were recovered. From these data an estimated 155 salmon spawned in Thomes Creek during the sampling period. Live fish were first observed in the creek November 11, 1980, but the first carcass was tagged 9 days later. The last carcass was tagged on January 12, 1981.

Fifty-seven (97 percent) of the fish tagged were located in the Tehama-Colusa Canal outlet channel. Only two fish (3 percent) were tagged in the mainstem. Observation of six redds and four live fish indicate there was some spawning activity in areas below Henleyville.

1981-82 Fall-Run Estimates. Thirty-eight chinook salmon carcasses were tagged during 10 surveys of Thomes Creek. Twenty of these carcasses were recovered. From the data an estimated 167 salmon spawned in Thomes Creek during the sampling period. All of the fish recovered were located in the Tehama-Colusa Canal outlet channel. No live fish or redd were seen in the mainstem.

1979-1980 Spring-Run Estimates. No adult anadromous salmonid was seen during the June 1979 or August 1980 spring-run chinook salmon surveys in Thomes Creek. Numerous juvenile steelhead and brown trout were seen in the area of the survey which may indicate that habitat for spring-run chinook salmon or summer steelhead may exist.

1999 Spring-Run Estimates. One adult spring-run chinook salmon was seen during August 1999 diving surveys in Thomes Creek. As in 1980, numerous juvenile steelhead and brown trout were seen in the area of the survey.

1979 Late Fall-Run. The late spawning characteristics of a few chinook salmon indicate that they were of the late fall-run. Those that spawned in late December and January were salmon of this race.

Resident Fishes and Migratory Nongame Fish

Twenty-two species of fish were observed in Thomes Creek (Table 6-23). DFG staff developed population and biomass estimates for 13 of these species (Table 6-24). Three species were gamefishes and 10 were nongame fishes. While steelhead were the most abundant fish above the Gorge, Sacramento pike minnow, Sacramento suckers, hardhead, California roach, and speckled dace were the more common fish below.

Most of the nongame fish that were caught in the reach below the gorge were juveniles, indicating that this reach serves mainly as a spawning and rearing area. Adult Sacramento suckers, Sacramento pike minnow, California roach, and hardhead migrate annually from the Sacramento River into Thomes Creek and its tributaries to spawn. Juveniles that do not emigrate immediately after hatching remain to rear until the following rainy season when water flows to the mouth.

Thomes Creek below Paskenta usually dries up except for a few residual pools scattered along the streambed during the late summer, making it impossible for resident adult fish to live throughout the summer months. Some adult game fish such as largemouth bass and smallmouth bass, bluegill, and green sunfish ascend the creek from the Sacramento River during the late spring and early summer to use these pools as spawning areas.

Table 6-23. Fish Species Found in Thomes Creek in 1982 (Brown et al. 1983).

Common Name	Scientific name
Bluegill	*Lepomis machrochirus*
Brown bullhead	*Ictalurus nebulosus*
California roach	*Lavinia symmetricus*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Golden shiner	*Notemigomus crysoleucus*
Goldfish	*Carassius auratus*
Green sunfish	*Lepomis cyanellus*
Hardhead	*Mylopharodon conocephalus*
Hitch	*Lavinia exilicauda*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Pacific lamprey	*Lampetra tredentata*
Prickly sculpin	*Cottus asper*
Sacramento pike minnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentatlis*
Smallmouth bass	*Micropterus dolomeiu*
Speckled dace	*Rhinicthys osculus*
Steelhead	*Onchorynchus mykiss*
Threespine stickleback	*Gasterosteus aculeatus*
Tule perch	*Hysterocarpus traski*
White catfish	*Ictalurus catus*

Table 6-24. Average Population Estimates and Biomass Estimates for Fish Caught in Sections of Thomes Creek in 1982 (Brown et al. 1983).

Species	Average Population Estimate	Average Biomass (lb/acre)
Bluegill	3	4.5
California roach	41	10.7
Carp	90	64.2
Goldfish	1	19.2
Green sunfish	14	15.2
Hardhead	47	47.3
Hitch	1	0.4
Largemouth bass	5	8.0
Prickly sculpin	1	1.8
Sacramento pike minnow	337	89.2
Sacramento sucker	143	16.1
Speckled dace	229	16.1
Tule perch	1	0.2

Stony Creek

Juvenile Chinook Salmon and Steelhead

During the 1980 sampling period, 181 juvenile chinook salmon were caught by seining (Table 6-25). Salmon were first caught during the second week of February, while the last salmon was caught during the first week of May. During the 1981 sampling period, 73 juvenile chinook salmon were captured by seining. Fish were first captured during the third week of February while the last fish were captured during the second week of April. During the 1982 sampling period, only four juvenile chinook salmon were captured by seining. Two fish were captured during January and two were captured during the first week of March.

Table 6-25. Juvenile Chinook Salmon Seined from Stony Creek in 1980, 1981, and 1982 (Brown et al. 1983).

Sample Period	Number of Fish	Average Length of Fish (in)
1980		
February	64	1.7
March	51	1.8
April	60	2.0
May	6	3.0
Total	181	
1981		
February	5	1.5
March	64	2.1
April	4	3.0
Total	73	
1982		
January	2	3.3
March	2	1.7
Total	4	

Adult Chinook Salmon

1981-82 Fall-Run Estimates. Thirty-six chinook salmon carcasses were tagged during five surveys. Two of these were recovered. From these data, DFG estimates that 393 salmon spawned in Stony Creek during the sampling period. Twenty-five fish (69 percent) were females while 11 fish (31 percent) were males. This represents a male-female ratio of 1:2.3.

Most of the spawning activity was located in lower Stony Creek in the reach between Interstate 5 bridge and the North Diversion Dam. At least 35 redds and 29 carcasses were counted in this area.

Resident Fish Surveys

Six species of fish, two game species and four nongame species, were captured in streams potentially inundated by the Newville Reservoir. These streams include North Fork Stony Creek, Salt Creek, and Heifer Camp Creek. Rainbow trout were captured in sections of streams above the inundation line where the water is cool and cover is abundant. California roach, Sacramento pike minnow, and Sacramento sucker, carp and green sunfish were captured in sections of streams below the inundation line. California roach, Sacramento pike minnows, and Sacramento suckers were more abundant species, while carp and green sunfish are relatively uncommon (Tables 6-26 and 6-27).

Table 6-26. Population Estimates for Fishes Caught in Selected Sections of Streams Within the Newville Reservoir Site in 1983 (Brown et al. 1983).

Species	North Fork Stony Creek	Salt Creek	Heifer Camp Creek
California roach	4	546	120
Carp	1		
Green sunfish	-	13	
Rainbow trout	-	24	8
Sacramento pike minnow	12	24	85
Sacramento sucker	> 2	45	6

Table 6-27. Average Biomass Estimates (lb/acre) for Fishes Caught in Selected Sections of Streams Within the Newville Reservoir Site in 1983 (Brown et al. 1983).

Species	North Fork Stony Creek	Salt Creek	Heifer Camp Creek
California roach	0.9	427.3	72.3
Carp	145.4	-	
Green sunfish	-	33.9	
Rainbow trout	-	74.9	18.7
Sacramento pike minnow	8	339.9	775.1
Sacramento sucker	0.09	88.3	

Upper Salt Creek supports a population of rainbow trout. Nongame fishes were not found in this area and, because of a waterfall, migratory Cyprinids cannot ascend the creek.

Twenty-eight species of fishes were observed in Stony Creek (Table 6-28). DFG staff developed population and biomass estimates for 22 of these species (Table 6-29). Nine species were game fishes and 13 were nongame fishes. Largemouth bass and bluegill were the most abundant gamefishes below Black Butte Reservoir and channel catfish and white catish were the most abundant game fishes above the Sacramento River. Sacramento pike minnows and suckers were found in all stations throughout Stony Creek, were the most abundant, and had the highest biomass for all species of fish. Prickly sculpin were found in all sections, but made up a very small portion of the total biomass. Most of the nongame fish that were caught in the reach below Black Butte Reservoir were juveniles, indicating that this reach serves mainly as a spawning and rearing area.

Table 6-28. Fish of the Stony Creek Drainage (Excludes Fish Within Newville Reservoir Site) (Brown et al. 1983).

Common Name	Scientific name
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis melas*
Bluegill	*Lepomis machrochirus*
Brown bullhead	*Ictalurus nebulosus*
California roach	*Lavinia symmetricus*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Golden shiner	*Notemigomus crysoleucus*
Goldfish	*Carassius auratus*
Green sunfish	*Lepomis cyanellus*
Hardhead	*Mylopharodon conocephalus*
Hitch	*Lavinia exilicauda*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Pacific lamprey	*Lampetra tridentata*
Prickly sculpin	*Cottus asper*
Rainbow trout	*Onchorynchus mykiss*
Redear sunfish	*Lepomis microlophus*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento pike minnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentatlis*
Smallmouth bass	*Micropterus dolomeiu*
Speckled dace	*Rhinicthys osculus*
Threadfin shad	*Dorosoma petenense*
Threespine stickleback	*Gasterosteus aculeatus*
Tule perch	*Hysterocarpus traski*
White catfish	*Ictalurus catus*
White crappie	*Pomoxis annularis*

Table 6-29. Average Population Estimates and Biomass Estimates for Fish Caught in Selected Sections of Stony Creek in 1982 (Brown et al. 1983).

Species	Average Population Estimate	Average Biomass (lb/acre)
Black crappie	8	87.4
Bluegill	19	8.0
Carp	5	64.2
Channel catfish	57	47.3
Goldfish	8	33.9
Green sunfish	7	2.7
Hardhead	9	24.1
Hitch	32	20.5
Largemouth bass	13	11.6
Mosquitofish	3	0.09
Prickly sculpin	57	11.6
Roach	200	54.4
Sacramento pike minnow	146	91.0
Sacramento sucker	96	256.9
Smallmouth bass	5	16.1
Speckled dace	318	41.9
Threadfin shad	2	0.9
Threespine stickleback	3	0.05
Tule perch	6	5.4
White catfish	30	34.8
White crappie	5	17.8

Red Bank Project

This section describes the results of current and past fish studies conducted on Red Bank and Cottonwood Creeks, the major tributaries of the Red Bank Project area. Past studies date back to 1969. Other studies reviewed include reports prepared by DFG and DWR in 1972, 1975, 1985, and 1987.

Red Bank Creek

In 1998, DFG biologists sampled fish at 28 stations within the footprint of Schoenfield Reservoir. Sixteen stations were seined on Red Bank Creek and its tributaries, Dry and Grizzly Creeks. Twelve stations were sampled on Red Bank Creek by electrofishing.

Four species of nongame fishes were observed (Table 6-30). The most common species of nongame fish found was California roach (0.588 fish/yd^2) followed by Sacramento pike minnow (0.158 fish/yd^2) (Table 6-31). Four species of resident game fish were also observed. The most common resident game fish were largemouth bass (0.009 fish/d^2). Juvenile steelhead were found in 2 of the 28 stations sampled.

Table 6-30. Nongame Fish Observed in Red Bank and Cottonwood Creeks

Common Name	Scientific Name	Cottonwood Creek (1976)	Red Bank Creek (1998)
California roach	*Hesperoleucus symmetricus*	X	X
Carp	*Cyprinus carpio*	X	
Golden shiner	*Notemigonus crysoleucas*	X	
Hardhead	*Mylopharodon conocephalus*	X	
Hitch	*Lavinia exilicauda*	X	
Mosquitofish	*Gambusia affinis*	X	
Pacific lamprey	*Lampetra tridentata*	X	X
Prickly sculpin	*Cottus asper*	X	
Sacramento pike minnow	*Ptychocheilus grandis*	X	X
Sacramento sucker	*Catostomus occidentalis*	X	X
Speckled dace	*Rhinichthys osculus*	X	
Threespine stickleback	*Gasterosteus aculeatus*	X	
Tule perch	*Hysterocarpus traski*	X	

Table 6-31. Relative Abundance of Non-Game Fish (Fish/Yard^2) Caught in Lower Cottonwood Creek, 1976, and in Red Bank Creek, 1998

Species	Cottonwood Creek (1976)	Red Bank Creek (1998)
California roach	0.003	0.588
Carp	0.003	
Hardhead	0.022	
Sacramento pike minnow	0.015	0.158
Sacramento sucker	0.006	0.091

Cottonwood Creek

Biologists conducted fisheries surveys of Cottonwood Creek from the confluence of the north fork to the mouth of Cottonwood Creek in 1976 to provide environmental documentation for reservoir planning. Observations were made by diving, seining, fyke netting, and electrofishing. Abundance estimates were made for fish caught by electrofishing. No estimates of abundance were done for fish caught in fyke nets, therefore these fish were not included in the relative abundance tables.

Thirteen species of nongame fishes were observed in Cottonwood Creek (Table 6-30). The most common species of resident nongame fish found were hardhead (0.022 fish/yd^2) and Sacramento pike minnow (0.015 fish/yd^2) (Table 6-31). Some Sacramento pike minnows and Sacramento suckers migrate to the Sacramento-San Joaquin estuary to rear and return to Cottonwood Creek as adults to spawn.

Biologists observed 10 species of resident game fish in the Cottonwood Creek system in 1976 (Table 6-32). The most common resident game fish were bluegill (0.022 fish/yd^2) and green sunfish (0.015 fish/yd^2) (Table 6-33). Steelhead were common in the higher reaches of the Cottonwood system, but not common in the lower reaches, while green sunfish and bluegill were more common in the lower reaches surveyed. No estimates of abundance were done for fish caught in fyke nets, therefore these fish were not included in the relative abundance tables.

Table 6-32. Game Fish Observed in Cottonwood Creek, 1976, and in Red Bank Creek, 1998

Common Name	Scientific Name	Cottonwood Creek	Red Bank Creek
Black bullhead	*Ictalurus melas*	X	
Bluegill	*Lepomis macrochirus*	X	X
Brown bullhead	Ictalurus nebulosus	X	
Brown trout	*Salmo trutta*	X	
Chinook salmon	*Onchorhynchus tshawytscha*	X	
Green sunfish	*Lepomis cyanellus*	X	X
Largemouth bass	*Micropterus salmoides*	X	X
Smallmouth bass	*Micropterus dolomieui*	X	
Steelhead	*Onchorhynchys mykiss*	X	X
White catfish	*Ictalurus catus*	X	

Table 6-33. Relative Abundance of Resident Game Fish (Fish/Yard^2) Caught in Lower Cottonwood Creek and in Red Bank Creek

Species	Cottonwood Creek (1976)	Red Bank Creek (1998)
Bluegill	0.022	0.001
Brown bullhead	0.006	
Green sunfish	0.015	0.001
Largemouth bass	0.003	0.009
Smallmouth bass	0.003	

Biologists found populations of juvenile steelhead in South Fork Cottonwood Creek in the Yolla Bolly Wilderness in the summer of 1976. No estimates of populations of juvenile steelhead were made. The Yolla Bolly Wilderness is well above the proposed Dippingvat Dam site. Adult steelhead were seined from the mouth of Cottonwood Creek in November 1976.

DFG estimates that Cottonwood Creek supports an average of 1,000 steelhead, based on the best estimates of biologists who were most familiar with Cottonwood Creek. Biologists found juvenile steelhead in the footprint of the proposed Schoenfield Reservoir in Red Bank Creek in 1998. They were found at a density of 0.002 fish/yd^2. Steelhead were found in 2 of 28 stations sampled.

Fall-run chinook salmon ascend Cottonwood Creek and spawn in late October through November. They spawn in Cottonwood Creek from the mouth to the confluence of North Fork Cottonwood Creek. About 53 percent of fall-run chinook salmon spawn from the mouth of Cottonwood Creek to the Interstate-5 highway bridge; 23 percent spawn from the Interstate-5 highway bridge to the confluence of Cottonwood Creek and the South Fork Cottonwood Creek; and 24 percent spawn in Cottonwood Creek between the confluence of the south and north forks. Their young begin migrating after they incubate in January. They migrate downstream from January through May. DFG estimates that an average of 3,600 fall-run chinook salmon spawn in Cottonwood Creek.

Late fall-run chinook salmon migrate up Cottonwood Creek and spawn in January. Biologists observed them spawning at the mouth of North Fork Cottonwood Creek in January 1976. Late fall-run chinook salmon young that migrate downstream in May and June are much smaller than the fall-run young at that time of year. Young late fall-run chinook salmon were caught in fyke nets near the mouth of Cottonwood Creek in May and June 1976. DFG estimates that an average of 300 late fall-run chinook salmon migrate up Cottonwood Creek.

Spring-run chinook salmon migrate up Cottonwood Creek in April and spend the summer in deep pools in South Fork Cottonwood Creek, Beegum Gulch, and North Fork Cottonwood Creek. Most are found in Beegum Gulch. Young spring-run chinook salmon migrate downstream from January through May. DFG estimates that an average of 500 spring-run chinook salmon run up Cottonwood Creek. Some young chinook salmon from the Sacramento River use the lower reach of Cottonwood Creek from Interstate-5 to the mouth for rearing during the summer and fall.

The most significant findings of these studies are the presence of fall-run chinook salmon, late fall-run chinook salmon, spring-run chinook salmon, and steelhead in Cottonwood Creek. The presence of steelhead in Red Bank Creek is also a significant finding.

Amphibian Surveys

Amphibian studies were initiated in 1997 for Sites, Colusa, and Red Bank projects. DFG collected data on occurrence, distribution, and relative abundance of amphibians at the proposed reservoir inundation areas for these projects. All aquatic habitats were categorized as to type of water body (e.g., pond, farm impoundment, vernal pool, or creeks). All ponds were measured for length, width, and depth during the initial assessment. DFG also reviewed past amphibian studies for Red Bank and Thomes-Newville Projects. A summary of the 1997 survey findings and findings of past studies are presented below. (See Appendix E for more detailed information).

Sites and Colusa Projects

California Red-Legged Frog. Surveys were conducted August 1997 to January 1998, and between the months of May through October 1998. All ponds and creeks in the study area were surveyed a minimum of four times during each of these periods. Both night and day surveys were conducted during this time, at least two of each for each habitat site. Day surveys were performed on clear, sunny days with minimal wind. Night surveys were conducted on warm, still nights from an hour past sunset until midnight. No California red-legged frogs were found during any of these surveys.

California Tiger Salamander. The historic range of California tiger salamanders was established using distribution records. Grasslands, vernal pools, and farm pond impoundments that contained water for only part of the year were examined as potential California tiger salamander habitat sites. All ponds and vernal pools, and the surrounding territory were examined for burrows, log debris, type of terrestrial vegetation, use of land and its current condition, embankments, and surrounding topography. Each pond was then seined.

Transect and visual pond inspections were conducted at night, during storms that continued from the day into the night, and when the air temperature was between 7-10 °C (45-50 °F) or warmer during the months of November and March for the 1997-98 and 1998-99 seasons.

Dip netting and seining surveys were done twice a year for each vernal pool and intermittent pond, at least fifteen days apart. The first survey was done between March 15 and April 15, and the second between April 15 and May 15. Only ponds that would hold water for at least 10 weeks during the survey time interval were inspected.

No California tiger salamanders were found during any of these surveys.

Surveys of Common Amphibians. General herpetology surveys were done by ground searching near ponds and other habitats, transects, and night driving studies.

A total of five species were found during this survey (Table 6-34). The most prevalent species found was the bullfrog, *Rana catesbieana*, with a catch per hour effort ratio of 4.8 (ground searching method only) for adults.

Table 6-34. Amphibian Species of the Sites Project Area

Common Name	Scientific Name
Bullfrog	*Rana catasbieana*
California newt	*Taricha torosa*
California slender salamander	*Batrachoseps attenuatus*
Pacific tree frog	*Hylla regilla*
Western toad	*Bufo boreas*

Oak woodland and farm ponds were habitat where the greatest diversity of species was found. All five species of amphibians were found in this type of habitat (Table 6-35). Pacific tree frogs were found in all five habitat types.

Table 6-35. Amphibian Species Found in Each Habitat Type in the Sites Reservoir Area

Common Name	Riparian	Oak Woodland	Grassland	Farm Pond	Vernal Pool
Bullfrog	X	X	X	X	
California newt		X		X	
California slender salamander		X		X	
Pacific tree frog	X	X	X	X	X
Western toad	X	X	X	X	

Ground searches were the most productive method of locating a variety of amphibians. Representatives of all species found during the study were located via ground searches. Dip netting and seining were particularly effective in capturing semi-aquatic amphibians, and especially larval amphibians. Bullfrog larvae were found in riparian habitat, oak woodland, and farm ponds. Both pacific tree frog larvae and western toad larvae were found in farm ponds and vernal pools. Western toad larvae were also found in riparian habitat.

No threatened or endangered amphibians were found in this study. All species caught or observed are regarded as common.

Thomes-Newville Project

Surveys for amphibians at the Thomes-Newville Project were conducted by DFG from April 1981 through May 1982 at the request of DWR to provide environmental information for water project planning. No new surveys of amphibians at the Thomes-Newville Project area were undertaken during the recent investigations of offstream storage.

The amphibian surveys were done by ground searching ponds and transects, seining or night driving studies. Ground searches were done both day and night, but driving surveys were done only at night. Pitfall trapping was also done in the Thomes-Newville Project area surveys. A camera was used to photograph specimens for species verification and to maintain a general record of the find.

This 1981-1982 survey produced observations of seven amphibian species that occur within the habitats in the project area and surrounding areas (Table 6-36). No estimate of population sizes was possible because of the small number of recaptures that occurred during the pitfall trapping.

Table 6-36. Amphibians Observed in the Thomes-Newville Project Area in 1982

Common Name	Scientific Name
Black salamander	*Aneides flavipunctatus*
Bullfrog	*Rana catesbeiana*
California slender salamander	*Batrachoseps attenuatus*
Foothill yellow-legged frog	*Rana boylei*
Pacific tree frog	*Hyla regilla*
Western spadefoot toad	*Bufo boreas*
Western toad	*Spea hammondi*

Western toads and Pacific tree frogs were found in all habitat types. Some species, such as black salamanders, were much more limited in their distribution (Table 6-37).

Table 6-37. Amphibian Species Found in the Thomes-Newville Project Area in 1982 (X = found in this habitat type).

Species	Grassland	Chaparral	Oak Savannah	Pine-Oak Woodland	Riparian	Stream	Standing Water
Black salamander				X			
Bullfrog					X	X	X
California slender salamander	X	X	X	X			
Foothill yellow-legged frog					X	X	X
Pacific tree frog	X	X	X	X	X	X	X
Western spadefoot toad	X		X				
Western toad	X	X	X	X	X	X	X

Pitfall traps tended to be selective for amphibians. This trapping method failed to provide any amphibian species not found by at least one other collection method.

Although no amphibian species listed as rare or endangered was found in the project area, two species were found that are considered of special concern by the State of California because of habitat losses. These species complete their reproductive cycle in both temporary and permanent ponds found throughout the inundation area. Spadefoot toads and foothill yellow-legged frogs occur in the streams coursing through the reservoir site. The presence of these species constitutes a significant finding.

Red Bank Project

DFG conducted studies of the Red Bank Project in 1986 and in 1997-1999. The major objectives of these surveys was to search for California red-legged frogs, which are listed as federally threatened, and to conduct general herpetology surveys. Two species listed as federal and California species of special concern that could potentially occur in the area, the foothill yellow-legged frog and western spadefoot toad, were searched for during these surveys.

Historic ranges of the species searched for were established. Physical observations of the present habitat, historic records, and DFG's Natural Diversity Database were also used to establish the list of potential species that could occur in the Red Bank Project areas. The results of past surveys conducted in the Red Bank Project were also reviewed.

Surveys were conducted during the fall of 1997 and during the months of May through October 1998 for California red-legged frogs. Surveys were not conducted during the breeding or rearing period of the frogs to avoid disturbing breeding frogs, eggs, or larvae. All ponds and creeks in the study area were surveyed a minimum of four times during this five-month period in 1998. Both night and day surveys were conducted during this time, at least two of each for each habitat site. No site was sampled twice within a twenty-four hour period. Day surveys were performed on clear, sunny days with minimal wind. Night surveys were conducted on warm still nights from an hour past sunset until midnight. Photographs were also taken of the environment in which animals were found in order to confirm field notes and to document the state of the habitat at the time it was surveyed.

General amphibian surveys were done by ground searching ponds and transects, seining, or night driving studies. Ground searches were done both day and night. Driving surveys were only done at night. Seining was done during the day. General amphibian surveys were conducted year round throughout the Red Bank Project areas, when the weather was appropriate for amphibian activity.

During these studies five species of amphibians were found (Table 6-38). The most common species of amphibians observed were foothill yellow-legged frogs (14.80/hr.) and western toads (13.10/hr.). The foothill yellow-legged frogs are a species of special concern,

Table 6-38. Relative Abundance of Amphibians Observed in the Red Bank Project Area

Species	Catch per Hour	
	Cottonwood Creek	Red Bank Creek
Bullfrog	0.02	1.06
California red-legged frog		<0.01
Foothill yellow-legged frog	14.80	3.91
Pacific tree frog	0.01	1.58
Western toad	13.10	5.65

The most significant find in the current investigation was the discovery of a California red-legged frog in Sunflower Gulch, a tributary to Red Bank Creek. Another individual was observed in the same location in 1986. Extensive searches failed to find other red-legged frogs in the study area. It is probable that the population of red-legged frogs is very small at the site of the proposed Red Bank Project.

One amphibian species of special concern was plentiful throughout the Red Bank Project study area, the foothill yellow-legged frog. They were found in both Red Bank Creek and South Fork Cottonwood Creek.

Reptile Surveys

DWR requested the DFG to conduct studies of the reptiles in the proposed Sites, Colusa, and Red Bank Project areas. DFG biologists conducted the sampling in spring and summer of 1998 and 1999. Past reptile studies for Red Bank and Thomes-Newville Projects were also reviewed.

Sites and Colusa Projects

DFG biologists looked for western pond turtles, a federal and State species of special concern, when seining or during daytime visual surveys in the project areas. Carapaces (shells) of dead turtles were also noted and measured. During periods of warm weather, biologists watched the creek when possible while traveling to and from work stations, which yielded positive results in locating Western pond turtles.

General herpetology surveys were done by ground searching near ponds, transects, and night driving studies. Ground searches were done both day and night, while driving surveys were only done at night. Searching ponds was done during the day. General herpetology surveys were conducted year round throughout the area when the weather was appropriate for reptile activity.

A total of 14 reptile species were found during this survey (Table 6-39). One species of special concern was found, the western pond turtle. Western pond turtles were found in the project area, as well as outside the reservoir footprint both upstream and downstream. Western fence lizards were the most common reptiles found (Table 6-40).

Table 6-39. Reptile Species of the Sites and Colusa Project Area

Common Name	Scientific Name	Status	
		State	Federal
Aquatic garter snake	*Thamnophis couchii*		
Common garter snake	*Thamnophis sirtalis*		
Common king snake	*Lampropeltus getula*		
Gopher snake	*Pituohpis catenifer*		
Ring neck snake	*Diadophis punctatus*		
Sharp-tailed snake	*Contia tenuis*		
Southern Alligator lizard	*Elgaria muliticoranata*		
Western fence lizard	*Sceloporus occidentalis*		
Western pond turtle	*Clemmys marmorata*	DFG: SC DFG: Protected	FSC
Western racer	*Coluber mormon*		
Western rattle snake	*Crotalus viridus*		
Western Sagebrush lizard	*Sceloporus graciosus gracilis*		
Western skink	*Eumeces skiltonianus*		
Western terrestrial garter snake	*Thamnophis elegans*		

DFG: California Department of Fish and Game
SC: Species of special concern
FSC: Federal species of special concern

Table 6-40. Catch Per Hour Effort for Each Survey Method

Common Name	Searching	Dip netting	Seining	Night Driving
Aquatic garter snake	0.0005	0.009	0	0
Common garter snake	0.02	0.04	0.02	0
Common king snake	0.003	0	0	0
Common racer	0.0002	0	0	0
Gopher snake	0.007	0.009	0	0
Ring neck snake	0.0005	0	0	0
Sharp-tailed snake	0.0005	0	0	0
Southern Alligator lizard	0.005	0	0	0
Western fence lizard	0.17	0	0	0
Western pond turtle	0.0009	0	0	0
Western rattlesnake	0.02	0.009	0.06	0.2
Western sagebrush lizard	0.0005	0	0	0
Western skink	0.006	0	0	0
Western terrestrial garter snake	0.05	0	0.02	0

Riparian habitat had the greatest diversity of reptiles found (Table 6-41). Eleven of the 14 species of reptiles were found in this type of habitat. The common garter snake, gopher snake, and western fence lizard were found in all five habitat types.

Table 6-41. Reptile Species Found in Each Habitat Type

Common Name	Riparian	Oak Woodland	Grassland	Farm Pond	Vernal Pool	Roads
Aquatic garter snake	X				X	
Common garter snake	X	X	X	X	X	
Common king snake	X		X	X		
Gopher snake	X	X	X	X	X	
Ring neck snake					X	
Sharp-tailed snake	X					
Southern Alligator lizard	X	X	X	X		
Western fence lizard	X	X	X	X	X	
Western pond turtle	X					
Western racer	X	X				
Western rattlesnake	X	X	X	X		X
Western Sagebrush lizard		X				
Western skink		X				
Western terrestrial garter snake	X	X		X		

Thomes-Newville Project

Surveys for reptiles at the Thomes-Newville Project were conducted from April 1981 through May 1982 at DWR's request to provide environmental information for water project planning. Reptile surveys were done by ground searching ponds and transects, seining, or night driving studies. Ground searches were done both day and night. Driving surveys were only done at night. Animals were identified using published identification keys. Pitfall trapping was also done in the Thomes-Newville Project area. A camera was used to photograph specimens for species verification and to maintain a general record of the find.

This survey produced observations of 15 reptile species that occur within the habitats in the project area and surrounding areas (Table 6-42). No estimate of population sizes was possible because of the small number of recaptures that occurred during the pitfall trapping.

Pitfall traps tended to be selective for lizards and smaller snakes, such as the sharp-tailed snake. Larger snakes, because of their length, could easily avoid falling into the traps. This trapping method failed to provide any reptile species not found by at least one other collection method.

Table 6-42. Observed Reptiles in the Thomes-Newville Project Area in 1982

Common Name	Scientific Name
Common garter snake	*Thamnophis sirtalis*
Common king snake	*Lampropeltis getulus*
Gopher snake	*Pituophis malanoleucus*
Sagebrush lizard	*Sceloperus graciosus*
Sharp-tailed snake	*Contia tenuis*
Southern alligator lizard	*Elgaria multicarinata*
Striped racer	*Masticophis lateralis*
Western aquatic garter snake	*Thamnophis couchi*
Western fence lizard	*Sceloperus occidentalis*
Western pond turtle	*Clemmys marmorata*
Western racer	*Coluber constrictor*
Western rattlesnake	*Crotalus viridis*
Western skink	*Eumeces skiltonianus*
Western terrestrial garter snake	*Thamnophis elegans*
Western whiptail	*Cnemidophorus tigris*

Western fence lizards were found in all habitat types (Table 6-43). Gopher snakes and western rattlesnakes were also found in most habitat types. The sagebrush lizards were much more limited in their distribution.

Table 6-43. Reptile Species Found in the Thomes-Newville Project Area in 1982

Species	Grassland	Chaparral	Oak Savannah	Pine-Oak Woodland	Riparian	Stream	Standing water
Common garter snake	X				X	X	X
Common king snake	X	X	X	X			
Gopher snake	X	X	X	X	X		
Sagebrush lizard		X					
Sharp-tailed snake	X	X					
Southern alligator lizard	X	X	X	X	X		
Striped racer	X	X					
Western aquatic garter snake					X	X	
Western fence lizard	X	X	X	X	X	X	X
Western pond turtle					X	X	X
Western racer	X	X	X		X		
Western rattlesnake	X	X	X	X	X		
Western skink	X	X	X				
Western terrestrial garter snake	X		X		X	X	X
Western whiptail		X	X	X			
Total number of species observed	**15**	**14**	**13**	**10**	**13**	**8**	**8**

Although no reptile species listed as rare or endangered was found in the Thomes-Newville project area, one species considered of special concern by the State of California is found throughout the inundation area. The western pond turtle occurs in streams coursing through the reservoir site. The presence of this species constitutes a significant finding.

Red Bank Project

Reptile surveys were conducted in the Red Bank Project area 1998. Surveys were done by ground searching near ponds, transects, seining, or night driving studies. Ground searches were done both day and night. Driving surveys were only done at night. Seining was done during the day. General reptile surveys were conducted year-round throughout the Red Bank Project areas, when the weather was appropriate for reptile activity. A 1986 survey of the Red Bank Project area was also reviewed.

The objectives of the reptile surveys within the Red Bank Project area were to search for one species listed as federal and California species of special concern. This species, the western pond turtles, were found distributed throughout the study area.

During the 1998 studies, 11 species of reptiles were found (Table 6-44). The most significant finding of these studies was the discovery of western pond turtles, a California species of special concern. They were found in Red Bank Creek and South Fork Cottonwood Creek. The most common species of reptiles observed were western terrestrial garter snakes.

Table 6-44. Names and Abundance of Reptiles in the Red Bank Project Area

Common Name	Scientific Name	Cottonwood Creek	Red Bank Creek
		Catch per Hour	
Common garter snake	*Thamnophis sirtalis*	0.39	0.03
Common king snake	*Lampropeltis getulus*	0.01	0.01
Gopher snake	*Pituophis malanoleucus*	0.05	0.01
Southern alligator lizard	*Elgaria multicarinata*	0.02	0.01
Western fence lizard	*Sceloperus occidentalis*	0.14	0.08
Western pond turtle	*Clemmys marmorata*	0.17	0.09
Western racer	*Coluber mormon*	--	0.01
Western rattlesnake	*Crotalus viridis*	0.12	0.01
Western sagebrush lizard	*Sceloperus graciosus gracilis*	0.02	0.01
Western skink	*Eumeces skiltonianus*	0.01	0.03
Western terrestrial garter snake	*Thamnophis elegans*	0.15	0.13

Cultural Resources

The objectives of the cultural resource surveys at Sites Reservoir, Colusa Cell, and Red Bank Project were to obtain information about the archaeological sites comparable to the data from the survey conducted at Thomes-Newville Reservoir site in 1982, and to determine if there are cultural resource issues serious enough to remove a reservoir project from further consideration. Many new sites were identified and documented during the surveys representing a varied array of site types and almost all of the previously recorded sites were found again and documented to current standards. Archaeological evaluations of the proposed reservoirs yielded a wide range of variability in numbers and types of sites between projects, from three sites in one reservoir basin to more than 100 sites in another.

The reservoir assessments were based on record searches and field surveys. Database files, maps, and reports were reviewed at the Northeast, Northwest, and North Central Information Centers of the California Historical Resources

Information System, an adjunct of the State Office of Historic Preservation. The goal was to determine the extent of coverage of prior surveys within the project footprints and to obtain the records of any previously recorded sites. The field surveys concentrated on those areas with the highest potential for significant archaeological sites, such as stream terraces and level woodland flats, although areas of lesser sensitivity, such as steep hill slopes and arid plains, were also sampled.

Sites Reservoir

Parts of the Sites Reservoir area were surveyed in 1967 by a field class from the University of California, Los Angeles, and Chico State College, under agreement to the National Park Service. A total of 15 prehistoric sites was recorded at that time. No further work has been done within the reservoir footprint until the present study, which resulted in the discovery of 26 new archaeological sites. Of the 41 sites, at least 17 appear to be significant, in that they provisionally meet the criteria for eligibility to the National Register of Historic Places. Six of the sites are not eligible and 16 have undetermined status. An accurate assessment could not be made of these sites based solely on evidence visible on the surface. If further studies are warranted, a site testing program utilizing techniques such as small scale excavations, auger borings, and soil column sampling would be implemented to determine if the sites have archaeological values that meet the criteria for eligibility to the National Register.

Prehistoric settlement in the project area was constrained by the limited food and fuel resources and the scarcity of water; however, the area would have been important for seasonal hunting and gathering forays. The larger and more permanent villages were situated along the lower reaches of the bigger streams, in the Sacramento Valley, and on the knolls and natural levees along the Sacramento River.

Historic sites, features, and standing structures are significantly under-represented in the site totals. These resources were not recorded because they are associated with working ranches, occupied buildings, and the town site of Sites. A future survey of historic resources may yield an estimated 15 to 20 significant historic sites in addition to the Historic District of the Town of Sites. Moving the large cemetery associated with Sites and several smaller cemeteries would be costly and present special problems but there is precedent when associated with a major public works project. No cultural resource problems are known that would remove this reservoir project from further consideration.

Colusa Cell

The record search indicated that the footprint of the Colusa Cell had never been surveyed for cultural resources and that there were no site records in the files of the State database. The field survey indicated an even greater scarcity of subsistence resources than existed in the Sites Project area, and an ephemeral water supply that was not suitable for extensive use or habitation during the prehistoric past.

A total of three sites was recorded, two historic ranches and one site with a prehistoric and an historic component. The significance of the sites is undetermined. The assessment of eligibility to the National Register could not be made on the basis of surface indications. Additional studies would be necessary to complete the evaluation. The Colusa Cell has no cultural resource issues that would preclude reservoir construction.

Thomes-Newville Project

A consultant for DWR completed a comprehensive survey of prehistoric sites within Thomes-Newville Reservoir in 1983. A total of 117 sites were recorded within the footprint of the proposed reservoir, representing a prehistoric settlement pattern that includes evidence of permanent or semi-permanent villages, seasonal campsites, and special resource procurement and use sites. The presence of perennial streams and availability of fuel and subsistence resources accounts for the intensive use of the project area during prehistoric times. Approximately 60 sites meet the criteria for eligibility to the National Register and would therefore qualify for some level of mitigation effort.

Historic features, sites, and standing structures are underrepresented in the site totals. These resources are now given the same consideration as prehistoric resources; however, that was not the case in the early 1980s when the survey was conducted. Additional survey work would be necessary to determine the number, type, and significance of the historic resources that are present.

As at Sites Reservoir, moving the historic cemeteries within the footprint of the Thomes-Newville Project would be costly and present special problems, but there are no cultural resource issues serious enough to remove this reservoir from consideration.

Red Bank Project

The record search for the Red Bank Project indicated that the project area had not been surveyed for cultural resources and no site records were present in the State database. The prior survey and excavations for the Red Bank Project conducted in the early 1950s by the University of California, Berkeley, for the National Park Service, was for a Sacramento River diversion project near Red Bluff that had the same name. The surveys completed in 1994 by California State University, Sacramento, for the Corps' Cottonwood Creek Project, were downstream of the current proposed project, with no overlap of the footprints.

A total of 31 sites were recorded within the footprint of three of the four reservoirs comprising the Red Bank Project; no sites were found at one reservoir. Twenty-eight sites are prehistoric and three are historic. Nine sites appear to meet the criteria for eligibility to the National Register, 16 sites are of undeterminable significance without further work, and 6 sites are not eligible for listing on the National Register, and are therefore not significant.

The prehistoric sites in the Red Bank Project were generally small and the artifact distribution relatively sparse. The sites were probably associated with seasonal upland hunting, fishing, and gathering activities. The larger permanent settlements were situated further downstream on the banks of the perennial streams and along the Sacramento River.

No issues were identified as a result of the survey of the Red Bank Project that were serious enough to prevent construction of the reservoirs.

Table 6-45. Probability of Occurrence and Listing Status of Animal and Plant Species Evaluated

Species	Status[1]			Occurrence Probability within Reservoir Sites [2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Invertebrates								
Desmocerus californicus dimorphus (valley elderberry longhorn beetle)	FT	none	none	X	X	X	X	X
Lepidurus packardi (vernal pool tadpole shrimp)	FE	none	none	*	*	*	*	-
Branchinecta lynchi (vernal pool fairy shrimp)	FT	none	none	*	*	*	*	-
Branchinecta conservatio (Conservancy fairy shrimp)	FE	none	none	*	*	*	*	-
Anthicus antiochensis (Antioch Dunes anthicid beetle)	FSC	none	none	-	-	-	-	-
Anthicus sacramento (Sacramento anthicid beetle)	FSC	none	none	-	-	-	-	-
Dubiraphia brunnescens (brownish dubiraphian riffle beetle)	FSC	none	none	-	-	-	-	-
Ochthebius reticulatus (Wilbur Springs minute moss beetle)	FSC	none	none	-	-	-	-	-
Paracoenia calida (Wilbur Springs shore fly)	FSC	none	none	-	-	-	-	-
Hydroporus leechi (Leech's skyline diving beetle)	FSC	none	none	-	-	-	-	-
Amphibian								
Ambystoma californiense (California tiger salamander)	FC	DFG	none	-	-	-	-	-
Rana aurora ssp. draytonii (California red-legged frog)	FT	CSC,DFG	none	-	-	-	-	X
Rana boylii (Foothill yellow-legged frog)	FSC	CSC,DFG	none	-	-	-	*	X
Scaphiopus hammondii	none	DFG	none	*	-	*	X	*

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Species	Status[1]			Occurrence Probability within Reservoir Sites[2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
(western spadefoot toad)								
Fish								
Lampetra tridentata (Pacific lamprey)	FSC	none	none	*	*	*	X	X
Mylopharodon conocephalus (Hardhead)	FS	CSC	none	X	X	X	X	X
Oncorhynchus mykiss (Steelhead)	FT	none	none	-	-	-	X	X
Oncorhynchus tshawytscha (Late fall-run Chinook salmon)	FPT	CSC	none	-	-	-	-	-
Oncorhynchus tshawytscha (Spring-run Chinook salmon)	FPE,FS	ST	none	X	-	-	X	X
Pogonichthys macrolepidotus (Splitail)	FE	SE	none	-	*	-	-	-
Reptile								
Clemmys marmorata ssp. marmorata (Northwestern pond turtle)	FSC	CSC,DFG	none	X	X	X	X	X
Phrynosoma coronatum ssp. frontale (California horned lizard)	FSC	CSC,DFG	none	*	-	*	*	-
Thamnophis gigas (Giant garter snake)	FT	ST,DFG	none	-	*	-	-	-
Birds								
Accipiter cooperii (Cooper's hawk)	none	CSC	none	X	X	X	X	X
Accipiter gentilis (Northern goshawk)	None	CSC	SC	-	-	-	-	-
Accipiter striatus (Sharp-shinned hawk)	none	CSC	none	X	X	X	*	X
Agelaius tricolor (Tri-colored blackbird)	none	CSC	SC	X	*	X	X	-
Ammodramus savannarum (Grasshopper sparrow)	none	CSC	CS	*	X	X	*	*

Species	Status[1]			Occurrence Probability within Reservoir Sites [2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Amphispiza belli ssp. belli (Bell's sage sparrow)	none	CSC	SC	-	-	-	*	-
Aquila chrysaetos (Golden eagle)	PR	CSC,CFP	none	X	X	X	X	X
Asio flammeus (Short-eared owl)	none	CSC	none	*	*	X	*	*
Asio otus (Long -eared owl)	none	CSC	none	X	*	X	X	X
Athene cunicularia (Burrowing owl)	FSC	CSC	none	X	X	X	X	*
Botaurus lentiginosus (American bittern)	MNBMC	none	none	*	X	*	*	*
Branta canadensis ssp. leucopareia (Aleutian Canada goose)	FT	none	none	-	*	-	-	-
Bucephala islandica (Barrow's goldeneye)	none	CSC	none	-	*	-	-	*
Buteo regalis (Ferruginous hawk)	none	CSC	SC	X	X	*	*	-
Buteo swainsoni (Swainson's hawk)	none	ST	none	*	*	*	*	-
Carduelis lawrencei (Lawrence's goldfinch)	MNBMC	none	none	*	X	X	*	X
Chaetura vauxi (Vaux's swift)	MNBMC	CSC	none	*	*	*	*	*
Charadrius semipalmatus (Western snowy plover)	FT	CSC	none	-	-	-	-	-
Charadrius montanus (Mountain plover)	PLT	CSC	none	*	-	*	*	-
Chondestes grammacus (Lark sparrow)	MNBMC	none	none	X	X	X	X	X
Circus cyaneus (Northern harrier)	none	CSC	none	X	X	X	X	X
Coccyzus americanus ssp. occidentalis (Western yellow-billed cuckoo)	none	SE	none	-	-	-	-	-

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Species	Status[1]			Occurrence Probability within Reservoir Sites[2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Dendroica occidentalis (Hermit warbler)	MNBMC	none	none	*	*	*	*	*
Dendroica petechia (Yellow-warbler)	none	CSC	none	X	-	-	-	-
Elanus caeruleus (White-tailed kite)	none	none	none	X	X	*	*	*
Empidonax traillii (Willow flycatcher)	none	SE	none	-	-	-	-	-
Eremophila alpestris ssp. actia (California horned lark)	none	none	SC	X	X	X	X	X
Falco columbarius (Merlin)	none	CSC	none	X	*	*	X	X
Falco mexicanus (Prarie falcon)	none	CSC	none	X	X	X	X	X
Falco peregrinus (Peregrine falcon)	FE	SE	none	*	*	*	*	*
Gavia immer (Common loon)	MNBMC	CSC	none	-	X	-	-	*
Mammals								
Antrozous pallidus (Pallid bat)	FS	CSC	none	X	NE	*	X	*
Bassariscus astutus (Ringtail)	none	CFP	none	X	NE	*	X	X
Corynorhinus townsendii ssp. pallescens (Pale big-eared bat)	FSC,FS	CSC	none	*	NE	*	*	*
Corynorhinus townsendii ssp. townsendii (Pacific western big-eared bat)	FS,FSC	CSC	none	*	NE	*	*	*
Euderma maculatum (Spotted bat)	FSC	CSC	none	-	NE	-	-	-
Eumops perotis californicus (Western mastiff bat)	FSC	CSC	none	-	NE	-	*	*
Lasiurus blossivillii (Western red bat)	FS	none	none	X	NE	*	*	X

Species	Status[1]			Occurrence Probability within Reservoir Sites [2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Martes americana (Pine marten)	FS	none	none	*	NE	*	*	*
Martes pennanti ssp. pacificus (Pacific fisher)	FSC,FS	CSC	none	*	NE	*	*	*
Myotis ciliolabrum (Small-footed myotis)	FSC	none	none	*	NE	*	*	*
Myotis evotis (Long-eared myotis)	FSC	none	none	*	NE	*	*	*
Myotis thysanodes (Fringed myotis)	FSC	none	none	-	NE	-	*	*
Myotis volans (Long-legged myotis)	FSC	none	none	-	NE	-	*	*
Myotis yumanensis (Yuma myotis)	FSC	CSC	none	*	NE	*	*	X
Perognathus inornatus ssp. inornatus (San Joaquin pocket mouse)	FSC	CSC	none	*	NE	*	*	-
Taxidea taxus (American badger)	none	CSC	none	X	NE	X	*	*
Plants								
Antirrhinum subcordatum (Dimorphic snapdragon)	none	none	1B	*	NE	*	X	X
Asclepias solanoana (Serpentine milkweed)	none	none	1B	-	NE	-	-	-
Astragalus rattanii var. jepsonianus (Jepson's milk-vetch)	none	none	1B	-	NE	-	X	X
Astragalus tener var. ferrisiae (Ferris's milk-vetch)	FSC	none	1B	*	NE	*	*	*
Atriplex cordulata (Heartscale)	FSC	none	1B	*	NE	*	*	*
Atriplex depressa (Brittlescale)	FSC	none	1B	*	NE	*	*	*
Atriplex joaquiniana (San Joaquin spearscale)	FSC	none	1B	*	NE	*	*	*

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Species	Status[1]			Occurrence Probability within Reservoir Sites [2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Atriplex persistens (Vernal pool saltbush)	none	none	1B	*	NE	*	*	-
Balsamorhiza macrolepis var. macrolepis (Big-scale balsamroot)	none	none	1B	*	NE	*	*	*
Brodiaea coronaria ssp. rosea (Indian Valley broadiaea)	FSC	SE	1B	*	NE	*	*	*
Chamaesyce hooveri (Hoovers spurge)	FT	none	1B	*	NE	*	*	-
Cordylanthus palmatus (Palmate-bracted bird's-beak)	FE	SE	1B	*	NE	*	*	-
Cryptantha crinita (Silky cryptantha)	none	none	1B	*	NE	*	*	*
Delphinium recurvatum (Recurved larkspur)	none	none	1B	*	NE	*	*	*
Eleocharis quadrangulata (Four-angled spikerush)	none	none	2	*	NE	*	*	-
Eriastrum brandegeae (Brandegee's eriastrum)	FSC	none	1B	-	NE	-	*	X
Eschscholzia rhombipetala (Diamond-petaled California poppy)	FSC	none	1A	*	NE	*	*	*
Fritillaria pluriflora (Adobe lilly)	FSC	none	1B	*	NE	*	X	X
Gratiola heterosepala (Bogg's Lake hedge-hyssop)	none	SE	1B	*	NE	*	*	*
Hesperevax acaulis var. acaulis (Dwarf evax)	none	none	1B	*	NE	*	*	*
Hesperolinon drymarioides (Drymaria-like western flax)	FSC	none	1B	-	NE	-	*	*
Hesperolinon tehamense (Tehama Co. western flax)	FSC	none	1B	-	NE	-	X	*
Juncus leiospermus var. leiospermus (Red Bluff dwarf rush)	none	none	1B	*	NE	*	*	*
Layia septentrionalis (Colusa layia)	none	none	1B	*	NE	*	*	*

Species	Status[1]			Occurrence Probability within Reservoir Sites[2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Legenere limosa (Legenere)	none	none	1B	*	NE	*	*	-
Lepidium latipes var. heckardii (Heckard's pepper-grass)	none	none	1B	*	NE	*	*	*
Lotus rubriflorus (Red-flowered lotus)	FSC	none	1B	*	NE	*	*	*
Lupinus milo-bakeri (Milo Baker's lupine)	FSC	ST	1B	*	NE	*	*	*
Lupinus sericatus (Cobb Mountain lupine)	none	none	1B	-	NE	-	*	*
Madia hallii (Hall's madia)	FSC	none	1B	-	NE	-	*	*
Madia stebbinsii (Stebbin's madia)	none	none	1B	-	NE	-	*	*
Microseris sylvatica (Woodland mocroseris)	none	none	3	*	NE	*	*	*
Myosurus minimus var. apus (Little mouse tail)	FSC	none	3	*	NE	*	*	-
Myosurus sessilis (Sessile mousetail)	none	none	3	*	NE	*	*	*
Neostaphia colusana (Colusa grass)	FT	SE	1B	*	NE	*	*	-
Orcuttia pilosa (Hairy Orcutt grass)	FT	SE	1B	*	NE	*	*	-
Orcuttia tenuis (Slender Orcutt grass)	PT	SE	1B	*	NE	*	*	-
Paronychia ahartii (Ahart's paronychia)	FSC	none	1B	*	NE	*	*	*
Sagittaria sanfordii (Sandford's arrowhead)	FSC	none	1B	*	NE	*	*	*
Silene campanulata var. campanulata (Red mountain catchfly)	FC	SE	1B	*	NE	*	*	*
Streptanthus morrisonii (Morrison's jewel flower)	FSC	none	1B	-	NE	-	*	-

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Species	Status[1]			Occurrence Probability within Reservoir Sites [2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank
Trichocoronis wrightii var. wrightii (Wright's trichocoronis)	none	none	2	*	NE	*	*	-
Tropidocarpum capparideum (Caper-fruited tropidocarpum)	FSC	none	1B	*	NE	*	*	*
Tuctoria greenei (Green's tuctoria)	FE	CR	1B	*	NE	*	*	-
Viburnum ellipticum (Western viburnum)	none	none	3	-	NE	-	*	*

Foot note#1

Status Key

1A=Presumed to be extinct in California (California Native Plant Society)
1B=Rare, Threatened or Endangered in California and elsewhere (California Native Plant Society)
2=Rare,Threatened or endangered in California but more common elsewhere
3=More information is needed
CFP=Fully protected under California Fish and Game
CR=State Listed as rare (Section1904, DFG code 1994)
CSC=California Species of Special Concern
DFG=California Department of Fish and Game Protected
FC=Federal Candidate Species
FE=Federally Endangered
FPE=Federally Proposed for listing as endangered
FPT=Federally Proposed as threatened
FS=Forest Service Sensitive Species
FSC=Federal Special Concern Species
FT=Federally Threatened
MNBMC=Migratory non-game bird of management concern (USFWS)
PLT=Proposed for listing as threatened under ESA
PR=Protected under the Bald Eagle Act
PT=Federally Proposed, threatened

Species	Status[1]			Occurrence Probability within Reservoir Sites [2]				
Scientific Name (Common Name)	Federal	State	Other	Sites	Funks	Colusa	Thomes-Newville	Red Bank

SB=Specified birds under California Fish and Game Code
SC=Other species of concern identified by CALFED
SE=State endangered
ST=State threatened

Foot note #2
Includes species that have been observed in survey efforts and the probability of species that may be present in the area, based on preliminary habitat evaluations, but have not been observed to date.

Occurrence Probability Key
X=Observed in the reservoir footprint or within 1 mile of it
*=Not observed to date but potential habitat exists in the reservoir footprint or within 1 mile of it
-=Not observed and not likely to occur in the reservoir footprint or within 1 mile of it
NE=Not evaluated in inundation area studies, see site 1-mile perimeter column for potential occurrence at Funks Reservior.

Chapter 7. Summary

DWR began the North of the Delta Offstream Storage Investigation in late 1997 as a two-year reconnaissance-level study authorized by Proposition 204, the Safe, Clean, Reliable Water Supply Act, approved by voters in 1996. In early 1999, CALFED consolidated all storage investigations under a comprehensive program called the Integrated Storage Investigations. The North of the Delta Offstream Storage Investigation was incorporated into one of seven ISI program elements and continues engineering, economic, and environmental impact analyses to determine the feasibility of four north of the Delta storage projects.

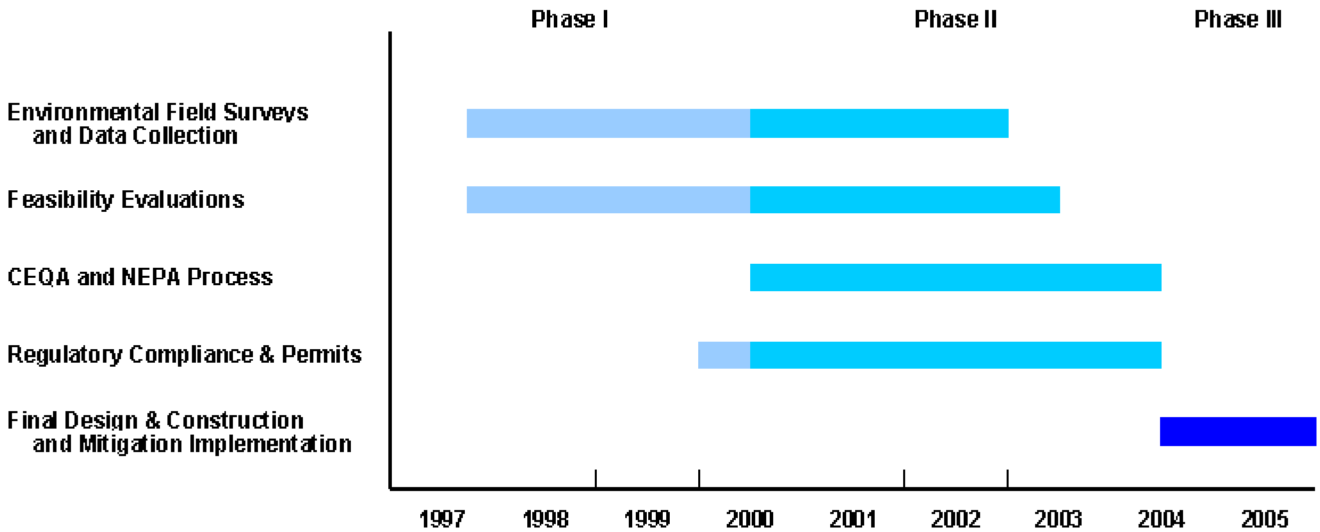
Phase I of this investigation, currently under way, includes preliminary field surveys of environmental and cultural resources; geological, seismic and foundation studies; and engineering feasibility evaluation. Phase II will start when CALFED's Record of Decision and Certification for the Programmatic EIR/EIS is filed, and if additional north of the Delta offstream storage is consistent with CALFED's preferred program alternative. Phase II will include completing the necessary fish and wildlife surveys, evaluating potential mitigation sites, preparing project-specific environmental documentation, completing a final project feasibility report, and acquiring permits necessary for project implementation. Phase III will consist of final design and construction, and mitigation plan implementation contingent on findings of Phase II investigations. Figure 7-1 shows the project timeline. A more detailed workplan is shown in Figure 1-2.

Phase I studies are designed to:

- Collect field data to identify any potential fatal flaws in any of the project alternatives;
- Provide necessary field data for project feasibility evaluation;
- Gather information that will help the decision-makers to formulate a preferred alternative for the North of the Delta Offstream Storage Program; and
- Provide field data for environmental documentation process, Habitat Evaluation Procedure, mitigation planning, and regulatory agencies' permit decisions.

Studies conducted in Phase I will be valuable in the decision-making process of choosing a preferred alternative project and in helping to formulate a plan for the North of the Delta Offstream Storage Program in an environmentally sensitive manner. Phase I studies have also provided basic information on the costs, benefits, and potential impacts of north of the Delta offstream storage for consideration in CALFED's programmatic EIR/EIS.

Figure 7-1. North of Delta Offstream Storage Investigation Timeline



Engineering studies conducted in the last two years focused on identifying major project features and alternative sources of water supply. Water supply studies; alternative conveyance facilities; geological exploration of dam sites; and initial design of dams, spillways, canals, stream diversions, pumping plants, and power generation facilities for Sites Reservoir have been the main activities. The following is a list of completed principal engineering activities:

- Preliminary hydrology and operation studies for each reservoir;
- Preliminary fault and seismic evaluation for the four project alternatives ;
- Preliminary design work for conveyance facilities to Sites Reservoir;
- Preliminary cost estimates for various conveyance alternatives;
- Aerial photography and topographic mapping, including 2-foot contour mapping at Sites and Golden Gate Dam sites, and conveyance alignments;
- Preliminary evaluation of embankment dam cross sections for Sites Reservoir;
- Preliminary design and cost estimates for dams and appurtenances at the Golden Gate Dam site;
- Location and characteristics of dam construction materials for Sites Reservoir;
- Preliminary design and cost estimates for pumping/generating facilities from Funks Reservoir to Sites Reservoir;
- Preliminary road and utilities relocations study for Sites and Colusa Reservoirs;

- Foundation mapping, drilling, and water pressure testing for Sites Reservoir and partial Colusa Project; and
- Initial detailed fault and seismic evaluation of Sites Reservoir.

Biological studies were initiated to identify endangered, threatened, or sensitive plant and wildlife species that exist within the reservoir inundation areas, along with cultural resources studies. These studies consisted of reviewing past studies and existing databases, and conducting field surveys. Environmental activities completed to date include:

- Delineation of all wetlands in all reservoir areas;
- Preliminary cultural resources inventory of all reservoir areas;
- Complete two-year botanical survey of all reservoir areas ;
- Complete survey of elderberry plants in all reservoir areas ;
- Complete two-year survey of threatened and endangered species in reservoir areas (Amphibian and reptile surveys were not conducted at Thomes-Newville Project area in the current efforts.) ;
- Survey of general species and their habitat as needed to begin the Habitat Evaluation Procedure;
- Fairy shrimp habitat survey and mapping for Thomes-Newville and Sites and Colusa Reservoir areas; and
- Preliminary evaluation of recreational facilities potential for Sites Reservoir.

Reconnaissance-level surveys for potential special-status shrimp habitat at the potential reservoir sites were performed using aerial photography and existing data. DWR is initiating a process to work with USFWS and affected landowners to obtain incidental take permits and right-of-entry permits, respectively, to conduct shrimp surveys using service protocol at the project areas. In addition to the shrimp surveys, environmental studies in Phase II will be extended to include areas outside of the reservoir footprint for project alternatives, along the alignment of conveyance facilities, and where other infrastructures associated with the project, including future road and recreation facilities, will be located.

Impacts of diversion from the Sacramento River on the ecosystem and fishery resources have been the subject of extended discussion. A series of studies to evaluate the potential impacts of project operation on fishery, riverine processes, and overall Sacramento River ecosystem is being initiated and will continue during the next two years. The following is a list of studies planned for this program. Work on some of these studies has begun and will continue during Phase II. Work has begun on these activities:

- Establish a process for proper coordination and consultation with resource agencies;
- Complete operation studies for project alternatives;
- Complete water quality investigation for project alternatives;
- Complete amphibian and reptile surveys;
- Complete tributaries fish studies for project alternatives;
- Complete highway and utilities relocation studies for project alternatives;

- Complete recreation facility design for project alternatives;
- Complete Sites and Golden Gate Dams design and cost estimates;
- Complete geological investigation for Sites Reservoir including foundation and borrow materials investigation;
- Complete fault and seismic analysis for Sites Reservoir;
- Develop a water exchange program for project alternatives; and
- Evaluate impacts of diversions on Sacramento River ecosystem.

Work on these activities will begin in mid-2000:

- Energy analysis and power transmission facilities for project alternatives;
- Evaluate impact of diversions on Sacramento River fishery resources;
- Initiate special status shrimp surveys for project alternatives;
- Initiate and complete the following studies outside the footprint of the Sites Reservoir: avian, wetlands, botanical resources, mammals, fish, amphibians, reptiles, and valley elderberry longhorn beetle;
- Conveyance facilities design and cost estimates for Sites and Colusa Projects;
- Embankment design and cost estimates for Golden Gate, Sites, and saddle dams;
- Update Newville Dam design and cost estimates;
- Update Newville Dam geological investigation, including borrow materials and foundation investigation;
- Update embankment design and cost estimates for Newville Dam and saddle dams;
- Update Newville Dam fault and seismic analysis;
- Complete conveyance facilities for Thomas-Newville Project;
- Develop project formulation;
- Complete CEQA and NEPA process;
- Complete Habitat Evaluation Procedure;
- Prepare mitigation plans;
- Acquire project permits;
- Complete economic feasibility of the project alternatives;
- Final engineering feasibility; and
- Complete general mammal surveys.

The Phase II investigations will culminate in preparation of environmental documents to comply with NEPA and CEQA. NEPA directs federal agencies to prepare an environmental impact statement for all major federal actions that may have a significant effect on the human environment. CEQA, modeled after NEPA, requires California public agency decision-makers to document and consider the environmental impacts of their actions. It requires an agency to identify ways to avoid or reduce environmental damage and to implement those measures where feasible.

In addition to environmental documentation, water project sponsors must comply with various laws protecting waters and wetlands as well as other aspects of the environment. The following is a list of major federal and State environmental permits and compliances that may be needed for project implementation.

Federal

- Section 404 of the Clean Water Act Permit for reservoir, conveyance system, and diversion structure
- Federal Endangered Species Act Compliance-Section 7 Take Permits
- National Environmental Protection Act Compliance
- Federal Energy Regulatory Commission Compliance
- National Historic Preservation Act Compliance
- Fish and Wildlife Coordination Act
- Rivers and Harbors Act Compliance
- Farmland Protection Act Compliance
- Executive Order 11988: Floodplain Management Compliance
- Executive Order 11990: Protection of Wetlands
- Clean Air Act Compliance
- Surface Mining Reclamation Act Compliance

State

- Regional Water Quality Control Board 401 Water Quality Certification
- Regional Water Quality Control Board Stormwater Permit
- Regional Water Quality Control Board Approval for Construction in Water Bodies and Discharge of Dewatering Water
- State Water Resources Control Board Water Rights Permits
- Department of Fish and Game 1600 Streambed Alteration Agreement
- Department of Fish and Game Dredge Permit (Section 5653 DFG Code)
- California Environmental Quality Act Compliance
- State Endangered Species Act Compliance
- Department of Water Resources Dam Safety Certification
- State Lands Commission Notification/Permit (Riverbed Modification)

The studies that have been conducted in the last two years have provided valuable engineering and biological data to the North of the Delta Offstream Storage Investigation. These studies, along with the work completed during the next several years, will be instrumental in the decision-making process, compliance with CEQA and NEPA, and mitigation planning for the preferred alternative for north of the Delta offstream storage. The previous chapters in this progress report have summarized the work that has been completed. The following section lists the findings and makes some recommendations as the program moves forward.

Findings and Recommendations:

- Four offstream storage alternatives are under investigation in the west side of the Sacramento Valley. Project formulation includes consideration of a water exchange program to use the water supply from the project for agricultural and wetland uses within the Colusa Basin in lieu of equivalent diversions from the Sacramento River.
- North of the Delta offstream storage can improve water supply reliability. Potential project benefits include increased operational flexibility; improved water quality; reduced flooding; additional water supply to meet agricultural, urban, and environmental demands; cooler water for Sacramento River salmon; and ecosystem benefits.
- Engineering and geologic investigations conducted at Golden Gate and Sites Dam sites indicate that these sites are suitable for construction of dams impounding a 1.8 maf Sites Reservoir.
- The dominant Natural Plant Community in the Sites, Colusa, and Thomes-Newville Project areas is California annual grassland. The Red Bank Project area is dominated by blue oak, mixed oak, foothill pine, and chaparral. Sites Reservoir contains a greater diversity of habitat types than found in the Colusa Cell. Thomes-Newville Project area has more habitat diversity than Sites Reservoir. Red Bank Project area, by far, has the most habitat diversity of the four.
- Habitat for the valley elderberry longhorn beetle occurs at each of the four proposed reservoir sites. VELB emergence holes were found within the proposed Sites and Newville Reservoir areas. No emergence holes were found within the proposed Colusa Cell and Red Bank Project areas. No adult beetles were observed at any of the proposed reservoir sites.
- Jurisdictional wetlands and waters of the U.S. are present in all four reservoir areas. The Newville Reservoir area with 413 acres of jurisdictional wetlands and 231 acres of other waters of U.S. has the most acreage of all four reservoir areas.
- Review of existing databases indicated that nine State and federally listed avian species could be found within the counties covering the west side of the Sacramento Valley and foothills. Three of these species were identified during field surveys, including sporadic wintering use by both adult and immature bald eagles, which have been documented at each of the four reservoir sites. A single sighting of a bank swallow was made near the proposed Colusa site. Five sandhill cranes were observed flying over the Colusa Project area during November 1997. This observation occurred on a foggy day in the Sacramento Valley when the sandhill cranes may have flown over the project area in the foothills which were fog-free to use the annual grasslands.

- The streams flowing through the proposed Sites Reservoir and Colusa Cell are warm water streams with poor water quality. These streams do not support habitat for anadromous fish and are generally intermittent in nature. Sampling of game and nongame fishes within these streams found very few fish above 6 inches long, suggesting that fish only rear in these areas. Hitch are the most abundant fish found in both reservoir areas.
- Thomes Creek was surveyed in 1980-81, 1981-82, and again in 1999 for the presence of salmon and steelhead. Fall and late fall-runs of salmon and steelhead were seen during these surveys. In the 1999 survey, one adult spring-run chinook salmon was found.
- DFG staff estimates that Cottonwood Creek supports a good population of steelhead. Steelhead were found in Red Bank Creek within the footprint of Schoenfield Reservoir. Fall-run and late fall-run chinook salmon were found by DFG staff in lower Cottonwood Creek from the mouth to the confluence of North Fork Cottonwood Creek. Spring-run chinook salmon migrate upstream in April and spend the summer in deep pools in South and North Fork Cottonwood Creek.
- No threatened or endangered amphibians were found within the Sites, Colusa, or Thomes-Newville Project areas. A California red-legged frog was found in the Red Bank Project area. (Amphibian surveys were not conducted at the Thomes-Newville Project area during the current efforts. Findings for the Thomes-Newville Project were from studies conducted in the early 1980s.)
- Fish species found in Cottonwood Creek are more diverse than in streams flowing through other alternative reservoir sites. Spring-run chinook salmon and steelhead were sampled in South Fork Cottonwood Creek where the proposed Dippingvat Reservoir would be located. Much more diverse habitat and species were present within the Schoenfield Reservoir area.
- Hydrologic studies of Red Bank Creek indicate that without diversions from Cottonwood Creek (or other sources), Schoenfield Reservoir is not feasible. The natural flow of Red Bank Creek at the proposed Schoenfield Reservoir averages about 16 taf per year, not adequate to fill Schoenfield Reservoir without additional water supplies. Diversion of Cottonwood floodflow to Red Bank Project is not feasible without constructing a diversion dam on South Fork Cottonwood Creek, which is not favorable because of its diverse fish resources. Therefore, it is recommended that the Red Bank Project studies be discontinued.
- Red Bank Creek is proposed to convey Schoenfield Reservoir water to the Tehama-Colusa Canal. Seepage of project water in Red Bank Creek may be excessive, making it an infeasible conveyance alternative.
- The embankment to storage ratio for the Colusa Cell is high, increasing the project cost considerably. This is primarily due to the very large embankments required to construct four main dams and seven saddle dams that would form the Colusa Cell. This large embankment volume increases the cost of the project and the unit cost of water considerably. Therefore, further field studies of the Colusa Project should be deferred until the

completion of an economic feasibility study of the project. These studies may be continued later, if economic evaluations indicate that the Colusa Cell is feasible.

- The environmental documentation process for the North of the Delta Offstream Storage Project should start this year if additional north of the Delta offstream storage is consistent with CALFED's preferred program alternatives as discussed in the Bay-Delta Program final programmatic EIS/EIR and Record of Decision.

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Glossary

A

active storage capacity the usable reservoir capacity available for seasonal or cyclic water storage. It is gross reservoir capacity minus inactive storage capacity.

afterbay a reservoir that regulates fluctuating discharges from a hydroelectric power plant or a pumping plant.

agricultural drainage (1) the process of directing excess water away from root zones by natural or artificial means, such as by using a system of drains placed below ground surface level; also called subsurface drainage; (2) the water drained away from irrigated farmland.

alluvial pertaining to or composed of alluvium

alluvium unconsolidated soil strata deposited by flowing water.

anadromous fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

aquifer a geologic formation that stores water and yields significant quantities of water to wells or springs.

average annual runoff for a specified area is the average value of annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

B

bedload the part of the sediment in a stream that is moved on or immediately abouve the stream bed usually consisting of boulders, pebbles, and gravel.

biota living organisms of a region, as in a stream or other body of water.

brackish water water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than sea water.

brooding water used by nesting waterfowl to rear their young.

C

California Species of Special Concern species designated by the California Department of Fish and Game as having declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction. The purpose of this designation is to halt or reverse their decline by calling attention to their plight and addressing issues of concern early enough to secure their long term viability.

candidate species species that have been petitioned to be listed as threatened or endangered based upon current information and data available. These species are under review and investigation through research for formal listing as threatened or endangered.

chaparral a major vegetation type in California characterized by dense evergreen shrubs with thick, hardened leaves.

colluvial overburden colluvium that is laying on hard rock which must be removed for construction to take place.

colluvium a general term applies to heterogeneous material of loose soil or rock fragments that is deposited at the base of a hill by rainwash or downhill creep.

compressive strengths the amount of pressure that can be applied to a rock, under certain conditions, before the rock breaks or is crushed.

conglomerate a sedimentary rock composed of rounded to subangular fragments larger than sand, surrounded by sand, silt, or clay. These fragments are usually cemented together.

conglomerate clasts the rock fragments that make up the coarse-grained portion of a conglomerate.

conjunctive use the operation of a groundwater basin in combination with a surface water storage and conveyance system. Water is stored in the groundwater basin for later use by intentionally recharging the basin during years of above-average water supply.

cretaceous a geologic period that covers the geologic time scale from about 65 to 144 million years ago.

D

deep percolation percolation of (irrigation) water through the ground into the groundwater.

dissolved organic compounds carbon-based substances dissolved in water.

dissolved oxygen (DO) the amount of oxygen dissolved in water or wastewater, usually expressed in milligrams per liter, parts per million, or percent of saturation.

drainage area the area of land from which water drains into a river; for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called watershed or river basin.

DFG harvest species species managed by the Department of Fish and Game for public hunting opportunities. Species include but are not limited to deer, ducks, bear, and pigs.

E

electrical conductivity a measurement of how easily electricity flows through water. This correlates with the Total Dissolved Solids in water. The higher the TDS, the more easily electricity flows through the water, the higher the electrical conductivity.

emergent wetlands wetlands containing erect, rooted vegetation such as tules (not including mosses and lichens).

endangered species a species at high risk to extinction in the wild in the near future.

environmental water the water for wetlands, for the instream flow in a major river or in the Bay-Delta, or for a designated wild and scenic river

ephemeral a stream, pool, or lake that occurs for only the "wet" portion of the year. These bodies of water disappear during the summer months.

eutrophic said of a body of water characterized by a high level of plant nutrients, with correspondingly high primary productivity.

F

fault gouge soft, uncemented, pulverized clayey material filling or partly filling a fault zone or found along a fault.

fluvial of or pertaining to a river or rivers.

forebay a reservoir at the intake of a pumping plant or power plant to stabilize water levels; also a storage basin for regulating water for percolation into groundwater basins.

fry a recently hatched fish.

G

Geologic province a large region characterized by similar geologic history and rocks.

gradient the steepness of the slope of the land surface or river

gross reservoir capacity the total storage capacity available in a reservoir for all purposes, from the streambed to the normal maximum operating level. Includes dead (or inactive) storage, but excludes surcharge (water temporarily stored above the elevation of the top of the spillway).

groundwater water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated.

groundwater area an area where because of the nature of the geologic material, groundwater is found. Unlike a groundwater basin, the boundaries of a groundwater area are less definitive.

groundwater basin a groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir. In some cases, the boundaries of successively deeper aquifers may differ and make it difficult to define the limits of the basin.

groundwater recharge the natural or intentional infiltration of surface water into the zone of saturation (i.e., into groundwater).

groundwater table the upper surface of the zone of saturation, in an unconfined aquifer.

H

Habitat Evaluation Procedure a computerized method used to inventory habitats and assess impacts that combines habitat quality with habitat area to calculate Habitat Units. The Habitat Units are sensitive to changes in both amount and quality of habitat. The project consists of quantitative information for each species or suite of species evaluated.

Habitat Suitability Index Model species models that are used for habitat-based evaluation techniques.

Holocene a geologic epoch in the Quaternary that ranges from now to 10,000 years ago.

hydrologic basin the drainage area upstream from a given point on a stream.

I

instream use use of water within its natural watercourse. For example, the use of water for navigation, recreation, fish and wildlife, aesthetics, and scenic enjoyment.

irrigation return flow applied water that is not transpired, evaporated, or infiltrated into a groundwater basin but that returns to a surface water body.

J

jurassic a geologic period that covers the geologic time scale from 144 to 208 million years ago.

L

land subsidence the lowering of the natural land surface due to groundwater (or oil and gas) extraction.

lenticular a sedimentary deposit that is lense-shaped

lineament a linear feature on the earth's surface that is believed to reflect the earth's structure (i.e. fractures, faults, aligned volcanoes, and straight stream courses).

M

maximum contaminant level (MCL) the highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

maximum storage the maximum amount of water that can be stored in a reservoir

mean sea level the average height of the surface of the sea for all stages of the tide over a long period of time. Mean sea level is used as a datum plane for the measurements of elevations and depths.

metavolcanic an informal term of volcanic rocks that shown evidence of having been subjected to pressure and temperature after their deposition from volcanic activity.

ML

multipurpose project a project, usually a reservoir, designed to serve more than one purpose, and whose costs are normally allocated among the different functions it provides. For example, a project that provides water supply, flood control, and generates hydroelectricity.

N

National Pollutant Discharge Elimination System (NPDES) a provision of Section 402 of the federal Clean Water Act that established a permitting system for discharges of waste materials to water courses.

nonpoint source waste water discharge other than from point sources. See also point source.

normal pool elevation (or reservoir) the highest elevation at which reservoir water is normally stored. This is usually the spillway crest elevation.

nomlaki tuff member a tuff unit in the Pliocene rock units that has been given a formal name. It has been identified throughout the Sacramento Valley.

O

offstream storage a reservoir on a small stream that does not significantly contribute to the water supply of the reservoir. The water supply for the reservoir is diverted from a nearby river via one or more conveyance facilities to the reservoir.

P

pathogens viruses, bacteria, or other organisms that cause disease.

pediment **a broad, gently sloping surface caused by erosion.**

permeability the capability of soil or other geologic formations to transmit water.

phytoplankton minute plants, such as algae, that live suspended in bodies of water.

pleistocene a geologic epoch that covers the geologic time scale from 10,000 to 1.6 million years ago.

pliocene a geologic epoch that covers the geologic time scale from 1.6 to 5.3 million years ago.

point source a specific site from which wastewater or polluted water is discharged into a water body.

pollution (of water) the alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

project yield the water supply attributed to all features of a project, including integrated operation of units that could be operated individually.

pumice a rock composed of volcanic ash. Its light weight many times will allow it to float on water.

pump lift the distance between the groundwater table and the overlying land surface.

pumped storage project a hydroelectric powerplant and reservoir system using an arrangement whereby water released for generating energy during peak load periods is stored and pumped back into the upper reservoir, usually during periods of reduced power demand.

pump-generating plant a plant which can either pump water or generate electricity, depending on the direction of water flow.

Q

quaternary a geologic period that covers the geologic time scale from now to 1.6 million years ago.

R

recent a geologic epoch in the Quaternary that ranges from now to 10,000 years ago. This epoch is sometimes referred to as the holocene.

recharge basin a surface facility constructed to infiltrate surface water into a groundwater basin.

recycled water urban wastewater that becomes suitable, as a result of treatment, for a specific beneficial use. Also called reclaimed water. See also water recycling.

return flow the portion of withdrawn water not consumed by evapotranspiration or system losses which returns to its source or to another body of water.

riparian located on the banks of a stream or other body of water. Riparian water rights are rights held by landowners adjacent to a natural waterbody.

runoff the volume of surface flow from an area.

S

salinity generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as an electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. See also total dissolved solids.

salmonid fish species belonging to the salmon family, including salmon and trout.

schist a metamorphic rock that readily splits into thin flakes.

seepage the gradual movement of a fluid into, through, or from a porous medium.

septic tank lechate the fluid that leaves a septic tank and usually percolates down to the groundwater table or moves laterally until it is used by vegetation or empties into a stream or lake.

service area the geographic area served by a water agency.

slake the crumbling or disintegration of rock upon exposure to air or moisture.

soil-stratigraphic unit a soil with physical characteristics and relationship with other soils that permit its consistent recognition and mapping.

soluble minerals naturally occurring substances capable of being dissolved.

submarine fan a fan-shaped deposit on the sea floor that is seaward of large rivers or submarine canyons.

surface supply water supply from streams, lakes, and reservoirs.

syncline a fold in sedimentary rocks that is concave upward.

T

tectonic boundary a boundary between two or more areas of similar faulting and folding.

tectonic scarps a line of cliffs producing by faulting

tertiary a geologic period that covers the geologic time scale from 1.6 to about 65 million years ago.

threatened species a species at high risk to extinction in the wild in the medium term future.

total dissolved solids (TDS) a quantitative measure of the residual minerals dissolved in water that remain after evaporation of a solution. Usually expressed in milligrams per liter. Abbreviation: TDS. See also salinity.

tuff a general term for all rock that is formed by volcanic material transported into place by air or water.

U

unconformity a gap or break in the deposition between two rock units. During this break in deposition, the lower rock unit has been eroded or weathered.

unimpaired flow the flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use.

V

vernal pools ephemeral wetlands forming in shallow depressions underlain by a substrate near the surface that restricts the percolation of water.

W

water gaps a deep pass in a mountain ridge, through which a stream flows.

water quality description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

water recycling the treatment of urban wastewater to a level rendering it suitable for a specific beneficial use.

watershed see drainage basin.

water table see groundwater table.

water transfers marketing arrangements that can include the permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; the sale or lease of a contractual right to water supply.

well completion reports reports of water wells constructed in California. The reports contain data about the well and the materials encountered in its construction.

wetlands delineations investigation of inundated areas to determine if hydrology, soils, and vegetation qualify the area to be subject to jurisdictional regulation.

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