
**FACILITY DESCRIPTIONS
AND UPDATED COST ESTIMATES
FOR TEHAMA-COLUSA CANAL EXTENSION**

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

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

This report summarizes the principal features, estimated costs, and environmental considerations of constructing the Tehama-Colusa Canal Extension. This project would increase the capacity of the Tehama-Colusa (T-C) Canal from the existing Funks Reservoir to the present terminus of the canal and would extend the canal into southern Yolo County to a point where it could be intertied with the conveyance system of the proposed Lake Berryessa Enlargement. This project has two potential configurations to increase the capacity of the existing canal: (1) expanding the capacity of the existing canal structure, or (2) constructing a parallel canal adjacent to the existing canal. Both options are explored in this evaluation. The general location of the T-C Canal Extension is shown in Figure 1.

This evaluation and others being performed by CALFED are intended to provide a facilities evaluation and updated cost estimates of representative storage and conveyance components. The objectives of the T-C Canal Extension evaluation are: (1) to provide an updated cost estimate which represents a cost that is within the range to be expected if the project were to be constructed today, and (2) to enable CALFED to equally compare this project against other projects that might be considered as part of a long-term CALFED solution strategy.

The cost estimate for the enlargement of the existing T-C Canal was developed from a new conceptual design of the canal and related facilities prepared by Bookman-Edmonston Engineering. The cost estimate for the construction of the parallel canal was determined by applying current cost indices to costs provided by the U.S. Bureau of Reclamation (Reclamation). The cost estimates provided by Reclamation were reviewed and adapted for this evaluation. The cost estimates for the canal extension and related facilities were developed by Bookman-Edmonston Engineering.

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

PROJECT BACKGROUND

In 1950, the T-C Canal was authorized as part of the Sacramento Canal Unit of the Central Valley Project (CVP) by Public Law (PL) 81-839. From 1950 to 1963, the number of water delivery contracts signed was insufficient to warrant construction of the canal. In 1964, it was determined that enough contracts had been signed to defray the annual operating and maintenance costs assigned to the irrigation portion of the canal and construction began in 1965. In August 1967, PL 90-65 amended PL 81-839 to increase the capacity of the 44-mile section of canal from Funks Creek to Bird Creek to enable future water service to Yolo, Solano, Lake, and Napa Counties.

The existing canal and related facilities were completed in May of 1980. The T-C Canal is 111 miles long, extending from the Red Bluff Diversion Dam on the Sacramento River in the north to Bird Creek in Yolo County in the south. The initial capacity of the canal is

2,530 cubic-feet-per-second (cfs) at the upper end of the canal and diminishes to 1,700 cfs at the terminus. Funks Reservoir, located at about mile 67 of the canal, acts as the only regulating facility on the canal.

The T-C Canal is owned by Reclamation, but operated and maintained as part of the CVP by the Tehama-Colusa Water Authority (TCCA). The TCCA was formed as a Joint Powers Agency of ten water districts in September 1987 and took over operations and maintenance of the T-C Canal and the Corning Canal systems as per a cooperative agreement with Reclamation in November 1988.

Extension of the T-C Canal into Yolo and Solano Counties has been investigated since the early 1960s. Reclamation released a reconnaissance appraisal report on the West Sacramento Valley Canal in November 1962. The appraisal report proposed enlarging the canal from Funks Reservoir to Bird Creek (later authorized under PL 90-65) and extending the canal into Solano County to Canyon Reservoir, located four miles southeast of Vacaville. Reclamation's plan for the West Sacramento Canal included the development of Sites Reservoir and several small regulating reservoirs along the canal alignment, including Oat Reservoir located near the canal's present terminus. The canal extension was proposed to serve 354,900 acre-feet between Funks Reservoir and Canyon Reservoir.

FACILITIES DESCRIPTION

This section provides an overview of the major features of the T-C Canal Extension Project, as well as a description of the existing facilities of the T-C Canal which would be either utilized or modified under the extension project. The canal extension would include two components: (1) increasing the conveyance capacity of the existing canal from Funks Reservoir to the canal's present terminus at Bird Creek in Yolo County, and

(2) extending the canal to the proposed conveyance facilities of an enlarged Lake Berryessa located near Winters in southern Yolo County. The extension of the T-C Canal would provide additional surface water supplies to Yolo and Solano Counties and would enable storage of available Sacramento River flows in an enlarged Lake Berryessa.

PROJECT DESCRIPTION

The T-C Canal Extension would involve increasing the capacity of the existing canal from Funks Reservoir to the canal's terminus and extending the canal from its terminus to the proposed Winters Pumping-Generating Plant in southern Yolo County. The total capacity of the T-C Canal would be 5,000 cfs from Funks Reservoir to the Winters Pumping-Generating Plant. Figures 2a and 2b show the alignment of the T-C Canal Extension. Figure 2a shows the alignment of the existing canal between Funks Reservoir and its terminus at Bird Creek. This section of the canal would be enlarged or a new parallel canal would be constructed immediately adjacent to the existing canal. Figure 2b shows the proposed alignment of the canal extension from Bird Creek to the proposed Winters Pumping-Generating Plant.

The T-C Canal Extension project would be developed in conjunction with two additional projects. These are the T-C Canal Enlargement and the Lake Berryessa Enlargement. The T-C Canal Enlargement would increase the capacity of the T-C Canal from the Red Bluff Diversion Dam to Funks Reservoir to match the capacity of the T-C Canal Extension project. The Lake Berryessa Enlargement would include construction of the Winters Pumping-Generating Plant which would be a component of the conveyance system to move water into or out of Lake Berryessa. The capacity of the conveyance system for Lake Berryessa would also match that of the T-C Canal Extension, 5,000 cfs.

The T-C Canal Enlargement from Red Bluff to Funks Reservoir and the Lake Berryessa Enlargement are the subject of separate evaluations being performed by CALFED. These evaluations are titled *Facility Descriptions and Updated Cost Estimates for Tehama-Colusa Canal Enlargement* and *Facility Descriptions and Updated Cost Estimates for Lake Berryessa Enlargement*. An additional evaluation being performed by CALFED is the Lake Berryessa Intertie, which would consist of a two-way conveyance facility from the Sacramento River near the Sacramento Weir in Yolo County to the Winters Pumping-Generating Plant located 4.5 miles north of the town of Winters. This facility would enable diversions from the lower Sacramento River, as well as releases from Lake Berryessa to the Sacramento River. The Lake Berryessa Intertie is an alternative to the T-C Canal Extension for providing Sacramento River water to Lake Berryessa. The Lake Berryessa Intertie evaluation is titled *Facility Descriptions and Updated Cost Estimates for Lake Berryessa Intertie*.

The ability to deliver water from the Sacramento River through the T-C Canal to Lake Berryessa would depend on ongoing activities associated with CALFED, the Central Valley Improvement Act (CVPIA), and Water Quality Standards for the Bay-Delta. Another significant issue which would bear on the ability to divert water from the upper Sacramento River would be the operation of the Red Bluff Diversion Dam.

EXISTING FACILITIES

The existing T-C Canal and its related facilities extend for 111 miles from the Red Bluff Diversion Dam in Tehama County to the terminus at Bird Creek in Yolo County. From north to south, some of the major facilities of the T-C Canal are the Red Bluff Diversion Dam, the Tehama-Colusa Canal Fish Screens and Bypass Facilities, and Funks Reservoir. Only Funks Reservoir and the T-C Canal south of Funks Reservoir are within the study area of this evaluation. A brief description of these facilities is included below.

Tehama-Colusa Canal

There are eight individual reaches identified along the T-C Canal from the Red Bluff Diversion Dam to its terminus. The capacity of the canal telescopes down from 2,530 cfs at Reach 1 to 1,700 cfs at Reach 8. Each canal reach is named by the creek crossed at the end of each reach. From north to south, the eight reaches include:

- Reach 1 - Red Bluff Diversion Dam to Thomes Creek
- Reach 2 - Thomes Creek to Stony Creek
- Reach 3 - Stony Creek to Wilson Creek
- Reach 4 - Wilson Creek to Logan Creek
- Reach 5 - Logan Creek to Funks Reservoir
- Reach 6 - Funks Reservoir to Freshwater Creek
- Reach 7 - Freshwater Creek to Elk Creek
- Reach 8 - Elk Creek to Bird Creek.

The T-C Canal Extension project is focused on the existing facilities south of Funks Reservoir which include Reaches 6, 7, and 8. Table 1 provides a summary of the physical characteristics of Reaches 6, 7, and 8.

Funks Reservoir

Funks Reservoir is used to regulate flows in the T-C Canal. The reservoir is located on Funks Creek at mile 67 of the canal, about five miles west of the town of Maxwell in Colusa County. It was constructed by Reclamation in 1975. The earthdam on Funks Creek is 34 feet high and 1,500 feet long. The reservoir has a storage capacity of about 2,000 acre-feet at its maximum operating elevation of 205 feet above mean sea level (MSL). Table 1 provides a summary of the physical characteristics of Funks Reservoir.

PRINCIPAL FACILITIES

The primary features of the T-C Canal Extension include the expansion of the three lower reaches of the existing T-C Canal and the construction of a new canal into southern Yolo County. Each of the three reaches of the existing canal would be enlarged so the entire 44-mile length of the canal between Funks Creek and the terminus would be concrete lined with a capacity of at least 5,000 cfs. There are two possible configurations for increasing the capacity of the existing canal: an enlarged canal configuration and a parallel canal configuration. Both configurations are described in the following sections. Also described in the following sections is the extension of the T-C Canal from its present terminus to the Winters Pump-Generating Plant. Some of the pertinent data for increasing the capacity of the existing canal and the canal extension are presented on Table 1.

Enlarged Canal Configuration

The enlarged canal configuration would increase the capacity of Reaches 6, 7, and 8 of the T-C Canal by enlarging the existing canal structure. Under this configuration, 44 miles of existing canal would be enlarged to a capacity of 5,000 cfs. The capacity of the existing canal ranges from 2,100 cfs at the outlet of Funks Reservoir to 1,700 at the terminus of the existing canal. Figures 3a and 3b show typical cross-sections of enlarging the canal in fill and in cut, respectively.

Enlargement of the canal would require excavation and lining of the existing canal and modification of numerous siphons, check structures, culverts, overchutes, bridges, and canal utilities. Table 2a provides a detailed cost estimate of expanding reaches 6, 7, and 8, as well as a summary of the facilities which would be modified for the canal expansion.

Parallel Canal Configuration

The parallel canal configuration would require a separate, parallel canal constructed with a capacity of 3,500 cfs for the entire 44-mile length of Reaches 6, 7, and 8. This would increase the capacity of the canal to 5,600 cfs for Reach 6 and 7, and 5,200 cfs for Reach 8. In this configuration, construction of a parallel canal would require excavation and lining of the canal and construction of siphons, check structures, culverts, overchutes, bridges and canal utilities similar in location and design to those of the existing canal. It is assumed that the parallel canal would require a 500-foot wide right-of-way adjacent to the existing canal.

Canal Extension

The canal extension from Bird Creek to the Winters Pumping-Generating Plant would add about 21 miles to the total length of the canal. The extension would be concrete-lined with a trapezoidal section with a capacity of 5,000 cfs. Figures 4a and 4b show typical canal sections for a canal in fill and a canal in cut, respectively. It would be assumed that the canal extension would require a 300-foot right-of-way. The construction of the canal extension would require excavation and lining of the canal and construction of siphons, check structures, bridges, overchutes, and culverts. Some of the larger canal crossings include Oat Creek, Cache Creek, and Highway 16.

COST ESTIMATE

The cost estimate for the T-C Canal Extension was developed based on available information, previous experience, and engineering judgment. No existing cost estimates were identified which described the enlargement or extension of the T-C Canal. The

cost estimate does not include environmental documentation, environmental mitigation, operation and maintenance, power, and interest during construction.

COST ESTIMATE METHODOLOGY

The cost estimate for the T-C Canal Extension--Enlarged Canal Configuration was developed by Bookman-Edmonston Engineering based on previous experience and engineering judgment. The cost estimate for the T-C Canal Extension--Parallel Canal Configuration was based on contractor bids received by Reclamation to construct the original T-C Canal. The cost estimate for the T-C Canal Extension--Extension from Bird Creek to Winters Pumping-Generating Plant was developed by Bookman-Edmonston Engineering based on previous experience and engineering judgement. The methodologies used to develop the cost estimates are discussed below.

Enlarged Canal Configuration

The cost estimate for the enlarged canal configuration was developed by Bookman-Edmonston Engineering based on available data and engineering judgment. Table 2a provides a detailed breakdown of estimated costs for the enlargement of Reaches 6, 7, and 8. The unit costs for the enlargement of the canal were developed based on available design drawings for Reach 5 of the T-C Canal. This information was utilized to develop a cost per linear foot of earthwork and concrete lining. Table 2b shows the information used to develop the unit costs for the enlargement excluding modifications to major structures. Modification to major structures required to complete the enlarged canal configuration includes siphons, culverts, farm bridges, county bridges, and overchutes which were designed to a conceptual level. Costs estimates for these facilities were developed by applying standard unit cost to the quantities taken from these conceptual designs.

Parallel Canal Configuration

The cost estimate for the parallel canal configuration utilized Reclamation's "Abstract of Bids" for each reach of the T-C Canal. For each reach the average of the three low bids was escalated to October 1996 level using the Reclamation's Construction Cost Trend (CCT) indices. Table 2c provides a detailed breakdown of the estimated costs for the construction of the parallel canal configuration. This was used as the base for the construction costs. The cost (escalated to October 1996 dollars) of the 3,500 cfs parallel canal was factored by the following empirical equation:

$$\frac{(Cost)_1}{(Cost)_2} = \frac{Q_1^{\%}}{Q_2^{\%}}$$

where Q is equal to capacity.

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

Canal Extension

The canal alignment for the canal extension was selected based on engineering judgment using the U.S. Geological Survey (USGS) 1:24,000 scale quad maps. A profile of the alignment using contours of the USGS maps was developed. A canal profile was prepared and placed on this alignment. Earthwork quantities, and concrete lining quantities were calculated. Facilities required to complete the canal extension including the siphons under Bird Creek, Oat Creek, Cache Creek, Highway 16, and the Southern Pacific Railroad were design to a conceptual level. Cost estimates for these facilities

were developed by applying standard unit cost to the quantities taken from the conceptual designs. Table 2d provides a detailed breakdown of the estimated costs of extending the T-C Canal from Bird Creek to the Winters Pumping-Generating Plant.

Rights-of-Way Costs

Rights-of-way costs of \$3,000 per acre were based on land use costs developed by Reclamation's Land Resource Branch (pers. comm. February 1997). Reclamation provided land use cost estimates at a subappraisal level for all storage and conveyance components reviewed by CALFED.

Contingencies and Other Costs

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

PRELIMINARY COSTS FINDINGS

Costs of the T-C Canal Extension and its supporting facilities have been updated to an October 1996 basis as described above. Table 3 summarizes estimated costs with selected project categories. The estimated cost for enlarging Reaches 6, 7, and 8 of the existing canal to a total capacity of 5,000 cfs ranges from \$132 to \$169 million. The estimated cost of constructing a new canal with 3,500 cfs capacity parallel to the existing canal ranges from \$200 to \$255 million. The estimated cost of constructing a new canal

extension ranges from \$194 to \$248 million. If the T-C Canal Extension was to be developed by enlarging the capacity of the existing canal structure, the estimated cost of the project would be \$326 to \$417 million. To develop the project by constructing a parallel canal would result in an estimated cost of \$394 to \$503 million.

ENVIRONMENTAL CONSIDERATIONS

[NOTE: The Environmental Considerations section needs to be reevaluated to reflect the canal extension from Funks Reservoir only. It also needs to be made consistent with write-up in previous section.]

This portion of the report provides a summary of environmental considerations related to the proposal for enlarging the existing T-C Canal and extending the canal from Dunnigan to Clifton Court Forebay (approximately 95 miles). Fish, wildlife, plant, and cultural resources that could be affected by the proposal are described and the extent of the impacts identified. For the most part, the information presented in this section was gathered from existing literature, with limited original research. No field work was conducted for this analysis.

WILDLIFE

Enlarging the canal within the existing alignment would result in minimal impacts to wildlife and their associated habitat. Potential impacts to fish could occur as a result of increased diversions at Red Bluff or at any other point of the Sacramento River.

Extending the canal from Dunnigan to Clifton Court Forebay could result in significant impacts to wildlife.

Fish, Amphibians, Reptiles, and Invertebrates

Confining the enlargement to the existing right-of-way is expected to have no impact on fish and minimal impact on amphibians, reptiles, and invertebrates. Extending the canal would have short-term impacts on these species.

The Sacramento River supports important resident and anadromous fish populations. Important resident fish species include channel catfish, largemouth bass, white catfish, Sacramento squawfish, and Sacramento sucker. The principal anadromous fish in this portion of the Sacramento River are chinook salmon, steelhead trout, striped bass, American shad, and white shad. Increases in diversions of water from the river could adversely affect migrating juvenile and adult anadromous fish. The degree of increased fish losses at the diversion point would depend on the timing of the diversions and the quality of fish screens.

General Wildlife

Lands along the existing alignment and the proposed extension alignment support a moderately diverse wildlife. Mammals which may be found in the area include opossum, shrew, bats, black bear, racoon, ring-tailed cat, weasel, badger, skunk, coyote, gray fox, squirrels, gophers, mice, rabbit, and black-tailed deer.

Numerous bird species are found along the canal alignment and the alignment of the proposed extension. Killdeer is found nesting in open fields adjacent to portions of the canal. Some of the common perching birds found nesting in the area include meadowlark, blackbird, jay, flycatcher, swallow, crow, starling, and mockingbird. Gamebirds found in the area include quail, pheasant, dove, and pigeon.

Sensitive and Listed Fish and Wildlife Species

No State or federally listed fish species would be affected directly by the proposed canal enlargement and the proposed extension.

According to the California Department of Fish and Game's California Natural Diversity Data Base records (CNDDDB - Version 8/96), there are seven wildlife species that are State or federally listed and nine that are either candidates for listing and/or species designated by CDFG as species of special concern known to occur in the area affected by the proposed project.

There are three wildlife species that are State or federally listed and four that are either candidates for listing and/or species designated CDFG as species of special concern known to occur in the alignment of the proposed T-C Canal Extension.

The listed wildlife species that could be affected by the proposed enlarged T-C Canal include Valley Elderberry Longhorn Beetle (Federal Threatened), Northern Spotted Owl (Federal Threatened), Swainsons Hawk (State Threatened), Western Yellow Billed Cuckoo (State Endangered), Bank Swallow (State Threatened), Giant Garter Snake (Federal and State Threatened), and Vernal Pool Fairy Shrimp (Federal Threatened).

The listed wildlife species that could be affected by the proposed T-C Canal extension include Swainson's Hawk (State Threatened), Western Yellow Billed Cuckoo (State Endangered), and Bank Swallow (State Threatened). The Valley Elderberry Longhorn Beetle (Federal Threatened), while not previously recorded along the proposed alignment of the extension, could potentially be affected (see below).

Wildlife species that are either candidates for State or federal listing, or considered species of special concern by the CDFG, that could be affected by the proposed enlarged T-C Canal include California Tiger Salamander (Federal Candidate/CDFG Species of Special Concern), Western Spadefoot (Federal and CDFG Species of Special Concern), Golden Eagle (CDFG Species of Special Concern), Burrowing Owl (CDFG Species of Special Concern), Yellow Warbler (CDFG Species of Special Concern), Yellow Breasted Chat (CDFG Species of Special Concern), Tricolored Blackbird (Federal and CDFG Species of Special Concern), San Joaquin Pocket Mouse (CDFG Species of Special Concern), and Northwestern Pond Turtle (Federal Candidate/CDFG Species of Special Concern).

Wildlife species that are either candidates for State or federal listing or considered species of special concern by the CDFG that could be affected by the proposed T-C Canal extension include California Tiger Salamander (Federal Candidate/CDFG Species of Special Concern), Burrowing Owl (CDFG Species of Special Concern), Tricolored Blackbird (Federal and CDFG Species of Special Concern), and Northwestern Pond Turtle (Federal Candidate/CDFG Species of Special Concern).

The Valley elderberry longhorn beetle, a federally listed threatened species, although not commonly found in the area, could potentially occur in areas adjacent to the canal alignment and the proposed alignment of the canal extension. Limited numbers of elderberry plants occur sporadically along the areas intermittent streams.

Vernal pool habitats, if present, have the potential to support the vernal pool fairy shrimp.

Several sensitive and State or federally listed bird species that have the potential to occur adjacent to the canal's present alignment and the proposed extension alignment include

Swainson' hawk, golden eagle, burrowing owl, and tricolored blackbird. It is also possible that the area may receive sporadic use by wintering bald eagles.

The Swainsons hawk, a State listed threatened species, may use the open grassland or cropland habitats adjacent to the T-C Canal alignment and proposed alignment extension. Potentially suitable nesting and foraging habitat is available for this species in areas adjacent to the canal.

Limited sporadic use of adjacent lands may also occur for wintering greater sandhill cranes. This species (State listed Threatened) is a common winter migrant to the eastern Sacramento Valley. While the crane does not nest in the project area, it could use the open grasslands for foraging.

The San Joaquin pocket mouse, a species of special concern, is known to occur in areas adjacent to the existing canal alignment.

VEGETATION

Vegetation along both sides of the Tehama-Colusa Canal consists of 60 percent agricultural lands and 38 percent grasslands. Approximately 1 percent of the lands along the sides of the canal are riparian and 1 percent of are disturbed lands. Vegetation along the proposed alignment of the T-C Canal Extension is similar to that of the existing alignment of the canal and consisting primarily of agricultural lands and grassland. Also, approximately 1 percent of the lands along the proposed extension alignment are riparian and 5 percent of the lands are disturbed.

Sensitive and Listed Plant Species

No listed plant species have been recorded along the existing alignment of the T-C Canal or the proposed alignment of the Tehama-Colusa Extension.

Candidate species or species of concern that may occur along the existing canal alignment include: Silky Cryptantha, Caper-fruited Tropicocarpum, Ahart's Paronychia, San Joaquin Saltbush, Ferris's Milk-vetch, Bakers Navarretia, Recurved Larkspur, Palmate-bracted Birds-beak, and Adobe Lily. One candidate/species of concern, Recurved Larkspur, may occur along the proposed extension of the canal alignment.

Four plants, Dwarf Downingia, Britblescale, Four-angled Spikerush, and Red Bluff Dwarf Rush, considered by the California Native Plant Society to be either rare, threatened or endangered in California and elsewhere, may occur along the canal alignment.

Several special status habitats may also be found along the existing canal alignment.

These communities include Valley Needlegrass Grassland, Northern Claypan Vernal Pool (see Wetlands section), Great Valley Oak Riparian Forest, Great Valley Mixed Riparian Forest, Great Valley Cottonwood Riparian Forest, and Great Valley Willow Scrub. No special status habitats are known to occur along the proposed alignment of the canal extension. However, field surveys may reveal the presence of one or more of these special status habitats.

Wetlands

The existing T-C Canal and proposed extension crosses 30 intermittent streambeds, one upper perennial stream, 13 emergent seasonally flooded wetlands (shallow marsh), 14 emergent seasonally flooded wetlands (excavated), 28 emergent temporarily flooded

wetlands (wet meadow), four emergent temporarily flooded wetland (excavated), one scrub-shrub seasonally flooded shallow marsh, one scrub-shrub/emergent intermittent temporarily flooded wetland (wet meadow), four forested/temporarily-flooded wetlands (wet meadow), one forested/seasonally flooded wetland-excavated shallow marsh, five scrub-shrub temporarily flooded wetland (wet meadow), one drainage canal, and two canal crossings.

One special status wetland habitat, Northern Claypan Vernal Pool, can be found in the area of the existing T-C Canal.

CULTURAL RESOURCES

The T-C Canal Enlargement could affect three prehistoric sites, one of which is significant. No other cultural resources of any type are known to exist in the right-of-way on the canal. The majority of the alignment of the canal expansion (approximately 95%) is expected to have a low archeological sensitivity, while the major stream crossings along the alignment are expected to have a moderate sensitivity. The extent of cultural resources along the proposed alignment of the canal extension is unknown.

BIBLIOGRAPHY

California Department of Fish and Game, "Natural Diversity Data Base," Update
Version: 8/96.

U.S. Bureau of Reclamation, November 1963, *Tehama-Colusa Canal, Thomes Creek to
Oat Creek Ranch-Engineering Geology for Feasibility Cost Estimates*,
Department of the Interior.

U.S. Bureau of Reclamation, December 1964, *West Sacramento Canal Unit, Central
Valley Project, California--A report on the Feasibility of Water Supply
Development*, Department of the Interior.

U.S. Bureau of Reclamation, June 1972, *Final Environmental Statement, Tehama-Colusa
Canal, Central Valley Project, California*, Department of Interior.

U.S. Bureau of Reclamation, May 1975, *Supplement to the Final Environmental
Statement, Tehama-Colusa Canal, Central Valley Project, California*, Department
of the Interior.

U.S. Bureau of Reclamation, Land Resources Branch, February 1997, personal
communication, Graham McMullen, Department of the Interior.

U.S. Fish and Wildlife Service, "National Wetlands Inventory Program."

U.S. Fish and Wildlife Service, September 1995, "Environmental Effects of Yield
Increase Options, Technical Appendix #9 to the Final Least-Cost CVP Yield
Increase Plan."

U.S. Geological Survey, "National Aerial Photography Program."

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Table 1
SUMMARY OF PHYSICAL CHARACTERISTICS
TEHAMA-COLUSA CANAL EXTENSION

	Existing Facilities	Enlarged Canal Configuration	Parallel Canal Configuration/	Canal Extension
Reach 6				
Length (miles)	16.4	16.4	16.4	
Capacity (cfs)	2,100	5,000	3,500	
Reach 7				
Length (miles)	13.5	13.5	13.5	
Capacity (cfs)	2,100	5,000	3,500	
Reach 8				
Length (miles)	14.5	14.5	14.5	
Capacity (cfs)	1,700	5,000	3,500	
Canal Extension				
Length (miles)	--	--		21.2
Capacity (cfs)	--	--		5,000
Funks Reservoir				
Normal Pool Elevation (feet above MSL)	205			
Storage at Normal Pool (acre-feet)	2,000			
Inundation Area (acres)	220			
Funks Dam				
Type	Earthfill			
Height Above Streambed (feet)	34			
Crest Length (feet)	1,500			

Table 2a
ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION
ENLARGED CANAL CONFIGURATION

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JUL. 60	USBR INDEX OCT. 96	UNIT COST JUL. 69	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
I. FUNKS RESERVOIR TO FRESHWATER CREEK REACH 6 : 16.4 MILES								
Modification of Outlet Work at Funks Reservoir	JOB	LS				\$500,000	\$500,000	1
Enlargement of Canal	86,740	LF				\$184	\$15,960,160	1
Modification of Check Structure (Sta. 3583+23)	JOB	LS				\$1,100,000	\$1,100,000	1
Modification of Stone Corral Creek Siphon	JOB	LS				\$5,600,000	\$5,600,000	1
Modification of Check Structure (Sta. 4064+50)	JOB	LS				\$1,100,000	\$1,100,000	1
Modification of Freshwater Creek Siphon	JOB	LS				\$1,500,000	\$1,500,000	1
Modification of County Road Bridges	4	EA				\$485,000	\$1,940,000	1
Modification of Farm Bridges	5	EA				\$285,000	\$1,425,000	1
Modification of Overchutes	JOB	LS				\$1,200,000	\$1,200,000	1
Modification of Culverts	JOB	LS				\$500,000	\$500,000	1
Modification of Utilities at Canal Structures	13	EA				\$10,000	\$130,000	1
SUBTOTAL REACH 6							\$30,955,160	
II. FRESHWATER CREEK TO ELK CREEK REACH 7 : 13.5 MILES								
Enlargement of Canal	71,410	LF				\$184	\$13,139,440	1
Modification of Salt Creek Siphon	JOB	LS				\$1,500,000	\$1,500,000	1
Modification of Spring-Walters Creek Siphon with Check Structure	JOB	LS				\$2,500,000	\$2,500,000	1
Modification of Cortina Creek Siphon	JOB	LS				\$1,500,000	\$1,500,000	1
Modification of Sand Creek Siphon	JOB	LS				\$1,500,000	\$1,500,000	1
Modification of Elk Creek Siphon with Check Structure	JOB	LS				\$2,500,000	\$2,500,000	1
Modification of County Road Bridges	5	EA				\$485,000	\$2,425,000	1
Modification of Farm Bridges	2	EA				\$285,000	\$570,000	1
Modification of Utilities at Canal Structures	12	EA				\$10,000	\$120,000	1
SUBTOTAL REACH 7							\$25,754,440	
III. ELK CREEK TO END OF CANAL REACH 8 : 14.5 MILES								
Enlargement of Canal	76,460	LF				\$230	\$17,585,800	1
Modification of Salt Creek Siphon	JOB	LS				\$1,650,000	\$1,650,000	1

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Table 2a
ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION
ENLARGED CANAL CONFIGURATION

DESCRIPTION	QUANTITY	UNIT ^a	USBR INDEX JUL. 60	USBR INDEX OCT. 96	UNIT COST JUL. 60	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Modification of Check Structure (Sta. 5398+50)	JOB	LS				\$1,210,000	\$1,210,000	1
Modification of Petroleum Creek Siphon	JOB	LS				\$1,650,000	\$1,650,000	1
Modification of Buckeye Creek Siphon	JOB	LS				\$1,650,000	\$1,650,000	1
Modification of County Road Bridges	11	EA				\$490,000	\$5,390,000	1
Modification of Farm Bridges	7	EA				\$280,000	\$1,960,000	1
Modification of Culverts	JOB	LS				\$500,000	\$500,000	1
Modification of Utilities at Canal Structures	22	EA				\$10,000	\$220,000	1
Modification of Terminal Structure	JOB	LS				\$200,000	\$200,000	1
SUBTOTAL REACH 7							\$32,015,800	
IV. LANDS								
Rights-of-ways	650	AC				\$3,000	\$1,950,000	2
SUBTOTAL LANDS							\$1,950,000	
SUBTOTAL FOR ENLARGEMENT OF TEHAMA-COLUSA CANAL							\$90,700,000	
CONTINGENCIES @ 20%							\$18,100,000	
ESTIMATED CONSTRUCTION COST							\$108,800,000	
ENG., LEGAL, AND ADM. @ 35%							\$38,100,000	
ESTIMATED CAPITAL COST FOR ENLARGEMENT OF TEHAMA-COLUSA CANAL							\$146,900,000	
ESTIMATED CAPITAL COST RANGE								
LOW (-10%)							\$132,000,000	
HIGH (+15%)							\$169,000,000	

Footnotes:

^aCY=cubic yard; LB=pound; EA=each; LS=lump sum; LF=linear foot; SF=square foot; TON=ton; MI=mile; AC=acre

Cost Reference:

1. Cost developed by Bookman-Edmonston Engineering.
2. U.S. Bureau of Reclamation, Land Resources Branch, Personal Communication with Graham McMullen, February 1997.

Table 20
ESTIMATED COST PER LINEAR FOOT OF ENLARGED CANAL
TEHAMA-COLUSA CANAL EXTENSION
REACH 5 - FROM LOGAN CREEK TO FUNKS RESERVOIR

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JUL. 60	USBR INDEX OCT. 96	UNIT COST JUL. 60	UNIT COST OCT. 96	TOTAL COST OCT. 96
I. EARTHWORKS AND CONCRETE LINING							
Earthworks and concrete lining	JOB	LS				\$8,466,900	\$8,466,900
Plus 15%							\$1,270,035
SUBTOTAL EARTHWORKS AND CONCRETE LINING							\$9,736,935
II. MODIFICATION OF PIPE OVERCHUTES							
24" Pipe Overchutes	7	EA				\$20,000	\$140,000
30" Pipe Overchutes	3	EA				\$22,000	\$66,000
39" Pipe Overchutes	1	EA				\$25,000	\$25,000
42" Pipe Overchutes	2	EA				\$26,000	\$52,000
SUBTOTAL MODIFICATION OF PIPE OVERCHUTES							\$283,000
III. MODIFICATION OF PIPE CULVERTS							
24" Single Pipe Culverts	5	EA				\$7,500	\$37,500
27" Single Pipe Culverts	1	EA				\$8,000	\$8,000
33" Single Pipe Culverts	1	EA				\$9,000	\$9,000
36" Single Pipe Culverts	2	EA				\$10,000	\$20,000
48" Single Pipe Culverts	1	EA				\$13,000	\$13,000
51" Single Pipe Culverts	1	EA				\$14,000	\$14,000
54" Single Pipe Culverts	1	EA				\$15,000	\$15,000
60" Single Pipe Culverts	1	EA				\$16,000	\$16,000
51" Double Barrel Pipe Culverts	1	EA				\$24,000	\$24,000
60" Double Barrel Pipe Culverts	1	EA				\$30,000	\$30,000
66" Double Barrel Pipe Culverts	1	EA				\$34,000	\$34,000
SUBTOTAL MODIFICATION OF PIPE CULVERTS							\$220,500
CALCULATION OF AVERAGE COST							
Earthworks and Concrete Lining	JOB	LS					\$9,736,935
Modification of Pipe Overchutes	JOB	LS					\$283,000
Modification of Pipe Culverts	JOB	LS					\$220,500
Average cost per linear foot of canal excluding major structures	55,818	LF				\$183.46	\$10,240,435
UNIT COST OF ENLARGEMENT EXCLUDING MAJOR STRUCTURES						\$184	

Footnotes:

* EA=each; LS=lump sum; LF=linear foot

All costs developed by Bookman-Edmonston Engineering.

TABLE 2C
ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION
PARALLEL CANAL CONFIGURATION

DESCRIPTION	QUANTITY	UNIT ^a	BID DATE	AVERAGE OF THREE LOW BIDS	USBR INDEX BID DATE	USBR INDEX OCT. 96	UNIT COST OCT. 96	"3/8 POWER" FACTOR	TOTAL COST OCT. 96	COST REFERENCE
PARALLEL CANAL REACHES										
Reach 6: 2,100 cfs canal capacity	JOB	LS	Apr. 1977	\$21,933,300	99	199	\$44,088,148	1.21	\$53,346,660	1
Reach 7: 2,100 cfs canal capacity	JOB	LS	Nov. 1977	\$14,476,900	102	199	\$28,244,148	1.21	\$34,175,419	1
Reach 8: 1,700 cfs canal capacity	JOB	LS	Dec. 1978	\$17,538,200	108	199	\$32,315,757	1.31	\$42,333,642	1
SUBTOTAL REACHES									\$129,855,721	
LANDS										
Right-of-Way	2,430	AC					\$3,000		\$7,290,000	2
SUBTOTAL LANDS									\$7,290,000	
SUBTOTAL FOR TEHAMA-COLUSA PARALLEL CANAL									\$137,000,000	
CONTINGENCIES @20%									\$27,400,000	
ESTIMATED CONSTRUCTION COST									\$164,000,000	
ENG., LEGAL, AND ADMIN @ 35%									\$57,400,000	
ESTIMATED CAPITAL COST FOR TEHAMA-COLUSA PARALLEL CANAL									\$221,000,000	
ESTIMATED CAPITAL COST RANGE										
LOW (-10%)									\$199,000,000	
HIGH (+15%)									\$254,000,000	

Footnote:

^aLS=lump sum; AC=acre

Cost Reference:

1. Bureau of Reclamation Abstract of Bids.
2. U.S. Bureau of Reclamation, Land Resources Branch, Personal Communication with Graham McMullen, February 1997.

ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION
EXTENSION OF CANAL FROM BIRD CREEK TO WINTERS PUMPING-GENERATING PLANT

DESCRIPTION	QUANTITY	UNIT*	UNIT COST OCT. 1996	TOTAL COST OCT. 1996	COST REFERENCE
I. CONCRETE LINED CANAL					
Clearing and Grubbing	900	AC	\$200.00	\$180,000	1
Excavation	10,136,000	CY	\$2.00	\$20,272,000	1
Compacted Embankment	3,046,000	CY	\$0.80	\$2,437,000	1
Common Embankment	1,980,000	CY	\$0.50	\$990,000	1
Borrow (Beginning of Canal to Oat Creek)	2,500,000	CY	\$2.00	\$5,000,000	1
Concrete Lining	138,000	CY	\$80.00	\$11,040,000	1
Fencing	224,000	LF	\$5.00	\$1,120,000	1
SUBTOTAL CONCRETE LINED CANAL				\$41,039,000	
II. SIPHONS					
Bird Creek Siphon (1,800 feet)					
Siphon Barrel Concrete	31,680	CY	\$600.00	\$19,008,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
Oat Creek Siphon (1,500 feet)					
Siphon Barrel Concrete	26,400	CY	\$600.00	\$15,840,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
Drainage Siphon (800 feet)					
Siphon Barrel Concrete	14,080	CY	\$600.00	\$8,448,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
County Road and Drainage Siphon (300 feet)					
Siphon Barrel Concrete	5,280	CY	\$600.00	\$3,168,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
County Road and Drainage Siphon (300 feet)					
Siphon Barrel Concrete	5,280	CY	\$600.00	\$3,168,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
Cache Creek Siphon (1,800 feet)					
Siphon Barrel Concrete	31,680	CY	\$600.00	\$19,008,000	1

TABLE 2A
ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION
EXTENSION OF CANAL FROM BIRD CREEK TO WINTERS PUMPING-GENERATING PLANT

DESCRIPTION	QUANTITY	UNIT*	UNIT COST OCT. 1996	TOTAL COST OCT. 1996	COST REFERENCE
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
Highway 16 and R.R. Siphon (300 feet)					
Siphon Barrel Concrete	5,280	CY	\$600.00	\$3,168,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
Railroad Shootfly	JOB	LS		\$200,000	1
County Road and Drainage Siphon (300 feet)					
Siphon Barrel Concrete	5,280	CY	\$600.00	\$3,168,000	1
Inlet/Outlet Transition Concrete	1,400	CY	\$600.00	\$840,000	1
SUBTOTAL SIPHONS				\$81,896,000	
III. CHECK STRUCTURES					
3 Check Structures	3	EA	\$1,100,000.00	\$3,300,000	1
SUBTOTAL CHECK STRUCTURES				\$3,300,000	
IV. COUNTY ROAD BRIDGES					
5 County Road Bridges	5	EA	\$420,000.00	\$2,100,000	1
SUBTOTAL COUNTY ROAD BRIDGES				\$2,100,000	
V. FARM ROAD BRIDGES					
4 Farm Road Bridges	4	EA	\$240,000.00	\$960,000	1
SUBTOTAL FARM ROAD BRIDGES				\$960,000	
VI. DRAINAGE OVERCHUTES					
3 Drainage Overchutes	3	EA	\$66,000.00	\$198,000	1
Winters Canal Overchute	JOB	LS		\$200,000	1
SUBTOTAL DRAINAGE OVERCHUTES				\$398,000	

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TABLE 20
ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION
EXTENSION OF CANAL FROM BIRD CREEK TO WINTERS PUMPING-GENERATING PLANT

DESCRIPTION	QUANTITY	UNIT ^a	UNIT COST OCT. 1996	TOTAL COST OCT. 1996	COST REFERENCE
VII. DRAINAGE CULVERTS					
13 Drainage Culverts	13	EA	\$54,000.00	\$702,000	1
SUBTOTAL DRAINAGE CULVERTS				\$702,000	
VIII. LAND COST					
350-Foot Canal Right of Way, Width 21.2 miles	900	AC	\$3,000.00	\$2,700,000	2
SUBTOTAL LAND COST				\$2,700,000	
SUBTOTAL FOR TEHAMA-COLUSA CANAL EXTENSION				\$133,000,000	
CONTINGENCIES 20%				\$26,600,000	
ESTIMATED CONSTRUCTION COST FOR TEHAMA-COLUSA CANAL EXTENSION				\$159,600,000	
ENGR., LEGAL, AND ADMIN. @35%				\$55,900,000	
ESTIMATED CAPITAL COST FOR TEHAMA-COLUSA CANAL EXTENSION				\$215,500,000	
ESTIMATED CAPITAL COST RANGE FOR TEHAMA-COLUSA CANAL EXTENSION					
LOW (-10%)				\$194,000,000	
HIGH (+15%)				\$248,000,000	

Footnotes:

^aCY=cubic yard; EA=each; LS=lump sum; LF=linear foot; AC=acre

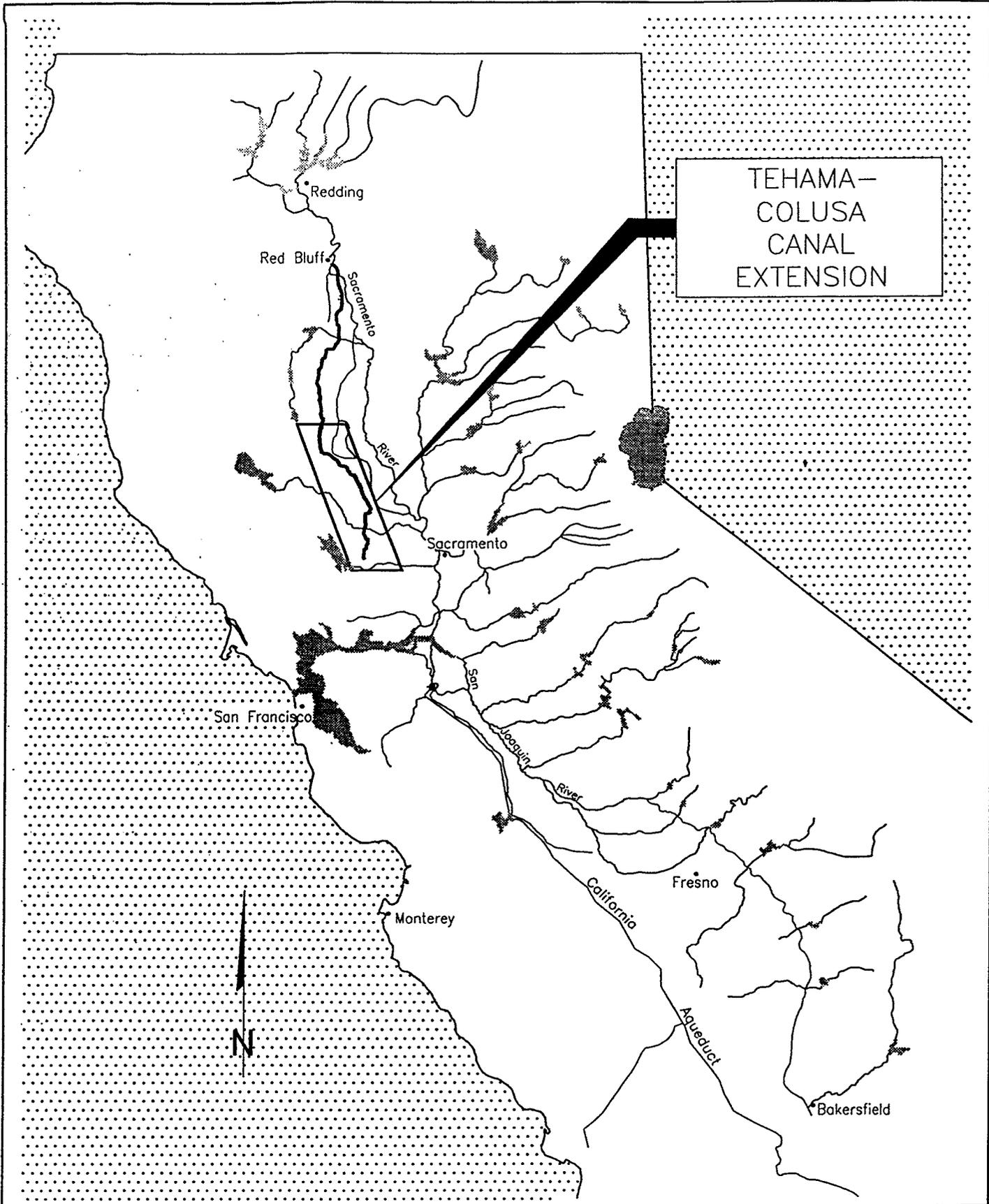
Cost Reference:

1. Cost developed by Bookman-Edmonston Engineering.
2. U.S. Bureau of Reclamation, Land Resources Branch, Personal Communication with Graham McMullen, February 1997.

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Table 3
SUMMARY OF ESTIMATED COSTS
TEHAMA-COLUSA CANAL EXTENSION

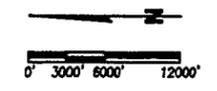
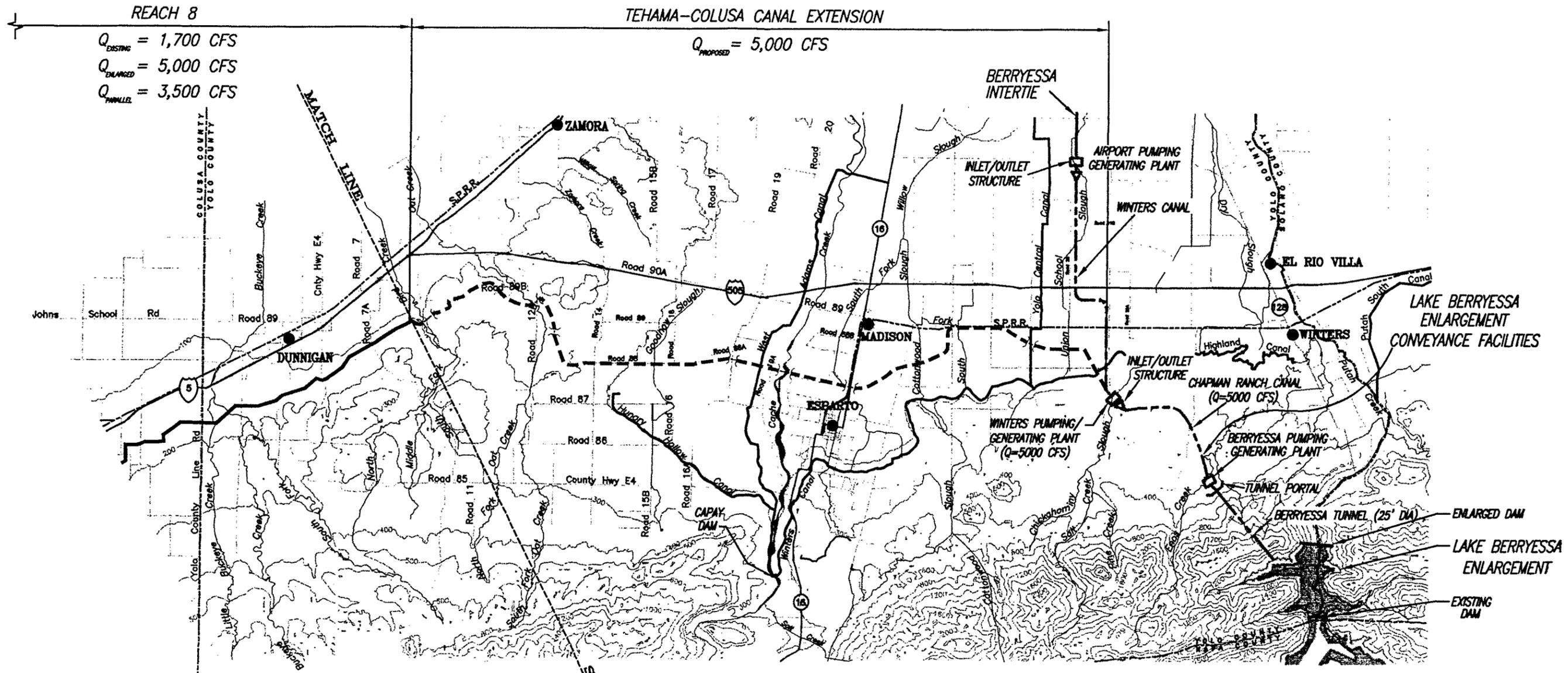
Cost Item	Estimated Cost (\$Millions)	
	Canal Enlargement Plus Canal Extension	Parallel Canal Plus Canal Extension
Canal Enlargement		
Reach 6	31.0	53.3
Reach 7	25.8	34.2
Reach 8	32.0	42.3
Lands	2.0	7.3
SUBTOTAL	90.7	137.1
Contingencies @20%	18.1	27.4
ESTIMATED CAPITAL COSTS	108.8	164.5
Eng., Legal, Admin. @ 35%	38.1	57.6
ESTIMATED CAPITAL COSTS	146.9	222.1
Capital Cost Range (minus 10% - plus 15%)	\$132 - \$169	\$200 - \$255
Canal Extension		
Concrete-Lined Canal	41.0	41.0
Siphons	81.9	81.9
Check Structures	3.3	3.3
County Road Bridges	2.1	2.1
Farm Road Bridges	1.0	1.0
Drainage Overchutes	0.4	0.4
Drainage Culverts	0.7	0.7
Land Costs	2.7	2.7
SUBTOTAL	133.1	133.1
Contingencies @20%	26.6	26.6
ESTIMATED CAPITAL COSTS	159.7	159.7
Eng., Legal, Admin. @ 35%	55.9	55.9
ESTIMATED CAPITAL COSTS	215.6	215.6
Capital Cost Range (minus 10% - plus 15%)	\$194 - \$248	\$194 - \$248
CANAL ENLARGEMENT AND CANAL EXTENSION		
Capital Cost Range (minus 10% - plus 15%)	\$326 - \$417	\$394 - \$503



TEHAMA-COLUSA
CANAL
EXTENSION

Figure 1
Project Location Map
Tehama-Colusa Canal Extension

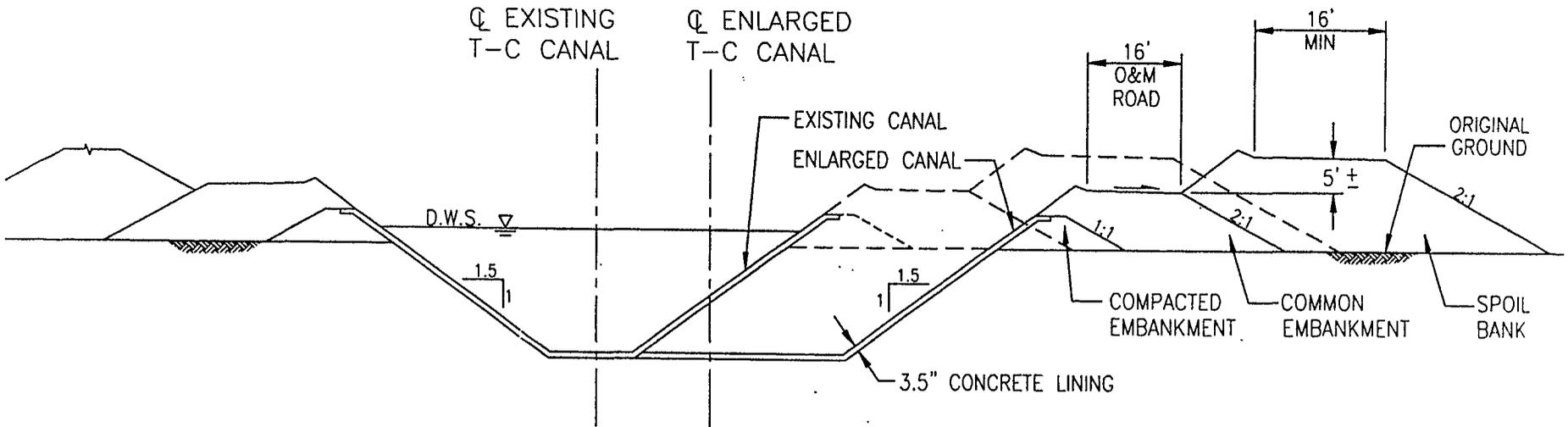




- LEGEND**
- Existing Lake Berryessa
 - Lake Berryessa Enlargement
 - Tehama-Colusa Canal Extension
 - Tehama-Colusa Canal Enlargement
 - Other Existing Canals
 - Proposed Lake Berryessa System
 - Existing Roads and Highways
 - Railroad
 - Existing Waterways
 - Proposed Canal Siphons
 - Pumping-Generating Plant

Figure 2b
Tehama-Colusa Canal Extension
 Sheet 2 OF 2

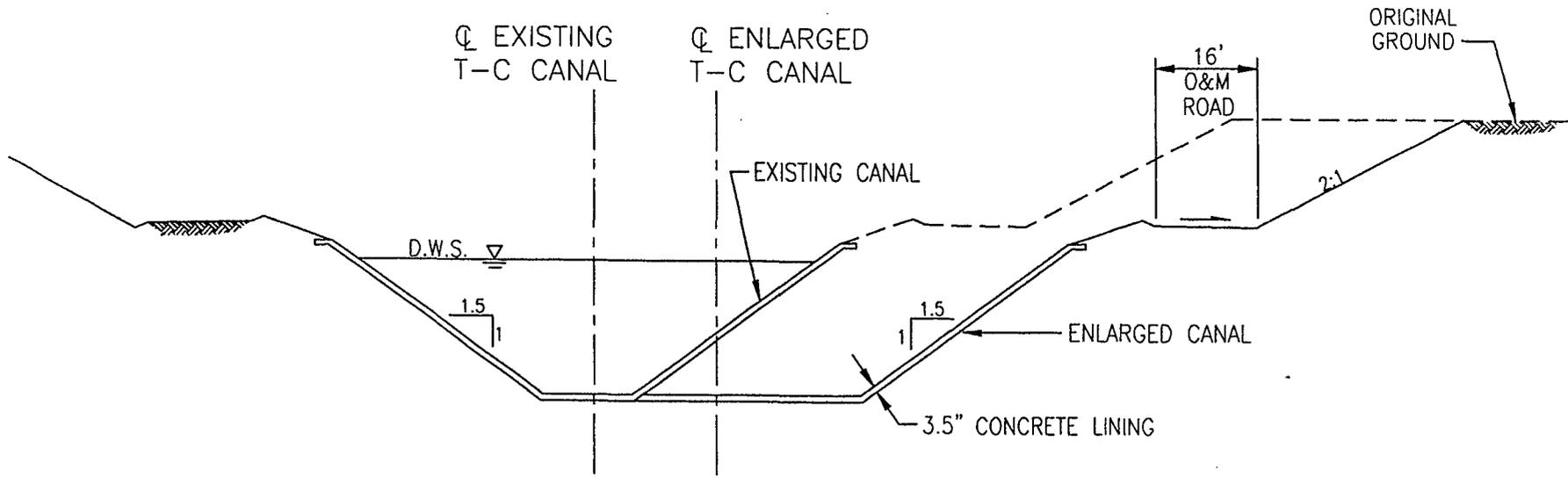




ENLARGED CANAL IN FILL
(Reaches 6, 7, and 8 of Existing Tehama-Colusa Canal)

NOT TO SCALE

Figure 3a
Tehama-Colusa Canal Extension
Typical Canal Section



ENLARGED CANAL IN CUT
(Reaches 6, 7, and 8 of
Existing Tehama-Colusa Canal)

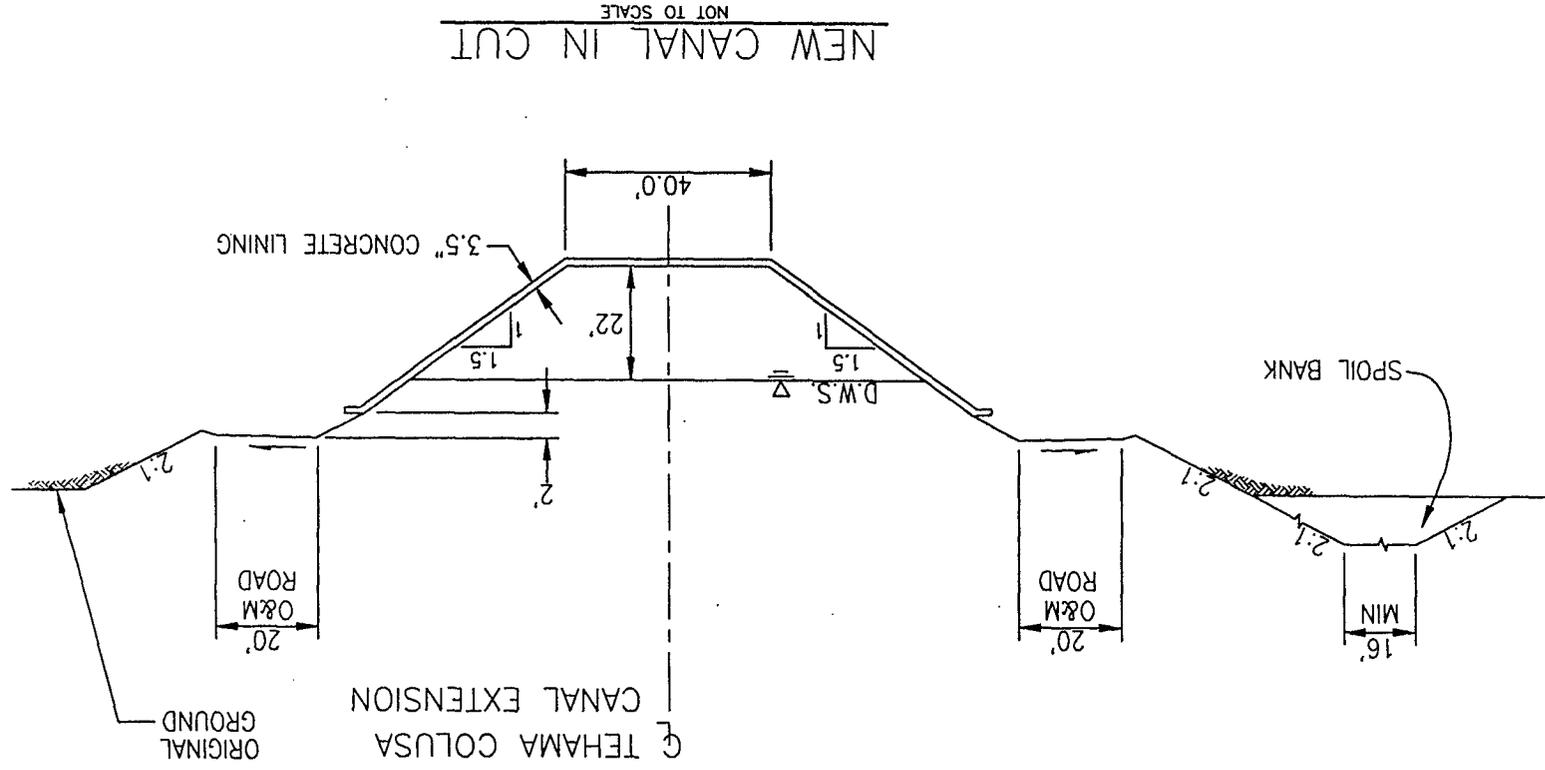
NOT TO SCALE

Figure 3b
Tehama-Colusa Canal Extension
Typical Canal Section



Figure 4b
 Tehama-Colusa Canal Extension
 Typical Canal Section

CALIFORNIA
 BAY-DELTA
 PROGRAM



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