# Conveyance Study A – Sacramento Valley

Central District has assisted Northern District in a Proposition 204-funded study of alternative diversion points and conveyance routes for delivery of diverted water from the Sacramento River to the Sites offstream storage option. CD's task was to examine the feasibility of providing up to 8,000 cfs total conveyance capacity from one or more diversion locations.

The alternatives include the potential use of existing facilities such as the Tehama-Colusa Canal, Glenn-Colusa Canal and Colusa Basin Drain; the construction of new conveyance facilities; or combinations of new and existing facilities. The Colusa Basin Drain flow is estimated at 3,000 cfs maximum and, when added to the 5,000 cfs Sacramento River diversions, could allow up to 8,000 cfs to be diverted to Funks Reservoir for lifting to the proposed Sites Reservoir.

Funks Reservoir on the Tehama-Colusa Canal would become the forebay for a large or small Sites Reservoir storage option. Funks Reservoir would also be the terminal point for the Sacramento River conveyance alternatives and water diverted from the Colusa Basin Drain.

## Study Area

The location of the Sites Reservoir offstream storage option is shown on a map of the study area (see Figure 1). The conveyance alternatives for the reservoir are located partially or entirely within Tehama, Glenn, and Colusa Counties.

## Description of Alternatives

### General Design Assumptions

- The following general assumptions were used to guide the development of alternatives:
- Divert up to 5,000 cfs surplus or flood water from the Sacramento River to existing canal(s), enlarged existing canal(s) and/or new canal(s).
- Alternatives I and II utilize existing canals or enlarged existing canals and do not include any diversion from the Colusa Basin Drain.
- The current diversion facilities at Red Bluff and Hamilton City are operated primarily during the irrigation season. The facilities are being modified or being studied by other agencies to reduce adverse impacts to fish during diversions. The design and costs of the modifications are not included in this study. However, the costs of new facilities that would increase the existing capacities are included in the alternatives.
- A new Sacramento River diversion, if proposed, would be located below River Mile 200.5, with a fish screen and pumping plant facilities to raise water to Funks Reservoir. A new canal would connect any new diversion to an existing canal or directly to Funks Reservoir.

- Divert up to 3,000 cfs of surplus or floodwater from the Colusa Basin Drain to Funks Reservoir. This water would be in addition to the water diverted from the Sacramento River and is included in Alternatives III through VII. The conveyance capacities would be enlarged above 5,000 cfs, wherever needed, to accommodate additional water from the Colusa Basin Drain.
- The new diverting canals will be concrete-lined, and diverted flows will be controlled by existing or new pumping plants and canal checks. The new canals will require several pumping plants to lift the existing canal flows to the higher elevation of Funks Forebay.
- The new canals are assumed to have zero slopes to allow pump-storage capability between the existing canals and Funks Reservoir. Pumping plants would have generating equipment to allow power recovery when water is delivered back to the existing canals for irrigation or back to the Sacramento River for environmental purposes.
- The alternatives include a conveyance system with a diversion facility, canals, pumping plants, penstocks, and appurtenant works necessary to deliver the water to Funks Reservoir for subsequent lifting into Sites Reservoir. The alternatives utilize existing canal systems, enlarged systems or new systems that will require modifications to existing or new diversion and fish facilities on the Sacramento River.
- CALFED staff recommended that diversion structures have the ability to divert water from the Sacramento River when flows are as low as 15,000 cfs.

A detailed list of design assumptions is included in Attachment B.

## FIGURE 1

PROPOSED CONVEYANCE ALTERNATIVES

ALTERNATIVE I (A): TC + GC/ NC4A
Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to TC just upstream of Funks Reservoir.

ALTERNATIVE I(B): TC + GC /NC4B
Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

ALTERNATIVE II(A): TC + GC/NC4A
Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to TC Canal just upstream of Funks Reservoir.

ALTERNATIVE II(B): TC + GC/NC4B
Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

ALTERNATIVE III: TC + GC + CD/NC
Existing 2100 cfs TC Canal and enlarged 2900 cfs GC Canal, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE IV(A): GC + CD/NC
Enlarge existing 3000 cfs GC Canal diversion at Hamilton City to 5000 cfs, 5000 cfs GC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE IV(B): GC/CLI + CD/NC
New 2100 cfs SR diversion near Chico Landing, 5000 cfs GC Canal enlargement below Chico Landing Intertie, plus added 3000 cfs from Colusa Basin Drain to New Canal.

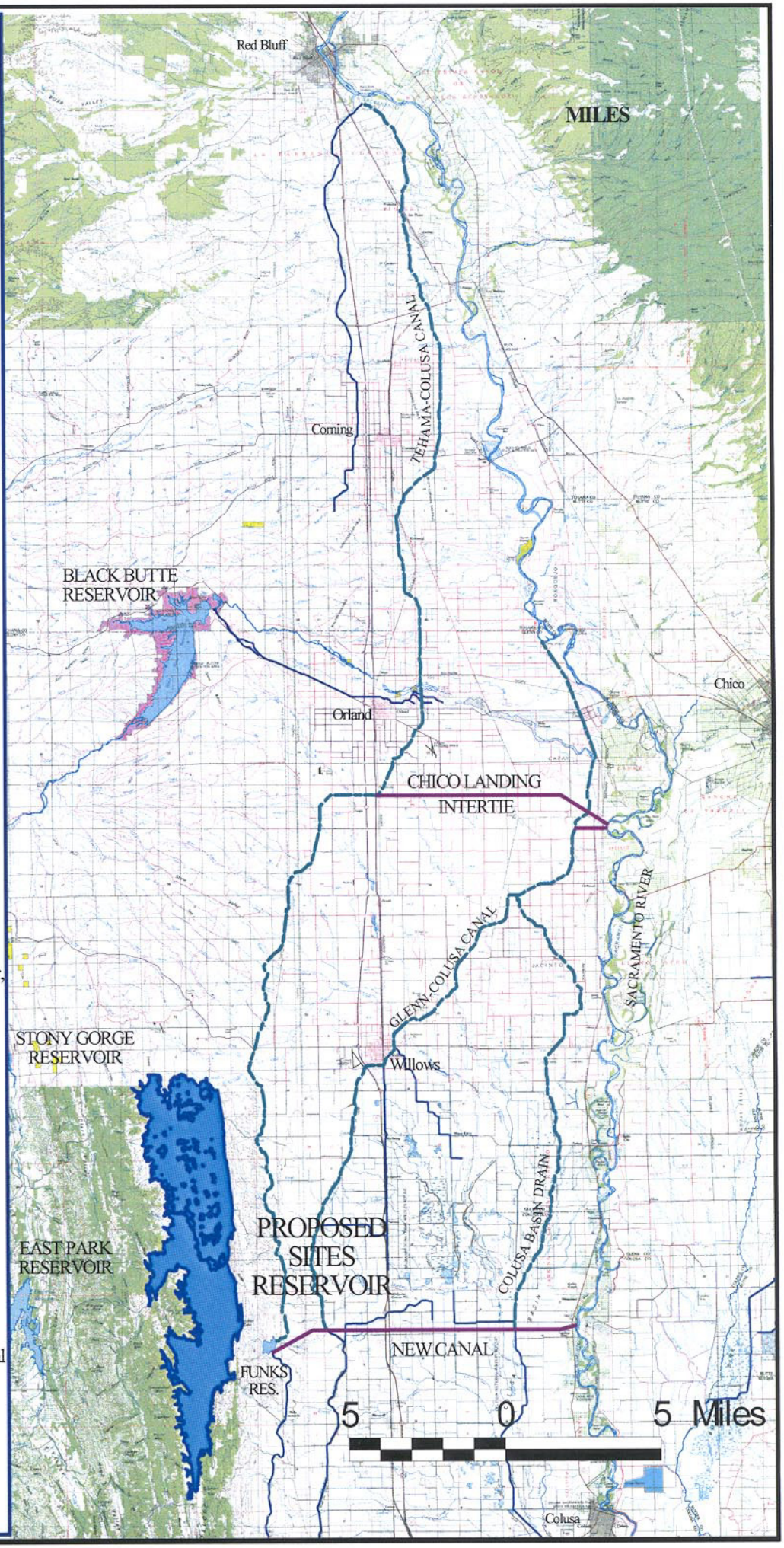
ALTERNATIVE V: NC/SR +CD/NC
New 5000 cfs SR diversion opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VI(A): TC + NC/SR + CD/NC
Existing 2100 cfs TC Canal, new 2900 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VI(B): GC + NC/SR + CD/NC
Existing 1800 cfs GC Canal, new 3200 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VII(A): TC + CD/NC
New 5000 cfs TC diversion dam, 5000cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VII(B): TC/CLI + CD /NC
New 5000 cfs SR diversion near Chico Landing, 5000 cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.



### Winter Operation Issues

All the conveyance alternatives would be operated to divert surplus flows, primarily occurring during the winter or non-irrigation season. Operating during this period requires accommodations for fish passage. There may also be other, yet to be determined, criteria related to operations addressed in future studies. Significant operational and environmental issues will need to be addressed in detailed studies. Issues include agency delivery priorities, interagency agreements, river diversion criteria and other factors.

### Modifications to the Red Bluff Diversion Dam

The U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Department of Fish and Game, and the Tehama-Colusa Canal Authority are continuing to investigate alternative diversion methods to improve fish passage at the diversion dam during the irrigation season. Fish passage problems occur whenever the gates are lowered to divert water into the canal headgates. Similar problems would occur if diversions were continued in the same manner during the winter or non-irrigation season to divert surplus flows.

CALFED investigated two alternatives that would increase diversions over a longer diversion period. A fish ladder alternative would improve fish passage on the left abutment of the dam when the gates are lowered during diversions. A pumping plant alternative would install a pumping plant downstream of the dam that could be used to divert water in lieu of lowering the gates. While it may be possible to divert surplus flows during the non-irrigation season with these or other alternatives, the cost of these alternatives for operating at the existing capacity is not included in the cost of the conveyance alternatives.

It is also assumed under this study that efforts to resolve fish passage problems would continue under existing conditions.

### Modifications to the Hamilton City Pumping Plant

The Glenn-Colusa Irrigation District and federal and State agencies have been investigating alternatives to improve the fish screens at the Hamilton City Pumping Plant. The purpose is to minimize losses of fish near the pumping plant diversion while maximizing GCID's capability to meet water supply delivery obligations by diverting the full quantity of water it is entitled to divert.

The alternatives being considered are designed to stabilize the hydraulic gradient of the channel adjacent to the pumping plant and to meet DFG and NMFS fish screen criteria to the fullest extent possible all year round. Improvements are currently being made to the fish screens, such as extending the length of the screen and raising the height of the headwall above the screen.

It is assumed that improvements will be implemented to allow the Hamilton City Pumping Plant to divert up to 2,900 cfs of surplus flows during the non-irrigation season and such costs are not included in the alternatives. Costs are included for diversions above the existing capacity of 2,900 cfs.

### Diversions from the Colusa Basin Drain

Alternatives III through VII include diversion and conveyance facilities to divert water from the Colusa Basin Drain that would supplement diversions from the Sacramento River. Based on limited hydrological information, it is estimated that a 3,000 cfs diversion near Delevan Road would be required to divert surplus flows from the drain. The new conveyance facilities required to divert water from the Sacramento River would be enlarged to accommodate diversions from the drain.

An important cost issue to be resolved in future studies will be the design of a fish screen, if required, for a diversion from the Colusa Basin Drain. It is assumed for this study that a control gate or turnout type structure without a screen component would be used in the alternatives. A fish screen component, similar to the inclined flat plate design used for a new diversion on the Sacramento River, would add significant cost to the alternatives.

### Formulation of Alternatives

The formulation of alternatives was an iterative process consisting of brainstorming, fatal flaw analysis, initial cost comparisons, and screening criteria. The process involved meetings with interdisciplinary staff from DWR's ND, CD, and Environmental Services Office, and CALFED. The alternatives were also discussed with the Tehama-Colusa Canal Authority and USBR during Technical Advisory Group meetings.

The objective of the formulation process was to identify a reasonable number of alternatives that would be retained for further study. In selecting alternatives for this study, the goal was to provide the decision-makers with an array of alternatives. As such, each alternative can be viewed as representing a reasonable design configuration for that type of alternative. See Attachment A for a further discussion of the formulation and screening process.

After several iterations of formulating and screening alternatives, five basic alternatives were initially identified for this study. Three of the alternatives have options based on different diversion locations or use of existing facilities.

In addition to the five basic alternatives (Alternatives III through VII) which are all capable of delivering 8,000 cfs maximum to Funks Reservoir, a sixth and seventh alternative were added after interim studies were completed. Alternative I utilizes the existing capacities of the Tehama-Colusa and Glenn-Colusa Canals' conveyance facilities but is only capable of delivering 3,900 cfs maximum to Funks Reservoir. Alternative II is similar to Alternative I but proposes only minor modifications to increase the capacity of the conveyance facilities. Alternatives I and II include two alignment options that connect the Glenn-Colusa Canal to Funks Reservoir.

The alternatives are described on the next pages and shown on Figure 1.

# Common Elements

### Funks Reservoir

Local Funks Creek inflow and the Tehama-Colusa Canal fill Funks Reservoir. The canal extends southerly from the reservoir to serve customers as far south as Yolo County. Funks Reservoir is being proposed as a forebay for the Sites Reservoir offstream storage option. Operational studies will determine if modifications to Funks Reservoir are required for use as a forebay. For this study, it is assumed that Funks Reservoir will not require modifications to increase its capacity.

### Reach 4 – New Canal from Glenn-Colusa Canal to Funks Reservoir

The approximate 2-mile long reach connecting the Glenn-Colusa Canal to Funks Reservoir was previously identified as Reach 4 of the new canal. The design flows range from approximately 1,800 cfs (existing Glenn-Colusa Canal flow only) to 8,000 cfs (enlarged 5,000 cfs Glenn-Colusa Canal or 5,000 cfs new Sacramento River diversion, plus 3,000 cfs Colusa Basin Drain diversion). The conveyance sizes of Reach 4 for different alternatives are shown below:

| Alt. No. | Q (cfs) Reach 4 | Q (cfs) Diversion Sources |
|---|---|---|
| I | 1,800 | 1,800 Canal (existing canal capacity) |
| IIA&IIB | 2,500 | 2,500 Glenn-Colusa (line or widen existing canal) |
| III | 5,900 | 2,900 Glenn-Colusa Canal+3,000 Colusa Basin Drain |
| IVA & IVB | 8,000 | 5,000 Glenn-Colusa Canal+3,000 Colusa Basin Drain |
| V | 8,000 | 5,000 New Diversion+3,000 Colusa Basin Drain |
| VIA | 5,900 | 2,900 New Diversion+3,000 Colusa Basin Drain |
| VIB | 6,200 | 3,200 New Diversion+3,000 Colusa Basin Drain |
| VIIA&VIIB | 3,000 | 3,000 Colusa Basin Drain |

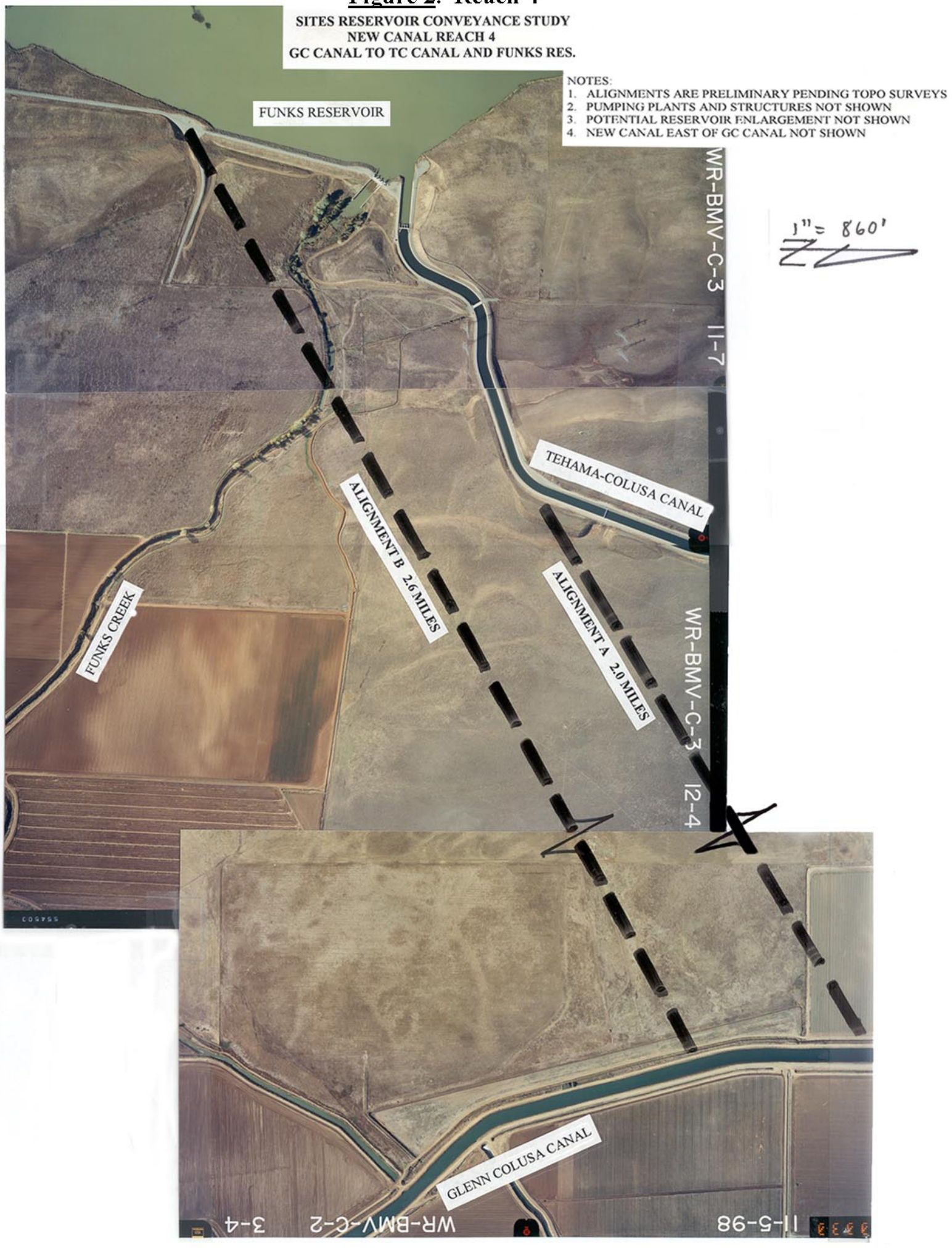
Bottom widths for the lined canal vary from 20 feet for 1,800 cfs to 32 feet for 8,000 cfs. Canal depths vary from 12.7 feet for 1,800 cfs to 22.8 feet for 8,000 cfs. Side slopes are at 1.5 H:V.

# Reach 4 Alignment Alternatives

Two possible alignments were considered for Reach 4 as shown in Figure 2. Alignment A would begin at the Glenn-Colusa Canal, approximately one-eighth mile south of Delevan Road. The alignment would proceed west, then southwesterly, connecting to the Tehama-Colusa Canal at the last bend before entering Funks Reservoir. Two pumping plants are assumed in order to lift the water from Glenn-Colusa to Tehama-Colusa Canals, approximately 82 feet (static). Preliminary pumping plant locations will need to be determined based on topographical data.

Alignment B would begin at the Glenn-Colusa Canal, approximately one-quarter mile south of Delevan Road. The alignment would proceed west, then southwesterly, crossing Funks Creek and connecting to the south abutment of Funks Reservoir. The alignment will not affect the existing Funks Dam embankment or southerly outlet to the Tehama-Colusa Canal. It may be

# Figure 2. Reach 4



necessary to realign an existing farm road at the south abutment and cut into the hillside for the discharge line construction. Similar to Alignment A, two pumping plants are assumed to lift the water from Glenn-Colusa to Funks Reservoir, approximately 82 feet (static).

If further studies indicate that more capacity is required in Funks Reservoir for use as a forebay, enlargement may be accomplished by moving Funks Dam and spillway easterly down Funks Creek. This would change the proposed Alternative Reach 4 Alignment B connection to the south abutment of the existing dam. Moving the dam would not change the proposed Alternative Reach 4, Alignment A, connection to the existing Tehama-Colusa Canal. A new dam and spillway would be longer, higher, and require more embankment material. Raising the existing dam and water surface would require pumping from the existing Tehama-Colusa Canal inlet and dropping water at the outlet, assuming no Tehama-Colusa Canal water surface changes. A greater lift from the Glenn-Colusa Canal would also be required. Deepening and enlarging the existing reservoir would require dewatering the reservoir, constructing a temporary canal through the reservoir area and extensive earthwork.

### Alternative I. Use the existing Tehama-Colusa and Glenn-Colusa Canals facilities

Alternative I utilizes the existing capacities of the Tehama-Colusa and Glenn-Colusa Canals to convey water to Funks Reservoir (see Figure 3). The canals' delivery capacities are limited by the sections of the canal at the downstream end of the system. The present Tehama-Colusa and Glenn-Colusa Canals' capacities are 2,100 cfs and 1,800 cfs, respectively. Neither the Tehama-Colusa nor Glenn-Colusa Canals would be improved in this alternative. A new 1,800 cfs canal for Reach 4, Alignment 4, will be required from the Glenn-Colusa Canal to Funks Reservoir.

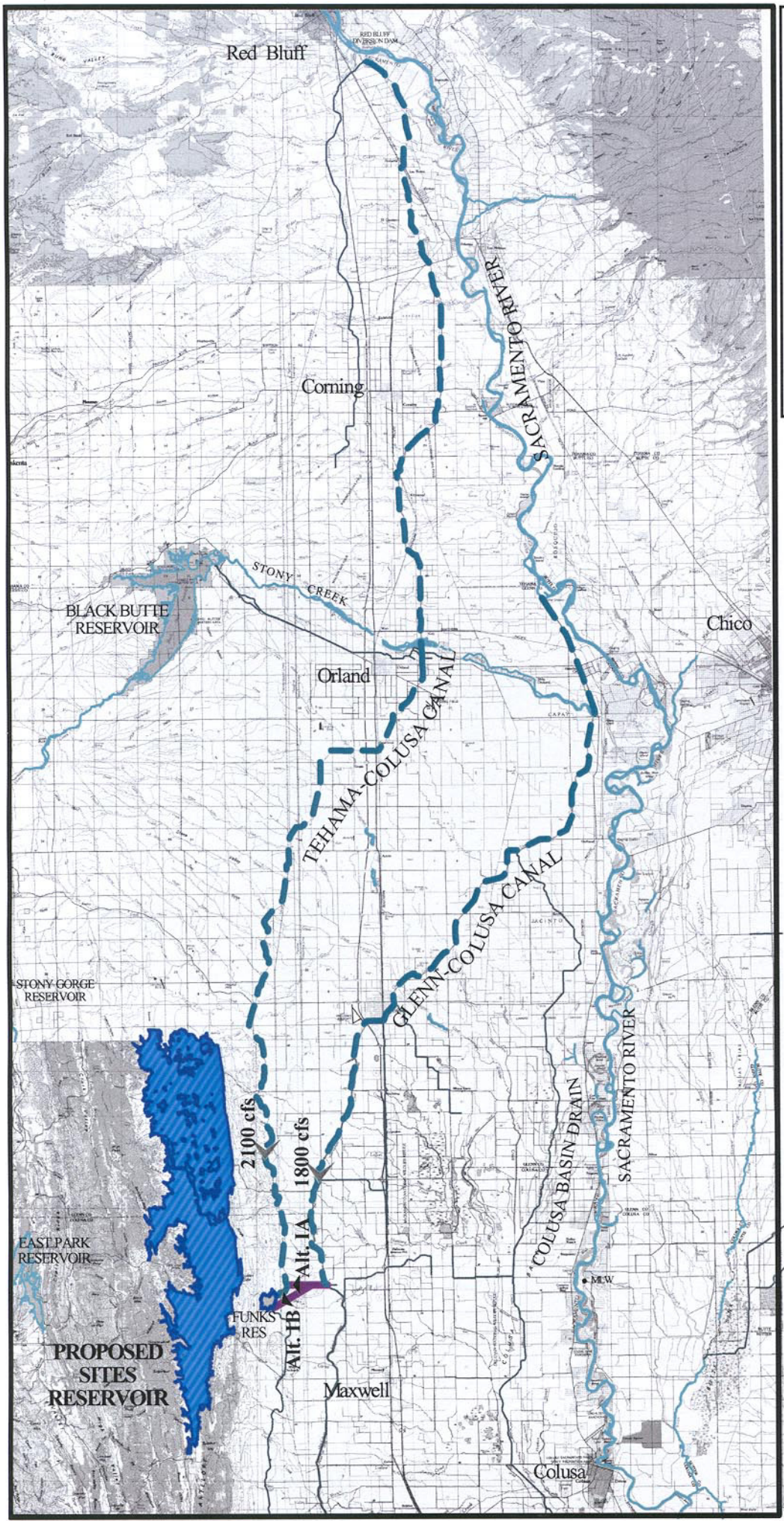
Alternative I does not propose modifications to the existing Tehama-Colusa diversion facility at Red Bluff or make any changes to the existing Tehama-Colusa Canal and facilities; however, it assumes that such modifications will be implemented to accommodate diversions during winter periods and meet standards required by the fishery agencies. Alternative I does not propose to divert any water from the Colusa Basin Drain to Funks Reservoir. Under both options, the total delivery capacity to Funks Reservoir is 3,900 cfs.

### Alternative II. Modify existing Tehama-Colusa and Glenn-Colusa Canals facilities with minor changes to increase capacity

Alternative II (see Figure 4) proposes to make minor changes to the Tehama-Colusa and Glenn-Colusa Canals' facilities described in Alternative I. The Glenn-Colusa Canal would be upsized to 2,500 cfs by lining or widening the existing sections, where needed, to provide for a flow of 2,500 cfs into a new canal, Reach 4. Reach 4 would extend from the Glenn-Colusa Canal to the Tehama-Colusa Canal (Alignment A) or directly to the south abutment of Funks Dam (Alignment B). Either increasing the freeboard lining or encroaching on the existing freeboard would increase the minimum capacity of the Tehama-Colusa Canal from 2,100 cfs to 2,500 cfs. The new canal would require two pumping

plants to lift the water from the Glenn-Colusa Canal to the Tehama-Colusa Canal or to Funks Reservoir.

Like Alternative I above, Alternative II does not propose to divert any water from the Colusa Basin Drain to Funks Reservoir. Under both options, the total delivery capacity to Funks Reservoir is 5,000 cfs.




# Figure 3

NORTHERN DISTRICT
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ALTERNATIVE I (A): TC + GC/ NC4A

Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to TC just upstream of Funks Reservoir.

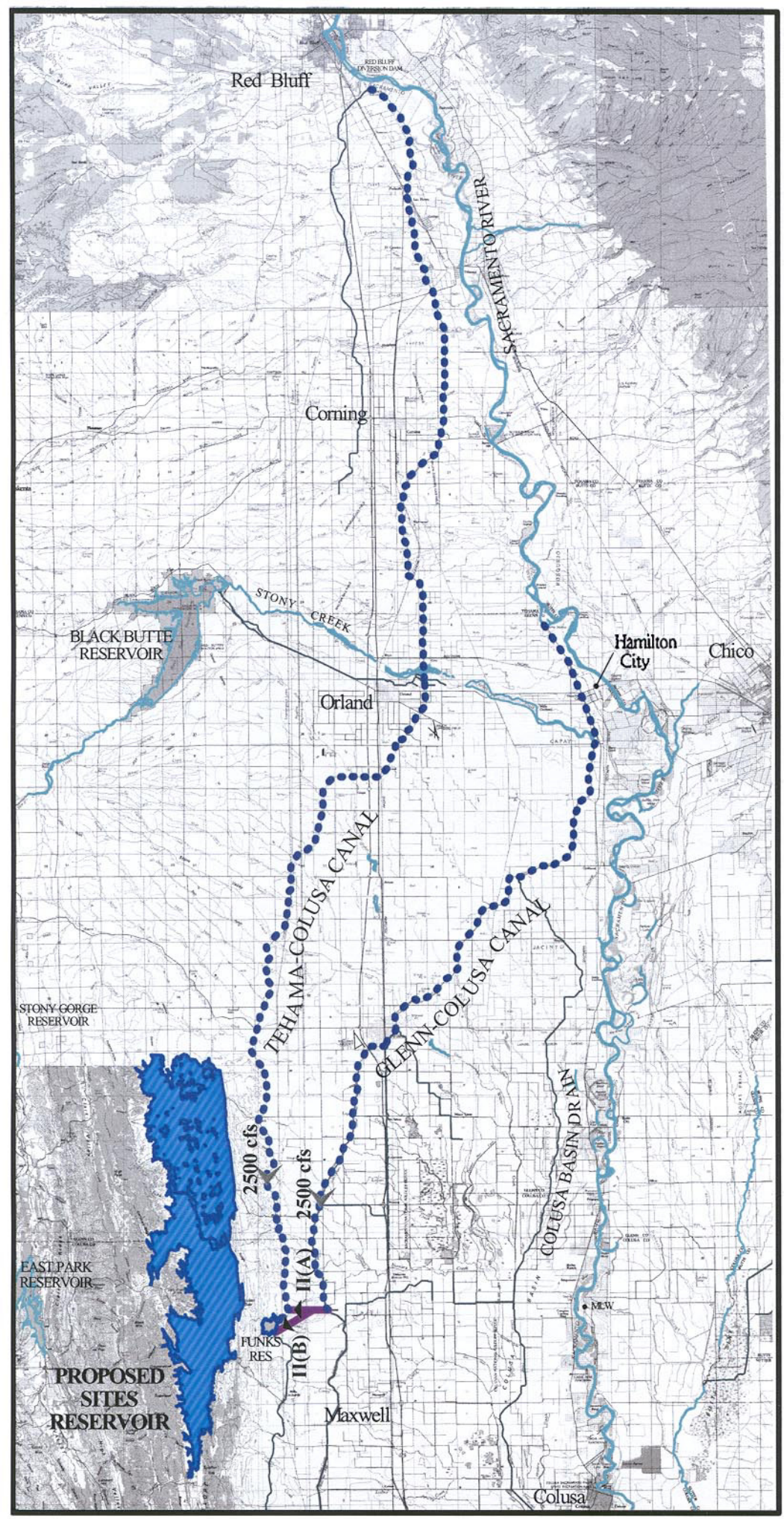
ALTERNATIVE I(B): TC + GC /NC4B

Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

5 0 5 10

Miles

| No. | Alternative | Diversion to Funks | Canal | Canal Reaches No. | Q(max) | Length Station | Length Distance | Status | From | To | Canal Lined |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cfs) | | | (cfs) | (1000 ft) (a) | (unit cost) (b) | (Miles) | | | |
| I A | TC+GC/NC4A | 3,900 | TC | all | 2,100 | 350.02 | 0 | 66.29 | Existing | RBPP | Funks | Yes |
| | Includes existing | | GC | all | 1,800 | 212.00 | 0 | 40.15 | Existing | HCPP | NC | No |
| | 2100 cfs TC and | | NC | all | 1,800 | 10.60 | 0.50 | 2.01 | New | GC | TC | Yes |
| | 1800 cfs GC | | TC | last | 3,900 | 2.50 | 0.35 | 0.47 | Enlarge | NC | Funks | Yes |
| | Total | | | | | | | | | | | |
| B | TC+GC/NC4B | 3,900 | TC | all | 2,100 | 352.52 | 0 | 66.77 | Existing | RBPP | Funks | Yes |
| | Includes existing | | GC | all | 1,800 | 212.00 | 0 | 40.15 | Existing | HCPP | NC | No |
| | 2100 cfs TC and | | NC | all | 1,800 | 14.00 | 0.50 | 2.65 | New | GC | Funks | Yes |
| | 1800 cfs GC | | | | | | | | | | | |
| | Total | | | | | | | | | | | |




# Figure 4

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ALTERNATIVE II(A): TC + GC/NC4A

Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to TC Canal just upstream of Funks Reservoir.

ALTERNATIVE II(B): TC + GC/NC4B

Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

5 0 5 10

Miles

| No. | Alternative | Diversion to Funks | Canal | Canal Reaches No. | Q(max) | Length Station | Length Distance | Status | From | To | Canal Lined |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cfs) | | | (cfs) | (1000 ft) (a) | (unit cost) (b) | (Miles) | | | |
| II A | TC+GC/NC4A | 5,000 | TC | all | 2,500 | 350.02 | 0.05 | 66.29 | Enlarge | RBPP | NC | Yes |
| | Includes enlarging | | GC | all | 2,500 | 148.11 | 0.00 | 28.05 | Existing | HCPP | I5 | Yes |
| | existing TC and GC | | GC | all | 2,500 | 63.89 | 0.35 | 12.10 | Enlarge | I5 | NC | Yes |
| | to 2500 cfs each | | NC | all | 2,500 | 10.60 | 0.65 | 2.01 | New | GC | TC | Yes |
| | | | TC | last | 5,000 | 2.50 | 0.44 | 0.47 | Enlarge | NC | Funks | Yes |
| | **Total** | | | | | | | | | | | |
| B | TC+GC/NC4B | 5,000 | TC | all | 2,500 | 352.52 | 0.05 | 66.77 | Enlarge | RBPP | NC | Yes |
| | Includes enlarging | | GC | all | 2,500 | 63.89 | 0.35 | 12.10 | Enlarge | I5 | NC | Yes |
| | existing TC and GC | | NC | all | 2,500 | 14.00 | 0.65 | 2.65 | New | GC | Funks | Yes |
| | to 2500 cfs each | | | | | | | | | | | |
| | **Total** | | | | | | | | | | | |

### *Modifications to the Tehama-Colusa Canal*

**Increasing Tehama-Colusa Canal Capacity to 2,500 cfs**. The design objective of increasing to 2,500 cfs would not require major modifications to the existing Tehama-Colusa Canal. The study considered two options for increasing the capacity of the Tehama-Colusa Canal: (1) raise the 67-mile long concrete lining by 1.25 feet to maintain the existing 2-foot minimum freeboard condition or (2) allow the existing freeboard to be encroached up to 1.25 feet, leaving a 0.75-foot minimum of concrete-lined freeboard. Both alternatives assume that the existing lined canal will continue to function at the 2,500 cfs flow without adversely affecting major structures such as siphons, checks, bridges, and drainage crossings. It may be necessary to modify some turnouts, but all structures should be investigated under potential higher flow conditions.

**Minimum Clearances**. Existing clearances at bridges, irrigation pipes and other crossings were checked for minimum clearance. The minimum clearance is 2.33 feet at several irrigation pipe crossings. If the existing canal were optimized to 2,500 cfs flow, then the minimum clearance would be reduced to 1.08 feet. Wind and wave action would further reduce the clearance depending on the crossing location, fetch and other factors.

**Encroaching on Existing Freeboard**. It was determined that raising the water surface 1.25 feet would increase the flow from approximately 2,100 cfs to 2,500 cfs and still reserve 0.75 feet of freeboard on the concrete lining. The feasibility of running the canal at 2,500 cfs, with reduced freeboard and clearance, should be checked with the Tehama-Colusa Canal Authority. Based on DWR design recommendations, it is assumed that encroachment on existing freeboard to increase capacity is not feasible.

**Increasing Freeboard**. Increasing the concrete lining by 1.25 feet would preserve the existing freeboard. However, the amount of unlined canal above the lined section would be reduced by the same amount. This method of increasing the capacity to 2,500 cfs is assumed for Alternative II.

### *Modifications to the Glenn-Colusa Canal*

**Increasing Glenn-Colusa Canal Capacity to 2,500 cfs**. Two basic options were considered for increasing the capacity of the Glenn-Colusa Canal to 2,500 cfs: 1) lining the existing unlined section and 2) widening the existing section.

1. **Lining the Existing Unlined Section.** Lining the existing 12-mile canal from Interstate 5 south of Willows to Reach 4 would allow a flow in excess of 2,500 cfs without widening or deepening the canal. The existing upstream flow limitation is approximately 2,500 cfs near Bayliss Road, although several reaches of the canal have capacities in excess of 3,400 cfs and the diversion capacity is approximately 2,900 cfs.
2. **Widening the Existing Section.** Widening the existing unlined canal from Interstate 5 will require extending the bottom width from 60 feet to 85-90 feet in order to obtain a diversion capacity of 2,500 cfs to Reach 4. The net increase in right of way will average approximately 30-50 feet for approximately 12 miles.

**Alternative III. Use the existing Tehama-Colusa Canal and enlarge the Glenn-Colusa Canal facilities.**

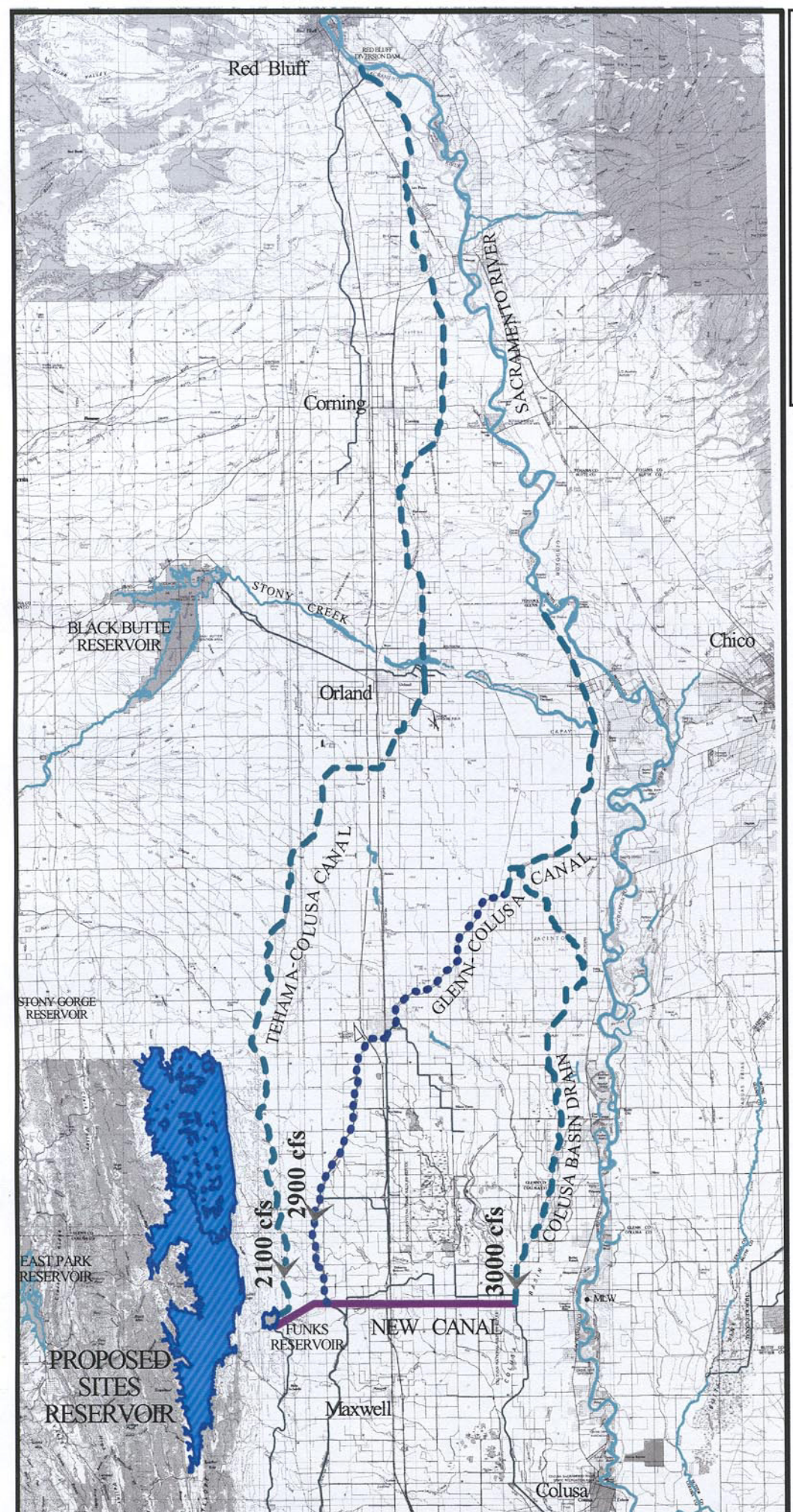
Alternative III would utilize the existing capacity of the Tehama-Colusa Canal and enlarge the lower reaches of the Glenn-Colusa Canal to convey water to Funks Reservoir (see Figure 5). The canals' delivery capacities are currently limited by canal sections at the downstream end of the system. The present Tehama-Colusa and Glenn-Colusa Canals' capacities are 2,100 cfs and 1,800 cfs, respectively near Funks Reservoir for a combined capacity of 3,900 cfs. The Glenn-Colusa Canal is unlined and its capacity would be increased to 2,900 cfs for a total combined capacity of 5,000 cfs. A new canal reach will be required from the Glenn-Colusa Canal to Funks Reservoir. Since no changes to the Tehama-Colusa Canal are proposed under Alternative III, Reach 4 follows Alignment B for this alternative.

**Colusa Basin Drain Connection**. Water from the Colusa Basin Drain would be diverted into a new canal and conveyed along an alignment for delivery to Funks Reservoir. It is assumed that the design capacity of a diversion and conveyance structure for water from the Colusa Basin Drain is 3,000 cfs. The design capacity of Reach 4 under Alternative III is 8,000 cfs. Three pumping plants will be required to lift the water from the Colusa Basin Drain up to Funks Reservoir. The total pumping lift is approximately 180 feet.

**Enlargement of the Glenn-Colusa Canal**. The existing canal would be enlarged to 2,900 cfs beginning near the check structure at Jacinto Road by widening and deepening the existing section or by trimming and lining the existing section. The canal would be enlarged for about 13.75 miles downstream to where the water would be diverted into a new canal (to Sites) at Delevan Road. The existing canal capacity at Delevan Road is about 1,780 cfs. It is assumed that the enlarged canal will remain unlined, although it may be necessary to line or pipe the canal in restricted urban areas. At the junction of the Glenn-Colusa Canal and NC (from the Colusa Basin Drain), it will be necessary to provide control gates to allow operational flexibility for (1) continued Glenn-Colusa flow south of NC, (2) Glenn-Colusa diversions to Funks Reservoir, and (3) NC diversions from the Colusa Basin Drain to Funks Reservoir. Enlargement of the Glenn-Colusa Canal will also require enlargement or replacement of existing check structures, siphons, bridges, drainage structures, and other facilities. No modifications to the Hamilton City Pumping Plant are proposed under this alternative.

**Alternative IV. Enlarge the capacity of the Glenn-Colusa Canal system**

Alternative IV would enlarge the Glenn-Colusa Canal system to deliver 5,000 cfs and would require a new 8,000 cfs canal reach from the Glenn-Colusa Canal to Funks Reservoir (see Figure 6). Additionally, Alternative IV would either require major improvements to the existing diversion facility at Hamilton City from 3,000 cfs to 5,000 cfs (Option A) or the construction of a new diversion facility on the Sacramento River downstream from the existing facility. A new diversion facility and intertie to the Glenn-Colusa Canal would be located near Sacramento River Mile 188 with a capacity of 2,000 cfs (Option B). Under Option B, the combined capacity of the existing Glenn-Colusa diversion and a new diversion is 5,000 cfs.




# Figure 5

NORTHERN DISTRICT
OCT 1999

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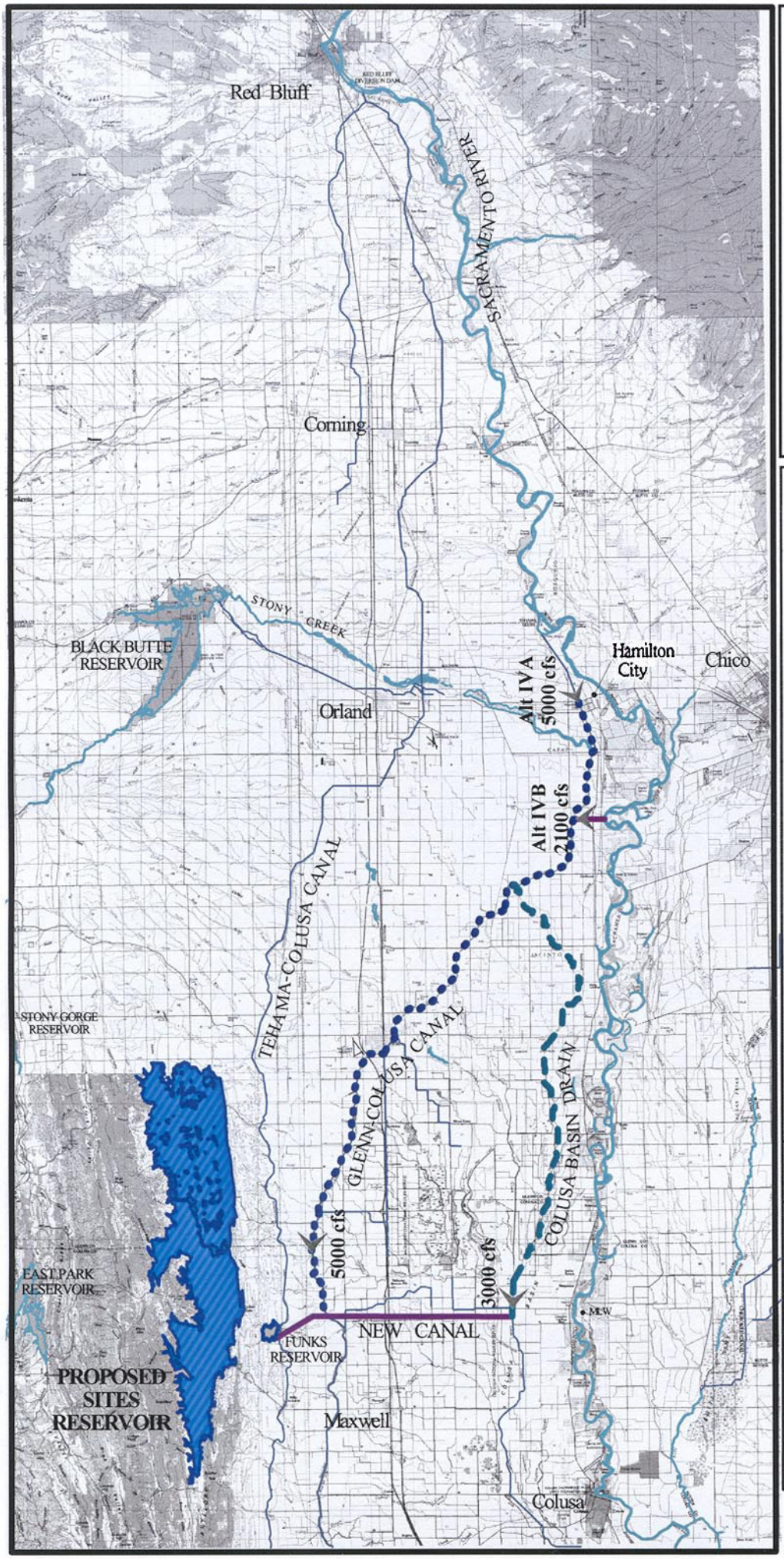
ALTERNATIVE III: TC + GC + CD/NC

Existing 2100 cfs TC Canal and enlarged 2900 cfs GC Canal, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10
Miles

| No. | Alternative | Diversion to Funks | Canal | No. | Canal Reaches | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Q(max) | Length | | Status | From | To | Canal Lined |
| | | | | | | Station | Distance | | | | |
| | | (cfs) | | | (cfs) | (1000 ft) | (unit cost) (Miles) | | | | |
| III | TC+GC+CD/NC | 8,000 | TC | all | 2,100 | 352.52 | 0 66.77 | Existing | RBPP | Funks | Yes |
| | Utilizes 2100cfs | | GC | 1 | 2,900 | 72.60 | 0 13.75 | Existing | HCPP | JC | No |
| | from existing | | GC | 2 | 2,900 | 139.40 | 0.04 26.4 | Enlarge | JC | NC | No |
| | RBPP Diversion | | NC | 1 | 3,000 | 30.40 | 0.20 5.76 | New | CD | PP1 | No |
| | Facilities | | NC | 2 | 3,000 | 17.00 | 0.54 3.22 | New | PP1 | PP2 | Yes |
| | | | NC | 3 | 5,900 | 2.50 | 0.69 0.47 | New | PP2 | PP3 | Yes |
| | | | NC | 4 | 5,900 | 11.00 | 0.69 2.65 | New | PP3 | Funks | Yes |
| | Total | | | | | | | | | | |




# Figure 6

NORTHERN DISTRICT
OCT 1999

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ALTERNATIVE IV(A): GC + CD/NC

Enlarge existing 3000 cfs GC Canal diversion at Hamilton City to 5000 cfs, 5000 cfs GC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE IV(B): GC/CLI + CD/NC

New 2100 cfs SR diversion near Chico Landing, 5000 cfs GC Canal enlargement below Chico Landing Intertie, plus added 3000 cfs from Colusa Drain to New Canal.

5 0 5 10

Miles

| No. | Alternative | Diversion to Funks | Canal | Canal Reaches No. | Q(max) | Length Station | Length Distance | Status | From | To | Canal Lined |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cfs) | | | (cfs) | (1000 ft) (a) | (unit cost) (b) | (Miles) | | | |
| IV A | GC+CD/NC | 8,000 | GC | all | 5,000 | 212.00 | 0.13 | 40.15 | Enlarge | HCPP | NC | No |
| | Includes new | | NC | 1 | 3,000 | 30.40 | 0.20 | 5.76 | New | CD | PP1 | No |
| | 2000 cfs HCPP | | NC | 2 | 3,000 | 17.00 | 0.54 | 3.22 | New | PP1 | PP2 | Yes |
| | Diversion | | NC | 3 | 8,000 | 2.50 | 0.76 | 0.47 | New | PP2 | PP3 | Yes |
| | Facilities | | NC | 4 | 8,000 | 11.00 | 0.76 | 2.08 | New | PP3 | Funks | Yes |
| | Total | | | | | | | | | | | |
| B | GC/CLI+CD/NC | 8,000 | CLI | 1 | 2,000 | 7.20 | 0.46 | 1.40 | New | SR | GC | No |
| | Includes new | | GC | 1 | 2,900 | 56.00 | 0 | 10.61 | Existing | HCPP | CLI | No |
| | 2100 cfs CLI | | GC | 2 | 5,000 | 16.60 | 0.17 | 3.14 | Enlarge | CLI | JC | No |
| | Diversion | | GC | 3 | 5,000 | 139.40 | 0.17 | 26.40 | Enlarge | JC | NC | No |
| | Facilities | | NC | 1 | 3,000 | 30.40 | 0.20 | 5.76 | New | CD | PP1 | No |
| | | | NC | 2 | 3,000 | 17.00 | 0.54 | 3.22 | New | PP1 | PP2 | Yes |
| | | | NC | 3 | 8,000 | 2.50 | 0.76 | 0.47 | New | PP2 | PP3 | Yes |
| | | | NC | 4 | 8,000 | 11.00 | 0.76 | 2.08 | New | PP3 | Funks | Yes |
| | Total | | | | | | | | | | | |

The Glenn-Colusa Canal would be enlarged to 5,000 cfs from the Hamilton City Pumping Plant to NC via the Colusa Basin Drain (Option A) or from near Sacramento River Mile 188 intertie to NC (Option B). Alternative IV will require modifications to the existing Glenn-Colusa Canal structures to accommodate the enlarged capacity.

Water from the Colusa Basin Drain would be diverted into NC as described in Alternative III. However, the capacity of the combined diversion of the Colusa Basin Drain and the Glenn-Colusa Canal would be 8,000 cfs for NC and conveyed along an alignment for delivery to Funks Reservoir. Reach 4 from the Glenn-Colusa Canal to Funks Reservoir would follow Alignment B. Alternative IV does not include any water delivered to Funks Reservoir by the existing Tehama-Colusa Canal.

### *Option A*

**Modifications to the Hamilton City Pumping Plant**. As mentioned earlier, GCID and federal and State agencies have been investigating alternatives to improve the fish screens at the Hamilton City Pumping Plant. Under this alternative, increasing the capacity from 3,000 cfs to 5,000 cfs would require major design changes to the diversion facility and fish screens. Because of the uncertainty of being able to increase the capacity of the existing facility, it is assumed that such a modification would involve increasing the length of the diversion inlet and fish screen after they have been modified to meet DFG and NMFS fish screen criteria. Additional pumps would also be required to lift the water into the Glenn-Colusa Canal.

**Enlargement of the Glenn-Colusa Canal**. The engineering issues are similar to those identified under Alternative III except that a larger cross section is required to increase the capacity of the canal to 5,000 cfs from the HCPP to NC at Delevan Road.

### *Option B*

**A New Diversion Facility.** Similar to Alternative VII, Option B, Alternative IV assumes a new diversion facility would be located about 4 miles south of Hamilton City. This facility would have a diversion capacity of 2,000 cfs and limit the velocity through the fish screen to no more than 0.4 feet per second. A detailed site investigation will need to be conducted to determine the feasibility of the proposed location.

**Intertie.** Under this alternative, an intertie similar to the one described under Alternative VII, Option B would convey water from the new diversion facility to the Glenn-Colusa Canal. However, the capacity would be less at 2,000 cfs and length about 1.4 miles. The reach would be unlined and would not require pumping plants. The major design components for the intertie include siphons under the Southern Pacific Railroad and Highway 45. A proposed outlet structure connects the intertie to the Glenn-Colusa Canal.

**Enlargement of the Glenn-Colusa Canal.** Option B is similar to Option A except that enlargement of the Glenn-Colusa Canal to 5,000 cfs would occur from where the intertie connects with the Glenn-Colusa Canal to where water would be diverted into the new canal at Delevan Road.

### Alternative V. A new diversion and conveyance facility from the Sacramento River

The new diversion would have a capacity of 5,000 cfs and be located across from the Moulton Weir on the Sacramento River (see Figure 7). Water would be conveyed west to Funks Reservoir in an open channel along an alignment that is located between the Delevan and Sacramento National Wildlife Refuges. NC also follows the same alignment as in Alternatives III and IV from where it diverts water from the Colusa Basin Drain to Funks Reservoir. The conveyance facility from this location to Funks Reservoir would have a design capacity of 8,000 cfs. Alternative V does not include any water delivered directly to Funks Reservoir by the existing Tehama-Colusa Canal.

#### *A New Diversion Facility*

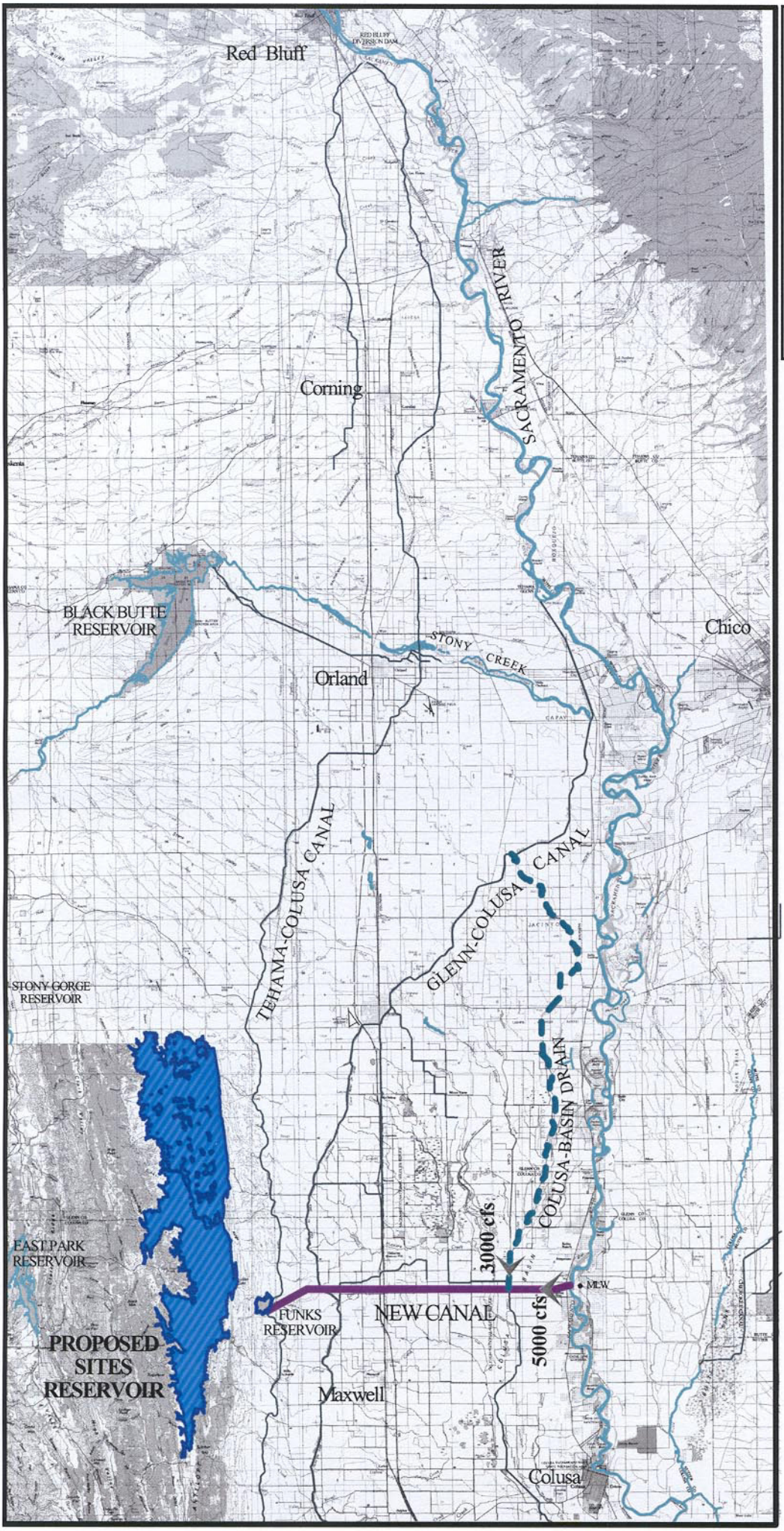
Several potential locations for a new diversion (see Figure 8) along the Sacramento River were investigated for Alternative V. In addition to being a stable site, the diversion was located as near as possible to the potential offstream storage reservoir at Sites. A location opposite the Moulton Weir through an existing levee provides control of the maximum water surface level in the vicinity of the diversion structure.

The type of diversion structure is significantly affected by the design of the fish screen components. It is assumed that detailed planning studies will determine the preferred configuration for the diversion and fish screen if Alternative V is selected. ESO developed conceptual designs of alternative fish screens for a new diversion on the Sacramento River.

The land adjacent to the diversion that would be displaced by the structure and sedimentation pond is currently farmed in orchards and other crops.

#### *A New Canal*

The alignment of the new canal was chosen to minimize environmental impacts and to minimize the length required to convey water from the Sacramento River to Sites Reservoir. The affected area is currently used for agriculture. The alignment is located just south of Delevan Road and follows parcel boundaries as much as possible; however, future designs should consider adjustments to the alignment where it may cause unacceptable disruption to farm operations.




# Figure 7

NORTHERN DISTRICT
MARCH 2000

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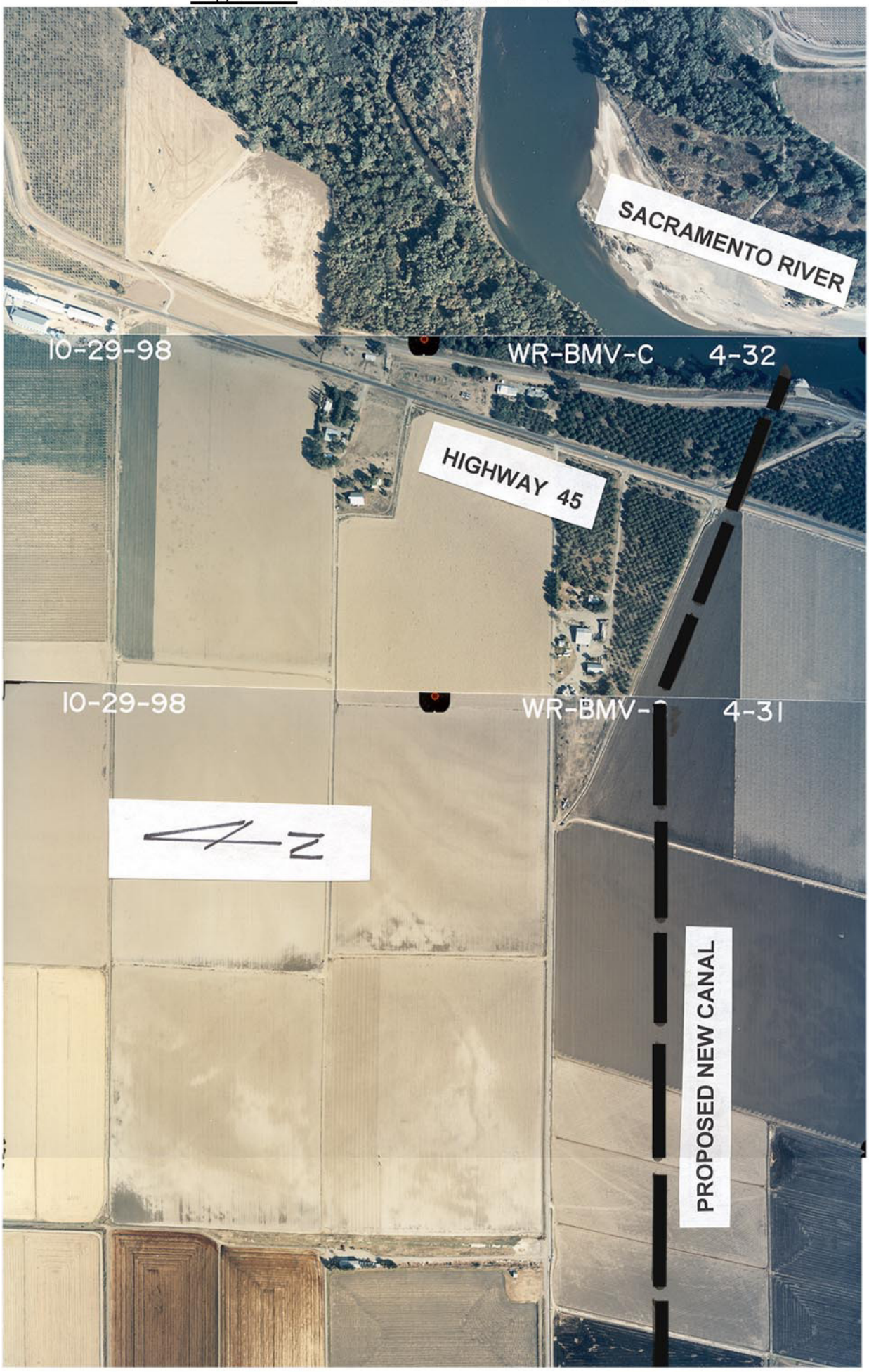
ALTERNATIVE V: NC/SR +CD/NC

New 5000 cfs SR diversion opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10
Miles

| No. | Alternative | Diversion to Funks | Canal | Canal Reaches: No. | Q(max) | Length: Station | Length: Distance | Status | From | To | Canal Lined |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cfs) | | | (cfs) | (1000 ft) (a) | (unit cost) (b) | (Miles) | | | |
| V | NC/SR+CD/NC | 8000 | NC | 1A | 5,000 | 15.20 | 0.28 | 2.88 | New | SR - CD | No |
| | Includes new | | NC | 1 | 8,000 | 30.40 | 0.36 | 5.76 | New | CD - PP1 | No |
| | 5000 cfs NC | | NC | 2 | 8,000 | 17.00 | 0.76 | 3.22 | New | PP1 - PP2 | Yes |
| | Diversion | | NC | 3 | 8,000 | 2.50 | 0.76 | 0.47 | New | PP2 - PP3 | Yes |
| | Facilities | | NC | 4 | 8,000 | 11.00 | 0.76 | 2.08 | New | PP3 - Funks | Yes |
| | Total | | | | | | | | | | |

**Figure 8. Sacramento River Diversion**



The canal section is unlined to the first of three pumping plants, located about 8-½ miles from the Sacramento River. A 5,000 cfs discharge would require a water depth of about 19-½ feet, bottom width of 45 feet, and a top width of 103 feet. The right of way is about 300 feet.

The capacity of the unlined canal section would be increased to 8,000 cfs to divert water from the Colusa Basin Drain. An 8,000 cfs discharge would require a water depth of about 20 feet, bottom width of 75 feet, and a top width of 135 feet. The right of way is about 350 feet.

An 8,000 cfs concrete-lined canal, beginning at the first pumping plant, would require a water depth of about 22 feet, bottom width of 40 feet, and a top width of 105 feet. The right of way is about 310 feet.

A pipeline design was considered in lieu of an open channel. However, preliminary cost estimates indicate that Alternative V is more expensive than a channel design.

Major crossings include Interstate 5, two Southern Pacific railroads (one near Sacramento River is abandoned), and State Highway 45 (see Figure 10). Minor crossings include county roads, farm roads, irrigation crossings, and utilities.

### *Colusa Basin Drain Connection*

Additional water would be made available from the Colusa Basin Drain by constructing a turnout where the new canal would cross the drain (see Figure 9). The drain turnout is assumed to have a capacity of 3,000 cfs, which would occur during wet years. It is also assumed that this could occur while a maximum of 5,000 cfs is being diverted from the Sacramento River. Therefore, the capacity of the canal is enlarged to 8,000 cfs downstream from this diversion.

**Figure 9. Colusa Basin Drain**

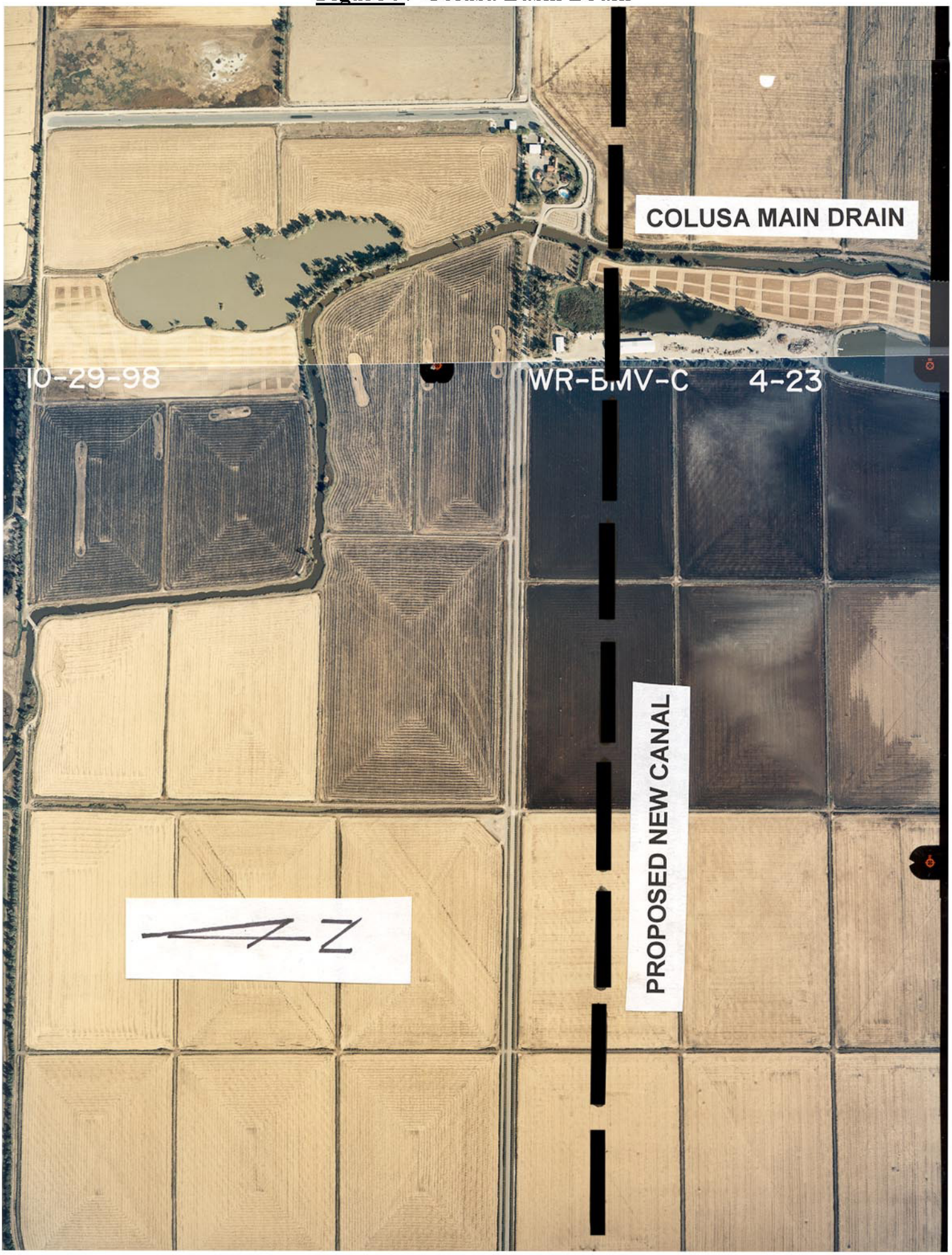
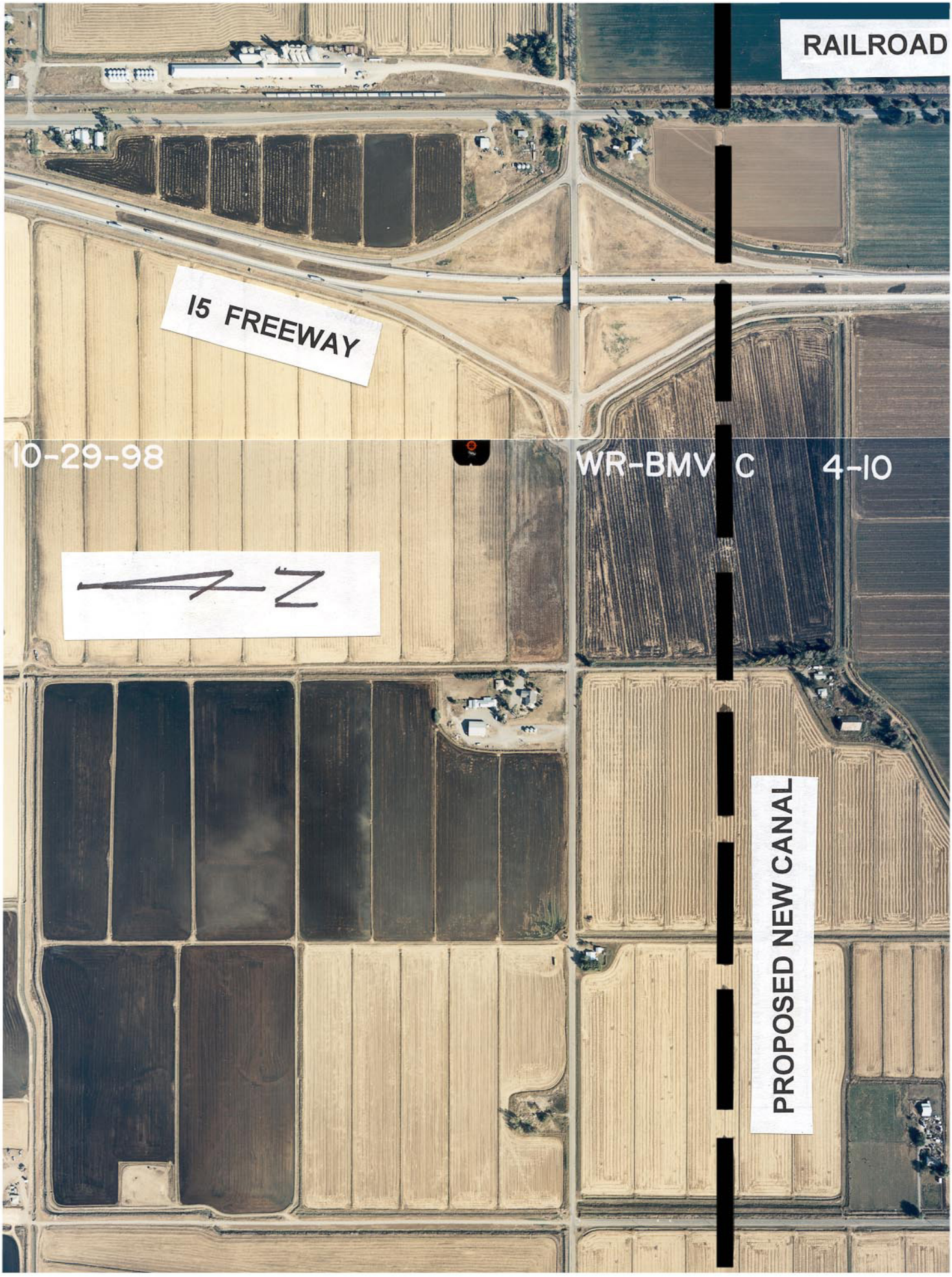


**Figure 10. Interstate 5 Crossing**



**Alternative VI. Use either the Tehama-Colusa or Glenn-Colusa Canal's existing facilities with a new smaller diversion on the Sacramento River.**

Alternative VI (see Figure 11) would use either one of the Tehama-Colusa or Glenn-Colusa Canal's existing facilities with a smaller new diversion from the Sacramento River for a total capacity of 5,000 cfs. The two options would be as follows:

**Option A**: Use existing Tehama-Colusa Canal's capacity of 2,100 cfs along with a new diversion (or new canal) on the Sacramento River that has a capacity of 2,900 cfs.

**Option B**: Use existing Glenn-Colusa Canal's capacity of 1,800 cfs along with a new diversion (or new canal) on the Sacramento River that has a capacity of 3,200 cfs.

For both options, the use of existing diversion facilities would be the same as described in Alternative I. In addition, the location of a new diversion and canal is the same as described in Alternative V. The capacity of the new canal would be increased to accommodate a 3,000 cfs diversion from the Colusa Basin Drain. Under Option B, the new canal would also be designed to receive water from the Glenn-Colusa Canal. Alignment B is assumed to connect the Reach 4 to Funks Reservoir. Under both options, the total delivery capacity at Funks Reservoir, including water from the Colusa Basin Drain, is 8,000 cfs.

***Options A and B***

**New Diversion, Canal Facilities, Colusa Basin Drain Connection, and Pumping Plants.** A new diversion would be similar to the one described in Alternative V, but have a lower capacity. The new canal alignment would follow the same alignment as described in Alternative V, including an increase in canal capacity to accommodate 3,000 cfs from the Colusa Basin Drain. The canal would also be enlarged to receive water diverted from the Tehama-Colusa Canal (Option A) or Glenn-Colusa Canal (Option B).

**Alternative VII. Enlarge the capacity of the Tehama-Colusa Canal system.** (See *CALFED* report.)

Alternative VII (see Figure 12) would enlarge the Tehama-Colusa Canal system to deliver 5,000 cfs at Funks Reservoir, plus 3,000 cfs from the Colusa Basin Drain. It would either require major improvements (or a new structure) to the existing diversion facility at Red Bluff (Option A) or the construction of a new facility on the Sacramento River (Option B). A new facility under Option B would be located near Sacramento River Mile 188 (between Chico Landing and Old Ferry) with a diversion capacity of 5,000 cfs. An intertie would deliver water from the new diversion near Sacramento River Mile 188 to an enlarged Tehama-Colusa Canal.

Under Option B, the Tehama-Colusa Canal would be enlarged to 5,000 cfs capacity from the Sacramento River Mile 188 intertie to Funks Reservoir. The enlargement would be accomplished by widening the existing concrete-lined section. Alternative VII will also require enlargement or replacement of existing check structures, siphons, bridges, drainage structures, and other facilities. Three

pumping plants will be required to lift the water from the Sacramento River up to the beginning of the enlarged Tehama-Colusa Canal. The total pumping lift is approximately 115 feet.

Up to 3,000 cfs of water from the Colusa Basin Drain would be diverted to Funks Reservoir similar to Alternative III and connected directly to Funks Reservoir using Alignment B for Reach 4. The total design capacity at Funks Reservoir under Alternative VII from the Tehama-Colusa and Colusa Basin Drain is 8,000 cfs. Alternative VII does not include any potential water that could be delivered to Funks Reservoir by the existing Glenn-Colusa Canal.

### *Option A*

**Modifications to the Red Bluff Diversion Dam.** As stated earlier, current fish passage problems at the dam would have to be resolved in order to divert water during the non-irrigation season. The October 1997 CALFED *Facility Descriptions and Cost Estimates* report concluded that increasing the diversion capacity would likely compound fish passage problems if the current fish passage facilities were not improved. Option A assumes the alternatives identified in the CALFED report could be implemented for improving the fish passage conditions and increasing the capacity of the diversion dam.

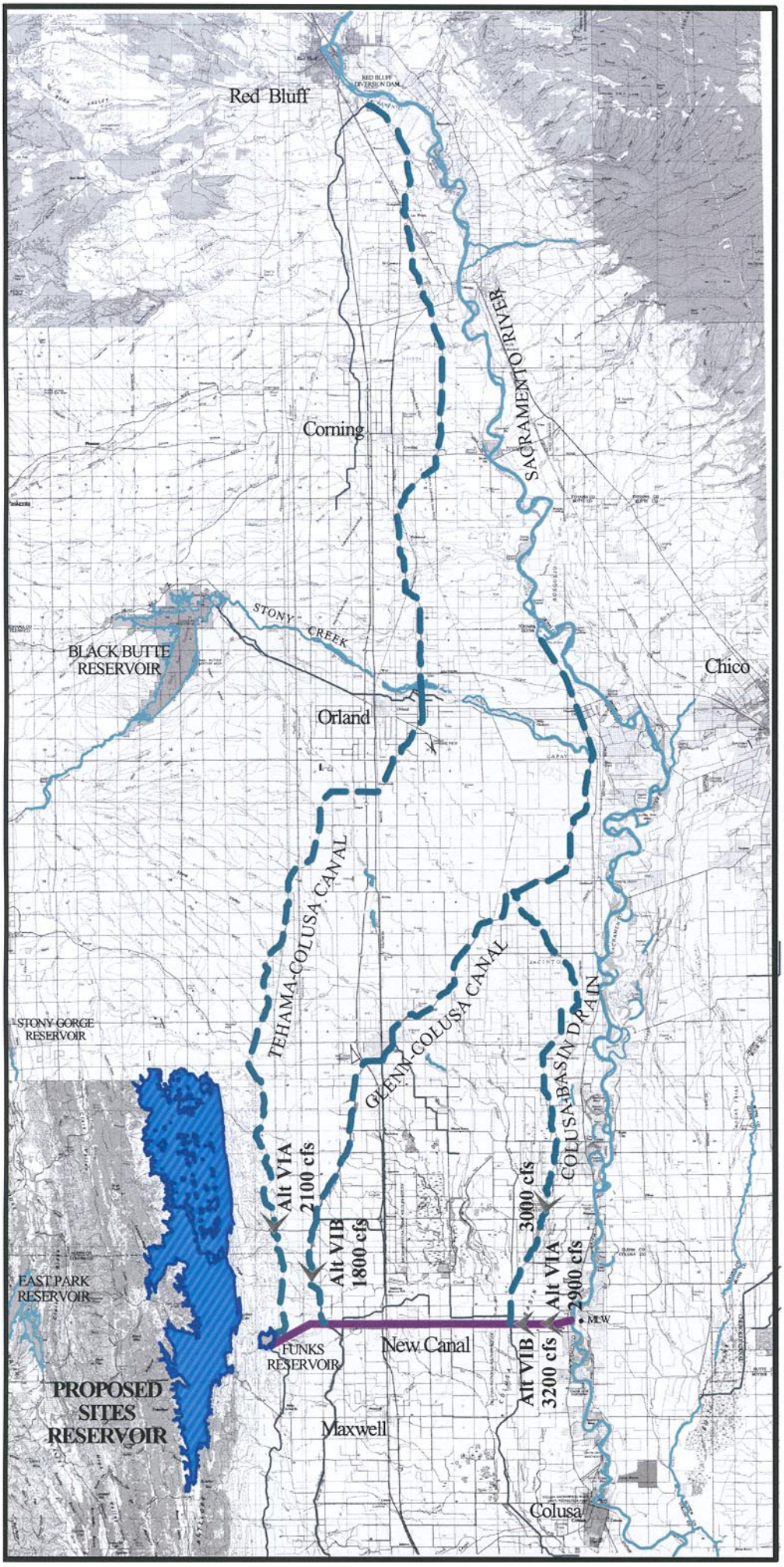
**Modifications to the Tehama-Colusa Canal.** The CALFED report contains estimated costs to increase the capacity of the Tehama-Colusa Canal from the diversion dam to Funks Reservoir. Under Alternative VII, the CALFED costs are assumed reasonable for comparison purposes.

### *Option B*

**A New Diversion Facility.** Under Option B, the CALFED report assumes a new diversion facility would be located about 4 miles south of Hamilton City. This facility would have a diversion capacity of 5,000 cfs and limit the velocity through the fish screen to no more than 0.4 feet per second. A detailed site investigation will need to be conducted to determine the feasibility of the proposed location.

**Intertie.** The CALFED report assumes an intertie from the new diversion structure consisting of three pumping plants and about 10 miles of concrete-lined conveyance canals. The major design components for the new canal would include siphons under the Southern Pacific Railroad and Glenn-Colusa Canal, nine county road bridges, and nine irrigation crossings. A proposed outlet structure connects the intertie to the Tehama-Colusa Canal.

**Modifications to the Tehama-Colusa Canal.** A similar estimate was made for Option B except that enlargement of the Tehama-Colusa Canal would occur from where the intertie connects with the Tehama-Colusa Canal to Funks Reservoir. CALFED estimates were assumed for this option.




# Figure 11

NORTHERN DISTRICT
OCT 1999

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ALTERNATIVE VI(A): TC + NC/SR + CD/NC

Existing 2100 cfs TC Canal, new 2900 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

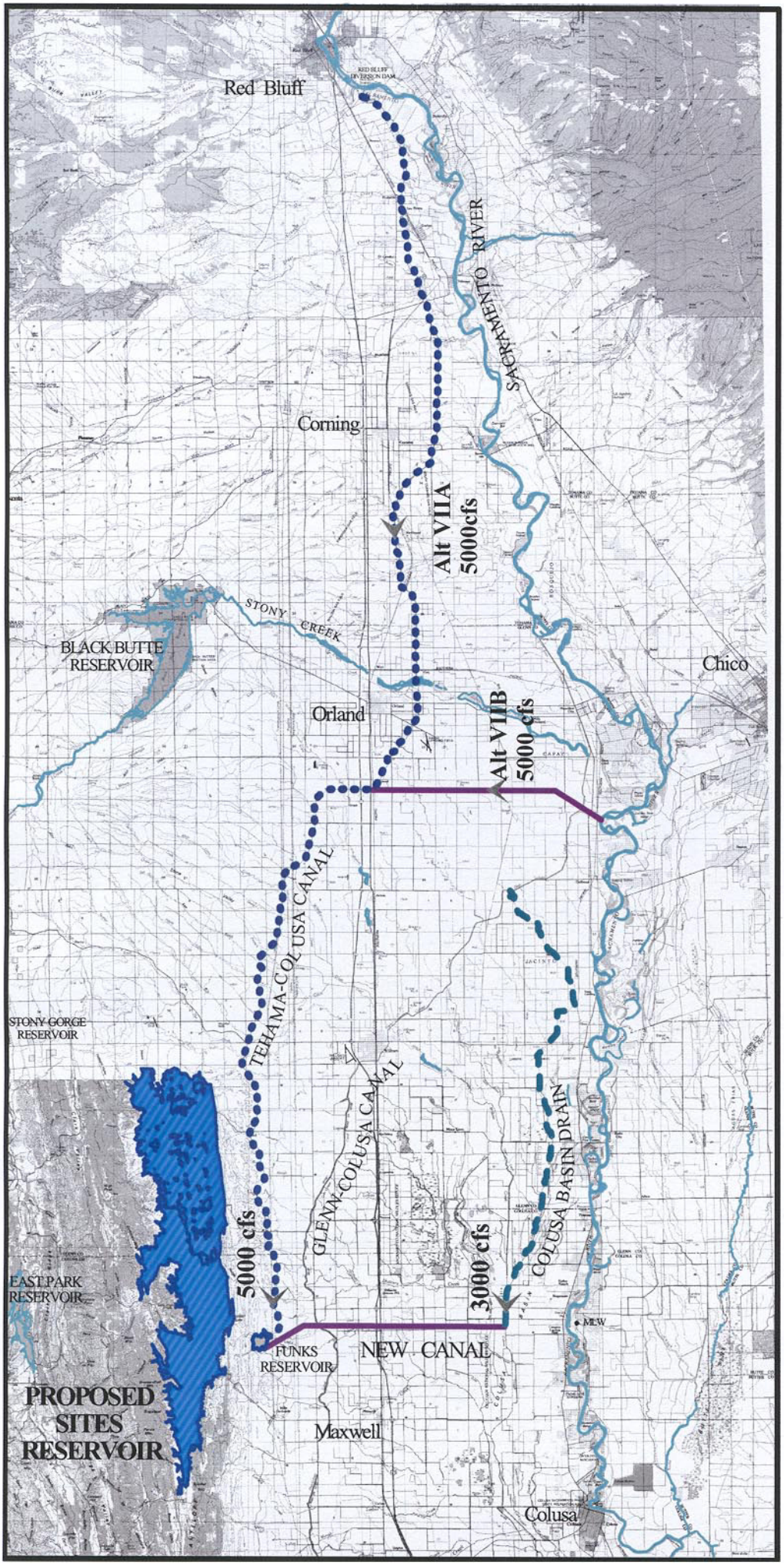
ALTERNATIVE VI(B): GC + NC/SR + CD/NC

Existing 1800 cfs GC Canal, new 3200 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10

Miles

| No. | Alternative | Diversion to Funks | Canal | No. | Canal Reaches | | | | | | Canal Lined |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Q(max) | Length | | Status | From | To | |
| | | | | | | Station | Distance | | | | |
| | | (cfs) | | | (cfs) | (1000 ft) (a) | (unit cost) (b) | | | | |
| VI A | TC+NC/SR+CD/NC | 8,000 | TC | all | 2,100 | 352.52 | 0 | Existing | RBPP | Funks | Yes |
| | Utilize 2100cfs from | | NC | 1A | 2,900 | 15.20 | 0.20 | New | SR | CD | No |
| | existing RBPP & new | | NC | 1 | 5,900 | 30.40 | 0.31 | New | CD | PP1 | No |
| | 2900cfs Diversion | | NC | 2 | 5,900 | 17.00 | 0.69 | New | PP1 | PP2 | Yes |
| | Facilities opposite | | NC | 3 | 5,900 | 2.50 | 0.69 | New | PP2 | PP3 | Yes |
| | Moulton Weir | | NC | 4 | 5,900 | 11.00 | 0.69 | New | PP3 | Funks | Yes |
| | Total | | | | | | | | | | |
| B | GC+NC/SR+CD/NC | 8,000 | GC | all | 1,800 | 212.00 | 0 | Existing | HCPP | NC | No |
| | Includes 3200 cfs | | NC | 1A | 3,200 | 15.20 | 0.21 | New | SR | CD | No |
| | new Diversion | | NC | 1 | 6,200 | 30.40 | 0.32 | New | CD | PP1 | No |
| | Facilities opposite | | NC | 2 | 6,200 | 17.00 | 0.70 | New | PP1 | PP2 | Yes |
| | Moulton Weir | | NC | 3 | 6,200 | 2.50 | 0.70 | New | PP2 | PP3 | Yes |
| | Total | | NC | 4 | 6,200 | 11.00 | 0.70 | New | PP3 | Funks | Yes |




# Figure 12

NORTHERN DISTRICT
OCT 1999

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ALTERNATIVE VII(A): TC + CD/NC

New 5000 cfs TC diversion dam, 5000cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VII(B): TC/CLI + CD /NC

New 5000 cfs SR diversion near Chico Landing, 5000 cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10

Miles

| No. | Alternative | Diversion to Funks | Canal | Canal Reaches No. | Q(max) | Length Station | Length Distance | Status | From | To | Canal Lined |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cfs) | | | (cfs) | (1000 ft) (a) | (unit cost) (b) | | (Miles) | | |
| VII A | TC+CD/NC | 8,000 | TC | all | 5,000 | 352.52 | 0.44 | Enlarge | RBPP | Funks | Yes |
| | Includes new | | NC | 1 | 3,000 | 30.40 | 0.20 | New | CD | PP1 | No |
| | 5000 cfs RBPP | | NC | 2 | 3,000 | 17.00 | 0.54 | New | PP1 | PP2 | Yes |
| | Diversion | | NC | 3 | 3,000 | 2.50 | 0.69 | New | PP2 | PP3 | Yes |
| | Facilities | | NC | 4 | 3,000 | 11.00 | 0.69 | New | PP3 | Funks | Yes |
| | Total | | | | | | | | | | |
| B | TC/CLI+CD/NC | 8,000 | CLI | 1 | 5,000 | 6.00 | 0.64 | New | SR | PP1 | Yes |
| | Includes new | | CLI | 2 | 5,000 | 22.20 | 0.64 | New | PP1 | PP2 | Yes |
| | 5000 cfs CLI | | CLI | 3 | 5,000 | 22.00 | 0.64 | New | PP2 | PP3 | Yes |
| | Diversion | | CLI | 4 | 5,000 | 7.40 | 0.64 | New | PP3 | TC | Yes |
| | Facilities | | TC | 2 | 5,000 | 169.83 | 0.44 | Enlarge | CLI | Funks | Yes |
| | | | NC | 1 | 3,000 | 30.40 | 0.20 | New | CD | PP1 | No |
| | | | NC | 2 | 3,000 | 17.00 | 0.54 | New | PP1 | PP2 | Yes |
| | | | NC | 3 | 3,000 | 2.50 | 0.69 | New | PP2 | PP3 | Yes |
| | | | NC | 4 | 3,000 | 11.00 | 0.69 | New | PP3 | Funks | Yes |
| | Total | | | | | | | | | | |

# Preliminary Cost Estimates

## Cost Estimate Methodology

Developing cost estimates for this study provides a reasonable estimate of each alternative's costs but more importantly allows for the comparison of alternatives. A comparison of costs seeks to identify any large differences in the cost of alternatives at the earliest point in the decision process. Such information is useful in determining whether to proceed with or defer an alternative.

Initial cost estimates were based on the October 1997 *CALFED Facility Descriptions and Cost Estimates* for: 1) the Red Bluff Diversion and Tehama-Colusa Canal Enlargement and 2) near the Sacramento River Mile 188 Intertie. The initial costs were modified by CD and DWR's Division of Engineering for the preliminary conceptual designs and facility quantity estimates.

Several types of costs are not included in the cost tables. They include environmental documentation, construction mitigation, and agency permit processing and fees. Alternatives involving a new or enlarged diversion from the Sacramento River would have a relatively higher additional cost than alternatives not diverting from the Sacramento River. Future studies should identify and include all project-related costs for a realistic comparison of alternatives.

## Component Costs

Preliminary component costs for each alternative include river diversion, conveyance canal, major structures and pumping plant direct payment (DP) construction costs. DP is the product of quantities times unit price or lump sum amount where quantities are not defined. In addition to the DP costs, it is necessary to add construction contingencies, right of way and state operation (SO) costs in order to arrive at the total construction cost for each alternative. SO is estimated at 35 percent and is the sum of planning, design, contract administration, legal, and other project related costs. Operation and maintenance costs are not included in the total construction costs. Unit costs are included in Attachment C.

## Diversion Facilities

New diversion structures that included fish screen, bypass, gates, sedimentation basin, pumps, and related works descriptions and costs were developed by DWR's ESO and DOE. Detailed design and cost estimates for 3,000 cfs and 5,000 cfs diversions were developed and used to estimate other size diversions.

## Conveyance Canals

Enlarged and/or new trapezoidal canal costs are based on quantities developed for each alternative. Unit costs for unlined and lined canals were developed from existing studies, past projects, CALFED and USBR data and engineering judgment. DOE provided unit costs for generic design criteria and CD staff modified the estimates for the specific pre-design conditions for each alternative canal reach and facility.

### Major Features

Enlarged and/or new major features costs are based on quantities as noted above for canals. Major features include canal check structures, highway and county road bridges, railroad siphons, and major drainage crossings. Unit costs for specific pre-design conditions for each alternative were derived as noted above for canals.

### Pumping Plants

Enlarged, replacement or new pumping plant costs are based on generic cost curves provided by DOE. The cost curve relates plant cost to the pumping power (in megawatts) required for lifting a given flow to a calculated total dynamic head. Plant cost for specific pre-design conditions for each alternative were derived from the curve.

### Right of Way

Enlarged and/or new right of way width is based on canal conditions. The width of the right of way varied from 300 to 350 feet. Predominately agricultural land to be acquired by right of way was calculated for each alternative and multiplied by the estimated cost per acre. Right of way for the river diversion facilities, major features and pumping plants is included in the canal right of way costs. Land and right of way costs are estimated at $3,000 per acre and based on recent land sales for similar lands.

### Construction Contingencies

The purpose of the contingency is to provide monies for unexpected construction costs such as change orders, additional work, unforeseen conditions or other justified or negotiated contractor expenses. Construction contingencies are estimated at 25 percent average, and are usually 15 and 45 percent of DP depending upon the estimator level of comfort, cost sensitivity, agency policy, and recent experience.

### Cost Sensitivity

The cost of alternatives is based on feasibility or near-feasibility estimates of unit and component costs using the most current data available. The accuracy of cost estimates is affected by the level of design, site conditions, quantity calculations, and the cost of material and labor. Table 1 displays the cost of major components for each of the alternatives. Each of the component categories contributes a significant cost to the total cost of the alternative.

The diversion works are subject to a high level of uncertainty because of questions about the effectiveness of a fish screen that will reduce adverse impacts to fish. The type of fish screen selected will also determine the design for the remainder of the diversion structure. An accurate cost estimate of this structure will not be known until an acceptable fish screen design is completed.

The design of pump stations is affected by site conditions and proposed operations; both are currently unknown. Site conditions such as unfavorable soils, high groundwater, and utilities will increase construction costs. If proposed

operations become known, an optimal pumping system can be designed to reduce costs.

At the time of this study, survey data was not available to determine an accurate cost of a new canal or enlarge an existing one. Surveys along the proposed alignment will result in more accurate designs and cost estimates.

The cost of major features, such as check structures and crossings, represent almost half the total cost for some of the alternatives. Similar to the other components, the cost is subject to significant change pending more detailed information on site conditions and design.

### Cost of Alternatives

Table 1 summarizes the cost of major components and the total capital cost for each of the alternatives. The alternatives range from $115 million to $651 million in capital costs. As expected, Alternative I is the least costly alternative but is limited by capacity. Alternative VI is the least costly alternative that meets the flow requirements at Funks Reservoir by supplementing the capacity of existing systems.

## Table 1. Funks Reservoir Diversion Alternatives Costs
## Proposition 204 North of the Delta Storage Facility Studies
## ($ millions)

| Alt. No. | | Alternative Name | Diversion to Funks *(cfs)* | Cost Item | DP % Add | Diversion Works [5] | Trapezoidal Canal [1] | Major Features [2] | Pumping Plants [3] | Total Costs |
|---|---|---|---|---|---|---|---|---|---|---|
| **I** | **A** | TC+GC/NC4A | 3,900 | Direct Payment | | 0.0 | 6.2 | 14.6 | 48.8 | 69.6 |
| | | Includes existing | | Constr. Contgcy. | 25% | 0.0 | 1.5 | 3.7 | 12.2 | 17.4 |
| | | 2,100 cfs TC and | | Right of Way [4] | | -- | 0.0 | -- | -- | 0.0 |
| | | 1,800 cfs GC | | State Operations | 35% | 0.0 | 2.2 | 5.1 | 17.1 | 24.4 |
| | | **Total** | | ***TOTAL ALT COST*** | | **0.0** | **9.9** | **23.4** | **78.1** | ***$111.3*** |
| | **B** | TC+GC/NC4B | | Direct Payment | | 0.0 | 7.0 | 14.6 | 48.8 | 70.4 |
| | | Includes existing | | Constr. Contgcy. | 25% | 0.0 | 1.8 | 3.7 | 12.2 | 17.6 |
| | | 2,100 cfs TC and | | Right of Way [4] | | -- | 0.0 | -- | -- | 0.0 |
| | | 1,800 cfs GC | | State Operations | 35% | 0.0 | 2.5 | 5.1 | 17.1 | 24.6 |
| | | **Total** | | ***TOTAL ALT COST*** | | **0.0** | **11.2** | **23.4** | **78.1** | ***$112.7*** |
| **II** | **A** | TC+GC/NC4A | 5,000 | Direct Payment | | 0.0 | 47.9 | 15.8 | 51.0 | 114.7 |
| | | Includes enlarging | | Constr. Contgcy. | 25% | 0.0 | 12.0 | 4.0 | 12.8 | 28.7 |
| | | existing TC and GC | | Right of Way [4] | | -- | 0.2 | -- | -- | 0.2 |
| | | to 2,500 cfs each | | State Operations | 35% | 0.0 | 16.7 | 5.5 | 17.9 | 40.1 |
| | | **Total** | | ***TOTAL ALT COST*** | | **0.0** | **76.8** | **25.3** | **81.6** | ***$183.7*** |
| | **B** | TC+GC/NC4B | | Direct Payment | | 0.0 | 49.1 | 15.8 | 51.0 | 115.9 |
| | | Includes enlarging | | Constr. Contgcy. | 25% | 0.0 | 12.3 | 4.0 | 12.8 | 29.0 |
| | | existing TC and GC | | Right of Way [4] | | -- | 0.2 | -- | -- | 0.2 |
| | | to 2,500 cfs each | | State Operations | 35% | 0.0 | 17.2 | 5.5 | 17.9 | 40.6 |
| | | **Total** | | ***TOTAL ALT COST*** | | **0.0** | **78.8** | **25.3** | **81.6** | ***$185.6*** |
| **III** | | TC+GC+CD/NC | 8,000 | Direct Payment | | 0.0 | 30.1 | 155.3 | 82.8 | 268.2 |
| | | Utilizes 2,100cfs | | Constr. Contgcy. | 25% | 0.0 | 7.5 | 38.8 | 20.7 | 67.1 |
| | | from existing RBPP | | Right of Way [4] | | -- | 24.7 | -- | -- | 24.7 |
| | | Diversion Facilities | | State Operations | 35% | 0.0 | 10.5 | 54.4 | 29.0 | 93.9 |
| | | | | ***TOTAL ALT COST*** | | **0.0** | **72.8** | **248.5** | **132.5** | ***$453.8*** |
| **IV** | **A** | GC+CD/NC | 8,000 | Direct Payment | | 13.5 | 53.0 | 168.4 | 105.7 | 340.6 |
| | | Includes new | | Constr. Contgcy. | 25% | 3.4 | 13.2 | 42.1 | 26.4 | 85.1 |
| | | 2,000 cfs HCPP | | Right of Way [4] | | -- | 4.0 | -- | -- | 4.0 |
| | | Diversion Facilities | | State Operations | 35% | 4.7 | 18.5 | 58.9 | 37.0 | 119.2 |
| | | | | ***TOTAL ALT COST*** | | **21.6** | **88.8** | **269.5** | **169.1** | ***$548.9*** |
| | **B** | GC/CLI+CD/NC | 8,000 | Direct Payment | | 13.5 | 55.3 | 166.4 | 98.5 | 333.6 |
| | | Includes new | | Constr. Contgcy. | 25% | 3.4 | 13.8 | 41.6 | 24.6 | 83.4 |
| | | 2100 cfs CLI | | Right of Way [4] | | -- | 3.3 | -- | -- | 3.3 |
| | | Diversion Facilities | | State Operations | 35% | 4.7 | 19.3 | 58.2 | 34.5 | 116.8 |
| | | | | ***TOTAL ALT COST*** | | **21.6** | **91.8** | **266.2** | **157.6** | ***$537.1*** |

## Table 1. (continued from previous page) ($ millions)

| Alt. No. | | Alternative Name | Diversion to Funks *(cfs)* | Cost Item | DP% Add | Diversion Works [5] | Trapezoidal Canal [1] | Major Features [2] | Pumping Plants [3] | Total Costs |
|---|---|---|---|---|---|---|---|---|---|---|
| **V** | | NC/SR+CD/NC | 8,000 | Direct Payment | | 33.7 | 38.4 | 134.8 | 90.5 | 297.4 |
| | | Includes new | | Constr. Contgcy. | 25% | 8.4 | 9.6 | 33.7 | 22.6 | 74.3 |
| | | 5,000 cfs NC | | Right of Way [4] | | | 2.1 | | | 2.1 |
| | | Diversion Facilities | | *State Operations* | 35% | 11.8 | 13.4 | 47.2 | 31.7 | 104.1 |
| | | | | ***TOTAL ALT COST*** | | **53.9** | **63.5** | **215.7** | **144.8** | ***$477.9*** |
| **VI** | **A** | TC+NC/SR+CD/NC | 8,000 | Direct Payment | | 19.6 | 33.4 | 134.8 | 85.5 | 273.3 |
| | | Utilize 2,100cfs of | | Constr. Contgcy. | 25% | 4.9 | 8.4 | 33.7 | 21.4 | 68.3 |
| | | existing RBPP & | | Right of Way [4] | | -- | 1.7 | -- | -- | 1.7 |
| | | new 2,900cfs | | State Operations | 35% | 6.9 | 11.7 | 47.2 | 29.9 | 95.7 |
| | | Diversion Facilities | | ***TOTAL ALT COST*** | | **31.4** | **55.2** | **215.7** | **136.8** | ***$439.0*** |
| | | opposite MW | | | | | | | | |
| | **B** | GC+NC/SR+CD/NC | 8,000 | Direct Payment | | 21.6 | 34.2 | 134.8 | 89.5 | 280.1 |
| | | Includes 3,200 cfs | | Constr. Contgcy. | 25% | 5.4 | 8.5 | 33.7 | 22.4 | 70.0 |
| | | new Diversion | | Right of Way [4] | | -- | 1.7 | -- | -- | 1.7 |
| | | Facilities opposite | | State Operations | 35% | 7.6 | 12.0 | 47.2 | 31.3 | 98.0 |
| | | Moulton Weir | | ***TOTAL ALT COST*** | | **34.6** | **56.4** | **215.7** | **143.2** | ***$449.8*** |
| **VII** | **A** | TC+CD/NC | 8,000 | Direct Payment | | 33.7 | 179.6 | 223.0 | 102.2 | 538.5 |
| | | Includes new | | Constr. Contgcy. | 25% | 8.4 | 44.9 | 55.7 | 25.6 | 134.6 |
| | | 5,000 cfs RBPP | | Right of Way [4] | | -- | 4.1 | -- | -- | 4.1 |
| | | Diversion Facilities | | State Operations | 35% | 11.8 | 62.9 | 78.0 | 35.8 | 188.5 |
| | | | | ***TOTAL ALT COST*** | | **53.9** | **291.4** | **356.8** | **163.5** | ***$865.6*** |
| | **B** | TC/CLI+CD/NC | 8,000 | Direct Payment | | 33.7 | 136.1 | 202.1 | 154.7 | 526.6 |
| | | Includes new | | Constr. Contgcy. | 25% | 8.4 | 34.0 | 50.5 | 38.7 | 131.6 |
| | | 5,000 cfs CLI | | Right of Way [4] | | -- | 3.9 | -- | -- | 3.9 |
| | | Diversion Facilities | | State Operations | 35% | 11.8 | 47.6 | 70.7 | 54.1 | 184.3 |
| | | | | ***TOTAL ALT COST*** | | **53.9** | **221.7** | **323.3** | **247.5** | ***$846.4*** |

### Abbreviations

CD Colusa Basin Drain
CLI Chico Landing Intertie
PP Pumping Plant
HC Hamilton City
RB Red Bluff Diversion Dam
DP Direct Payment to Contractor
MW Moulton Weir
NC New Canal
GC Glenn -Colusa Canal
TC Tehama-Colusa Canal
SR Sacramento River
JC Jacinto Check
Funks Funks Reservior

**Footnotes**

1. Totals from Table 1.
2. Totals from Table 3.
3. Totals from Table 4.
4. Totals from Table 5.
5. No cost shown for utilization of existing headworks on TC canal.

# Discussion

### Alternative I

As expected, utilizing the existing capacities of the Tehama-Colusa and Glenn-Colusa Canal systems would be the least costly alternative; however, it does not meet the general design objective of delivering 5,000 cfs to Funks Reservoir. The most costly elements are the new canal and pumping plants associated with diverting water from the Glenn-Colusa Canal to Funks Reservoir. Option B, which would divert water from the Glenn-Colusa Canal to the south abutment of Funks Reservoir, would cost about $1.4 million more than Option A.

### Alternative II

Alternative II estimates an additional cost of $72 million to Alternative I for modifying existing canals to deliver 5,000 cfs to Funks Reservoir. Most of the additional cost is attributed to the construction of the larger new canal from the Glenn-Colusa Canal to Funks Reservoir. It would cost about $1.9 million more under Option B to connect new canal to the south abutment of Funks Reservoir than connecting it to the Tehama-Colusa Canal under Option A.

### Alternative III

Alternative III is significantly costlier than the first two alternatives because of the extended NC coming from the Colusa Basin Drain. A 3,000 cfs NC from the Colusa Drain represents about 75 percent of the total cost of the alternative. The remaining costs are the enlargement of the existing Glenn-Colusa Canal and enlargement of the canal structures.

### Alternative IV

Alternative IV estimates $83 million to $95 million more than the cost of Alternative III to increase the capacity of the Glenn-Colusa Canal and not utilize the Tehama-Colusa Canal. Option B would supplement the existing diversion capacity at Hamilton City Pumping Plant with a new diversion and intertie near Chico Landing. It is about $12 million less than enlarging the pumping plant canal under Option A. Option B is less costly due to the cost of building a short intertie near Chico Landing while not having to enlarge the Glenn-Colusa Canal reach from Hamilton City to the intertie connection point. Alternative IV would also not require modifications to the siphon at Stony Creek to increase its capacity to 5,000 cfs.

### Alternative V

The cost to build a new conveyance system to deliver 8,000 cfs at Funks Reservoir without utilizing existing diversion and canal facilities is close to the cost of Alternatives III, IV, and VI that utilize existing facilities. While it is costly to build new facilities under Alternative V, the additional length of the new canal is much less than the cost of enlarging existing canals in the other alternatives. In addition, most of the cost for Alternatives III, IV, V, and VI is from common

elements that would divert water from the Glenn-Colusa Canal and/or Sacramento River, and the Colusa Basin Drain. Alternative V, however, would provide greater flexibility in operating and maintaining the system when compared to the other alternatives. Detailed investigations may result in a more efficient and less costly design of Alternative V, but may incur additional costs associated with right of way acquisition and mitigation of adverse impacts.

### Alternative VI

Supplementing the existing capacities of the Tehama-Colusa or Glenn-Colusa Canal systems with a new diversion on the Sacramento River is a compromise between Alternatives III, IV, and Alternative V. Alternative VI combines the cost of Alternative I with a lower capacity design of Alternative V. As expected, it is about $28 million to $39 million less than Alternative V because of its reliance on using the existing Tehama-Colusa and Glenn-Colusa systems. It also has the least cost for an alternative that would convey 8,000 cfs to Funks Reservoir. Using existing facilities reduces the size and cost of a new canal while providing some operational flexibility.

### Alternative VII

Alternative VII indicates a substantial cost to increase the deliverable capacity of the Tehama-Colusa Canal system to Funks Reservoir for Options A and B. It is highest in terms of total cost because it is equal to or more costly than the other alternatives for all the major cost components shown in Table 1.

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