Table A-6. November – March Estimated Streamflow Volumes, 1945–1994: Optional Water Supply Source Streams

Source and Location	Minimum (MAF)	Maximum (MAF)	Average (MAF)
Sacramento River at Butte City	1.613	14.415	5.460
Whiskeytown Reservoir at Keswick Reservoir [a]	0.541	1.297	0.937
Stony Creek below Black Butte Dam	0.001	1.052	0.235
Colusa Basin Drain at Highway 20	0.039	0.759	0.209
Inflow to Stony Gorge Reservoir	0.004	0.509	0.151
Thomes Creek at Paskenta	0.007	0.359	0.1509
Beegum Creek, Dry Creek, Cold Fork Creek, Hensley Creek, and South Fork Cottonwood Creek to Cottonwood South Reservoir [b]	0.089	0.238	0.144
Beegum Creek and Dry Creek to Cottonwood North Reservoir [b]	0.084	0.222	0.134
Inflow to Proposed Grindstone Reservoir	0.009	0.301	0.0854
Middle Fork Cottonwood Creek to Veteran's Lake [b]	0.053	0.141	0.085
Inflow to East Park Reservoir with Rainbow Diversion	0.001	0.222	0.0762
South Fork Cottonwood Creek at Dippingvat	0.005	0.259	0.0754
Clear Creek at Whiskeytown Reservoir [c]	0.021	0.206	0.063
North Fork Cottonwood Creek to Veteran's Lake [b]	0.021	0.057	0.034

[a] Values extrapolated based on 10 years of records from Reclamation.
[b] Values derived from SCS runoff methodologies.
[c] Values derived from 46 years of records from USGS gauging station, Clear Creek at Igo.
MAF = million acre-feet
SCS = Soil Conservation Service
USGS = United States Geological Survey

By far, the Sacramento River is the largest water supply source for the options considered. With an average historical 5-month flow volume of nearly 5.5 MAF at Butte City, the river's flow is more than 5 times the size of the second-largest option: Whiskeytown Reservoir. The six smallest optional water supply sources are Grindstone Creek, Middle Fork Cottonwood Creek, East Park Reservoir, South Fork Cottonwood Creek, Clear Creek, and North Fork Cottonwood Creek; each with an average November through March runoff of less than 0.1 MAF. The sources are not independent options. All of the tributary streams contribute to the flow of the Sacramento River. Outflow from East Park Reservoir becomes inflow to Stony Gorge, and ultimately contributes to the flow below Black Butte.

Streamflow volumes are dependent on diversion location. In general, volumes increase in the downstream direction. Optional diversion locations for the Sacramento River are at the existing T-C Canal diversion in Red Bluff, the existing GCID Canal diversion near Hamilton City, and a new diversion opposite Moulton Weir. Diversion locations investigated for Stony Creek include Black Butte Lake, Stony Gorge Reservoir, and East Park Reservoir, with additional water from the Rainbow Diversion and at the GCID Canal crossing. The diversion location investigated for CBD is due west of Moulton Weir, approximately 10 miles north of Highway 20. Thomes Creek diversion locations include a number of options west of Paskenta and at the T-C Canal crossing. The Grindstone Creek diversion location is from a potential Grindstone Reservoir. The Grindstone Dam site is approximately 2.5 miles upstream from the confluence with Stony Creek. The diversion location for South Fork Cottonwood Creek is at the proposed Dippingvat

Reservoir for the Red Bank Project. A diversion from the GCID Canal was evaluated for Newville Reservoir.

Biological Resources

The following sections summarize biological resources found in the reservoir footprint areas, such as vegetation, fish, and wildlife.

Vegetation

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

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

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

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

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

Ninety-nine percent of the Colusa Cell area is dominated by an annual grasslands community. The remaining 1 percent of the land area is divided between blue oak woodland, riparian, emergent wetlands, and non-vegetated areas. No chaparral, blue oak/foothill pine woodland, or cultivated grain is present within the reservoir footprint. As elevation increases above the western edge of the reservoir boundary, the blue oak savanna community becomes dominant.

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

Annual grasslands dominate approximately 94 percent of the surface area of the proposed Sites Reservoir. Blue oak woodland occurs around the fringe of the reservoir area. Relatively small amounts of blue oak woodland, chaparral, riparian, wetlands, cultivated grain, and non-vegetated areas make up the remainder of the inundation area. As elevation increases above the western edge of the reservoir boundary, the foothill pine community becomes dominant with large chamise chaparral stands present on shallow soils and southern exposures.

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

The vegetation in the Cottonwood Reservoir area is dominated by blue oak woodland (*Quercus douglasii* Woodland Alliance), valley oak woodland (*Quercus lobata* Woodland Alliance), and introduced annual grassland alliance dominated by a variety of non-native grass species such as wild oats (*Avena barbata*), rye grasses (*Lolium* spp.), non-native barley (*Hordeum* spp.), and brome grasses (*Bromus* spp.). Several smaller areas dominated by foothill pine, chaparral, riparian and wetland plant species are also present and contain a large diversity of native plant species.

Blue oak woodlands occur in higher areas of rolling hills throughout the Cottonwood Reservoir area. Valley oak woodlands are located primarily near the valley bottoms. Both of these plant communities are dominated almost solely by the two species of oak. Oak woodlands are considered sensitive plant communities and are strictly protected by California law (Senate Concurrent Resolution 17 and Public Resources Code Section 21083.4).

Based on the California Natural Diversity Database (CNDDB) (California Department of Fish and Wildlife [CDFW]), several listed plant species have a high potential to occur in the Cottonwood Reservoir area. These plant species include the dimorphic snapdragon (*Antirrhinum subcordatum*), Jepson's milk-vetch (*Astragalus rattanii* var. *jepsonianus*), big-scale balsamroot (*Balsamorrhiza macrolepis* var. *macrolepis*), Brandegee's eriastrum (*Eriastrum brandegeeae*), Tracy's eriastrum (*Eriastrum tracyi*), Stebbin's harmonia (*Harmonia stebbinsii*), dubious pea (*Lathyrus sulphureus* var. *argillaceus*), woolly meadowfoam (*Limnanthes floccosa* ssp. *floccosa*), and leafy–stemmed miterwort (*Mitella caulescens*).

The vegetation in the Veteran's Lake area is dominated by three major vegetation alliances: blue oak woodland (*Quercus douglasii* Woodland Alliance), valley oak woodland (*Quercus lobata* Woodland Alliance), and introduced annual grassland alliance dominated by a variety of non-native grass species such as wild oats (*Avena barbata*), rye grasses (*Lolium* spp.), non-native barley (*Hordeum* spp.), brome grasses (*Bromus* spp.) and others. Several smaller areas dominated by foothill pine, cypress, chaparral, riparian, and wetland plant species are also present.

Blue oak woodlands are typically found in higher areas on rolling hills throughout the Veteran's Lake site. Valley oak woodlands occur near the valley bottoms where they can reach the underground water table. Both of these plant communities are dominated by the two species of oak, and both are considered sensitive and strictly protected by California law (Senate Concurrent Resolution 17 and Public Resources Code Section 21083.4). The northern interior cypress forest alliance is another sensitive plant community with a high potential to occur in the area, based on the CNDDB records. Two listed plant species with a high potential to occur in the Veteran's Lake area are the Siskiyou fireweed (*Epilobium siskiyouense*) and blushing wild buckwheat (*Eriogonum ursinum* var. *erubescens*).

Aquatic and Fishery Resources

The watersheds of the North Coast Range draining east toward the Sacramento Valley contain native and non-native species, warm- and coldwater species, and anadromous and resident fish species. At least 24 species of fish are present in these watersheds. Several Federally or State of California (State)–listed fish species occur in the region, including steelhead and various runs of Chinook salmon. Coldwater habitats are present in the upper watersheds of the major streams, including Cottonwood Creek, Red Bank Creek, and Thomes Creek.

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

A more recent survey on South Fork Cottonwood Creek and Red Bank Creek within the Red Bank Reservoir footprint area located six species of resident game fishes and six species of non-resident game fishes. Steelhead were identified in the Red Bank Creek watershed.

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

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

In 1976, the California Department of Fish and Game (now the CDFW) conducted studies in lower Cottonwood Creek (below the north fork confluence) and in South Fork Cottonwood Creek. The survey found 10 resident game species and 13 nongame species of fishes. The survey

also found runs of fall-run, late fall-run, and spring-run Chinook salmon in lower Cottonwood Creek, and spring-run Chinook salmon and steelhead in South Fork Cottonwood Creek.

In addition to providing habitat for salmon, Cottonwood Creek is the most important source of sediments to the Sacramento River; sediments that help maintain riparian rejuvenation. Cottonwood Creek has been designated as Essential Fish Habitat by the National Marine Fisheries Service (NMFS) and the Pacific Fisheries Management Council. Essential fish habitat is habitat necessary to support a long-term, sustainable salmon fishery.

Wildlife

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

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

Federally or State-listed wildlife species have been studied and documented at or near each proposed reservoir location. Both wintering sandhill cranes (State threatened) and a migrating bank swallow (State threatened) have been detected at or near the proposed Colusa Cell. Extensive surveys of the proposed Sites and Colusa Cell Reservoir footprint areas have failed to detect any California tiger salamanders or red-legged frogs. Protocol for the field surveys requires that the study include areas around the proposed reservoirs where proposed facilities, roads, and utilities would be relocated. One red-legged frog (Federal threatened) has been reported in the Red Bank Reservoir footprint area. Numerous Federally listed Species of Concern, California Species of Special Concern, Federal Migratory Nongame Birds of Management Concern, or candidate species occur in each of the proposed reservoirs.

The Bald and Golden Eagle Protection Act of 2009 also has application. Wintering bald eagles (Federal threatened, State endangered) occur in low numbers at each proposed reservoir location, and golden eagles are one of the most common raptors throughout the Study Area.

Several CDFW harvest species occur in the proposed reservoirs. Upland game includes black-tailed deer, black bear, feral pig, gray squirrel, wild turkey, California and mountain quail, and mourning dove. Waterfowl use is limited in each of the proposed reservoirs, and generally restricted to winter use of stock ponds and small lakes. Limited wood duck and mallard nesting also occur in stock ponds and along the stream channels, where adequate brooding water exists.

Relatively high deer use of portions of the Newville Reservoir and Red Bank Reservoir footprint areas during winter has been reported. Substantially less deer use has been observed in the Sites Reservoir area, and no use has been noted in the Colusa Cell area. Observations indicate that feral pigs occur in low to moderate numbers in each of the proposed reservoirs, with the greatest use in the Red Bank Reservoir footprint area. Wild turkeys are relatively common in portions of the Red Bank Reservoir footprint area and Newville Reservoir area.

According to the Natural Diversity Database, several Federally listed invertebrate species may occur in the four proposed reservoir sites. These species include vernal pool fairy shrimp, Conservancy fairy shrimp, and vernal pool tadpole shrimp.

Socio-Economic Resources

The following sections discuss socio-economic resources encountered in the Study Area.

Land Use

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

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

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

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

Seasonal and year-round livestock grazing dominates land use in the Newville Reservoir area; however, limited horse and sheep grazing also occurs. At least 20 occupied ranch sites are found in the reservoir area. Limited firewood harvest has occurred in some areas.

Land use in the Cottonwood Reservoir Complex is dominated by seasonal and year-round livestock grazing. Limited horse and sheep grazing may also occur. Only two occupied ranch complexes exist in the project area. However, several corrals and stock ponds to support livestock occur in the reservoir area. Limited commercial firewood harvesting may occur in some areas.

Land use in the Veteran's Lake is dominated by seasonal and year-round livestock grazing. Limited horse and sheep grazing may also occur. One large, occupied ranch complex exists in the project area. Several corrals and stock ponds to support livestock occur in the reservoir area.

Cultural Resources

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

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

Results of the record search for the Red Bank Study Area at the Northwest Information Center of the California Historical Resources Information System at California State University, Chico, indicated that the reservoir footprint area had not been surveyed for cultural resources, and no cultural resources were previously recorded in the reservoir footprint area. The surveys completed in 1994 for the USACE Cottonwood Creek project were downstream of the project described here, with no overlap of the footprints.

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

Much of the Sites Reservoir Study Area was surveyed between 2001 and 2003. Based on the results of this study and earlier surveys, 147 sites have been recorded in the Sites footprint. These include 67 prehistoric sites, 46 historic-era sites, and 34 sites that contain both prehistoric and historic-era components. An additional 419 isolates have been recorded, most of which consisted of historic-era items related to ranching and farming. At least 18 sites appeared to be significant. Prehistoric settlement in the Study Area was constrained by the limited food and fuel resources and the scarcity of water. However, the area would have been important for seasonal hunting and gathering forays. The larger and more permanent villages were situated along the lower reaches of the bigger streams, and on the knolls and natural levees along the Sacramento River. To date, no sites have been evaluated for formal inclusion in the National Register of Historic Places.

The town of Sites is likely significant as a Historic District. Moving the cemetery associated with Sites, along with several smaller historic-era cemeteries, would present special consideration. Similarly, many of the large prehistoric village sites in the Sites Study Area have a high probability of containing burials, which would require considerable coordination with local Native American tribes.

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

Current information on the cultural resources present in the Cottonwood Reservoir area has not been ascertained. However, the Cottonwood Reservoir locale is upstream and adjacent to the Tehama Lake project surveyed by the USACE in 1982, and it is possible that the two projects may overlap to a degree. The Tehama Lake survey identified 122 cultural resources within 22,000 acres. The resources are represented by 80 prehistoric sites and 43 historic-era deposits. A large percentage of the prehistoric resources were midden habitation sites; the remaining sites were lithic scatters. Virtually all of the historic sites reflect some element of ranching; only one mining site was recorded.

Future studies of the Cottonwood Reservoir location would likely have results similar to that of the Tehama Lake survey, due to similar topography and the availability of comparable resources.

A record search was not completed for the Veteran's Lake area. However, data are available from an intensive survey that was conducted in 1981-1982 for the proposed 24,000-acre Dutch Gulch Lake, which was directly downstream from the Veteran's Lake site. It is worthy to note that the Dutch Gulch Lake study included the lower reaches of Veteran's Lake along Roaring Creek. This survey resulted in the identification of 283 sites (117 prehistoric and 166 historic-era). The prehistoric deposits represent long- and short-term habitation and a variety of resource procurement sites. The historic-era remains primarily reflect ranching and mining activities, including a number of Chinese mining sites. Further studies at Dutch Gulch resulted in the recommendation of three prehistoric and one historic-era district, and seven prehistoric and two historic-era individual sites that are eligible for listing in the National Register of Historic Places.

The land forms and resources present in the Veteran's Lake project are similar to those found at Dutch Gulch. This similarity would suggest that an intensive survey of Veteran's Lake would produce a similar site density of cultural resources.

Summary of Reservoir Location Considerations

Three viable surface storage measures suitable for more detailed evaluation were identified through the initial evaluation process: Colusa Reservoir Complex, Newville Reservoir, and Sites Reservoir. Potential reservoir locations associated with the Red Bank were not recommended for additional evaluation.

Because it is an onstream reservoir, Dippingvat Reservoir has more extensive environmental impacts and is not considered consistent with the objective to increase the populations of anadromous fish and other aquatic species. Without Dippingvat Reservoir, the Red Bank Project would be limited to Schoenfield Reservoir, reducing the storage volume to 0.25 MAF. Furthermore, in spite of Red Bank having the smallest reservoir footprint area, it contains one of the most diverse habitats, and several stages of habitats, and has considerable environmental and fishery impacts. The following impacts support the conclusion for not recommending Red Bank Project for further evaluation:

- The California red-legged frog, a Federally threatened species, was observed within the reservoir footprint.
- To provide water supply to the reservoir, this measure would block a portion of the Cottonwood Creek watershed. The Cottonwood Creek watershed is a known anadromous fishery for steelhead, and fall-run and late–fall-run Chinook salmon.
- Cottonwood Creek is the largest undammed tributary to the Upper Sacramento River, and it is the Sacramento River's most important source of sediment.
- Constructing this facility would impact an area with a high diversity of habitat.
- Hydrologic conditions do not favor the Red Bank Project unless a diversion dam is constructed across Cottonwood Creek to divert the flow needed to fill the Schoenfield site, which would impede anadromous fish passage and spring-run salmon and steelhead.
- Initial geotechnical investigations indicate the potential for excessive reservoir leakage for this project, compared to other viable measures considered in this study.
- The project would reduce the release of sediment, gravel, and large, woody debris needed for ecological function in the Sacramento River.

The Cottonwood Reservoir Complex proposes a larger reservoir, and the height of the dam increases the potential for hydropower generation through pumped storage. Major concerns include the ability to fill the reservoir rapidly enough to provide a cost-effective yield, and the cost of conveyance. The proposed diversion schemes reduce the fish passage conflicts with steelhead and Chinook, but the alteration of flows could have significant impacts on anadromous fish. The effects of the intakes on sediment transport and the size distribution of the sediment would also need to be studied. The effect of the reservoir on sediment transport in Cottonwood Creek and the lack of coldwater pool benefits would also be concerns. In addition, the limited size of the natural channel downstream of Cottonwood Reservoir Complex would constrain the rate of discharging water from the reservoir to less than 1,000 cubic feet per second (cfs); and if higher outflows are required, the additional construction and operating cost would be higher when compared to Sites Reservoir.

Veteran's Lake could be filled from North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, and Duncan Creek. Reservoir sizes of 0.5 thousand acre-feet (TAF) and 1 MAF are possible. Because the reservoir would be filled from tributaries to the Sacramento River, there is less water available to fill the reservoir than is available directly from the Sacramento River. Mean annual runoff from Cottonwood Creek is 650 TAF, compared to a mean annual runoff in the Sacramento River of 8,518 TAF at Colusa (DWR 2009). Challenges in filling the reservoir

would significantly constrain the yield for Veteran's Reservoir. The cost of new conveyance at Veteran's Lake from Whiskeytown Reservoir or the Sacramento River through Whiskeytown Reservoir to minimize the fill time would be high, in comparison to the cost of constructing the reservoir itself. Water surface elevation in the reservoir would vary significantly in response to demand due to the relatively steep topography. As an offstream reservoir, Veteran's Lake would not create a new barrier to fish passage, but the intakes on Cottonwood Creek might alter the sediment load or size distribution of the sediment in Cottonwood Creek. Altering the flows in Cottonwood Creek by operating a diversion might be detrimental to spawning salmon, and is likely to be a significant concern to NMFS, United States Fish and Wildlife Service, and CDFW. Veteran's Lake is also unlikely to offer the magnitude of the coldwater pool benefits at Shasta Lake that can be accomplished with Sites Reservoir. Additionally, the size of the natural channel downstream of Veteran's Lake would constrain the rate for discharging water from the reservoir to less than 1,000 cfs; and if higher outflows are required, the additional construction and operating cost would be higher when compared to that for Sites Reservoir.

Based on this analysis, the most promising alternatives were determined to be the Colusa Reservoir Complex, Newville Reservoir, and Sites Reservoir.

Economic Evaluation of Colusa Reservoir Complex, Newville Reservoir, Sites Reservoir, and Locations

To provide a preliminary economic assessment for the three surface storage measures, costs for the construction of the reservoirs were compared with yield and unit costs. These costs are presented in Table A-7. The estimated average annual cost per yield is similar in magnitude for Sites and Newville Reservoirs. The construction cost of Colusa Reservoir Complex would be approximately 4.4 times that of Sites Reservoir, and six times that of Newville Reservoir, while the increase in yield over what would be produced by the Sites and Newville Reservoirs is approximately 10 to 25 percent. Because of this lack of efficiency, the Colusa Reservoir Complex measure was not recommended for inclusion in the alternatives for further consideration.

It should be noted that the costs presented in Table A-7 do not include mitigation.

Both the reservoir location and conveyance system associated with Sites Reservoir would have significantly fewer environmental impacts than the location and conveyance system associated with Newville Reservoir. Table A-8 shows the biological, ecological, and cultural attributes of several environmental resources within the reservoir footprints. Potential effects of the two reservoirs on these resources are displayed using quantity indicators.

Table A-7. Comparison of Total Construction and Yield Cost in 2015 Dollars

Attribute	Measure–Colusa Reservoir Complex	Measure–Sites Reservoir	Measure–Newville Reservoir
Gross Storage (acre-feet)	3,000,000	1,810,000	1,900,000
Dead Storage (acre-feet)	100,000	40,000	50,000
Construction Cost	$20.1B	$4.5B	$4.8B
Average Annual Cost [a]	$722M	$165M	$173M
Estimated Average Annual Yield (acre-feet)	328,000	274,000	275,000
Average Annual Cost/Yield (acre-feet)	$2,201/acre-foot	$602/acre-foot	$629/acre-foot

CALFED 2000b.

[a] A = average annual cost based on P = Project Life Cost ($2015), I = 3.5%, and n = 100 years (current amortization rate used by Reclamation).

Formula is:

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

where:

A = average annual cost

P = present-day total capital investment (project life capital cost)

I = annual amortization rate

n = number of amortization periods

:
B = billion
CVP = Central Valley Project
M = million
SWP = State Water Project

Table A-8. Relative Reservoir Footprint Environmental Impacts Comparison

Preliminary Site Survey Results by Biological/Ecological Attributes	Sites Reservoir	Newville Reservoir
Wetland (acres)	249	**525**
Riparian (acres)	75	**476**
Blue oak woodland (acres)	924	**2,532**
Valley oak woodland (acres)	4	**104**
Number of elderberry stems greater than 1 inch in diameter	684	**1,204**
Number of elderberry stems with emergence holes [a]	18	**222**
Total number of bird species	**160**	146
Number of California and Federal bird species of concern	**25**	19
Prehistoric cultural resource components	45	**117**
Historic cultural resource components	27	**65+**

The larger value of the two for each impact considered is shown in **bold** text.

[a] Elderberry delisting is under consideration.

The review of potential environmental impacts within the footprints for the Sites Reservoir and Newville Reservoir indicates a much greater impact potential for the Newville Reservoir. With the exception of potential impacts to the number of California and Federal bird species of concern, possible project-related impacts for all of the other biological/ecological attributes are higher for Newville Reservoir. In addition to the number of impacts within the reservoir

footprints, the Sites Reservoir location offers the advantage of being able to use the existing T-C and GCID Canals, which would significantly reduce the extent of excavation, real estate, and environmental mitigation required for conveyance.

The Sites Reservoir location offers several advantages over the selection of Newville Reservoir. The most significant advantages include:

- Sites Reservoir is much closer to the Sacramento River, which has the largest supply of divertible flow.
- The existing T-C and GCID Canals already divert 3,900 cfs from the Sacramento River to close vicinity to Sites Reservoir. This diversion would significantly reduce the environmental impacts and costs associated with new conveyance. Although the reservoir cost for Sites Reservoir is higher, the conveyance is much less expensive. The total project costs were considered comparable for the two reservoirs.
- The construction of dams to create Newville Reservoir would have greater environmental impacts, including impacts to salmon in Thomes Creek.
- The cost of the Sites Reservoir would be lower.

Sites Reservoir would have fewer environmental impacts than Newville Reservoir. It also better meets the purpose of the feasibility studies because it is more consistent with the definition for offstream storage, due to the impact of Newville Reservoir on the Thomes Creek watershed. The watersheds associated with Sites Reservoir are ephemeral, and much smaller by comparison. The water supply available to fill Sites Reservoir is also more reliable. As a result, Sites Reservoir was selected for the development of detailed alternatives.

A.7 Screening of Conveyance Measures

The screening of conveyance measures and reservoir size is summarized in Chapter 5, Evaluation of Conveyance and Reservoir Size, of the Draft Feasibility Report.

The preceding section, Alternative Reservoir Locations, provided the rationale for the selection of Sites Reservoir as the preferred location for north-of-the-Delta offstream storage, but there are still multiple ways to convey water into and out of the reservoir. This section presents the evaluation of various conveyance packages and reservoir size for Sites Reservoir.

Development of Conveyance Measures

Water must be delivered both to and from the reservoir. As a result, the evaluation of conveyance measures includes several diversion facilities, with the associated conveyance to deliver water into Sites Reservoir. Conveyance measures are also evaluated that can deliver water from Sites Reservoir to service areas or locations with various water resources needs and uses.

Table A-9 provides a list of potential conveyance measures.

Table A-9. Conveyance Measures Considered

Conveyance Facility	Source	Capacity Description
T-C Canal	Sacramento River at Red Bluff	Existing 2,100 cfs capacity Modify to 2,700 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
GCID Canal	Sacramento River at Hamilton City	Existing 1,800 cfs capacity Expand to 3,000 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
Stony Creek Pipeline Diversion	Stony Creek at existing Black Butte Lake Afterbay	1,000 cfs capacity 2,100 cfs capacity
Delevan Pipeline	Sacramento River Opposite Moulton Weir	1,500 cfs capacity 2,000 cfs capacity 3,000 cfs capacity 4,000 cfs capacity 5,000 cfs capacity
Colusa Basin Pipeline	Colusa Basin Drain	1,000 cfs pipeline capacity 3,000 cfs pipeline capacity

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
T-C = Tehama-Colusa

Alternative Diversion Locations and Conveyance Facilities

Potential diversions from the Sacramento River include the GCID Canal, the T-C Canal, and a new pipeline (called the Delevan Pipeline), as illustrated in Figure A-5. Tributary source conveyance facilities include a new pipeline from the CBD and a new pipeline from Stony Creek, originating at the Black Butte Afterbay, and connecting to the T-C Canal below Orland. These five conveyance measures can be combined in numerous ways to provide sufficient inflow

to reliably fill Sites Reservoir. Preliminary operation simulations indicate that 3,000 to 6,000 cfs of total inflow capacity to Holthouse Reservoir (an expansion of the existing Funks Reservoir) on the T-C Canal are needed to reliably fill Sites Reservoir.

Each of these five proposed diversion locations and the associated conveyance facilities has a range of capacity sizes. A total of 17 combinations of diversion locations and conveyance facility sizes was identified for evaluation, as presented in Table A-9. Preliminary cost estimates were developed for each of the 17 alternatives. Figure A-6 shows a graphical representation of the conveyance measures. Preliminary cost estimates were developed for each alternative, without consideration of how the alternatives could be combined or integrated with other conveyance measures.

Additional details for each of the conveyance measures, by facility, follow.

T-C Canal Alternatives

The T-C Canal is an existing, concrete-lined canal with an existing capacity of 2,100 cfs to Funks Reservoir. T-C Canal alternatives offer the advantage of diverting water through the new fish screens and pumping plant from the completed Fish Passage Improvement Project. The T-C Canal capacity could be increased to 2,700 cfs; however, this increase would require improvements along the length of the canal, such as modifications at road and water crossings. Expansion of the T-C Canal beyond 2,700 cfs would require more substantial reconstruction and expansion of the canal prism. Preliminary estimates were developed for 4,000 and 5,000 cfs.

GCID Canal Alternatives

The GCID Canal is an earth-lined canal with an existing capacity of 3,000 cfs near its diversion, and approximately 1,800 cfs near a proposed Terminal Regulating Reservoir (TRR). All GCID Canal conveyance measures require a TRR and a pipeline connecting to Holthouse Reservoir on the T-C Canal. The pipeline connecting the TRR and Holthouse Reservoir, the Delevan Pipeline, and the Colusa Basin Pipeline all use the same alignment. Only minor modifications to the pumping plant and fish screen on the Sacramento River are required for the 1,800 cfs and 3,000 cfs alternatives. The 3,000 cfs GCID Canal Alternative also would require substantial earthwork to expand the capacity of the canal to the TRR. The 4,000 cfs and 5,000 cfs conveyance management alternatives require major modifications to the GCID Canal, fish screen, and pumping plant. GCID Canal alternatives would facilitate delivery of Sites Reservoir water to the GCID service area, facilitating an integrated operation with the CVP.

Stony Creek Pipeline Alternatives

Stony Creek Pipeline is a proposed new pipeline that would convey flows from the existing Black Butte Afterbay on Stony Creek to the T-C Canal. The 1,000- and 2,000 cfs pipeline options would use existing conveyance space in the lower portion of the T-C Canal.

Delevan Pipeline Alternatives

The Delevan Pipeline was designed to provide the shortest conveyance distance from the Sacramento River to Holthouse Reservoir. A Delevan canal was also considered, but dismissed from detailed evaluation due to a variety of environmental effects. The 1,500 cfs Delevan Pipeline requires two 12-foot-diameter pipes. The remaining four Delevan Pipeline alternatives

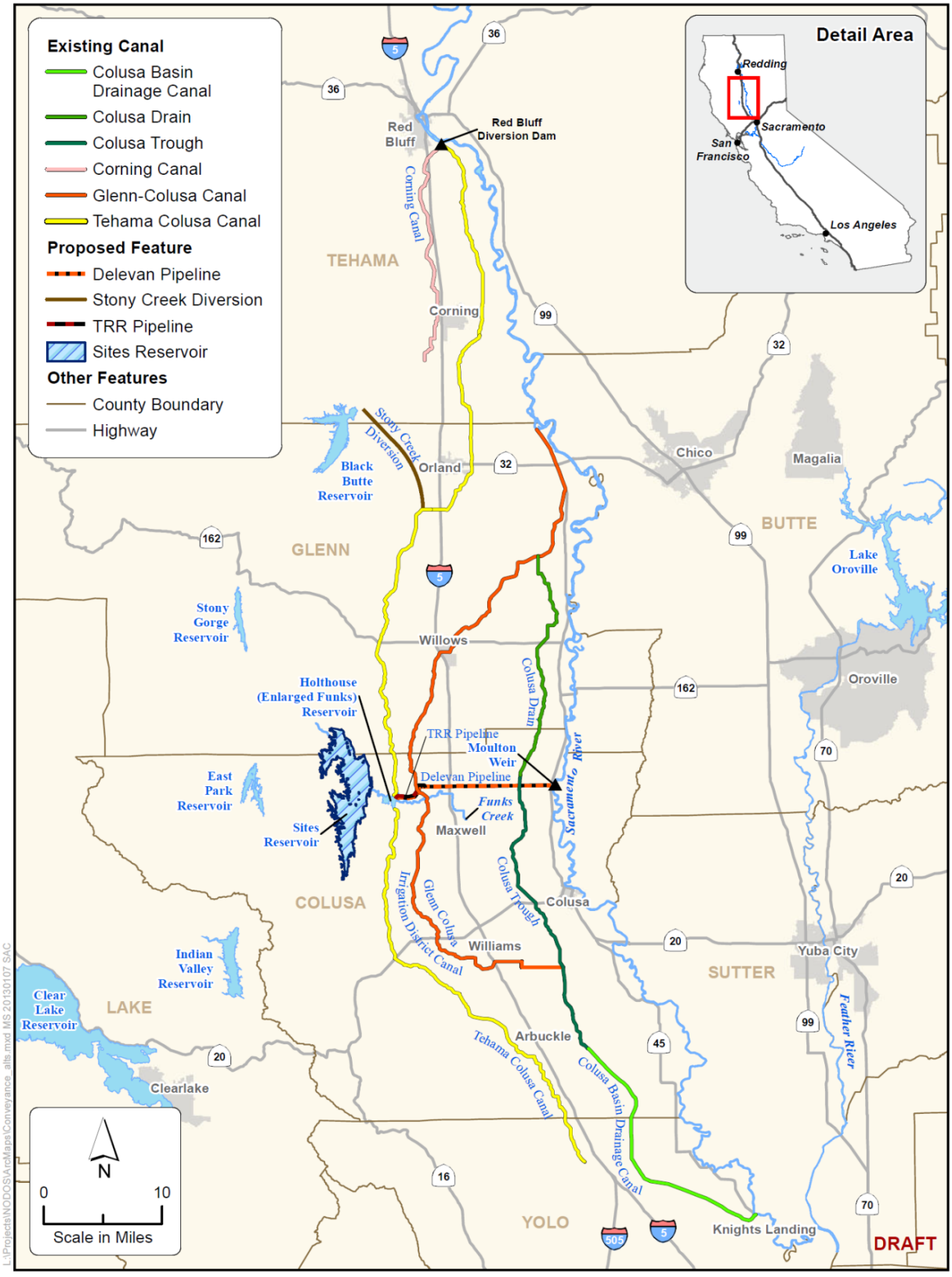

Figure A-5. NODOS Project Conveyance Measures

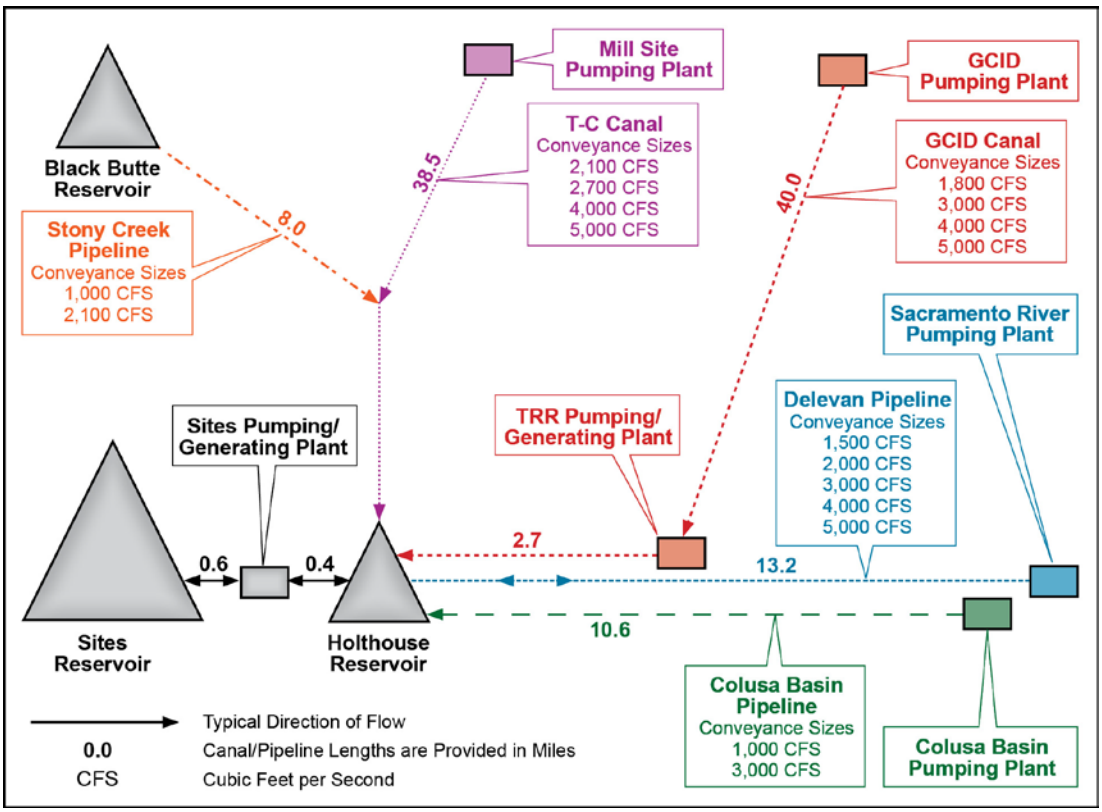

Figure A-6. Conveyance Measures Flow Diagram

require one 12-foot-diameter pipe for each additional 1,000 cfs. Diversion facilities include pumps and fish screens. Delevan Pipeline alternatives also can be used to release water back to the Sacramento River to meet downstream needs directly, or to facilitate an integrated operation with the CVP and SWP.

Colusa Basin Pipeline Alternatives

The 1,000- and 3,000 cfs Colusa Basin Pipeline alternatives rely on a similar design and use the same alignment as the Delevan Pipeline, but divert water from CBD. The design and installation of fish screens and pumps would be required. This analysis considered relying on the CBD as one of the primary diversions for filling Sites Reservoir, rather than its applicability as a supplemental, secondary source for diversions and releases.

Important Considerations When Evaluating Conveyance Measures

The conceptual representation of the conveyance management alternatives shown on Figure A-6 reveals several important attributes that must be considered.

All alternatives convey water to Holthouse Reservoir; consequently, they can be compared directly to determine their relative performance in conveying water to storage. By contrast, each alternative's ability to convey water from Sites Reservoir storage to areas of need or use, or directly to the Sacramento River, varies. Any conveyance system would facilitate delivery of

water to a portion of the T-C service area, because Sites Reservoir uses Holthouse Reservoir on the canal as an afterbay. However, the Stony Creek Pipeline and T-C Canal alternatives do not provide conveyance to other potential users.

Both the 4,000 cfs and 5,000 cfs T-C Canal alternatives and Stony Creek Pipeline alternatives require increasing the capacity in the portion of the T-C Canal from Orland to Holthouse Reservoir. If these two conveyance measures are combined, they cannot use the same capacity in the lower T-C Canal at the same time. Therefore, the cost to expand the capacity of the lower portion of the T-C Canal below Orland also has been estimated.

Table A-10 presents an initial comparison of conveyance measures, listing the conveyance capacities at Holthouse Reservoir and the screening level construction costs. Costs are rounded to the nearest $100 thousand. Table A-10 also identifies if the conveyance measure has the ability to directly release water to the Sacramento River. This capability is noted because conveyance measures that can release water directly to the Sacramento River can support export for the CVP and SWP, as well as public benefits throughout the Sacramento River and San Joaquin River watersheds and Delta.

Table A-10. Screening-level Cost Estimates and Other Considerations for Potential Conveyance Measures

Conveyance Facility	Capacity Description	Conveyance Cost Estimate (millions) [a]	Ability to Provide Release to Sacramento River?
T-C Canal	Existing 2,100 cfs capacity [b]	$0	No
	Modify to 2,700 cfs capacity	$133.0	No
	Expand to 4,000 cfs capacity	$477.6	No
	Expand to 5,000 cfs capacity	$667.4	No
GCID Canal	Existing 1,800 cfs capacity	$214.1	No
	Expand to 3,000 cfs capacity	$362.6	No
	Expand to 4,000 cfs capacity	$556.3	No
	Expand to 5,000 cfs capacity	$662.4	No
Stony Creek Pipeline	1,000 cfs capacity	$105.4	No
	2,100 cfs capacity	$201.9	No
Delevan Pipeline	1,500 cfs capacity	$437.6	Yes
	2,000 cfs capacity	$385.5	Yes
	3,000 cfs capacity	$688.8	Yes
	4,000 cfs capacity	$896.2	Yes
	5,000 cfs capacity	$1,100.1	Yes
Colusa Basin Pipeline	1,000 cfs pipeline capacity	$175.0	Indirect
	3,000 cfs pipeline capacity	$435.3	Indirect

[a] Costs are escalated from the PFR estimates (Reclamation and DWR 2008); are 2015 preliminary construction costs for conveyance screening; and do not include mitigation, engineering, or administrative costs.

[b] Although the Red Bluff Fish Screen has a capacity of 2,500 cfs, the current diversion capacity for the canal is 2,100 cfs.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
PFR = Plan Formulation Report
T-C = Tehama-Colusa

Conveyance from Reservoir to Service Areas or Locations with Various Water Resource Needs and Uses

The following evaluation considers the ability of various conveyance system packages to convey water to service areas or locations with varying water resource needs and uses. This was a preliminary evaluation to screen conveyance options prior to more detailed evaluations with an operations model (i.e., the California Statewide Integrated System Model [CALSIM]).

For Sites Reservoir, three general methods can be used to facilitate the delivery of water to areas of need and use.

- Water can be delivered directly from Sites Reservoir to meet local needs downstream from Holthouse Reservoir through the existing GCID and T-C Canals.
- Sites Reservoir can deliver water locally in an integrated way (e.g., water supply exchanges) with CVP operations, thereby facilitating an ability to meet additional needs throughout the San Francisco Bay–Sacramento River and San Joaquin River Delta (Bay-Delta) system. All conveyance systems for Sites Reservoir would be connected to Holthouse Reservoir, and therefore, to the T-C Canal. This connection facilitates integration with the CVP, independent of the conveyance measures selected. Additional connection to and integration with the CVP would be facilitated by the GCID Canal alternatives. The benefits resulting from this type of integrated exchange operation relate directly to the amount of water served to the local area by Sites Reservoir that was previously served by other CVP facilities. In exchange, the CVP can serve the primary objectives of this project without affecting current uses.
- The Delevan Pipeline alternatives offer the unique ability to release water into the Sacramento River from Sites Reservoir (the Colusa Basin Pipeline could release water indirectly to the river through the CBD). This release of water maximizes the ability of Sites Reservoir to provide public benefits throughout the Bay-Delta system. Water released from the Delevan Pipeline could provide downstream benefits for Delta water quality, and water supply reliability for CVP, SWP, and incremental Level 4 refuge supply. This enables the Delevan Pipeline alternatives to provide public benefits to a greater degree than any of the other alternatives.

The release capacity of conveyance pipelines from Holthouse Reservoir to the Sacramento River was estimated to be 75 percent of the pipeline pumping capacity, for the purposes of the screening analysis. This reduction in capacity results from pressure losses in the pipe. Table A-11 shows the conveyance measures associated with direct conveyance to the Sacramento River, and each alternative's release capacity to the river.

Table A-11. Conveyance Measures Associated with Direct Conveyance to the Sacramento River

Conveyance (Capacity to Pump Water into Sites Reservoir)	Release Capacity (from Holthouse Reservoir to Sacramento River)
Delevan Pipeline – 1,500 cfs	1,125 cfs
Delevan Pipeline – 2,000 cfs	1,500 cfs
Delevan Pipeline – 3,000 cfs	2,250 cfs
Delevan Pipeline – 4,000 cfs	3,000 cfs
Delevan Pipeline – 5,000 cfs	3,750 cfs

cfs = cubic feet per second

Initial Evaluation of Environmental Considerations of the Conveyance Measures

The following environmental considerations also are noted for evaluating the various conveyance measures.

- Water Quality. The water from the CBD is considered to be of relatively poor quality outside of the wet season when compared to Sacramento River water; and therefore, is less desirable as a primary source for diversions. The CBD is the single largest source of agricultural return flows to the Sacramento River. Flows from the CBD have elevated values for alkalinity, electrical conductivity (EC), total dissolved solids (TDS), nitrogen, and phosphorus during certain times of the year. Diversions would need to be restricted to periods when the CBD is primarily conveying natural runoff of higher-quality water to avoid water quality impacts to Sites Reservoir users.
- Agricultural Land. California's desire to preserve agricultural land is reflected in the California Land Conservation Act, also known as the Williamson Act. The effectiveness of the Williamson Act is often measured by the amount of prime agricultural land (as defined in the act) in the program. Expansion of the GCID Canal (4,000 and 5,000 cfs options) would require the acquisition of temporary and permanent rights-of-way (ROWs). The 4,000 and 5,000 cfs alternatives for the GCID Canal would require approximately 1,890 acres of land during construction. Permanent land area acquired for the canal expansion would be 940 acres, of which 727 acres are classified as prime agricultural land. Similar impacts to agricultural land are associated with the expansion of the T-C Canal: 2,468 acres of agricultural land were determined to be within 100 feet of the project footprint; of these, 1,244 acres are classified as prime agricultural land.
- Environmental Effects. As already noted, alternatives that expand the existing canals would affect large areas of land—both temporarily and permanently. Some environmental effects of land conversions associated with expanding the T-C Canal and the GCID Canal to 4,000 or 5,000 cfs have been preliminarily identified.

Environmental reconnaissance surveys of T-C Canal expansion areas have identified vernal pools within 100 feet of the expansion project fence line. At least two vernal pools were found on each side of the T-C Canal at the same mile marker. Vernal pools were found east of Corning and near Funks Reservoir. Approximately 170 elderberry stems of a size suitable for valley elderberry longhorn beetle (VELB) use were found. Effects to salmon and steelhead related to siphon enlargements at some nearby streams are likely; their presence would affect construction

timing and require mitigation. T-C Canal is partially within the range of the giant garter snake near Orland; expansion of the existing canal beyond 2,700 cfs could result in the loss of giant garter snake habitat. Swainson's hawk nesting habitat also extends into a portion of the T-C Canal alignment; numerous nests have been recorded along the canal. Additional environmental impacts include roughly 64 acres of jurisdictional wetlands (including vernal pools), primarily at the culvert crossings and siphon locations. Although ponds and toe drains also occur, they might require mitigation if the large expansions were implemented. These impacts could be avoided, minimized, and/or mitigated, but not without some amount of additional cost.

The environmental reconnaissance of T-C Canal expansion areas also determined that midden soils are present in several locations; these are frequently associated with long-term occupation and human remains. There is a midden under T-C Canal, near State Route 162. As a rough estimate, up to 30 buildings are within 100 feet of the T-C Canal, and numerous farmhouses and buildings are within 100 feet of the T-C Canal between Orland and Red Bluff.

Environmental reconnaissance surveys limited to within 100 feet of the potential GCID expansion project footprint, on both sides and at siphon locations, have indicated approximately 286 elderberry stems greater than 1 inch in diameter at ground level, which is considered habitat for VELB. Effects to salmon and steelhead related to siphon enlargements are likely on some nearby streams; their presence would affect construction timing, and would require mitigation. The GCID Canal alignment is entirely within the range of the giant garter snake; the canal itself and areas within 100 feet are considered habitat (at least 945 acres). A Swainson's hawk nesting habitat exists in the vicinity of the GCID Canal; there are numerous records of nests along the canal. Additional environmental impacts include approximately 35 acres of jurisdictional wetlands (including vernal pools), primarily at the culvert crossings and siphon locations. Although ponds and toe drains also occur, the jurisdictional wetlands might require mitigation if a canal expansion project were implemented.

The expansion study areas and adjacent lands have not been surveyed for cultural resources; however, the GCID Canal qualifies as a historic structure. Records searches indicate 11 historic sites within 1 mile of the GCID Canal, and no recorded prehistoric sites. Several graves in a portion of the Willows Cemetery are within 100 feet of the existing GCID Canal footprint; expansion might require the relocation of a portion of this cemetery. As a rough estimate, 10 buildings are within 100 feet of the GCID Canal (mostly houses in Willows).

Table A-12 provides a summary of the potential issues and impacts that might result from enlarging the T-C Canal or the GCID Canal to 4,000 or 5,000 cfs.

Table A-12. Summary of Potential Issues and Impacts from Enlarging T-C Canal or GCID Canal to 4,000 or 5,000 cfs

Category	Potential Issue or Impact
Environmental Permits/ Documentation Potentially Required	NEPA Compliance
	CEQA Compliance
	Federal ESA or California ESA Compliance (Consultation, Biological Assessment)
	CDFW Streambed Alteration Agreement
	Clean Water Act 404 Compliance
	Clean Water Act 401 Compliance
	RWQCB Storm Water Permit
	Federal 106 (Cultural/Historic Resources) Compliance
Potential Environmental Issues	Impacts to Prime Farmland, Unique Farmland, or Farmland of Statewide Importance
	Impacts to Lands Under Williamson Act Contracts
	Impacts to Jurisdictional Wetland Habitats and Waters of the U.S.
	Impacts to Wildlife Migration or Movement
	Impacts Related to Short-Term Noise, Air Quality, or Traffic Increases
California- and Federally Listed Species Potentially Impacted	Bald eagle
	Bank swallow
	Swainson's hawk
	Mountain plover
	Greater sandhill crane
	Giant garter snake
	California tiger salamander
	Central Valley spring-run Chinook salmon
	Central Valley steelhead
	Western yellow-billed cuckoo
	Winter-run Chinook salmon
	Green sturgeon
	Conservancy fairy shrimp
	Valley elderberry longhorn beetle
	Vernal pool fairy shrimp
	Vernal pool tadpole shrimp
	Greene's tuctoria
	Hoover's spurge
	Hairy Orcutt grass
	Slender Orcutt grass
	Palmate-bracted birds beak
Other	Potential Impacts to Cultural and Historical Resources
	Impacts to Housing (Necessitating Relocation)

CDFW = California Department of Fish and Wildlife
CEQA = California Environmental Quality Act
cfs = cubic feet per second
ESA = Endangered Species Act
GCID = Glenn-Colusa Irrigation District
NEPA = National Environmental Policy Act
RWQCB = Regional Water Quality Control Board
T-C = Tehama-Colusa

Construction of the Delevan Pipeline would also result in temporary land disturbance during construction, along with new permanent ROW; however, significantly less land is affected than is needed to expand the capacity of the T-C Canal. A temporary easement of approximately 350 acres is required for the Delevan Pipeline (length is approximately 13.5 miles), with a permanent ROW of approximately 270 acres. Construction would occur in giant garter snake habitat.

Construction of the CBD Pipeline would be similar to construction of the Delevan Pipeline because they share the same alignment, but the CBD Pipeline is 2 to 3 miles shorter (temporary easement of approximately 218 acres). Construction would occur in giant garter snake habitat. As noted previously, there are additional water quality concerns, with heavier reliance on the CBD for conveyance. One benefit for the CBD pipeline is reduced reliance on diversions from the Sacramento River, thereby reducing impacts to fish migration in the river. This benefit could still be achieved to a significant extent if the CBD were used as a secondary source for diversions.

Conveyance Recommendations

Table A-13 shows conveyance measures recommended for further consideration, based on the initial evaluation of costs; ability to meet the water quality objective by releasing water to the Sacramento River; and environmental considerations described in the previous section, as well as those not recommended for further consideration.

The Colusa Basin Pipeline was not recommended as a primary conveyance due to quality concerns and its inability to release water to the Sacramento River to satisfy the primary objective of water quality improvement. The use of a smaller diversion from the CBD as a supplemental intake may be further considered as a future enhancement if the project moves forward.

The Stony Creek Pipeline could be used to convey water to the reservoir, but would not support releases for beneficial uses. The existing T-C Canal and GCID Canal can be used to fill the reservoir at a lower cost. The cost analysis and preliminary environmental analysis recommends the existing T-C Canal 2,100 cfs measure and the GCID Canal 1,800 cfs measure. In addition, three Delevan Pipeline alternatives (1,500 cfs, 2,000 cfs, and 3,000 cfs) were recommended to provide the ability to release water directly into the Sacramento River. If a Delevan Pipeline measure is included in a reservoir plan with existing-capacity canals, total diversion capability would range from 5,400 to 6,900 cfs.

This recommendation leaves five conveyance measures for continuing consideration in the NODOS feasibility studies. These alternatives can be combined to provide a range of alternatives for conveyance to Holthouse Reservoir, with up to 6,900 cfs total capacity, for use in initial alternative development. In addition, the conveyance measures retained would allow for an evaluation of benefits associated with various conveyance measures, as previously described.

Evaluation of Various Sites Reservoir Sizes

Four sizes have been considered for Sites Reservoir: 800 TAF, 1.3 MAF, 1.8 MAF, and 2.1 MAF. The reservoir sizes studied were chosen to reflect a range of storage values that would allow for a useful comparison of the developed cost and quantity estimates, and provide for reasonably reliable interpolation for other reservoir sizes not specifically addressed by the selected reservoir sizes.

Table A-13. Conveyance Measures Retained and Conveyance Measures Not Recommended for Further Consideration

Conveyance Measures Recommended for Further Consideration	
T-C Canal	Existing 2,100 cfs capacity
GCID Canal	Existing 1,800 cfs capacity
Delevan Pipeline	1,500 cfs capacity 2,000 cfs capacity 3,000 cfs capacity
Conveyance Measures Not Recommended for Further Consideration	
T-C Canal	Modify to 2,700 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
GCID Canal	Expand to 3,000 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
Stony Creek Pipeline	1,000 cfs capacity 2,100 cfs capacity
Delevan Pipeline	4,000 cfs capacity 5,000 cfs capacity
Colusa Basin Pipeline [a]	1,000 cfs pipeline capacity 3,000 cfs pipeline capacity

[a] A smaller pipeline may be appropriate as a supplemental intake.
cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
T-C = Tehama-Colusa

Table A-14 presents a summary of each reservoir storage alternative. Included in this table is the total number of dams required to impound Sites Reservoir, and the total embankment volume (amount of material required to create the dams) for each of the four reservoir alternatives.

Table A-14. Sites Reservoir Alternative Reservoir Size Summary

Reservoir Storage (MAF)	Maximum Water Surface Elevation (feet)	Reservoir Surface Area (acres)	Total Number of Dams (main + saddle) [a]	Total Embankment Volume (CY)
0.8	440	10,200	2 + 3	6,900,000
1.3	480	12,400	2 + 6	11,600,000
1.8	520	14,200	2 + 9	22,300,000
2.1	540	15,100	2 + 7 [b]	33,800,000

[a] Total number of dams includes the main dams (Sites and Golden Gate) and the saddle dams.
[b] Saddle dams 7, 8, and 9 become one continuous embankment in the 2.1 MAF reservoir alternative.
CY = cubic yards
MAF = million acre-feet

Based on review of the reservoir rim topography, site geology, the presence of geologic features trending through the reservoir rim, and a cursory evaluation of the relationship between embankment volume and reservoir storage, it was determined that a 2.1 MAF reservoir may be infeasible. This determination was based on a review of the reservoir rim, which indicated that reservoir elevations at or above 540 feet would likely require extensive grouting of the saddle areas along the relatively steep ridges of the eastern rim to ensure the structural integrity of the project. This treatment, combined with the increasing proportion of required embankment material volume, would result in larger unit costs (reservoir cost/AF of storage) for reservoir elevations above 540 feet. Using a maximum water surface elevation of 520 feet (1.8 MAF capacity) provides greater assurance of the ability to control costs associated with construction and grouting on the relatively steep slopes of the eastern reservoir rim. Therefore, reservoir sizes of 800 AF, 1.3 MAF, and 1.8 MAF were considered for alternative development.

Evaluation of Various Conveyance and Reservoir Packages

Based on the initial screening of the conveyance measures and reservoir sizes described above, the following alternatives were further evaluated:

- Sites Reservoir Size:
  - 800 TAF
  - 1.3 MAF
  - 1.8 MAF
- Conveyance Measures:
  - Existing T-C Canal (2,100 cfs)
  - Existing GCID Canal (1,800 cfs)
  - Delevan Pipeline
    - 1,500 cfs
    - 2,000 cfs
    - 3,000 cfs

Preliminary costs and operations modeling were developed for these alternatives to help identify the appropriate reservoir size and conveyance packages.

Table A.15 identifies the reservoir size and conveyance packages evaluated.

Table A.15. Storage and Conveyance Screening Scenarios

Reservoir Storage (TAF)	Conveyance				Screening Construction Cost ($billion, 2007)[a]
	T-C+GCID (cfs)	Delevan Pipeline		Total Diversion Capacity	
		Diversion (cfs)	Release (cfs)		
800	3,900	0	0	3,900	2.35
800	3,900	1,500	1,125	5,400	3.50
800	3,900	2,000	1,500	5,900	3.75
800	3,900	3,000	2,250	6,900	4.27
1,270	3,900	0	0	3,900	2.66
1,270	3,900	1,500	1,125	5,400	3.78
1,270	3,900	0	1,500	3,900	3.71
1,270	3,900	2,000	1,500	5,900	4.03
1,270	3,900	3,000	2,250	6,900	4.55
1,810	3,900	0	0	3,900	3.17
1,810	3,900	1,500	1,125	5,400	4.27
1,810	3,900	0	1,500	3,900	4.20
1,810	3,900	2,000	1,500	5,900	4.52
1,810	3,900	0	2,250	3,900	4.58
1,810	3,900	3,000	2,250	6,900	5.03

[a] Costs escalated from the PFR (Reclamation and DWR 2008) are 2015 preliminary construction costs for screening of alternative reservoir sizes and do not include mitigation, engineering, Interest During Construction, or non-contract costs.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
PFR = Plan Formulation Report
T-C = Tehama-Colusa
TAF = thousand acre-feet

Modeling results from the PFR suggested that a 2,000 cfs Delevan Pipeline conveyance was adequate to meet the project objectives. Constructing a larger Delevan Pipeline would include a larger intake/discharge structure that would result in greater environmental impacts due to both the construction of a larger intake/discharge structure into an area with sensitive habitat and the effects on geomorphology from discharging an additional 1,000 cfs. It would also require a larger penetration of the existing levee on the bank of the Sacramento River. Constructing a larger pipeline would also significantly increase the cost of the project. To further refine and optimize the remaining reservoir size and conveyance packages, preliminary operations modeling was conducted and an estimate of the potential net benefits was made.

Table A.16 presents a preliminary estimate of the net benefit associated with each potential package, ranked in order of highest potential net benefit to lowest.

Table A.16. Preliminary Net Benefit Determinations for Storage and Conveyance Screening Scenarios

Reservoir Storage (TAF)	Conveyance				Net Annual Benefit ($Million, 2007)
	T-C+GCID (cfs)	Delevan Pipeline		Total Diversion Capacity (cfs)	
		Diversion (cfs)	Release (cfs)		
1,810	3,900	0	1,500	3,900	$16.25
1,270	3,900	2,000	1,500	5,900	$16.15
1,810	3,900	2,000	1,500	5,900	$14.09
1,270	3,900	1,500	1,125	5,400	$7.59
1,810	3,900	1,500	1,125	5,400	$7.88
1,810	3,900	0	2,250	3,900	$4.10
1,270	3,900	0	1,500	3,900	-$0.72
1,270	3,900	3,000	2,250	6,900	-$4.72
800	3,900	1,500	1,125	5,400	-$14.14
800	3,900	2,000	1,500	5,900	-$17.41
1,270	3,900	0	0	3,900	-$18.06
800	3,900	0	0	3,900	-$22.97
800	3,900	3,000	2,250	6,900	-$30.92
1,810	3,900	0	0	3,900	-$33.69

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
T-C = Tehama-Colusa
TAF = thousand acre-feet

The top three performers in terms of net benefits were:

- A 1.8 MAF reservoir without a new diversion, but capable of releasing 1,500 cfs to the Sacramento River through the Delevan Pipeline.
- A 1.3 MAF reservoir with a new 2,000 cfs diversion and a 1,500 cfs release through the Delevan Pipeline.
- A 1.8 MAF reservoir with a new 2,000 cfs diversion and a 1,500 cfs release through the Delevan Pipeline.

These three scenarios were used to develop alternative plans.

There is a significant break in net annual benefits after the first three scenarios in

Table A.16. These results indicate:

- A release of 1,500 cfs to the Sacramento River significantly increases all benefits when compared to a release of 1,125 cfs, or no release at all.
- A significant increase in cost with little increase in benefits resulting from a 2,250 cfs release.

A.8 Initial Plan Formulation

Alternatives A, B, C, and D, presented in Chapter 6, Alternative Development, of this Draft Feasibility Report, were developed using the results of preliminary modeling for a series of initial alternatives that were evaluated in the PFR. This section summarizes the findings from this evaluation of the initial alternatives.

The IAIR recommended developing alternatives that were focused on a single objective (water supply and reliability, anadromous fish and other aquatic species, or water quality) to get some indication of the range of benefits that Sites Reservoir could potentially provide. The PFR used this strategy to develop nine initial alternatives to address the primary planning objectives (hydropower was not identified as a primary objective until after the PFR).

The initial action alternative plans were as follows:

- A No Project (NEPA)/No Project (CEQA) Alternative
- Three initial action alternative plans with a water supply focus (Alternatives WS1A, WS1B, and WS1C)
- Two initial action alternative plans with an environmental enhancement focus to improve the survival of anadromous fish and other aquatic species (Alternatives AF1A and AF1B)
- One initial action alternative plan that blends water supply (with enhanced M&I use) with environmental enhancement (Alternative WSFQ)
- Two initial action alternative plans with a water quality focus (Alternatives WQ1A and WQ1B)

Table A-17 presents the initial action alternatives. Table A-18 shows the yield targets (percent) for each beneficiary category for each initial action alternative. The yield targets were used in CALSIM II modeling to allocate the storage in Sites Reservoir to provide benefits. The yield targets for each purpose were varied, depending on the focus. The actual percentage of the yield differed slightly from the yield targets because of operations constraints (e.g., pumping and conveyance capacity limits, storage capacity). It should be noted that at the time the initial alternatives were evaluated, long-term implementation of the Environmental Water Account (EWA) was assumed. The EWA was dropped from the modeling to support Chapter 6, Alternative Development, of this Draft Feasibility Report.

Ecosystem Restoration Account Features

The initial alternatives evaluated in the PFR included the use of an Ecosystem Restoration Account (ERA). The NODOS/Sites Reservoir Project allows a unique opportunity to provide a firm ERA in California—managed by the State, and dedicated to restoration actions beyond regulatory requirements. As part of CALFED, the Ecosystem Restoration Program (ERP) has developed an integrated systems approach based on reversing the fundamental causes of decline in fish and wildlife populations by recognizing the natural forces that created historic habitats,

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Table A-17. Initial Alternatives with Alternative Focus on Primary and Secondary Objectives (2007)

Initial Action Alternative Plans	Conveyance	Alternatives Retained										
		Primary Objectives								Secondary Objectives		
		Water Supply				Anadromous Fish and Aquatic Species Survivability			Water Quality			
		New Offstream Storage at Sites Reservoir	Conjunctive Use	Water Transfers	Water-Use Efficiency	Restore Abandoned Gravel Mines	Improve Instream Aquatic Habitat	Replenish Spawning Gravel	Improve Flows to Delta from New Storage	Hydropower	Recreation	Flood Damage Reduction
No Project Alternative	N/A	—	X	X	X	—	—	—	—	—	—	—
WS1A – Reliance on Existing Canals	1,800 cfs GCID Canal 2,100 cfs T-C Canal	X	X	X	X	—	—	—	X	X	X	X
WS1B – New 1,500 cfs Pipeline	1,800 cfs GCID Canal 2,100 cfs T-C Canal 1,500 cfs Pipeline Diversion 1,125 cfs Pipeline Release	X	X	X	X	—	—	—	X	X	X	X
WS1C – New 2,000 cfs Pipeline	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X	—	—	—	X	X	X	X
AF1A – New 1,500 cfs Pipeline	1,800 cfs GCID Canal 2,100 cfs T-C Canal 1,500 cfs Pipeline Diversion 1,125 cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
AF1B – New 2,000 cfs Pipeline	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
WSFQ – New 2,000 cfs Pipeline with Fish Enhancements	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
WQ1A – New 1,500 cfs Pipeline	1,800 cfs GCID Canal 2,100 cfs T-C Canal 1,500 cfs Pipeline Release	X	X	X	X	—	—	—	X	X	X	X
WQ1B – New 2,000 cfs Pipeline	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X	—	—	—	X	X	X	X

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
N/A = not applicable
T-C = Tehama-Colusa
— = not included

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Table A-18. Increased Delivery Target for Each Beneficiary Category

Beneficiary	Plan Formulation Increased Delivery Targets [a] (%) [b]							
	Initial Action Alternative Plans							
	WS1A	WS1B	WS1C	AF1A	AF1B	WSFQ	WQ2A	WQ1B
Water Supply (Agriculture, M&I, and Environmental)								
Urban and Agricultural	65	65	65	40	40	50	50	50
Local (non-CVP)	3	3	3	3	3	0	3	3
SWP	30	30	30	20	20	30	25	25
CVP	10	10	10	7	7	5	10	10
Environmental								
Incremental Level 4 Refuge	8	8	8	5	5	5	5	5
EWA	14	14	14	5	5	10	7	7
Water Quality (Urban and Restoration)	15	15	15	15	15	30	30	30
Ecosystem Restoration	20	20	20	45	45	20	20	20
Total	100	100	100	100	100	100	100	100

[a] Targets allocated based on operational priorities of alternatives.
[b] Percentages developed using professional judgment for initial modeling evaluation.
CVP = Central Valley Project
EWA = Environmental Water Account
M&I = municipal and industrial
SWP = State Water Project

and using these forces to help regenerate habitats. The ERP was not designed as mitigation for CALFED projects; instead, it is intended to fulfill the objectives of improving ecological processes and increasing the amount and quality of habitat, equal with other program goals related to water supply reliability, water quality, and levee system integrity.

The CALFED ERP has identified more than 600 programmatic actions to improve ecological health. The ERP advocates an adaptive management implementation strategy that supports the flexible use of environmental water. This adaptive approach has been accommodated in the NODOS/Sites Reservoir Project planning by dedicating a NODOS project allocation to ERP objectives (an ERP pool or account), and then giving resource managers the ability to adjust priorities based on the monitoring of implemented actions, as well as potential new priorities. The NODOS/Sites Reservoir Project planning team identified ERP objectives that could be supported by implementing a NODOS/Sites Reservoir Project, and prioritized actions with input from a Sacramento River Flow Regime Technical Advisory Group. The list of potential ERP objectives includes both tributary actions and Delta actions. This group included environmental advocacy groups, academics, and representatives from Federal and California water resource and wildlife agencies. Ultimately, the NODOS/Sites Reservoir Project planners adopted a short list and longer list (as in AF1A and AF1B) of ERP objectives that were incorporated into the operations strategy for the initial action alternative plans (see Table A-19).

Table A-19. NODOS Project ERA Objectives Considered in the PFR (Reclamation and DWR 2008)

Description	Initial Action Alternative Plans			
	WS1A	**AF1A, AF1B**	**WSFQ**	**WS1B, WS1C, WQ1A, WQ1B**
ERP Objectives (ERA Short List)				
Improve the reliability of coldwater carry-over storage at Shasta Lake (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream Temperatures, Target 1/Action 1) (CALFED 2000c).	✓	✓	✓	✓
Increase supplemental flows for coldwater releases for salmon and steelhead between Keswick and RBDD (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream Temperatures, Target 1—use November 1997 AFRP targets) (CALFED 2000c).	✓	✓	✓	✓
Reduce diversions at Red Bluff to provide water into the T-C Canal and at Hamilton City to provide water into the GCID Canal during July, August, and September. Priority is to reduce diversions at GCID. This concept is designed to minimize diversion effects to fish during identified critical periods (from the 2000 CALFED ERP Plan, Sacramento River Zone, Water Diversion, Target 1/Action 1C) (CALFED 2000c).	✓	✓	✓	✓
Improve the reliability of coldwater carry-over storage at Folsom Lake, and stabilize flows in the American River (from the 2000 CALFED ERP Plan, American River Basin Zone, Central Valley Stream-flow, Targets 1, 2, and 3) (CALFED 2000c).	✓	✓	✓	✓
Modify spring flows into a “snowmelt pattern” in years with peak storm events in late winter and early spring, from Red Bluff to Colusa. The snowmelt pattern would be designed to increase the success of cottonwood cohorts, specifically (from the 2000 CALFED ERP Plan, Sacramento River Zone, Riparian and Riverine Aquatic Habitats, Target 1/Action 1C) (CALFED 2000c).	✓	✓	✓	✓
Stabilize fall flows to avoid abrupt reductions from Keswick to Red Bluff (assumes November 1997 AFRP flow targets). This action is intended to reduce adverse conditions for spawning fall-run Chinook salmon (USFWS 1997).			✓	
Stabilize fall flows to avoid abrupt reductions from Keswick to Red Bluff (assumes 6,000 cfs target from October through January; and 4,500 cfs target for September). This concept is designed to avoid adverse conditions for spawning fall-run Chinook salmon (i.e., egg desiccation) (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream-flow, Target 2/Action 2) (CALFED 2000c).		✓		✓
ERP Objectives (ERA Long List – ERA Short List Plus Actions Below)				
Provide a flow event by supplementing normal operating flows from Shasta and Keswick Dams in March during years when no flow event has occurred during winter, or is expected to occur. Flow events would be provided only when sufficient inflow to Shasta Lake was available to sustain the prescribed releases. This action could be refined by evaluating its indirect costs and the overall effectiveness of achieving objectives, which are 8,000 to 10,000 cfs in dry years, and 15,000 to 20,000 cfs in below-normal years (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream-flow, Action 1/Target 1) (CALFED 2000c).		✓		

Description	Initial Action Alternative Plans			
	WS1A	AF1A, AF1B	WSFQ	WS1B, WS1C, WQ1A, WQ1B
Provide a March Delta outflow from the natural late-winter and early-spring peak inflow from the Sacramento River. This outflow should be at least 20,000 cfs for 10 days in dry years; at least 30,000 cfs for 10 days in below-normal water years; and 40,000 cfs for 10 days in above-normal water years. Wet-year outflow is generally adequate under the present level of development (from the 2000 CALFED ERP Plan, Sac-SJ Delta Zone, Central Valley Stream-flow, Target 1) (CALFED 2000c).		✓		
Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years (from the 2000 CALFED ERP Plan, Sacramento-San Joaquin Delta Zone, Central Valley Stream-flow, Target 4) (CALFED 2000c).		✓		

AFRP = Anadromous Fish Restoration Program
CALFED = CALFED Bay-Delta Program
cfs = cubic feet per second
ERA = NODOS Ecosystem Restoration Account
ERP = CALFED Ecosystem Restoration Program
GCID = Glenn-Colusa Irrigation District
NODOS = North-of-the-Delta Offstream Storage
PFR = Plan Formulation Report
RBDD = Red Bluff Diversion Dam
T-C = Tehama-Colusa

In addition to the restoration account described, the Delta water quality action would also improve pelagic habitat conditions. The water quality action would improve water quality for agricultural, urban, and environmental diversions from the Delta, and for several pelagic species, including Delta smelt.

Initial Alternatives Operations Strategy

Current operating rules for releases from Shasta Dam to the Sacramento River are governed by temperature and instream flow requirements, contractual obligations, Delta water quality and outflow requirements, and flood control.

For the evaluation of initial NODOS/Sites Reservoir Project action, alternatives focused on (1) criteria for meeting primary objectives; (2) determination of Keswick Reservoir releases; and (3) determination of Sites Reservoir releases. Each initial alternative was simulated to meet three primary objectives, but priorities assigned to each objective varied, depending on the focus of the alternative—water supply, survival of anadromous fish, or Delta water quality. The modeled reservoir and the system operations used the alternative operating rules through a wide range of hydrologic and operational conditions.

Common Features for Initial Alternatives

Table A-20 provides a summary of the common features of the initial action alternative plans under analysis as part of the PFR process.

Table A-20. Summary of Common Features of NODOS Project Initial Action Alternative Plans

Location	Description
Sites Reservoir	Gross Storage Capacity – 1.8 MAF Water Surface Elevation – 520 feet msl Minimum Operating Pool – 320 feet msl Inundation Area – 14,000 acres
Golden Gate Dam (Sites Reservoir)	Location – Funks Creek Earth Rockfill Embankment Dam Crest Length – 2,250 feet Maximum Height – 310 feet Embankment Volume – 10,590,000 cubic yards
Sites Dam (Sites Reservoir)	Location – Stone Corral Creek Earth Rockfill Embankment Dam Crest Length – 850 feet Maximum Height – 290 feet Embankment Volume – 3,836,000 cubic yards
Saddle Dams (Sites Reservoir)	Location – North End from Funks Creek to Hunter Creek Earth Rockfill Embankment Dams Dams 1, 2, 4, 9 – 40 to 50 feet high Dams 3, 5, 6, 7, 8 – 70 to 130 feet high
Signal Spillway (Sites Reservoir)	Location – Saddle Dam 4 Diameter – 7 feet Inlet Elevation – 526 feet
Sites Pumping Plant	Location – Downstream from Golden Gate Dam Capacity – Varies
Funks Reservoir	Active Storage Volume – 1,300 to 5,290 AF Pumping Capacity – 3,900 to 5,900 cfs
GCID Canal Fish Screens	Modified Crest Elevation – 159.0 feet msl Maximum Operating Flow – 150,000 cfs
GCID Canal	Existing Capacity at Funks Reservoir (With Minor Reshaping) – 1,800 cfs
T-C Canal	Existing Capacity at Funks Reservoir – 2,100 cfs
GCID Canal Terminal Regulating Reservoir	Capacity – 2,000 AF Footprint – 200 acres Depth – 17 feet Maximum Embankment Height – 21 feet
Ecosystem Restoration Account	See Table A-19
Road Relocations and Access Roads	Road Alignments Additional Roads
Utility Relocations	Four- or Six-Breaker Ring Configuration Transmission Lines
Hydroelectric Facilities	Generation at TRR and Delevan Pipeline Intake Facilities
Recreation Facilities	Five Recreation Areas
Sites Reservoir Operations Strategy	Reservoir Operations Developed and Formulated with Facilities to Provide Optimum Benefits for Each Project Objective

AF = acre-foot
cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
NODOS = north-of-the-Delta offstream storage
T-C = Tehama-Colusa
TRR = Terminal Regulating Reservoir

It should be noted that all of the initial alternatives included Funks Reservoir as the forebay/afterbay for Sites Reservoir. Subsequent alternatives (see Chapter 5, Evaluation of

Conveyance and Reservoir Size, in the main report) replaced Funks Reservoir with a larger reservoir (Holthouse Reservoir).

Alternative WS1A (Reliance on Existing Canals)

Initial Action Alternative Plan WS1A (Alternative WS1A) (see

Table A-21 and Figure A-7) would focus on meeting the primary objective for water supply by constructing Sites Reservoir and relying on the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) to convey water to and from the reservoir.

Table A-21. Alternative WS1A Major Components and Operations Prioritization

Major Components of Alternative WS1A	Details of Major Components
Operations Priority 1. SWP contractors 2. CVP contractors 3. Local water supply 4. Alternative source of incremental Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. Delta water quality 7. ERA short list (see Table A-19) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir is being further refined in the feasibility studies under way).
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = Terminal Regulating Reservoir

Alternative WS1A would use the common features already described. WS1A could deliver water from Sites Reservoir to the local GCID and T-C service areas. By coordinating Sites Reservoir operations with Shasta Lake and Lake Oroville, benefits would be achieved throughout the CVP and SWP systems and the associated watersheds. The highest priorities of Alternative WS1A would be to improve the water supply reliability of CVP and SWP contractors and local

T-C Canal water users, to provide long-term water supplies for the EWA, and to provide an alternative source for wildlife refuge incremental Level 4 water supply.

Sites Reservoir, through direct release to the T-C and GCID Canals, could deliver water to serve up to half of the TCCA and GCID contractors' service areas that, without Sites Reservoir, would be delivered entirely by direct diversion from the Sacramento River. These deliveries would facilitate coordinated operations with other CVP and SWP reservoirs, additional deliveries to contractors, and other NODOS project benefits. Improved local water supply reliability for the T-C Canal users could be delivered directly from Sites Reservoir. Other benefits associated with the CVP, including supply reliability to south-of-Delta contractors, the EWA, and an alternative source for incremental Level 4 water (the amount of water required for optimal management of the refuges) supplies to wildlife refuges, would require coordinated operation with Shasta Lake. Benefits associated with the SWP, including improvements to contractor reliability and the EWA, would be accomplished by also coordinating operations with Lake Oroville Reservoir.

Operations of Sites Reservoir also would be coordinated with the operation of Shasta Lake to provide benefits to anadromous fish in the Sacramento River and water quality in the Delta. Conveyance would terminate at an enlarged Funks Reservoir that would serve as a forebay and afterbay for the Sites Pumping Plant, and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. For modeling purposes, operations under Alternative WS1A were prioritized, as presented in Table A-21.

For the initial alternative action plan analysis, a 1.8 MAF reservoir was used in CalSIM II modeling runs to assess potential benefits to water users. The size of the reservoir is being refined in the feasibility studies.

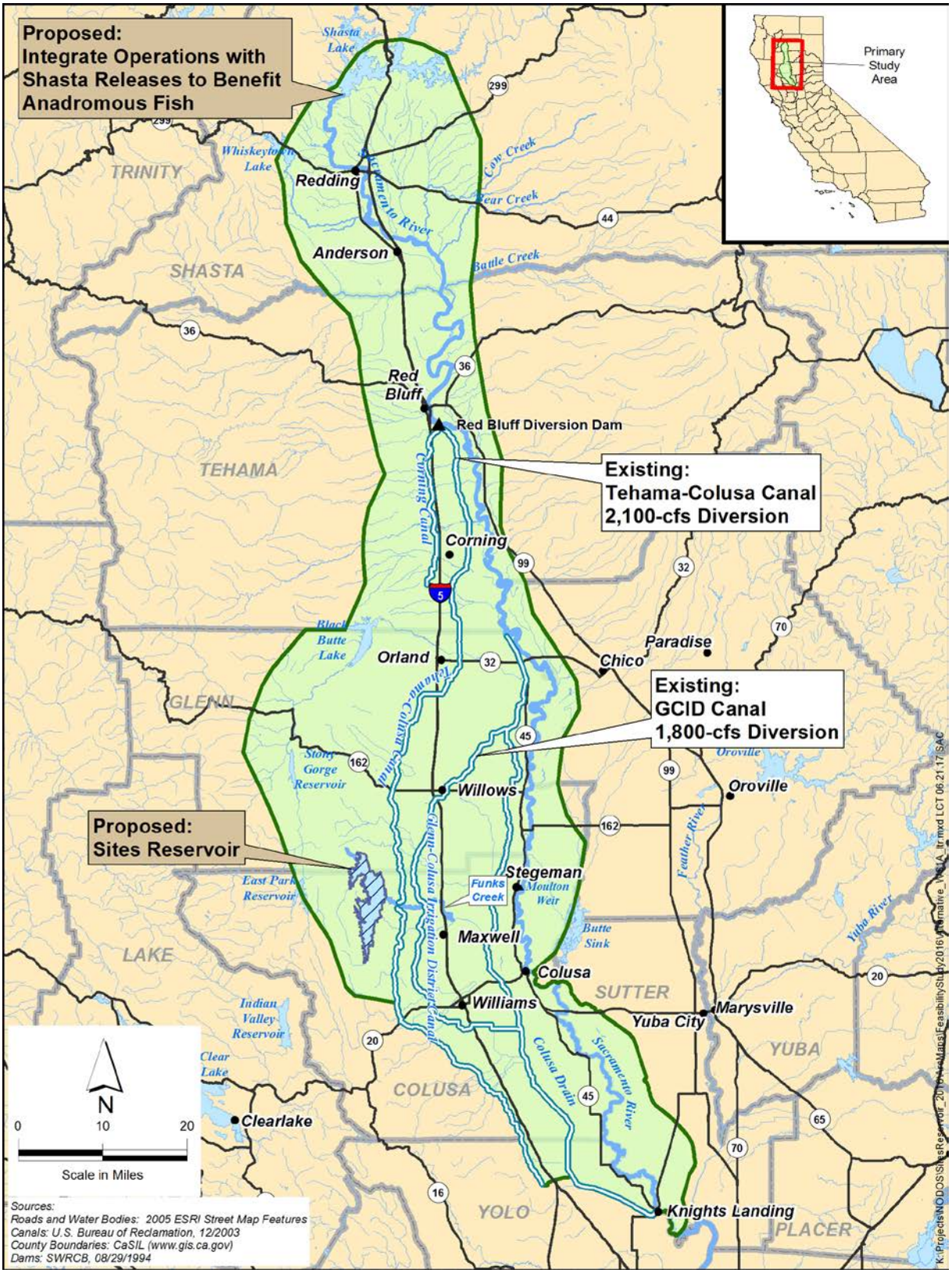

Figure A-7. WS1A-Water Supply with Reliance on Existing Canals

Alternative WS1B (New 1,500 cfs Diversion and 1,125 cfs Release Pipeline)

Initial Action Alternative Plan WS1B (Alternative WS1B) (see Table A-22 and Figure A-8) would focus on meeting the primary objective of water supply by constructing Sites Reservoir, and would include a new conveyance (pumping plant and pipeline) from the Sacramento River to supplement the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) to convey water to and from the reservoir.

In Alternative WS1B, the Delevan Pipeline would provide capacity for a 1,500 cfs diversion with a 1,125 cfs release. Alternative WS1B would use the common features already described, and would provide diversion from the Sacramento River at three locations and release back to the river at the Delevan Pipeline diversion location. This release capability would facilitate direct benefits "downstream," primarily in the Delta. The coordinated operation would provide additional benefits associated with the integration of Sites Reservoir storage into existing system operations. The highest priorities of Alternative WS1B would be to improve the reliability of water supply to CVP and SWP contractors and local T-C Canal water users; to provide long-term water supply for the EWA; and to provide an alternative source for incremental Level 4 water supply for wildlife refuges.

Table A-22. Alternative WS1B Major Components and Operations Prioritization

Major Components of Alternative WS1B	Details of Major Components
Operations Priority 1. SWP contractors 2. CVP contractors 3. Local water supply 4. An alternative source of incremental Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. Delta water quality 7. ERA short list (see Table A-19) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 1,500 cfs diversion and capacity to release up to 1,125 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal just before connecting to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

Notes for Table A-22
cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = Terminal Regulating Reservoir

Benefits to T-C Canal users could be delivered directly from Sites Reservoir through the T-C Canal. Other benefits would derive from a combination of direct delivery through the Delevan Pipeline, and coordinated operations with existing reservoirs.

Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and the Red Bluff Diversion Dam (RBDD).

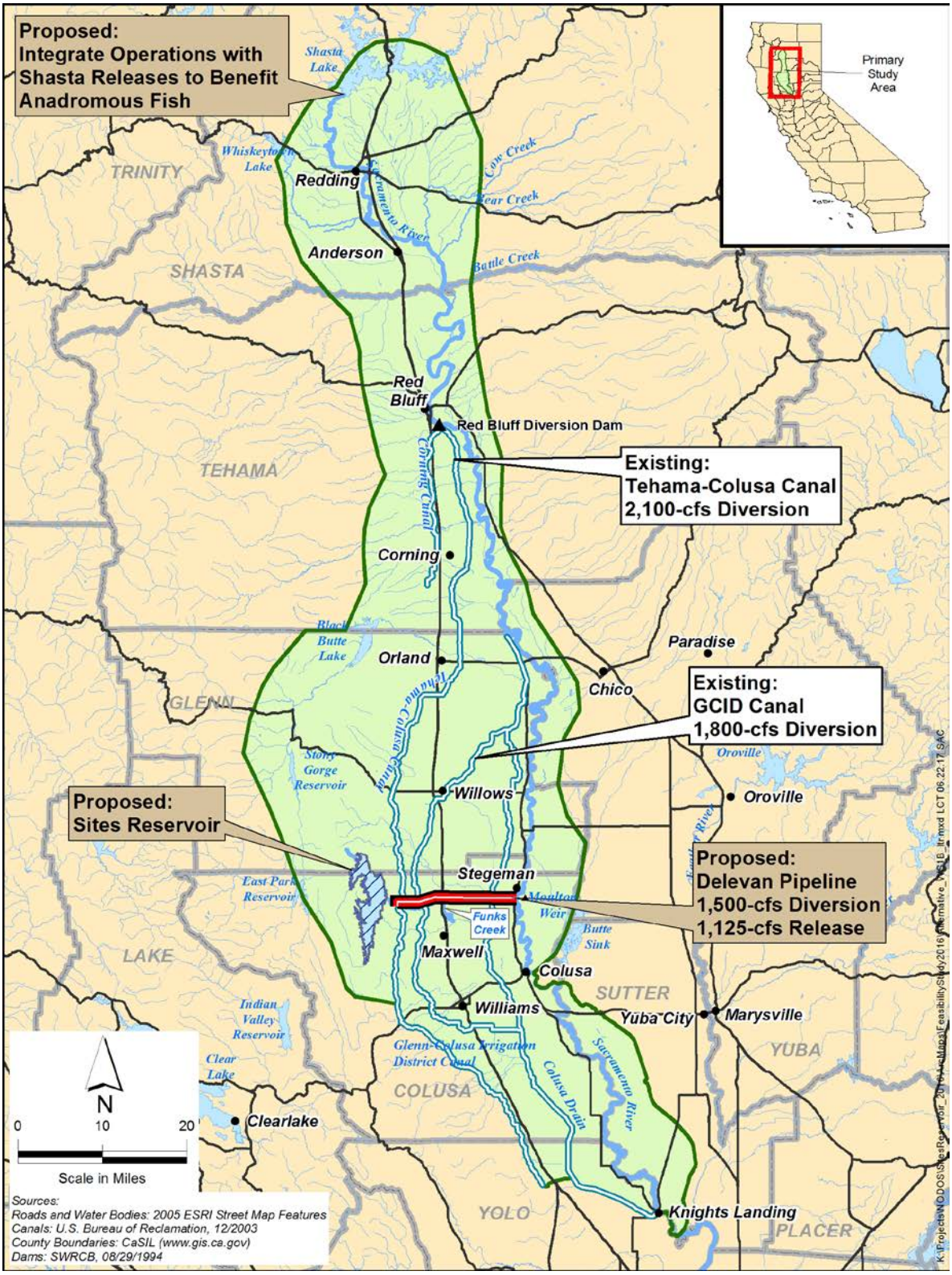

Figure A-8. WS1B-Water Supply with Conjunctive Use of Groundwater and 1,500 cfs Pipeline

Alternative WS1C (New 2,000 cfs Diversion and 1,500 cfs Release Pipeline)

Initial Action Alternative Plan WS1C (Alternative WS1C) (see Table A-23 and Figure A-9) would focus on meeting the primary objective of water supply. It would include the Delevan Pipeline to supplement the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) to convey water to and from the reservoir. Alternative WS1C would use the common features already described.

Table A-23. Alternative WS1C Major Components and Operations Prioritization

Major Components of Alternative WS1C	Details of Major Components
Operations Priority 1. SWP contractors 2. CVP contractors 3. Local water supply 4. Alternative source of incremental Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. Delta water quality 7. ERA short list (see Table A-19) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 2,000 cfs diversion capacity to release up to 1,500 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal just before connection to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = Terminal Regulating Reservoir

In Alternative WS1C, the Delevan Pipeline would be formulated with the capacity for a 2,000 cfs diversion and a 1,500 cfs release. The highest priorities of this alternative would be to improve the reliability of water supply to CVP and SWP contractors and local T-C Canal users, to provide long-term water supplies for the EWA, and to provide an alternative source for incremental Level 4 water supply for wildlife refuges. Conveyance would terminate at an enlarged Funks Reservoir (identified as Holthouse Reservoir in subsequent iterations of the planning process), which would serve as the forebay and the afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. For modeling purposes, operations under Alternative WS1C were prioritized as presented in Table A-23.

The operation of Sites Reservoir would be integrated with the operation of Shasta Dam as described in the Sites Reservoir Operations Strategy to reduce summer irrigation diversions, provide flows to support downstream migration for juvenile anadromous fish and improve water temperatures between Keswick Dam and Red Bluff, and improve the reliability of the coldwater pool at Shasta Lake.

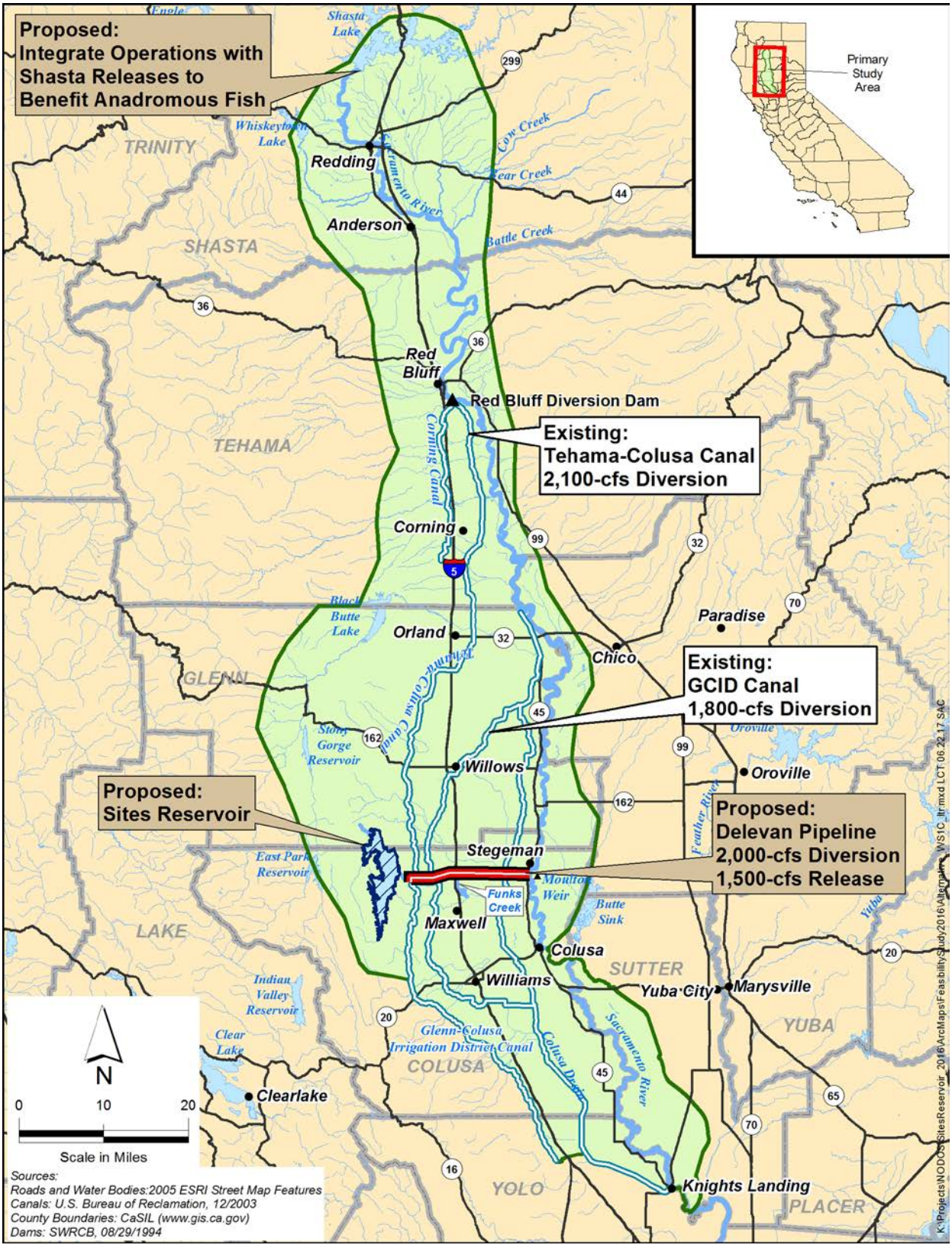

Figure A-9. WS1C-Water Supply with 2,000 cfs Pipeline

Alternative AF1A (New 1,500 cfs Pipeline with Enhanced Ecological Benefits)

Initial Action Alternative Plan AF1A (Alternative AF1A) (see Table A-24 and Figure A-10) would focus on meeting the primary objective of anadromous fish survival by using Sites Reservoir to provide additional flexibility in water management that would benefit anadromous fish. Alternative AF1A would include the common features previously described and the Delevan Pipeline (1,500 cfs diversion) to supplement the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) to convey water to and from the reservoir. The Delevan Pipeline capacity in Alternative AF1A would provide up to 1,125-cfs release capacity to the Sacramento River.

Table A-24. Alternative AF1A Major Components and Operations Prioritization

Major Components of Alternative AF1A	Details of Major Components
Operations Priority 1. ERA long list (see Table A-19) of river and Delta restoration actions 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for incremental Level 4 water supply for wildlife refuges 6. Delta water quality 7. EWA or similar future program demands	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 1,500 cfs diversion capacity to release up to 1,125 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal just before connecting to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = Terminal Regulating Reservoir

Conveyance would terminate at an enlarged Funks Reservoir (subsequently identified as Holthouse Reservoir), which would serve as forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir.

Alternative AF1A also incorporates the following three alternatives to benefit anadromous fish.

- Abandoned Gravel Mine Restoration: Alternative AF1A would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features might be created to encourage spawning and rearing, and to prevent stranding.
- Spawning Gravel Replenishment: Alternative AF1A would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River.
- Instream Aquatic Habitat Improvements: Alternative AF1A would include restoring instream habitat along the lower arms of the Sacramento River. This component would include improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders; and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. Alternative AF1A also would include improving and restoring instream aquatic habitat using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments could include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that would cause scouring and help clean gravel.

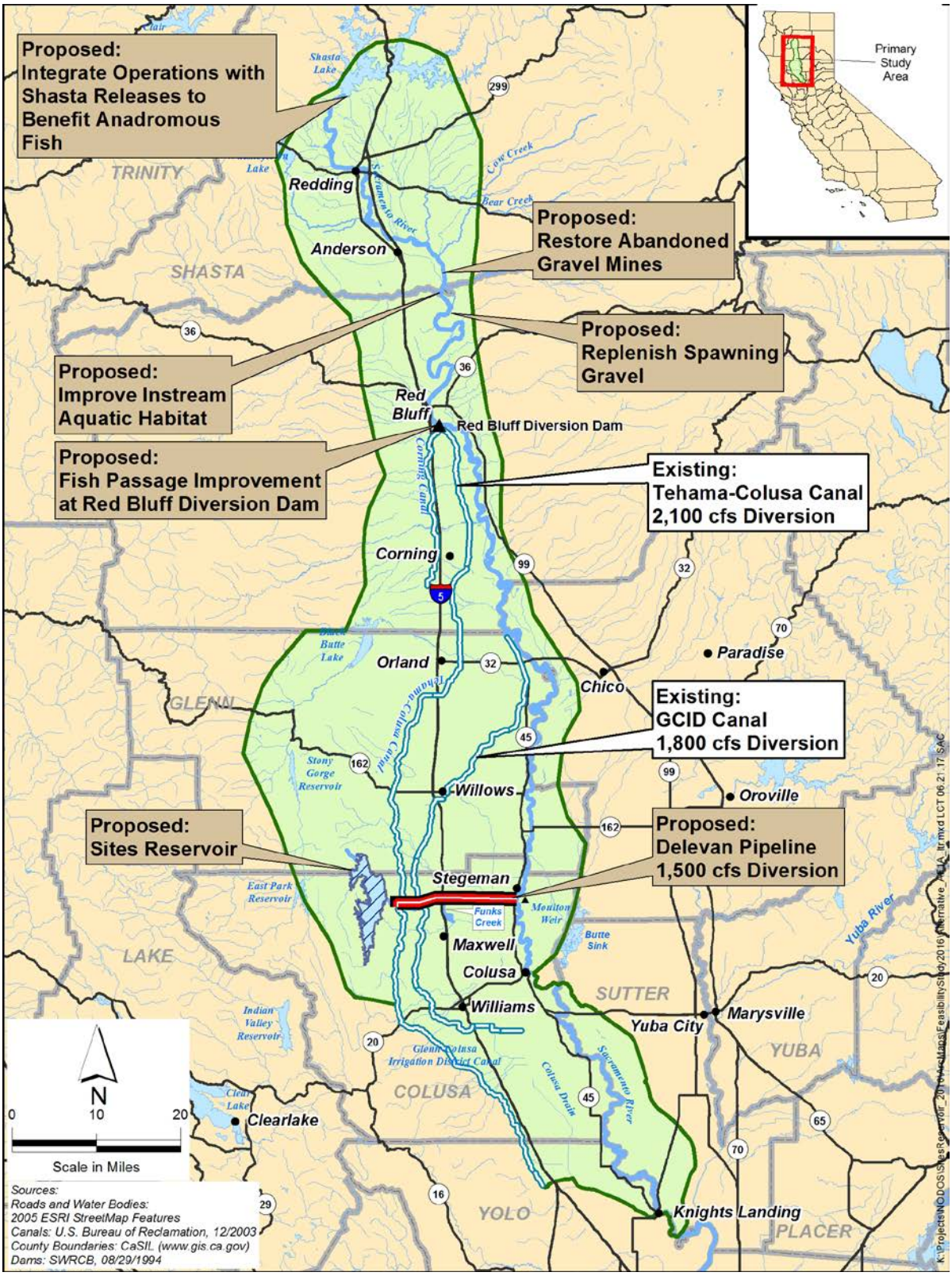

Figure A-10. AF1A-Water Supply with 1,500 cfs Pipeline

Alternative AF1B (New 2,000 cfs Diversion and 1,500 cfs Release Pipeline)

Initial Action Alternative Plan AF1B (Alternative AF1B) (see Table A-25 and Figure A-11) would focus on meeting the primary objective of anadromous fish survival by using Sites Reservoir to provide additional flexibility in water management that would benefit anadromous fish. Alternative AF1B includes the common features previously described and the Delevan Pipeline (2,000 cfs diversion) to supplement the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) to convey water to and from the reservoir. The Delevan Pipeline in Alternative AF1B would provide up to 1,500 cfs release capacity to the Sacramento River.

Table A-25. Alternative AF1B Major Components and Operations Prioritization

Major Components of Alternative AF1B	Details of Major Components
Operations Priority 1. ERA long list (see Table A-19) of river and Delta restoration actions 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for incremental Level 4 water supply for wildlife refuges 6. Delta water quality 7. EWA or similar future program demands	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 2,000 cfs diversion and capacity to release up to 1,500 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal, just before connecting to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
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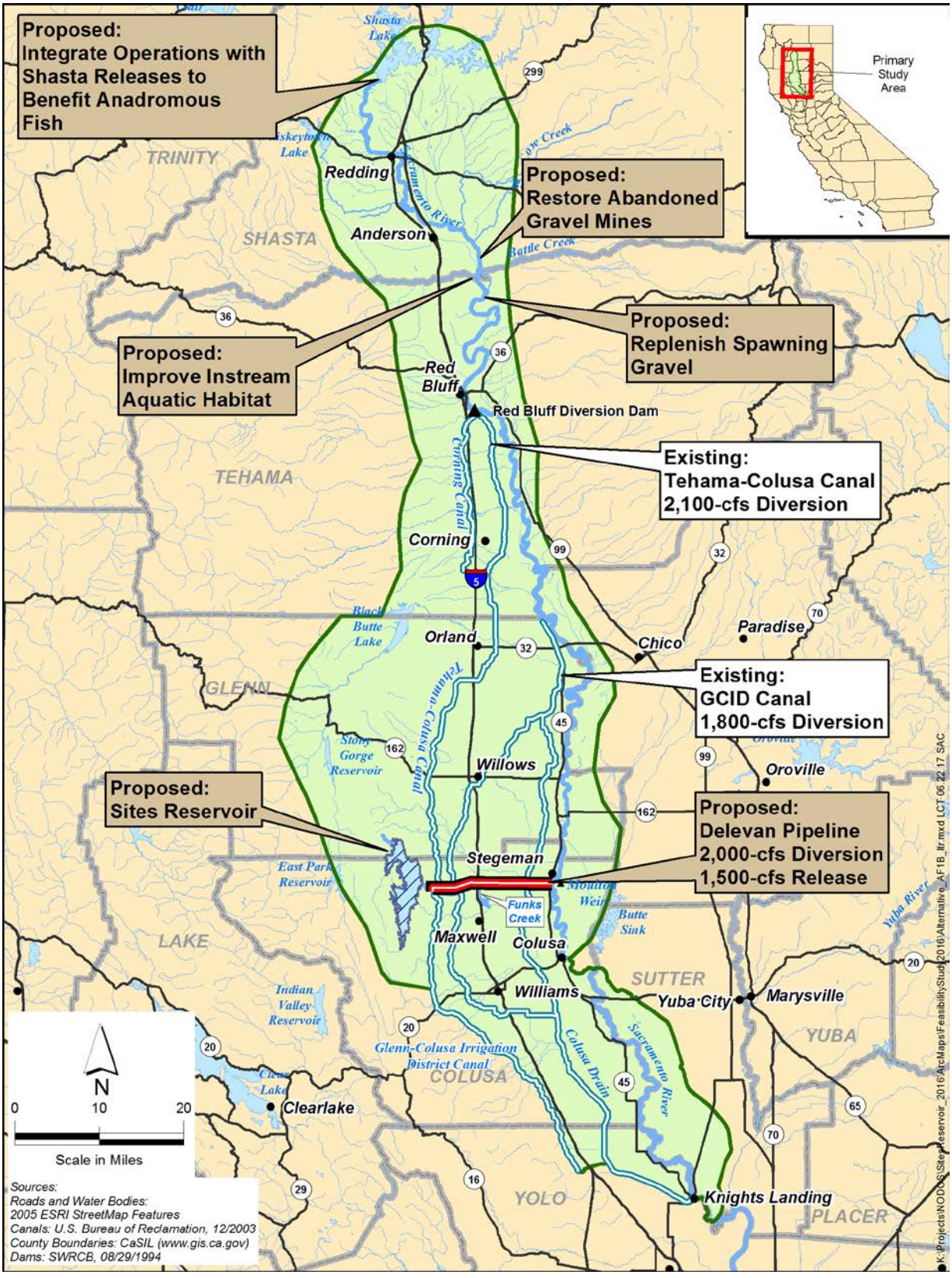

Figure A-11. AF1B-Anadromous Fish Enhancement with 2,000 cfs Pipeline

Alternative AF1B also would incorporate the following three alternatives to benefit anadromous fish.

- **Abandoned Gravel Mine Restoration:** Alternative AF1B would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features might be created to encourage spawning and rearing, and to prevent stranding.
- **Spawning Gravel Replenishment:** Alternative AF1B would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River.
- **Instream Aquatic Habitat Improvements:** Alternative AF1B would include restoring instream habitat along the lower arms of the Sacramento River. This component would include improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. Alternative AF1B also would include improving and restoring instream aquatic habitat using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments might include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that would cause scouring and help clean gravel.

Alternative WSFQ (New 2,000 cfs Diversion and 1,500 cfs Release Pipeline with Fish Enhancements)

Initial Action Alternative Plan WSFQ (Alternative WSFQ) (see Table A-26 and Figure A-12) would focus on meeting the primary objectives of water supply and water quality by releasing water to the Sacramento River to increase Delta outflows during the summer and fall. The priorities of Alternative WSFQ would be to improve both water quality and the reliability of water supply to CVP and SWP contractors; to provide long-term water supply for the EWA; and to provide an alternative source for incremental Level 4 water supply for wildlife refuges and Delta water quality improvements. Alternative WSFQ would include the common features previously described, and the Delevan Pipeline (2,000 cfs diversion with 1,500-cfs release), to supplement the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) to convey water to and from the reservoir (Table A-26). Conveyance would terminate at an enlarged Funks Reservoir (subsequently identified as Holthouse Reservoir), which would serve as the forebay and the afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and RBDD.

Table A-26. Alternative WSFQ Major Components and Operations Prioritization

Major Components of Alternative WSFQ	Details of Major Components
Operations Priority 1. SWP contractors 2. Delta water quality 3. CVP contractors 4. Alternative source for incremental Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. ERA short list (see Table A-19) of Sacramento River restoration actions, but not including stabilization of fall flows	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide a new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs)
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

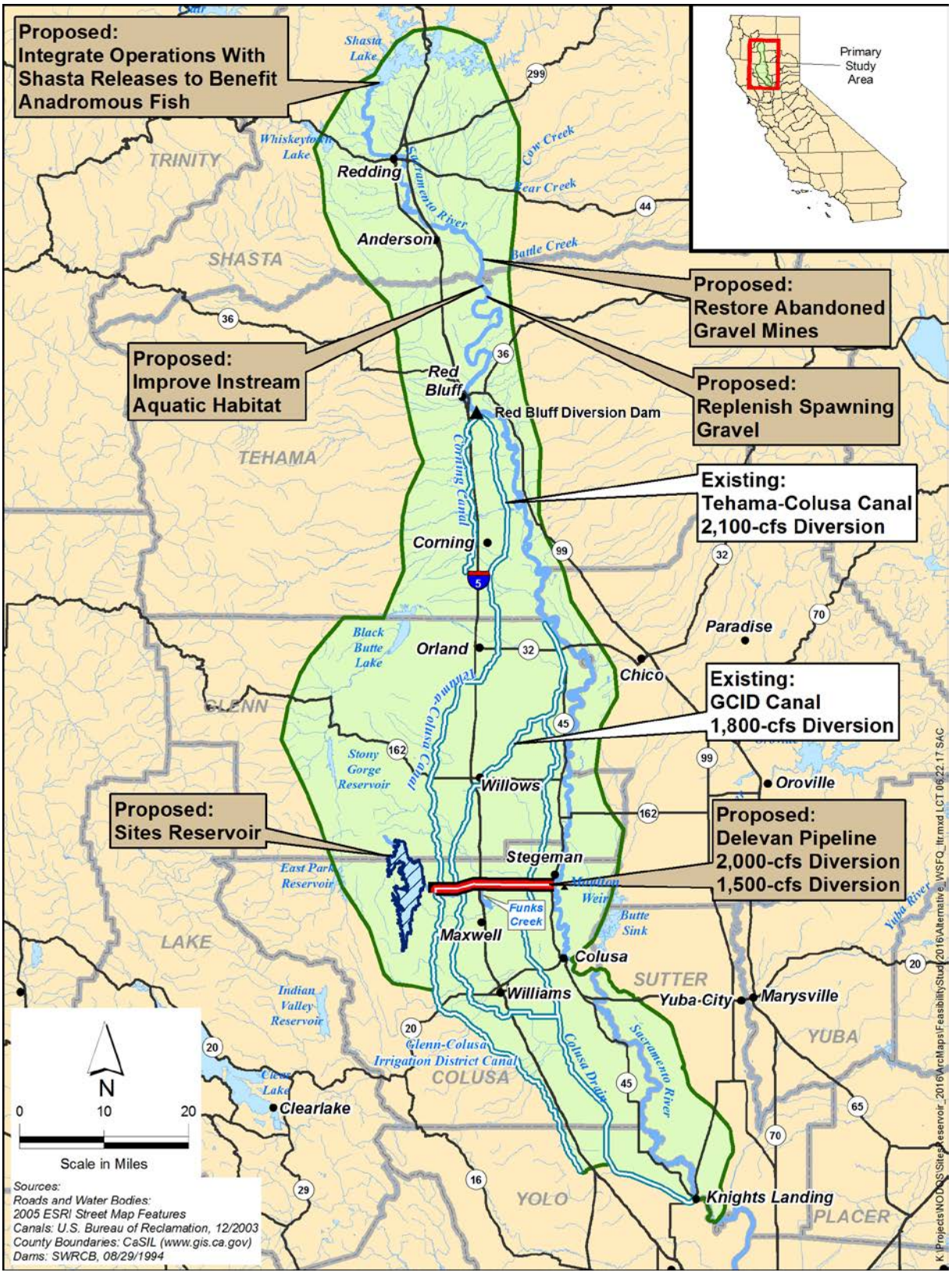

Figure A-12. WSFQ-Water Supply with Fish Enhancement and 2,000 cfs Pipeline

Alternative WSFQ also would incorporate the following three alternatives to benefit anadromous fish.

- **Abandoned Gravel Mine Restoration:** Alternative WSFQ would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features might be created to encourage spawning and rearing, and to prevent stranding.
- **Spawning Gravel Replenishment:** Alternative WSFQ would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River.
- **Instream Aquatic Habitat Improvements:** Alternative WSFQ would include restoring instream habitat along the lower arms of the Sacramento River. This component would include improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. Alternative WSFQ also would include improving and restoring instream aquatic habitat using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments might include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that would cause scouring and help clean gravel.

Alternative WQ1A (New 1,500 cfs Release Pipeline)

Initial Action Alternative Plan (Alternative WQ1A) (see Table A-27 and Figure A-13) would focus on meeting the primary objective of water quality by releasing water to the Sacramento River to increase Delta outflow during the summer and fall months. Alternative WQ1A would use the common features already described and a new release-only Delevan Pipeline. The pipeline would be designed to release up to 1,500 cfs to the Sacramento River. The reservoir would be filled using the existing T-C Canal and GCID Canal. Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and Red Bluff. Conveyance would terminate at an enlarged Funks Reservoir (subsequently identified as Holthouse Reservoir), which would serve as the forebay and the afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir.

Table A-27. Alternative WQ1A Major Components and Operations Prioritization

Major Components of Alternative WQ1A	Details of Major Components
Operations Priority 1. Delta water quality 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for incremental Level 4 water supply for wildlife refuges 6. EWA or similar future program demands 7. ERA short list (see Table A-19) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would allow releases to the Sacramento River (up to 1,500 cfs), but would not serve as a diversion for additional water to fill Sites Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
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GCID = Glenn-Colusa Irrigation District
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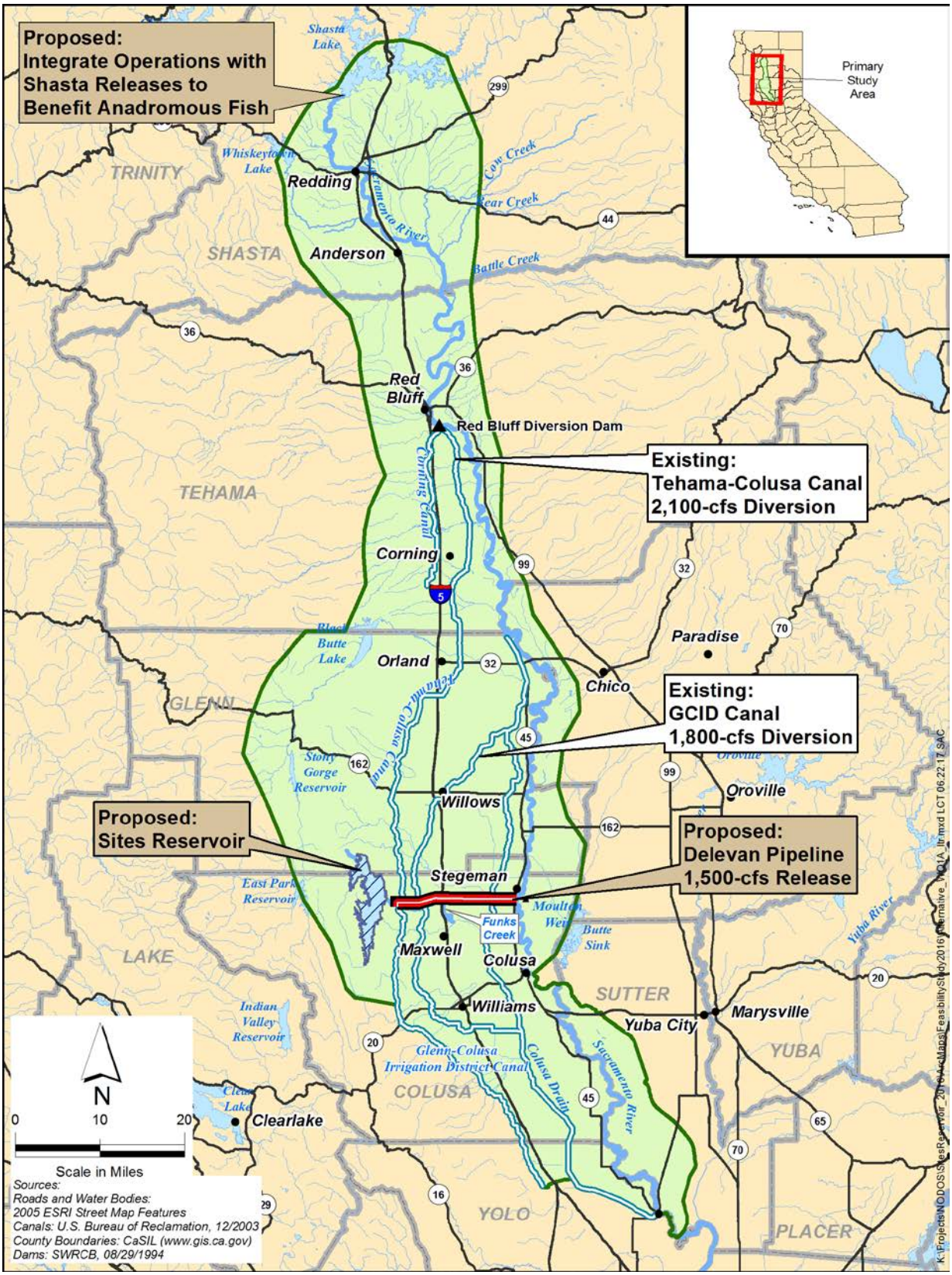

Figure A-13. WQ1A-Water Quality with 1,500 cfs Pipeline

Alternative WQ1B (New 2,000 cfs Diversion and 1,500 cfs Release Pipeline)

Alternative WQ1B (see Table A-28 and Figure A-14) would use the common features already described and would include the Delevan Pipeline capable of a 2,000 cfs diversion with a 1,500 cfs release that would supplement the existing T-C Canal (2,100 cfs diversion) and GCID Canal (1,800 cfs diversion) in conveying water to and from the reservoir. Alternative WQ1B would focus on meeting the primary objective of water quality by releasing water to the Sacramento River to increase Delta outflows during the summer and fall months. Conveyance would terminate at an enlarged Funks Reservoir (subsequently identified as Holthouse Reservoir), which would serve as the forebay and the afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and Red Bluff.

Table A-28. Alternative WQ1B Major Components and Operations Prioritization

Major Components of Alternative WQ1B	Details of Major Components
Operations Priority 1. Delta water quality 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for incremental Level 4 water supply for wildlife refuges 6. EWA or similar future program demands 7. ERA short list (see Table A-19) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide a new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs).
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID. Minor reshaping of 13 miles of the canal. Replacement of 1 siphon, 1 check, 1 bridge. Installation of a TRR. Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
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T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = Terminal Regulating Reservoir

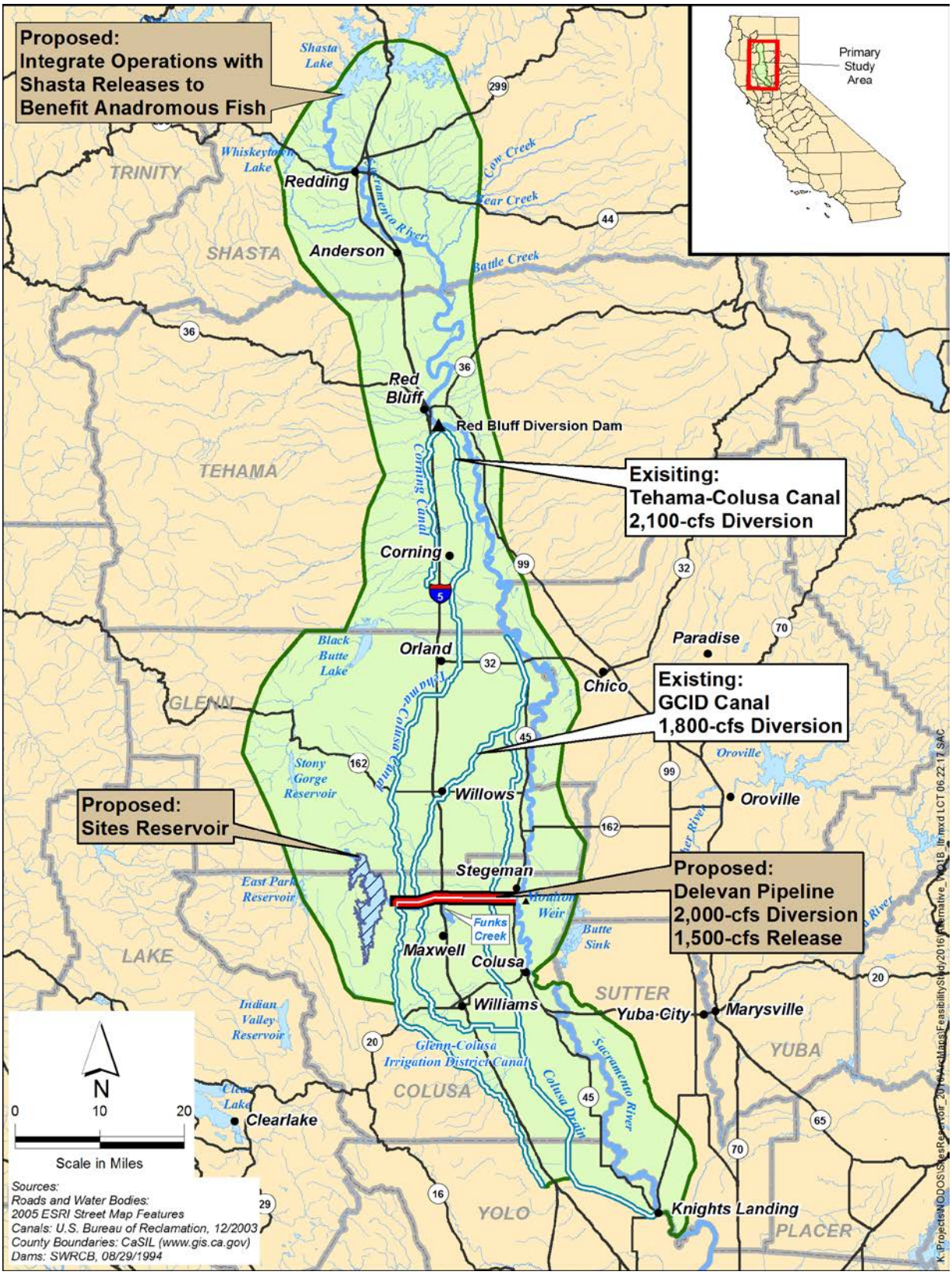

Figure A-14. WQ1B-Water Quality with 2,000 cfs Pipeline

A.9 Initial Alternative Physical Accomplishments

This section discusses the potential accomplishments of the initial alternatives relative to the objectives. The accomplishments were evaluated using CalSIM II. The CalSIM II results were used to for an initial assessment of the potential annual benefits. The conceptual costs for the initial alternative were based on initial engineering concepts (incremental Level 4 cost estimates). Table A-29 summarizes the accomplishments and conceptual-level cost estimates and benefits for each of the initial alternatives.

Comparison of Initial Alternatives

The initial alternatives were evaluated using the four evaluation criteria identified in the P&Gs for water resources planning. These criteria are (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability.

Completeness

Completeness, with respect to the initial alternatives formulated by the NODOS feasibility studies, is the extent to which each initial alternative provides and accounts for all necessary investments or other actions by Reclamation or DWR, and by local entities, to ensure the realization of the planned effects. Other public or private actions crucial to realizing the objectives of the initial alternatives are identified as well. Key considerations include the ability of the initial alternative to meet all objectives of the NODOS feasibility studies, and the reliability of the project in all types of water years. Key observations include the following:

- The No Project Alternative rates very low. Each initial alternative contributes to meeting all of the primary and secondary objectives.
- The initial alternatives do not rely heavily on any other actions. The performance of all of these plans would be enhanced through the implementation of conjunctive-use programs; however, the additional benefits associated with conjunctive use were not included in the modeling effort or benefits determinations used in evaluating alternatives.
- The initial alternatives are considered equally reliable from an engineering standpoint. OM&R requirements would be reduced for Alternative WS1A, given the absence of the Delevan Pipeline. However, some differences in reliability would be evident under dry conditions. The reliability of Alternative WS1A in meeting all of the primary objectives would be reduced under dry conditions. Alternative WQ1B would be the best performer under dry conditions.

Effectiveness

Effectiveness is the extent to which the initial alternatives eliminate the specified problems and achieve the objectives of the NODOS feasibility studies.

Water Supply and Water Supply Reliability (Primary Objective)

Table A-30 provides a comparative summary of the water supply increases achieved by each initial alternative over the No Project Alternative.

The analysis of this objective includes CVP, SWP, local water supply, incremental Level 4 supply for refuges, and EWA. It does not include additional water released to improve Delta water quality. General observations from review of Table A-30 include the following:

Alternatives WS1C, WS1B, and WS1A provide the highest average long-term annual water supply, with total water supply increases over the No Project Alternative (382, 368, and 336 TAF/year, respectively).

Alternative AF1A provides the lowest average long-term annual water supply, with a total water supply increase over the No Project Alternative of only 184 TAF/year.

Water supply reliability is also improved by reductions in groundwater pumping to reduce overdraft. The greatest reductions are for Alternatives WS1A, WS1B, and WS1C, which reduce groundwater pumping by 70, 64, and 70 TAF per year, respectively. Alternatives WQ1A and WQ1B provide reductions of 54 and 64 TAF per year, respectively. Lesser reductions in pumping of 39, 38, and 37 TAF per year, respectively, are achieved by alternatives AF1A, AF1B, and WSFQ.

Water Quality (Primary Objective)

Improved water quality in the Delta was evaluated in terms of the ability of each alternative to improve Delta environmental water quality and to reduce the adverse effects of salinity on drinking water quality and other beneficial uses. By improving water quality in the Delta, it is also expected that a subsequent decrease in treatment cost of exported water would be realized.

The X2[1] location is the distance in kilometers (km) from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand. Regulatory standards are defined for maintaining the X2 location downstream from specific locations in the western Delta for a predefined number of days. Table A-31 shows the change in X2 location for dry and critical years. Figure A-15, Figure A-16, Figure A-17, and Figure A-18 show the average X2 position by month for the long-term average, wet and above-normal years, below-normal years, and dry and critical years. The greatest improvement is during the fall in dry and critical years, where the X2 location is shifted by 1 to 3 kilometers (km) inland.

[1] A Delta management tool, defined as the distance in kilometers from the Golden Gate Bridge to the location where the tidally averaged near-bottom salinity in the Delta measures 2 parts per thousand.

Table A-29. Summary of Relative Accomplishments of Initial Alternatives and Estimates of Preliminary Costs and Benefits

Item	Initial Alternatives							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Objectives and Accomplishments								
Water Supply [a] Increase (Driest Periods Average Increase/Average Annual Increase) (TAF/year)	273/336	316/368	361/382	166/184	144/189	262/276	241/225	301/276
Anadromous Fish Rating [b]	Low	Medium	Medium	High	High	Medium	Medium	Medium
Water Quality Improvement [c]	Low	Low	Low	Low	Low	High	High	High
Hydropower Generated Long Term (in GWh)	105	147	153	152	157	150	128	151
Recreation [d]	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Flood Damage Reduction and Emergency Water [e]	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Economics ($ millions) [f]								
Construction Cost	$2,138.1	$2,936.7	$3,021.8	$2,951.2	$3,036.4	$3,036.4	$2,664.5	$3,021.8
Total Annual Cost	$134.2	$183.0	$188.1	$184.1	$189.3	$189.0	$166.1	$188.1
Annual NED Benefits	$113.11	$151.96	$154.94	$107.69	$110.80	$214.85	$144.42	$183.20
Net Benefits (Annual Benefits – Annual Cost)	-$21.09	-$31.04	-$33.16	-$76.41	-$78.50	+$25.85	-$21.68	-$4.9

[a] Water supply increases exceed the No Project Alternative and include supplies for agriculture, M&I, and environmental (incremental Level 4 and EWA). Driest period's average is the average quantity for the combination of periods of May 1928 through October 1934, October 1975 through September 1977, and June 1986 through September 1992. Average annual is for the period of October 1922 through September 2003.

[b] Anadromous fish rating is based on the ability to meet flow and temperature objectives in the Sacramento River, and the number of ecosystem restoration features in the alternative.

[c] Reductions in conductivity and TDS, bromide, and chloride concentrations were approximately doubled for the two WQ alternatives in modeling simulations.

[d] Ranking based on ability of alternatives to support flat water recreation at Sites Reservoir.

[e] Ranking based on ability of alternatives to provide emergency flushing flows in the event of catastrophic levee failure in the Delta.

[f] All costs and benefits for initial alternatives evaluated in the PFR are at an appraisal level and presented in 2007 dollars. Refined alternatives with feasibility level costs and benefits are currently under development.

EWA = Environmental Water Account
GWh = gigawatt-hours
M&I = municipal and industrial
TAF = thousand acre-feet
TDS = total dissolved solids
WQ = water quality

Table A-30. Water Supply Increases[a] (Dry Periods Average Increase[b]/Average Annual Increase) (TAF/Year)

Water Supply Locale and Use	Initial Alternatives							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Sacramento Valley								
TCCA Delivery[c]								
TCCA CVP Delivery	19 / 11	14 / 8	19 / 9	8 / 5	4 / 4	6 / 5	16 / 7	14 / 9
TCCA Non-CVP Delivery	35 / 20	30 / 21	32 / 23	19 / 15	18 / 14	1 / 1	35 / 23	36 / 23
CVP Agriculture (includes TCCA CVP Delivery)	21 / 12	15 / 10	22 / 11	9 / 5	5 / 5	7 / 6	18 / 8	16 / 10
CVP M&I	2 / 0	1 / 1	2 / 1	0 / 0	0 / -0	0 / 0	1 / 0	1 / 0
Bay Area								
CVP Agriculture	4 / 2	3 / 2	4 / 2	2 / 1	1 / 1	1 / 1	3 / 1	3 / 1
CVP M&I	3 / 1	2 / 1	4 / 2	0 / 0	0 / 0	1 / 0	3 / 1	2 / 1
SWP M&I	4 / 12	9 / 14	8 / 14	5 / 7	6 / 7	13 / 15	5 / 8	11 / 12
San Joaquin Valley								
CVP Agriculture	105 / 41	81 / 32	110 / 41	50 / 23	28 / 21	30 / 13	86 / 34	79 / 32
CVP M&I	0 / 0	0 / 0	1 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
SWP Agriculture	16 / 20	36 / 29	32 / 27	19 / 15	20 / 17	50 / 32	19 / 17	38 / 26
South and Central Coast								
SWP M&I	0 /84	55 / 111	60 / 111	27 / 46	30 / 51	105 / 116	34 / 62	72 / 92
Total Ag and M&I								
CVP, SWP, and Local Supply	190 / 192	232 / 221	275 / 232	131 / 112	108 / 116	208 / 184	204 / 154	258 / 197
Environmental								
Incremental Level 4 Supply for Refuges	32 / 56	24 / 55	26 / 55	11 / 23	11 / 24	15 / 35	15 / 31	17 / 35
EWA	51 / 88	60 / 92	62 / 95	24 / 49	25 / 49	39 / 57	22 / 40	26 / 44
Total – All Users	**273 / 336**	**316 / 368**	**363 / 382**	**166 / 184**	**144 / 189**	**262 / 276**	**241 / 225**	**301 / 276**

[a] Increases from the No Project Alternative.
[b] Driest periods increases are the average quantity for the combination of the periods May 1928 through October 1934, October 1975 through September 1977, and June 1986 through September 1992. Average annual increases are based on average quantities for October 1922 through September 2003.
[c] For purposes of preliminary evaluations in this PFR phase, TCCA deliveries were used to model local deliveries. This is subject to change as additional modeling studies are made for the feasibility studies and Feasibility Report.

CVP = Central Valley Project
EWA = Environmental Water Account
M&I = municipal and industrial
PFR = Plan Formulation Report
SWP = State Water Project
TAF = thousand acre-feet
TCCA = Tehama-Colusa Canal Authority

Table A-31. Change in X2 Location During Dry and Critical Years (km)

	Initial Alternatives [a]							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Oct	-1	-2	-2	-1	-1	-2	-2	-3
Nov	0	0	-1	0	0	-1	-1	-1
Dec	0	0	0	0	0	-1	0	-1
Jan	1	0	0	0	0	0	0	0
Feb	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1
Apr	1	1	1	0	0	1	1	1
May	0	0	0	0	0	0	0	0
Jun	0	0	0	-1	-1	0	0	0
Jul	0	0	0	0	0	0	0	0
Aug	-1	-1	-1	-1	-1	-1	-1	-1
Sep	-1	-1	-1	-1	-1	-2	-2	-2

[a] Negative numbers (decrease in distance) indicate X2 is closer to the Golden Gate Bridge than the future No Project Alternative, whereas positive numbers (increase in distance) indicate X2 is further from the Golden Gate Bridge than the future No Project Alternative.

km = kilometer

Relative impacts to salinity were evaluated by comparing simulated EC, TDS, and chloride concentrations (see Table A-32). Relative impacts related to a decrease in toxic effects of disinfectant byproducts were evaluated by comparing simulated bromide concentrations. Key observations from Table A-32 include the following:

- Simulations predict that the implementation of all project alternatives would result in some reduction to average EC, TDS, and chloride concentrations at the Banks Pumping Plant; and therefore, would achieve some degree of improvement to salinity in water available for export.
- Water quality Alternatives WSFQ, WQ1A, and WQ1B would provide substantially greater reduction in salinity, bromides, and chlorides than the other project alternatives.

In summary, Alternatives WSFQ, WQ1A, and WQ1B best meet the objective of improving Delta water quality.

Table A-32. Quality of Banks Pumping Plant Exports (Weighted Average of all Values of Monthly Simulation)

Simulated Using DSM2 Parameter	Initial Alternatives								
	Future No Project	WS1A (% Difference from FNP)	WS1B (% Difference from FNP)	WS1C (% Difference from FNP)	AF1A (% Difference from FNP)	AF1B (% Difference from FNP)	WSFQ (% Difference from FNP)	WQ1A (% Difference from FNP)	WQ1B (% Difference from FNP)
EC (µmhos/cm)	442.7	435.5 (-2)	434.6 (-2)	431.3 (-3)	434.9 (-2)	434.1 (-2)	434.1 (-5)	423.2 (-4)	418.9 (-5)
TDS (mg/L)	283.3	276.6 (-2)	278.1 (-2)	276.0 (-3)	278.3 (-2)	277.8 (-2)	269.3 (-5)	270.9 (-4)	268.1 (-5)
Chloride (mg/L)	76.15	73.16 (-4)	73.83 (-3)	72.90 (-4)	73.92 (-3)	73.71 (-3)	69.93 (-8)	70.60 (-7)	69.36 (-9)
Bromide (mg/L)	0.248	0.238 (-4)	0.240 (-3)	0.237 (-4)	0.241 (-3)	0.240 (-3)	0.227 (-9)	0.229 (-8)	0.225 (-9)

EC = electrical conductivity
FNP = Future No Project
mg/L = milligrams per liter
TDS = total dissolved solids
µmhos/cm = micromhos per centimeter

Survival of Anadromous Fish and Other Aquatic Species (Primary Objective)

The NODOS/Sites Reservoir Project alternatives include an ERA that would be used to provide water for restoration actions in the Bay-Delta watershed. The account is conceived to provide first-of-its-kind-in-California firm water assets, owned and managed by the Federal and/or State Government, for restoration actions beyond regulatory requirements. The initial NODOS/Sites Reservoir Project formulations include a set of restoration actions associated with the Sacramento River; including, for example, an improved temperature regime below Shasta Lake, reduced diversions, and stabilization of flows for anadromous fish. Alternatives AF1A, AF1B, and WSFQ present several habitat restoration programs, including restoration of gravel mines, improvement of instream habitat, and replenishment of spawning gravels.

The relative effectiveness of the various alternative plans was evaluated based on the performance of the ecosystem restoration actions, including improvements in temperature in the Upper Sacramento River, and improvements in Delta outflow in March (Table A-33). This ranking system assumes that increasing diversion rates at all of the diversions would not result in substantial mortality associated with these diversions. This assumption is based on ongoing studies at GCID; it further assumes that recent actions to reduce predation rates will be successful.

Table A-33. Effect of Initial Action Alternatives on Anadromous Fish and Aquatic Resources

	Initial Alternatives							
	WS1A	**WS1B**	**WS1C**	**WQ1A**	**WQ1B**	**AF1A**	**AF1B**	**WSFQ**
Habitat Enhancements	N	N	N	N	N	SB	SB	SB
Increased Diversions	SA	SA	SA	SA	SA	SA	SA	SA
ERA Level 1 Benefits[a]	SB	SB	SB	SB	SB	SB	SB	SB
ERA Level 2 Benefits[b]	NA	NA	NA	NA	NA	SB	SB	NA
Sacramento River Temperatures	SA	SA	SA	N	SA	SB	SB	SB
Delta Habitat Water Quality (March)	SB	SB	SB	SB	SB	SB	SB	SB
Overall	N	N	N	N	N	SB	SB	SB

[a] Objectives identified in Table A-20 that all initial action alternatives would address.
[b] Additional objectives identified in Table A-20 that only some initial action alternatives would address.
ERA = Ecosystem Restoration Account
N = neutral
NA = not applicable
SA = slight adverse effect
SB = slight beneficial effect

The SALMOD model projects that these alternatives would have provided for better production of spring- and winter-run Chinook in drought periods, especially in the periods from 1930 to 1935 and 1988 to 1993; however, these benefits did not necessarily manifest themselves in shorter drought periods, such as 1977 to 1978. Key observations include the following:

- The two anadromous fish alternative plans (Alternatives AF1A and AF1B) would provide greater benefits for fisheries than the remaining alternatives. Alternative WSFQ also includes fish habitat enhancements, but the operations are not quite as beneficial to fish as those for Alternatives AF1A and AF1B.

- The remaining alternatives would provide substantially lower potential benefits to aquatic resources.

In addition to benefiting anadromous fish and aquatic species in the Sacramento River Basin, the NODOS project also would benefit aquatic species in the Delta. By providing an increase in Delta outflow, the NODOS project would help maintain an X2 position at 80 km (immediately west of Collinsville) from May to December. This outflow increase would increase Delta smelt habitat, and may reduce entrainment and improve food availability.

Ancillary Benefits of Hydropower Generation (Secondary Objective)

Although each of the project alternatives would be a net consumer of power, each would also have the ability to generate electricity when water is released from the reservoir. Table A-34 summarizes the total power that would be generated at the Sites Reservoir generating facilities under each alternative. The results show that alternatives with conveyance to the Sacramento River would produce more power than Alternative WS1A, which does not have conveyance to the Sacramento River.

Table A-34. Long-Term Total Power Generated (GWh)

	Initial Alternatives							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Power Generated (GWh)	105	147	153	152	157	150	128	151

GWh = gigawatt-hours

It should be noted that although none of the initial alternatives is intended to contribute a large supply of additional power to the statewide grid, the Sites Reservoir complex is capable of adding power to the statewide grid during the summer, and power generation facilities would help offset the power usage, and provide some ancillary power benefits to the local or State power grid.

Recreation (Secondary Objective)

Several recreational opportunities, such as hiking, boating, camping, fishing, and swimming in the immediate vicinity of Sites Reservoir, would be provided at comparable levels by all initial alternatives.

The NODOS/Sites Reservoir Project would affect flatwater, or reservoir-based, recreation in the following ways:

- Recreational opportunities at Sites Reservoir
- Water level impacts at Shasta Lake, Lake Oroville, and Folsom Lake

Operating strategies will be employed to mitigate any impacts to recreation at Shasta Lake, Lake Oroville, and Folsom Lake (these impacts are not expected to be adverse, and should be generally beneficial).

For initial evaluation in this PFR, differentiation of flatwater recreational opportunities focused on the average annual water surface elevation at Sites Reservoir. At full pool, Sites Reservoir

would store 1.8 MAF at an elevation of 520 feet. The maximum surface area of the reservoir would be 14,130 acres. The reservoir would be fully useable for recreation. At a water surface elevation of 480 feet, the reservoir surface area would be nearly 90 percent of the maximum surface area and would be fully useable. This determination is based on an assumption that boat launch ramps would be functional to an elevation of 400 feet (Rischbieter and Elkins 2000). Alternative WS1A would maintain a reservoir level at or above 440 feet on the most frequent basis (78 percent), and would experience less drawdown than the other initial alternatives. All of the other initial alternatives would be generally similar in performance, relative to each other.

Flood-Damage Reduction and Emergency Water (Secondary Objective)

Water storage in Sites Reservoir could provide flood-damage reduction benefits through coordination with other reservoirs. The diversions off of the Sacramento River would not be large enough to affect the magnitude of the peak flows meaningfully; however, through coordination with other reservoirs and accurate forecasting, water could be held in Sites Reservoir in lieu of water in other reservoirs to create flood-control storage space in other reservoirs. This coordination would require modification of the rule curves for the reservoirs in the system. All of the alternatives would provide almost equivalent performance in meeting this objective.

With no direct release back to the Sacramento River, Alternative WS1A would have no direct ability to provide flushing flows (to prevent saltwater intrusion from the Bay) through the Delta in the event of catastrophic levee failures of multiple islands in the Delta. The remaining seven alternatives, all of which have the Delevan Pipeline, could provide some flushing flows in the event of catastrophic levee failures. Although these flows would not be a large release, the proximity of Sites Reservoir to the Delta would make this an important feature because of the improved response time (flows would reach the Delta faster than they would from existing upstream reservoirs).

Acceptability

Acceptability assesses the degree of acceptance by Federal, California, and local entities and the public, and considers compatibility with existing laws, regulations, and public policies. A strategy for future public and stakeholder outreach has been developed (see Chapter 10, Findings and Conclusions) to evaluate the acceptability of the alternative plans. At this stage in the planning process, it appears that all initial alternatives would be ranked similarly. Key issues affecting all alternatives are likely to include the following:

- Affected property that would be inundated by Sites Reservoir
- Impacts to cultural resources from the construction of Sites Reservoir
- Opportunities for new recreational facilities associated with Sites Reservoir
- Benefits to water supply and water supply reliability
- Benefits to wildlife, habitat, and fisheries
- Benefits to water quality

Efficiency

Efficiency is the extent to which the initial alternatives are the most cost-effective means of alleviating the specified problems and realizing the project objectives, consistent with protecting the environment. The efficiency was evaluated through an analysis of the likely mitigation requirements and the alternatives' costs and benefits.

Environmental Impacts and Mitigation

Most of the adverse impacts identified for the NODOS/Sites Reservoir Project would be associated with the construction of the reservoir and conveyance facilities.

Many of the adverse impacts would be associated with features common to all of the alternatives. The level of short-term, construction-related, potential impacts to air quality, traffic, cultural resources, land use, biology, and water quality would be slightly greater for alternatives in which the amount of construction disturbance was greater. However, these impacts generally are considered short-term, could be addressed through mitigation, and therefore are not likely to determine the selected alternative.

Table A-35 summarizes the potential impacts and environmental consequences that are key differentiators between alternative plans.

Table A-35. Differentiating Potential Impacts and Mitigations for Initial Alternatives

Resource Area	Potential Impact Description	Applicable Plans	Potential Mitigation
Physical Environment			
Geomorphology, Sedimentation, and Erosion	Additional Delevan Pipeline diversion of 0.7% to 4.4% of the river flow on average. Releases might create potential for river channel scour.	All, except WS1A	Requires further analysis.
Water Quality	Scour and sedimentation from the Delevan Pipeline could increase downstream turbidity and sedimentation.	All, except WS1A	Outlet structure should be engineered to reduce or eliminate scour.
Water Quality	Increase in turbidity and pollutant discharge during gravel mine restoration and replenishment of spawning gravel.	AF1A, AF1B, WSFQ	Comply with conditions of 404, 401, and 1602 permits.
Biological Environment			
Aquatic and Fishery Resources	Potential for losses from impingement or entrainment from Delevan Diversion.	All, except WS1A	State-of-the-art fish screen proposed for Delevan Pipeline to mitigate entrainment.

Summary of Potential Benefits

National Economic Development Account

The P&Gs identify four "accounts" to display the potential effects for the evaluation of alternatives (National Economic Development [NED], Regional Economic Development [RED], Environmental Quality [EQ], and Other Social Effects [OSE]). Tables A-36 and A-37 provide a

preliminary analysis of annual NED benefits by initial alternative and annual NED benefits and annual costs by initial alternative, respectively.

Table A-36. Annual NED Benefits by Initial Alternatives

Annual Benefit	Initial Alternatives (Preliminary, 2007 $ Million) [a]							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Water Supply								
Agricultural	10.22	9.57	10.64	6.10	5.94	5.85	8.18	9.39
Urban [b]	50.07	74.38	73.52	38.12	42.55	94.41	46.75	76.65
Other Urban [c]	8.26	17.25	17.68	6.46	6.46	20.72	11.04	15.48
EWA	13.19	13.94	14.36	7.19	7.27	8.72	5.95	6.71
Refuges	12.64	12.21	12.28	5.27	5.15	7.68	6.78	7.88
Total	94.38	127.35	128.48	63.14	67.37	137.38	78.70	116.11
Water Quality								
Urban	8.44	10.61	12.34	8.01	7.71	22.05	16.36	20.53
Other Urban	1.00	1.80	2.17	1.01	0.87	3.60	2.85	3.08
Fisheries Restoration and Enhancement								
Upstream	2.55	6.95	6.67	18.04	18.47	11.58	9.44	8.16
Delta	12.20	17.75	18.62	14.92	15.93	52.36	38.03	43.52
Recreation	17.01	16.79	16.49	17.34	17.13	17.81	14.54	17.34
Hydropower	-22.47	-29.29	-29.83	-14.77	-16.68	-29.93	-15.50	-25.54
Total	113.11	151.96	154.94	107.69	110.80	214.85	144.42	183.20

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility-level costs are currently under development.
[b] Urban – Urban water users in the South Coast and South Bay hydrologic regions.
[c] Other Urban – Urban water users in the Central Coast and interior Southern California outside of South Coast and South Bay.
EWA = Environmental Water Account
NED = National Economic Development
PFR = Plan Formulation Report

Table A-37. Annual NED Benefits and Annual Costs by Initial Alternatives [a]

Measure	Initial Alternatives (Preliminary $ Millions)							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Annual Benefits	113.11	151.96	154.94	107.69	110.80	214.85	144.42	183.20
Annual Costs	134.20	183.00	188.10	184.10	189.30	189.00	166.10	188.10
Net Benefits (Benefits – Costs)	-21.09	-31.04	-33.16	-76.41	-78.50	+25.85	-21.68	-4.90

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility-level costs are currently under development.
NED = National Economic Development

Total annual benefits are greatest for Alternative WSFQ, and least for Alternative AF1A. Water supply benefits are higher than those for any other project purpose for all initial alternatives; with Alternative WSFQ the highest at $137 million, and Alternative AF1A the lowest at $63 million.

Table A-37 shows a preliminary comparison of annual NED values for the initial alternatives. Alternative WSFQ provides the largest net benefits. Net benefits are negative for the remaining alternatives. Additional investigation is required to provide more rigorous quantification of the physical benefits and economic values. Some of the ecosystem restoration and water quality benefits have not been quantified. Additional development of analytical tools and methodologies is currently under way to more fully quantify both the ecosystem restoration and water quality economic benefits.

Regional Economic Development Account

RED impacts can be determined at both the California and regional levels. With additional water supply, the value of agricultural output increases, because the NODOS/Sites Reservoir Project would increase supplies of project water and reduce crop idling for water transfers to environmental and urban water users. RED impacts will be developed further in the next stage of the feasibility studies.

Environmental Quality Account

Assessment of ecosystem restoration benefits is a complex analysis that puts a financial value on the benefits derived from protecting and enhancing aquatic and terrestrial species and their habitat. Although it may be comparatively easy to quantify the direct costs associated with many ecosystem actions, evaluating the benefits derived by society is not a simple matter.

Table A-38 provides a summary of potential EQ benefits. The aquatic resources analysis found that all of the water supply and water quality alternatives would have a slight beneficial effect on anadromous fish runs.

The anadromous fish alternatives (AF1A and AF1B) would have more of a beneficial effect on anadromous fish runs in the upstream (Sacramento River) area, but these alternatives provide less water supply for Delta outflow than some other alternatives. For every alternative, it was assumed that 100 TAF/year of the upstream fisheries water supply would be required to offset the effects of upstream project operations. For the anadromous fish alternatives, approximately 125 TAF/year more are provided for upstream flow, but only 73 to 76 TAF/year are provided for Delta outflow. For alternatives other than the anadromous fish alternatives, only 17 to 76 TAF/year above the offset are provided for upstream flow, but anywhere from 74 to 170 TAF/year are provided for Delta outflow.

There is a degree of uncertainty about the fisheries restoration benefits. Only some of the physical effects of the project have been measured. It is likely that some of the physical effects would be negative for some anadromous fish runs. Furthermore, some assumptions for the No Project Alternative are not clear at this time, and the selection of these assumptions could have large effects on the benefits estimates.

Table A-38. Summary of Potential Environmental Quality Benefits

Resource Area	Potential Impact Description	Applicable Plans
Physical Environment		
Geomorphology, Sedimentation, and Erosion	Reduce erosion in lower Sacramento River associated with reducing peak flood flows.	All
Water Quality	Improve water quality in lower Sacramento and Delta.	All
Water Quality	Improve water quality in Extended Study Area.	All
Biological Environment		
Aquatic and Fishery Resources	Improve coldwater carry-over storage at Shasta Dam.	All
Aquatic and Fishery Resources	Provide supplemental flows for coldwater releases between Keswick and RBDD.	All
Aquatic and Fishery Resources	Reduce diversions at RBDD into T-C Canal and at GCID Canal from July through September.	All
Aquatic and Fishery Resources	Stabilize fall flows from Keswick to RBDD to avoid abrupt reductions, assuming November 1997 AFRP flow targets.	WSFQ
Aquatic and Fishery Resources	Stabilize fall flows from Keswick to RBDD with 6,000 cfs target from October through January, and 4,500 cfs for September.	WS1B, WS1C, WQ1A, WQ1B, AF1A, AF1B
Aquatic and Fishery Resources	Improve coldwater carryover storage at Folsom Lake and stabilize flows in American River.	All
Aquatic and Fishery Resources	Modify spring flows into snowmelt pattern with peak storm in late winter and early spring from RBDD to Colusa, to benefit cottonwoods.	All
Aquatic and Fishery Resources	Provide flow event supplementing normal flows from Shasta and Keswick in March, when no winter flow event has occurred.	AF1A, AF1B
Aquatic and Fishery Resources	Provide a March Delta outflow from late winter through early spring peak inflow from the Sacramento River.	AF1A, AF1B
Aquatic and Fishery Resources	Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years.	AF1A, AF1B
Aquatic and Fishery Resources	Improve water temperature in the Sacramento River in compliance with NMFS temperature criterion of 56°F.	AF1A, AF1B, WSFQ
Aquatic and Fishery Resources	Create new warm-water fish habitat in Sites Reservoir.	All
Aquatic and Fishery Resources	Fish enhancements (abandoned gravel mine restoration, instream aquatic habitat improvement, replenishing spawning gravel, and improving fish habitat in main stem Sacramento).	AF1A, AF1B, WSFQ
Wildlife	Contribute to incremental Level 4 water supply, benefiting wildlife refuges.	All

AFRP = Anadromous Fish Restoration Program
cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
NMFS = National Marine Fisheries Service
RBDD = Red Bluff Diversion Dam
T-C = Tehama-Colusa
°F = degrees Fahrenheit

Following is a set of restoration actions focused on Delta species and ecosystem processes that may be supported with water from Sites Reservoir. These actions are derived from multiple sources, including the CALFED ERP and Delta Regional Ecosystem Restoration Implementation Plan, the Delta Vision Delta Ecosystem Restoration Plan, and DWR's Pelagic Fish Action Plan. Many of these actions are also considered in the Resources Agency's Bay Delta Conservation Plan. The Action 1 objective, described hereafter, is supported in all of the initial alternatives, using the water quality objective described previously. In current formulations, water from the restoration account is not used to achieve this objective, even though there is an apparent ecosystem restoration benefit. As the feasibility studies progress, additional exploration of these Delta restoration actions may be warranted, and these actions may be included explicitly in NODOS/Sites Reservoir Project restoration account actions as part of an alternative plan.

1. **Maintain X2 West of Collinsville from May through December (Summer/Fall)**. An increase in Delta outflow, by maintaining an X2 position at 80 km from May to December, would increase Delta smelt habitat and may reduce entrainment and improve food availability. Water from the NODOS project could support this action directly.
2. **Provide Flows through Yolo Bypass into Cache Slough (summer)**. Flows in Yolo Bypass currently flow upstream in summer to meet several user needs in the Bypass. Maintaining positive flow would provide downstream transport of high food web productivity associated with the Yolo Bypass into the Delta. Water from the NODOS project could be provided to the Yolo Bypass from the ERA using a number of optional infrastructure and water delivery changes. Infrastructure and/or operational modifications would be required to provide summertime deliveries using Knights Landing Ridge Cut, Fremont Weir, or Sacramento Weir. In addition, it is likely that fish passage from the Yolo Bypass to the Sacramento River would require improvement with additional infrastructure. Another option is to exchange water with Yolo or Solano County users, and allow additional flow from Cache and Putah Creeks to flow through the Yolo Bypass. Under these options, deliveries would be made from the NODOS project by extending the T-C Canal.
3. **Manage Flooding in North Delta for Seasonal Floodplain Habitat**. These actions would increase the area and time of inundation in the Yolo Bypass and the Cosumnes River floodplain to increase plankton production to support juvenile, adult, and egg production of Delta smelt. The NODOS/Sites Reservoir Project could contribute to an action associated with the Yolo Bypass. This action probably would require infrastructure and/or operational modifications to allow additional water into the Yolo Bypass; the concept also may require land-use modifications.
4. **Relocate North Bay Aqueduct (NBA) Intake on Barker Slough and Relocate Large Local Agricultural Intakes**. These two intake relocation actions would shift net flow downstream and mitigate drinking water dissolved organic carbon issues. These actions would be part of a larger effort to restore the tidal marsh in the Cache Slough complex. The NODOS/Sites Reservoir Project could provide alternative intake locations with a reliable Delta-independent diversion for the NBA contractors and agricultural users. One option is to extend the T-C Canal to the NBA pipeline. Another option is to provide exchange water to Solano agricultural Putah Creek users, and then use Solano Project water as a replacement for NBA users.

5. **Yolo Bypass Enhancements**. Actions include: (1) add operable structure to Fremont Weir to allow lower Sacramento River flows into the Bypass; (2) enhance fish passage through Fremont Weir for multiple species (salmon, steelhead, sturgeon); (3) enhance Lower Putah Creek local floodplain; (4) enhance connectivity, fish passage, and agricultural access along toe drain/Lisbon Weir; (5) update fish ladder at Fremont Weir; and (6) provide localized floodplain enhancement, such as along toe drain.

   These actions will provide: (1) increased inundation frequency to yearly or biannual; (2) improved quality and availability of juvenile salmonid rearing habitat; (3) improved quality and availability of splittail spawning and rearing habitat; (4) improved primary production exports to lower Sacramento River/west Delta; (5) improved salmon and splittail access to Putah Creek; (6) improved fish passage at Fremont weir; and (7) improved migratory and resident bird habitats.

   Ongoing discussions regarding restoration in the Yolo Bypass indicate a strong connection between infrastructure and water supply. A new and reliable supply dedicated to users in the Yolo Bypass may help facilitate an implementation plan. If additional reliable water were available in the Yolo Bypass, water could be delivered to Bypass water users, and thereby make the tidal Lisbon Weir (which is a fish barrier) unnecessary. A check dam near the Putah Creek confluence with the toe drain also could be operated in a more fish-friendly way if sufficient water supply were made available to users currently dependent on the dam.

6. **Increase Spring Delta Outflows**. An increase in total Delta outflow during the February–to-June period in "below normal," "dry," and "critically dry" water years would create low-salinity habitat (i.e., 1 to 3 parts per thousand salinity) in Suisun Bay. The action would increase the amount of low-salinity open-water habitat; facilitate downstream transport of sediment, nutrients, prey, and anadromous and estuarine juvenile fish; and promote improved abundance and survival of multiple fish and aquatic invertebrate species. The NODOS/Sites Reservoir Project could support these supplemental outflows directly.

7. **Experiment with Targeted Salinity Intrusions to Control Invasive Species and Promote Fish Populations**. This action is designed to test the effectiveness of promoting conditions that support desirable aquatic species, such as Delta smelt, and control Brazilian waterweed, water hyacinth, and Asian clam. The NODOS/Sites Reservoir Project could support experimental flow strategies, as described here. The restoration account could support experimental flow strategies in many locations (especially below the CVP and SWP reservoirs) in the Bay-Delta watershed.

Other Social Effects Account

Table A-39 summarizes potential positive OSE. Potential OSE also include the following:

- Temporary construction-related benefits might derive to local communities, with limited opportunities for long-term, operation-related employment.
- There could be potential short-term adverse effects for those directly affected by construction.
- Storage in Sites Reservoir would provide ancillary benefits in flood-damage reduction.

- More than 14,000 acres of land would have to be acquired for Sites Reservoir and proposed facilities; relocation of affected people and property would be required.
- Potential impacts to instream aquatic habitats must be identified and assessed collaboratively with the Federally recognized tribes and Bureau of Indian Affairs.

Table A-39. Summary of Potential OSE Benefits

Resource Area	Potential Impact Description	Applicable Plans
Socioeconomic Environment		
Environmental Justice	No disproportionate impacts to disadvantaged groups were identified for any alternative.	
Land Use		
Land Use	Conversion of natural and irrigated grassland and pasture into Sites Reservoir.	All
Recreation and Public Access	Increased recreation opportunities from new reservoir, including 1,350 acres of shoreline lands.	All
Water Supply	Long-term increases in CVP and SWP water supply reliability.	All
Power and Energy	Increased contribution to the power grid during on-peak demand from new hydropower generation facilities.	All

CVP = Central Valley Project
OSE = Other Social Effects
SWP = State Water Project

Summary of Comparisons of Initial Alternatives and Conclusions

Table A-40 summarizes the evaluation of the plans with respect to the four criteria. Each plan is complete and effective in addressing the NODOS feasibility studies planning objectives and constraints. Additional investigation is required to provide more rigorous quantification of the physical benefits and economic values.

Table A-40 presents a qualitative comparison and ranking of alternative plans that uses the criteria of completeness, effectiveness, efficiency, and acceptability. This preliminary comparison ranks alternative plans WSFQ and WQ1B higher than the other plans. Alternative WSFQ has a benefit-to-cost ratio greater than 1 and also offers the greatest total benefits of any of the initial action alternatives considered.

Alternative WQ1B has costs that are only slightly greater than benefits. This alternative merits additional investigation to better define the design, costs, and benefits. This analysis would include additional characterization of ecosystem benefits to the Delta, and water quality benefits to agriculture south of the Delta.

Alternative WS1A is ranked third among the alternative plans when comparing benefits to costs. It has the third-highest benefit-to-cost ratio. This plan’s benefit-to-cost ratio could change substantially if the reservoir size were optimized. This alternative is also the least expensive of the alternatives considered.

Table A-40. Summary Comparison of Initial Alternatives

Alternative	Comparison Criteria for Completeness	Comparison Criteria for Effectiveness	Comparison Criteria for Efficiency	Comparison Criteria for Acceptability	Relative Ranking
No Project Alternative	Addresses none of the planning objectives. Reliability is very low under dry conditions.	Does not address any of the primary objectives.	By taking no action, problems and needs will continue to increase, resulting in either more costly actions or water supply shortages.	Does not address any of the CALFED goals.	
Relative Rank	*Very Low*	*None*	*None*	*Very Low*	*Very Low*
WS1A	Addresses all objectives, but reliability is low for all objectives under dry conditions. OM&R requirements are simplified by the absence of the Delevan Pipeline.	Modeling results demonstrate the absence of the Delevan Pipeline diversion would substantially reduce water supply under dry conditions. Provides moderate improvement in Delta water quality. and an overall low benefit to anadromous fish and aquatic resources. Provides low hydropower benefit. Reservoir benefits recreation because it is typically full. Absence of Delevan Pipeline eliminates direct ability to provide emergency flushing flows.	Impacts are short-term and can be mitigated. Annual benefits are moderate ($113 million). Has lowest construction cost of any alternative, but a negative net benefit (-$21 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Low*	*Low*	*Moderate*	*Moderate*	*Moderate*
WS1B	Addresses all objectives. Has high reliability for water supply, moderate reliability for supporting anadromous fish, and low reliability for Delta water quality improvements.	Highly effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality, and an overall low benefit to anadromous fish and aquatic resources. Provides low hydropower and recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has highest annual benefits ($152 million). Has moderate construction cost and negative net benefit (-$31 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*Moderate*[a]
WS1C	Addresses all objectives. Has high reliability for water supply, moderate reliability for supporting anadromous fish, and low reliability for Delta water quality improvements.	Highly effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality, and an overall low benefit to anadromous fish and aquatic resources. Provides low hydropower and recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has moderate annual benefits ($155 million). Has moderate construction cost and negative net benefit (-$33 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*Moderate*
AF1A	Addresses all objectives. Has high reliability for supporting anadromous fish, and moderate reliability for water supply and Delta water quality improvements.	Moderately effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality, and an overall high benefit to anadromous fish and aquatic resources. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has lowest annual benefits ($108 million). Has moderate construction cost and negative net benefit (-$76 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Low*	*Moderate*	*Moderate*[a]
AF1B	Addresses all objectives. Has high reliability for supporting anadromous fish, and moderate reliability for water supply and Delta water quality improvements.	Moderately effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality, and an overall high benefit to anadromous fish and aquatic resources. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has lower annual benefits ($111 million). Has moderate construction cost and negative net benefit (-$78 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Low*	*Moderate*	*Moderate*
WSFQ	Addresses all objectives. Has high reliability for water supply and water quality improvements. Reliability is moderate for supporting anadromous fish.	Highly effective in improving water supply and water supply reliability. Provides high improvement in Delta water quality. Has an overall high benefit to anadromous fish and aquatic resources. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has high annual benefits ($214 million). Has moderate construction cost and positive net benefit ($26 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*High*	*High*	*High*	*Moderate*	*High*

Alternative	Comparison Criteria for Completeness	Comparison Criteria for Effectiveness	Comparison Criteria for Efficiency	Comparison Criteria for Acceptability	Relative Ranking
WQ1A	Addresses all objectives. Has high reliability for Delta water quality improvement, and moderate reliability for water supply and supporting anadromous fish.	Moderately effective in improving water supply and water supply reliability. Provides great improvement in Delta water quality. Has an overall low benefit to anadromous fish and aquatic resources in the Sacramento River, but more significant benefit to Delta habitat. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has lower annual benefits ($144 million). Has moderate construction cost and negative net benefit (-$22 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*Moderate*
WQ1B	Addresses all objectives. Has high reliability for Delta water quality improvement and water supply, and moderate reliability for supporting anadromous fish.	Highly effective in improving water supply and water supply reliability. Provides high improvement in Delta water quality. Has an overall low benefit to anadromous fish and aquatic resources in the Sacramento River, but higher benefit to Delta habitat. Provides low hydropower and recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has second-highest annual benefits ($183 million). Has moderate construction cost and a slightly negative net benefit (-$5 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*High*	*High*	*Moderate*	*Moderate*	*Moderate to High*

The ongoing feasibility studies consider combining features from the initial alternatives to enhance completeness and improve net benefits. Particular emphasis will be placed on combining alternatives (e.g., WS1B and AF1A) to maximize benefits to both water supply and the survivability of anadromous fish and other aquatic species.

CALFED = CALFED Bay-Delta Program
OM&R = operation, maintenance, and replacement

A.10 Final Alternatives and Sites Reservoir Facility Siting Considerations

Chapter 6, Alternative Development, and Chapter 7, Alternative Evaluation, of the main text provide descriptions of the final alternatives that were developed and evaluated based on the findings from the initial alternative evaluations. Four final alternatives were developed.

- No Action Alternative – The No Action Alternative considers the future conditions of the Study Area and the future level of demand for water in 2025 if an action alternative is not implemented.
- Alternative A – Alternative A is a 1.3 MAF reservoir with a new intake (2,000 cfs) on the Sacramento River (Delevan Intake) that would be operated primarily for Delta export.
- Alternative B – Alternative B is a 1.8 MAF reservoir without a new intake on the Sacramento River that would be operated primarily for Delta export.
- Alternative C – Alternative C is a 1.8 MAF reservoir with a new intake (2,000 cfs) on the Sacramento River (Delevan Intake) that would be operated primarily for Delta export.
- Alternative D – Alternative D is a Locally Preferred Alternative developed by the Sites Project Authority. This alternative includes a 1.8 MAF reservoir with a new intake (2,000 cfs) on the Sacramento River (Delevan Intake). Approximately half of the water provided for water supply would be for agencies within the Sacramento River Valley. Approximately half of the water would be exported.

The development of Alternatives A, B, C, and D included additional engineering evaluation of the size and alignment of several key facilities. This section summarizes the findings from those evaluations.

Terminal Regulating Reservoir Alternative Evaluation

DWR performed a limited engineering evaluation of alternative locations and configurations for the TRR (see *Sacramento River Terminal Regulating Reservoir and Sites Reservoir Pumping/ Generating Plants and Funks Reservoir Modification* [DWR 2010]). The latest plan (DWR 2014a) proposed to locate a 2,000 AF TRR in the vicinity of Lenahan Road and McDermott Road, upstream of the Funks Check Structure on the GCID Canal. The 2,000 AF capacity for the reservoir was selected based on a preliminary evaluation of various operational scenarios involving the GCID Canal, the Main GCID Canal Pump Station on the Sacramento River, and the TRR Pump Station. In summary, the evaluation allocated approximately 50 percent of the capacity (1,000 AF) to GCID for regulation of canal flows after the construction of Sites Reservoir; and the remaining 50 percent (1,000 AF) would be available to continue pumping from the TRR for a period of 8 hours following a shutdown of the GCID Canal or Main Pump Station on the Sacramento River. The evaluation of TRR storage is presented in Section 4.0 of *Engineering Feasibility Report on Modification to Glenn-Colusa Irrigation District Fish Screen and Enlargement of Main Canal* (CH2M Hill 2003).

The topography in the area and the assumed depth to groundwater indicate that approximately 200 acres of land would be required for a 2,000 AF pond and the facilities constituting the TRR. The key features of the pond proposed by DWR would include the following:

- Combination of cutting below grade and embankment filling around the perimeter of the pond to provide the required volume
- Homogeneous and impervious embankment fill (no zoning of materials)
- Inside slopes of 3:1 on the embankment and excavated pond and a 2:1 outside slope on the embankment
- The depth would be approximately 15 feet, which would consist of 2 feet of dead storage, 5 feet of operational storage, 5 feet for emergency storage, and 3 feet of freeboard.
- The wave height in pond would be 3 feet, and there would be 4 feet of freeboard above maximum pond level
- Emergency overflow spillway to Funks Creek; and low-level outlet pipe to Funks Creek to drain the pond
- New gate control structure on the GCID Canal at the entrance to the pond; and a new gate control structure on the GCID Canal downstream of the pond to help regulate water levels and downstream flows

The original design concept did not include a membrane-type liner over the inner pond area, but the cost of such a liner has been included in some of the cost estimates prepared for the facility.

GCID indicated that approximately 200 to 300 AF of storage would be required solely for flow regulation, compared with the 1,000 AF assumed in the previous studies. Further, GCID indicated that leaks and other issues that disrupted canal flows in the past have historically been addressed in 6 to 8 hours without long-term outages. Based on this information, it is assumed that the TRR storage could be reduced to approximately 1,200 AF. This would provide for operational storage, and for up to approximately 8 hours of pumping at TRR Pump Station to Holthouse Reservoir, in the event of a flow interruption in the canal. Under this assumption, pumping would be curtailed in the event of a canal outage lasting more than approximately 8 hours. With a reduced pond capacity, GCID also requested that several pumps be provided in the TRR to aid them in managing their water balance in the canal using their operational storage allocation.

Three alternatives for the TRR sites have been identified and considered (see Figure A-15). Pond size is assumed to be approximately 1,200 AF, as described above.

Alternative 1 TRR North of Funks Creek: This alternative site establishes a 1,200 AF, partially below-grade reservoir along the eastern side of the GCID Canal as part of the water supply, and reliability improvements associated with construction of Sites Reservoir. This alternative incorporates connectivity and regulated transfer between Holthouse Reservoir and the GCID Canal. The North TRR is situated at the triangular area southwest of Lenahan Road and McDermott Road north of the Funks Creek GCID siphon, and bounded on the west by the GCID Canal (in NE quarter of Section 18, Township 17 N, Range 3 W). Connectivity to Holthouse

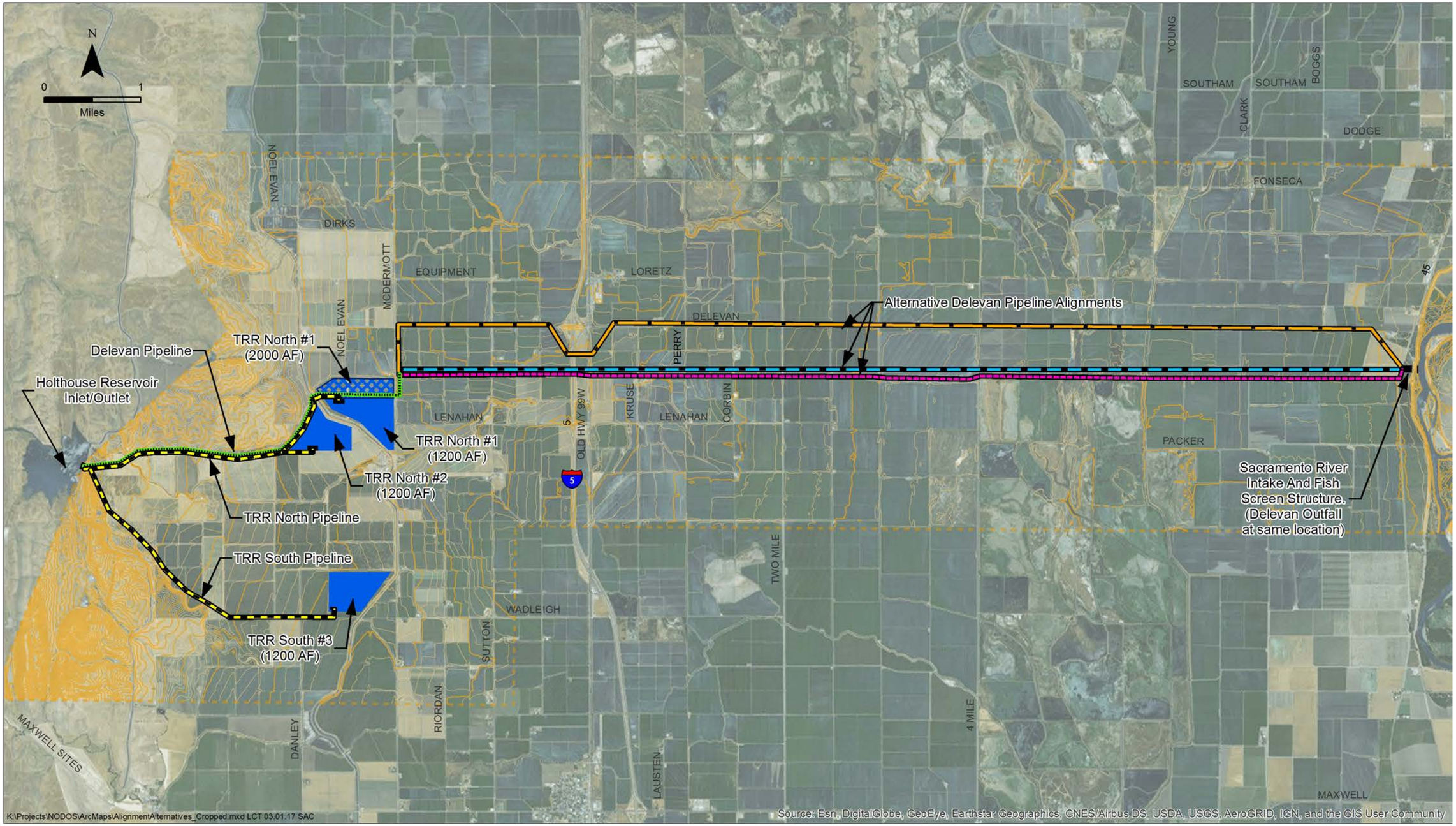

Figure A-15. Alternative Locations for the TRR and Delevan Pipeline Alignments

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Reservoir consists of a new pump station and pipeline from the TRR paralleling the Delevan Pipeline from the GCID Canal, westward to Holthouse Reservoir. Flow can be bi-directional between Funks and TRR. Two 12-foot-diameter pipelines would be required to handle flows. During the irrigation season, flows being released back to TRR could pass through dedicated turbine units in the pump station to generate power.

Alternative 2 TRR North of Funks Creek: This alternative site establishes a 1,200 AF, partially below-grade reservoir along the western side of the GCID Canal as part of the water supply, and reliability improvements associated with construction of Sites Reservoir. This alternative incorporates connectivity and regulated transfer between Holthouse Reservoir and the GCID Canal. This North TRR alternative is located along the northern edge of the Funks Creek floodplain on the western side of the GCID Canal, north of Funks Creek (NE quarter of Section 18, Township 17 N, Range 3 W). Connectivity to Holthouse Reservoir consists of a new pump station and pipeline from the TRR paralleling the Delevan Pipeline from the GCID Canal westward to Holthouse Reservoir. Flow can be bi-directional between Holthouse Reservoir and TRR. Two 12-foot-diameter pipelines would be required to handle flows. During the irrigation season, flows being released back to TRR could be passed through dedicated turbine units in the pump station to generate power.

Alternative 3 TRR South of Funks Creek: This alternative site establishes a 1,200 AF, partially below–grade regulating reservoir on the western side of the GCID Canal, and south of the North TRR site by approximately 1 mile. This site would provide regulated connectivity between the GCID Canal and the Holthouse Reservoir. The South TRR is situated along the western side of the GCID Canal, west of McDermott Road, and approximately 1½ miles south of the intersection of McDermott Road and Lenahan Road (SW quarter of Section 19, Township 17 N, Range 3 W). Connection to Holthouse Reservoir consists of a new pump station and pipeline from TRR, westward to Holthouse Reservoir. Flow can be bi-directional between Funks and TRR. Two 12-foot-diameter pipelines would be required to handle flows. During the irrigation season, flows being released back to TRR would pass through dedicated turbine units in the pump station to generate power.

The pros and cons of the three alternatives are presented in Table A-41. Alternative 2 has significant impacts on local landowners; Alternative 3 has significant impacts on GCID operations and would also require the construction of additional facilities (e.g., enlarged siphon and canal enlargement). Alternative 1 is recommended for evaluation in the EIR/EIS.

Table A-41. Pros and Cons of Alternative TRR Locations

Alternative 1 TRR North of Funks Creek and East of GCID Canal	Alternative 2 TRR North of Funks Creek and West of GCID Canal	Alternative 3 TRR South of Funks Creek and West of GCID Canal
Pros • Direct connection to GCID Canal via gate control structure and short channel. • Adjacent to Delevan Pipeline alignment, allowing for more efficient Delevan and TRR pipeline construction to Funks Reservoir. • Favorable topography for pond construction. • Easier site access from existing roads.	Pros • Direct connection to GCID Canal via gate control structure and short channel. • Favorable topography for pond construction. At-grade site elevation slightly higher than for Alternative 1.	Pros • Direct connection to GCID Canal via gate control structure and short channel. • Favorable topography for pond construction. At-grade site elevation slightly higher than for Alternative 1.
Cons • ROW acquisition concerns. • Likely require the displacement of one resident at the southwestern corner of Lenahan Road and McDermott Road. • Relocation of water supply ditches along McDermott required. • Additional pumps may be required in reservoir GCID Canal regulation.	Cons • ROW acquisition concerns. • Site access requires new access road and possible bridge over GCID Canal. • Close proximity to creek and wetlands along northern side. • Longer transmission line connection to pump station.	Cons • Situated south of GCID Canal siphon undercrossing of Funks Creek. Requires enlarging the siphon for increased capacity to serve the TRR. • Likely requires expansion of GCID Canal between Funks Creek siphon and TRR turnout to accommodate addition 1,800 cfs flow for Sites Reservoir. • Site access requires new access road and possible bridge over GCID Canal. • Requires longer TRR pipeline connection and separate pipeline trench to Holthouse Reservoir. • Longer transmission line connection to pump station.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
ROW = right-of-way
TRR = Terminal Regulating Reservoir

Pipeline Alignment

North and South Alignments: The evaluation of pipeline alignments included an assessment of the preferred location for the inlet/outlet structure. Two locations were considered: one near Golden Gate Dam, and one near Sites Dam. The northern alignment (Golden Gate Dam) offers several advantages:

- Locating the structure north of Funks Creek is necessary because the capacity of the GCID Canal is reduced across the Funks Creek siphon structure. It would be necessary to enlarge the canal to avoid negatively impacting reservoir operations if the intake were located to the south.