Reconnaissance Report

MARCH 1992

YOLO BYPASS, CALIFORNIA

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1. Little Dell Lake, Salt Lake City Streams, Utah, Embankment Criteria and Performance Report, August 1994
2. Caliente Creek Stream Group Investigation California, Draft Feasibility Report, June 1987
3. Fanchier Creek Dam Fresno, California, Embankment Criteria and Performance Report, July 1994
4. Sacramento Metropolitan Area California: Final Feasibility Report and Final Environmental Impact Statement/Final Environmental Impact Report, February 1992
5. Geologic and Seismologic Investigation, Hidden and Buchanan Dams, Hensley Lake and Eastman Lake, Fresno and Chowchilla Rivers, California, December 1988
6. Sacramento River Flood Control Project, California, Mid-Valley Area, Phase III, Design Memorandum, Volumes 1 and 2, August 1995
7. Reconnaissance Report Yolo Bypass, California, March 1992
8. Provo and Vicinity, Utah, General Investigation Reconnaissance Report, April 1997
9. Sacramento-San Joaquin Delta, California, Draft Feasibility Report and Draft Environmental Impact Statement, October 1982

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RECONNAISSANCE REPORT

YOLO BYPASS, CALIFORNIA

March 1992

Department of the Army
Sacramento District, Corps of Engineers
Sacramento, California

SUMMARY

The purpose of this study was to investigate flooding and related water resources problems associated with the Yolo Bypass and determine the Federal interest in proceeding into feasibility phase studies. The study area included lands on the west side of the Yolo Bypass from the Fremont Weir in the north to the vicinity of Liberty Island in the south. The Knights Landing area, west of the bypass, was included because it experiences potential flood impacts from the Yolo Bypass. At the request of Yolo County, the study area also included the Elkhorn Slough area, east of the bypass.

During the flood of 1986, the Yolo Bypass flows approached or exceeded design flows. Although no levee failures occurred in the study area, wave action in the bypass required emergency actions to prevent levee overtopping and continued loss of levee embankment material. Future floods of a greater magnitude or duration could result in levee failures and flooding.

Preliminary alternative plans were developed for five areas: Knights Landing, Elkhorn Slough, Willow Slough Bypass, the unleveed area south of Putah Creek, and the area west of Liberty Island and north of Cache and Haas Sloughs. The objective was to provide the areas with increased levels of flood protection. The plans consisted primarily of raising and strengthening existing levees, providing new cross levees, and constructing a new levee in one area. However, all preliminary alternative plans were eliminated from consideration due to economic reasons, except for plans for the Knights Landing area which appeared more promising. First costs for the eliminated plans ranged from $4,330,000 to $13,740,000, with benefit-to-cost ratios (BCRs) ranging from 0.1 to 0.4.

The three plans for the Knights Landing area and the no action plan were considered as final alternative plans and analyzed in more detail. The Knights Landing area plans consisted of three different alignments to provide flood protection to varying portions of the area. The plans consisted of raising and strengthening existing levees and providing new cross levees if needed. First costs for the alignments were $8,793,000, $5,184,000, and $7,665,000, with BCRs of 0.4, 0.6, and 0.4.

In summary, based upon the reconnaissance level study of costs and benefits for the various levee improvements within the study area, no economically feasible solutions exist. Therefore, there is no Federal interest in proceeding into feasibility phase studies at this time.

RECONNAISSANCE REPORT

YOLO BYPASS, CALIFORNIA

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CHAPTER I - INTRODUCTION

AUTHORITY

This study was conducted under the authority of the Flood Control Act of 1962 (Public Law 87-874). A portion of the act reads as follows:

"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: ... Sacramento River Basin and the streams in northern California draining into the Pacific Ocean for the purposes of developing, where feasible, multi-purpose water resource projects."

Under the authority provided under Public Law 87-874, Congress directed the U.S. Army Corps of Engineers (Corps) in the Conference Report, dated September 7, 1989, (Public Law 101-235) to initiate a reconnaissance study of flood protection for the west side of the Yolo Bypass in Yolo and Solano Counties, California. The study was to evaluate the existing levees and other flood control facilities on the west side of the bypass and adjacent streams, including Cache Creek, Putah Creek and Willow Slough, and suggest appropriate measures to provide a high level of flood protection in the area west of the bypass, particularly near the cities of Woodland and Davis, California.

PURPOSE AND SCOPE

This report is an interim response to the study authority. The purposes of this reconnaissance study were to:

(1) investigate problems and opportunities, and identify potential solutions;

(2) determine whether the study should proceed into a feasibility phase, based on a reconnaissance level appraisal of costs, benefits, and environmental impacts of the potential solutions;

(3) estimate the time and costs needed for the feasibility phase; and

(4) assess the level of interest and support of non-Federal interests in the potential solutions.

The study area includes lands on the west side of the Yolo Bypass from the Fremont Weir in the north to the vicinity of

Liberty Island in the south. The Knights Landing area, west of the bypass, was included, because it experiences potential flood impacts from the Yolo Bypass. At the request of Yolo County the study area also included the Elkhorn Slough area, east of the bypass.

STUDY PARTICIPANTS AND COORDINATION

The study was done at the request of Yolo County. The State of California (State), represented by the Department of Water Resources and The Reclamation Board, also expressed interest in the study. Reclamation District interests in Solano County participated in the study as well. The Corps, Sacramento District, conducted the study. The work included coordination of study efforts with local interests and other agencies, and formulation and evaluation of flood control alternatives.

PRIOR STUDIES AND REPORTS

This investigation was coordinated with other ongoing Corps investigations, including the Sacramento Metropolitan Area Investigation, the American River Watershed Investigation, the Yuba River Basin Investigation, the Sacramento River Flood Control System Evaluation, and the Yolo Basin Wetlands Project. Technical assumptions and results of these studies have been integrated into the Yolo Bypass Reconnaissance Study, as appropriate. Additional prior Corps reports are as follows.

(1) Definite Project Report, Sacramento River Deep Water Ship Channel Project, Sacramento River, California, July 1949

(2) Cache Creek Basin, California, Feasibility Report and Environmental Statement for Water Resources Development, February 1979

(3) Special Study on the Lower American River, California, March 1987

(4) Report on the February 1986 Floods in Northern California and Northwestern Nevada, January 1987

(5) American River Watershed Investigation, California, Feasibility Report and Environmental Impact Statement/Environmental Impact Report, December 1991

(6) Sacramento Metropolitan Area Investigation, California, Feasibility Report and Environmental Impact Statement/Environmental Impact Report, February 1992

(7) Sacramento River Deep Water Ship Channel, California, Supplement No. 1 to the General Design Memorandum of March 1986, May 1988

(8) Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Sacramento Urban Area, May 1988

(9) Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Marysville/Yuba City Area, January 1990

(10) Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Mid-Valley Area, January 1991

CHAPTER II - STUDY AREA DESCRIPTION

EXISTING CONDITIONS

Existing Water Resources Projects

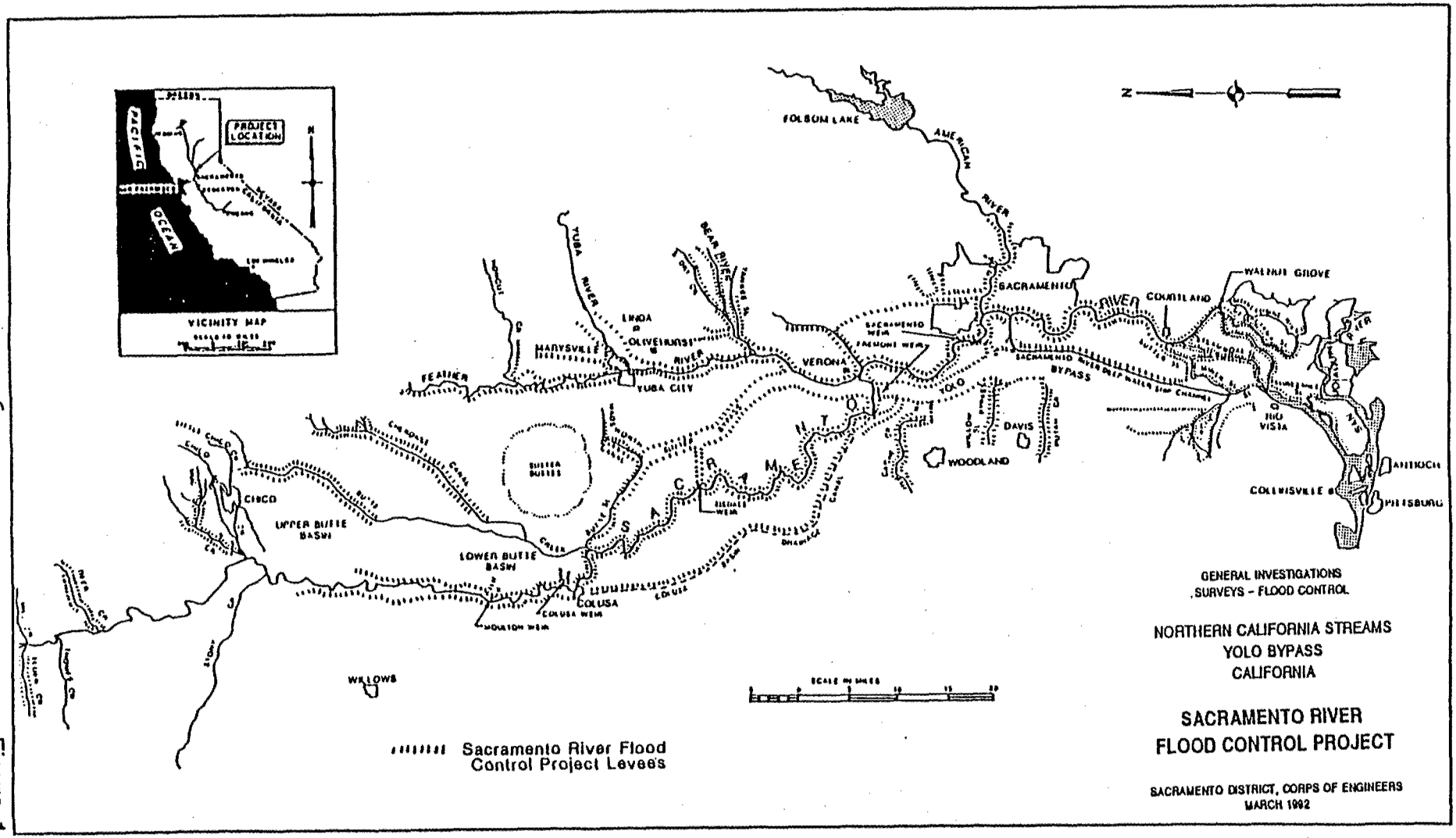
Projects described in this section are completed projects. Projects that have completed portions, but are in part under construction, or projects that are entirely under construction are described in "Related Studies and Projects."

Sacramento River Flood Control Project. - The Sacramento River Flood Control Project was authorized by the Flood Control Act of 1917. Construction began in 1918 on this local cooperation project, sponsored by the State Reclamation Board, and most of the components were completed by 1958. The project consists of a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, overbank floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River.

The flood control project includes approximately 980 miles of levee construction (including 170 miles of levees on the Feather River and tributaries) providing flood protection to about 800,000 acres of agricultural lands; the cities of Colusa, Gridley, Live Oak, Yuba City, Marysville, Sacramento, West Sacramento, Davis, Woodland, Knights Landing, Courtland, Isleton, Rio Vista, and numerous smaller communities; two transcontinental railroads; feeder railroads; and many state and county highways. The project has prevented billions of dollars in flood damage during its history.

The flood control project allows potential flood waters to be contained between levees on various river channels and sloughs, and to be diverted into the Butte Basin and the Sutter and Yolo Bypasses (see Figure 1). Three flood relief structures in the Butte Basin and five weirs located along the Sacramento River accomplish the diversions. Levees along the streams, sloughs, and tributaries provide protection against overbank flooding. Operation and maintenance of the project is the responsibility of the State.

American River Flood Control Project. - The American River Flood Control Project was completed by the Corps in 1958 and is operated and maintained by the State. The project consists of about 7 miles of levee extending from high ground near Carmichael downstream along the north side of the American River to the Sacramento River Flood Control Project levee, ending near the Interstate Business 80 (I-80) crossing. Two pumping plants are part of the project, which pump storm drainage, collecting in low areas landside of the levees, into the river. In conjunction with


PACIFIC
OCEAN
PROJECT LOCATION
VICINITY MAP
FOLSOM LAKE
AMERICAN RIVER
SACRAMENTO
WALNUT GROVE
COURTLAND
RIVER
YUBA RIVER
BEAR RIVER
LINDA
OLIVEHURST
MARYSVILLE
YUBA CITY
FEATHER
VERONA
SACRAMENTO WEIR
FREMONT WEIR
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
YOLO BYPASS
YOLO
DAVIS
WOODLAND
RIO VISTA
ANTIOCH
COLLINSVILLE
PITTSBURG
CHICO
UPPER BUTTE BASIN
LOWER BUTTE BASIN
BUTTE BASIN
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FLOOD CONTROL PROJECT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992
Sacramento River Flood Control Project Levees

Figure 1

Folsom Lake, the leveed section can carry design releases from Folsom Dam of 115,000 cubic feet per second (cfs) for flood control purposes along the river downstream.

Central Valley Project. - The Central Valley Project (CVP) was authorized for construction in 1937. Constructed and operated by the U.S. Bureau of Reclamation (USBR), the CVP is a multi-purpose development that stores and transfers surplus waters primarily from the Sacramento and Trinity River basins to the water-deficient lands of the San Joaquin River and Tulare Lake basins. The main source of CVP project water is Shasta Reservoir, which was completed in 1943. The reservoir stores 4.5 million acre-feet (af) of water, and during the rainflood season, 1.3 million af are reserved for flood control. Regulation and operation of the CVP reservoirs for flood control are established by cooperative agreement between the USBR and the Corps.

Folsom Dam and Reservoir are located on the main stem of the American River 20 miles upstream from Sacramento near the town of Folsom. Construction of the project was completed by the Corps in 1956. After completion, operation and maintenance of the Folsom facilities were transferred to USBR as part of the CVP. The reservoir has a storage capacity of one million af, including 400,000 af of authorized flood control space.

California State Water Project. - In 1959, the State Legislature authorized the construction and operation of the State Water Project (SWP). The SWP facilities are designed to balance California's water resources and water needs. The major feature of the SWP is Oroville Lake, located 4 miles northeast of the city of Oroville on the Feather River. Oroville Dam was completed in 1967 and is the highest earthfill dam in the United States. The dam impounds a 3.5 million-acre-foot reservoir, 750,000 af of which are reserved for flood control. Flood control operations are coordinated with New Bullards Bar Reservoir on the North Fork of the Yuba River according to rules prescribed by the Corps.

Related Studies and Projects

The other related studies and projects are identified and discussed briefly in this section.

Sacramento River Flood Control System Evaluation. - The purposes of this 5-phase study are to evaluate the integrity of and the level of protection provided by the existing Sacramento River Flood Control Project levees, to determine whether or not the levees currently function as designed, and if levee reconstruction is needed, to determine the Federal interest in proceeding with construction. In general, the study objective is to develop reconstruction plans such that the project levees can safely pass the design flow (according to existing Corps criteria and guidance) at the design water surface.

The first two phases of the System Evaluation include the most heavily populated project areas, the Sacramento area and the Marysville/Yuba City area. Construction has begun on Phase I - Sacramento Urban Area and is expected to be completed by late 1992. The advanced engineering and design work has been initiated on Phase II - Marysville/Yuba City Area. Construction is tentatively scheduled to begin in 1994 and be completed by 2000.

The final three phases are evaluating areas in the Mid-Valley, Lower Sacramento (or Delta), and Upper Valley areas. The Mid-Valley area evaluation (Phase III) includes portions of the Yolo and Sutter Bypasses, levees on the Feather and Bear Rivers not considered in Phase II, as well as project levees on Yankee Slough and Dry Creek. The Lower Sacramento area evaluation (Phase IV) includes project levees south of Sacramento and West Sacramento as well as tributaries to the west of the Yolo Bypass including Cache Creek, Willow Slough Bypass, and South Fork Putah Creek. The Upper Valley area evaluation (Phase V) includes the area from Knights Landing north to Red Bluff, including tributaries with authorized flood control project levees such as Elder and Butte Creeks.

Folsom Dam and Reservoir Reoperation. - This special study is evaluating the impacts of temporarily increasing the dedicated flood control space in Folsom Reservoir. Results of the study will be used to decide if and how Folsom Dam and Reservoir will be reoperated on a temporary basis to provide increased flood protection to the Sacramento area until a long-term solution can be implemented. The special study was completed in June 1991, and the decision document and Environmental Impact Statement (EIS) is scheduled for completion in mid-1992.

American River Watershed Investigation. - The objectives of this feasibility study are to define the flood problems in the American River Watershed, including the 55,000-acre Natomas area, and develop alternative plans to resolve these problems. The selected plan includes a 200-year, flood-control-only detention facility located above Auburn and levee raising around the Natomas area. The Feasibility Report and EIS/Environmental Impact Report (EIR) was completed in December 1991, and is under Washington level review.

Sacramento Metropolitan Area Investigation. - The objectives of this feasibility study are to evaluate the need for additional flood protection in the Sacramento Metropolitan area not included in the American River Watershed Investigation and to determine the Federal interest in alternative solutions. The selected plan provides for raising of existing levees around West Sacramento along the east side of the Yolo Bypass and the south side of the Sacramento Bypass of approximately 5.5 feet. This construction work will provide West Sacramento in conjunction with the improvements recommended by the American River Watershed Investigation with approximately 400-year level of flood

protection. The Feasibility Report and EIS/EIR was completed in February 1992, and is under Washington level review.

Yolo Basin Wetlands Project. - This project was authorized by the Water Resources Development Act of 1986, Section 1135(b). The purpose of the project is to restore wetlands within the Yolo Basin area and contribute to a larger program currently being planned by an interagency group of Federal, State, and local agencies and organizations. Corps planning and engineering expertise is being used to create and restore wetlands within, and adjacent to, the Yolo Bypass. Proposed work includes the creation of permanent and seasonal wetlands, riparian forest, and upland grassland habitat. A draft project modification report was completed in February 1992. Three sites, the Putah Creek Sinks site, the Yolo Causeway site, and the Davis site, have been recommended. For the three sites, a total of about 3,700 acres of agricultural and fallow lands would be converted to about 2,300 acres of seasonal wetlands, 700 acres of grassland/upland habitat, 300 acres of riparian woodland, and 400 acres of permanent wetlands.

U.S. Fish and Wildlife Service (USFWS) Putah Creek Management Plan. - The USFWS is preparing a resource management plan for Putah Creek. The study area for the plan is from Monticello Dam eastward to the Putah Creek sinks in the Yolo Bypass. The plan will evaluate the fish and wildlife resources of the creek and make recommendations for their enhancement. The plan will be completed in 1992.

Cache Creek Settling Basin. - This project includes raising the levees surrounding the existing Cache Creek Settling Basin at the entrance to the Yolo Bypass and raising the existing weir. This work will improve the ability of the settling basin to trap sediment, thus substantially reducing sediment deposition in the Yolo Bypass. This project is currently under construction and is scheduled to be completed in 1992.

Sacramento River Bank Protection Project. - The bank protection project provides bank protection works to protect the integrity of the Sacramento River Flood Control Project from erosion damage. Construction consists primarily of rock revetment on banks and levees. Construction is being completed in phases. The first phase, consisting of 430,000 linear feet (LF) of bank protection, was begun in 1963 and completed in 1974. The second phase, consisting of 405,000 LF, began in 1974 and is tentatively scheduled for completion in 1996. A third phase for work beyond 1996 is presently under study. The bank protection project can place bank protection on the flood control project levees in the study area to prevent or correct erosion damage due to floodflows or wind-induced waves.

Sacramento River Deep Water Ship Channel. - The ship channel was completed in 1963; the Sacramento-Yolo Port District is the

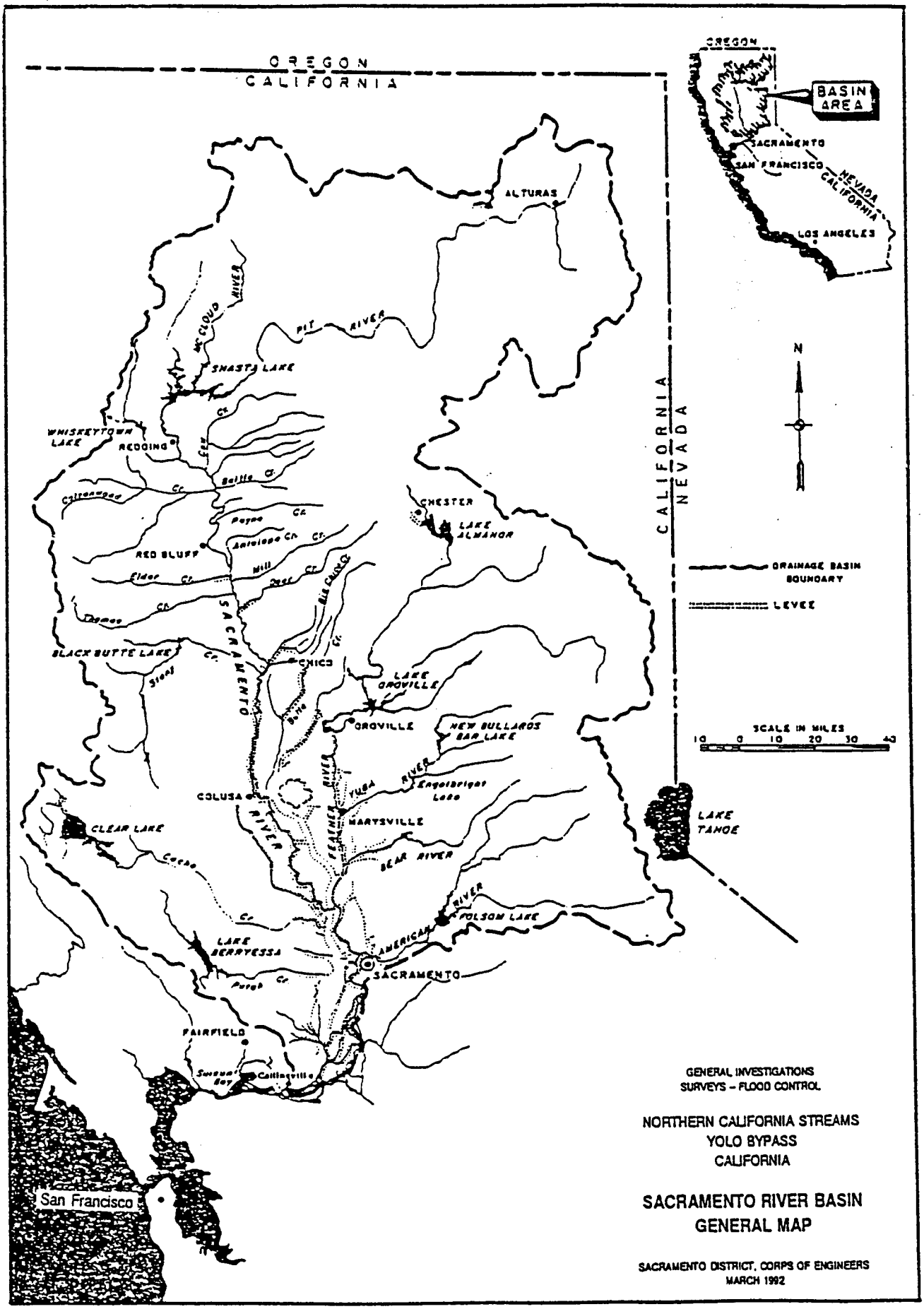
sponsor of this local cooperation navigation project. The 43-mile long 30-foot deep channel was formed by widening and deepening existing channels from Suisun Bay to Rio Vista, and by excavating a new channel from that point to Lake Washington near Sacramento. The project also includes a triangular harbor and turning basin in Lake Washington and a shallow-draft barge canal with a navigation lock between the harbor and the Sacramento River. A project to deepen the channel to a depth of 35 feet is currently under construction and is scheduled to be completed in 1995. The lock is presently in caretaker status.

Environmental Setting and Natural Resources

Study Location. - The study area is within the Sacramento River Basin (Figure 2). It is located within the bounds of the Sacramento River Flood Control Project in Yolo and Solano Counties. The area is about 5 miles west of Sacramento and about 100 miles northeast of San Francisco.

Area Description. - The study area includes the west side of the Yolo Bypass and covers areas within Yolo and Solano Counties (Figure 3). In a north-south direction, the study area covers lands on the west side of the Yolo Bypass from the Fremont Weir in the north to the vicinity of Liberty Island in the south. In the east-west direction, the study area covers from the Yolo Bypass on the east, to lands west of the cities of Davis and Woodland. Watercourses within the area include the Yolo Bypass, Knights Landing Ridge Cut, Cache Creek, Willow Slough, Willow Slough Bypass, Putah Creek, and the South Fork Putah Creek. The Knights Landing area was included because the Yolo Bypass forms the eastern boundary of the area and the bypass influences the Knights Landing Ridge Cut. The Knights Landing area is bounded by the Sacramento River on the north, the Knights Landing Ridge Cut on the south and the Colusa Basin Drain on the west. At the request of Yolo County, the study includes an analysis of the Elkhorn Slough area to the east of the Yolo Bypass and north of the Sacramento Bypass. Portions of Cache and Haas Sloughs were also incorporated since flood control project levees located along these sloughs provide flood protection to the area directly west of Liberty Island.

Function of the Yolo Bypass. - The Yolo Bypass is a major structural feature of the flood control project. The bypass allows potential flood waters from storms in the north central valley to be directed around the major urbanized areas of Sacramento, West Sacramento, Woodland, and Davis. Flood water from the Sacramento River and the Sutter Bypass, including flood water from the Feather River system, is directed into the Yolo Bypass by the Fremont Weir. Flood water from the American and Sacramento Rivers is directed into the bypass by the Sacramento Weir. Flood water from the Colusa Basin is directed into the bypass via the Knights Landing Ridge Cut. Flood water from westside tributaries in Yolo County is directed into the bypass by flood control project levees along


OREGON
CALIFORNIA
BASIN AREA
SACRAMENTO
SAN FRANCISCO
NEVADA
CALIFORNIA
LOS ANGELES
ALTURAS
MC CLOUD RIVER
PIT RIVER
SHASTA LAKE
WHISKEYTOWN LAKE
REDDING
Cottonwood Cr.
Battle Cr.
Paynes Cr.
Antelope Cr.
RED BLUFF
Elder Cr.
Mill Cr.
Deer Cr.
Thomes Cr.
BLACK BUTTE LAKE
Stony Cr.
SACRAMENTO RIVER
ELK CREEK
Cr.
CHICO
Butte
OROVILLE
LAKE OROVILLE
NEW BULLARDS BAR LAKE
YUBA RIVER
Englebright Lake
COLUSA
FEATHER RIVER
MARYSVILLE
CLEAR LAKE
Cache Cr.
BEAR RIVER
AMERICAN RIVER
FOLSOM LAKE
LAKE BERRYESSA
Putah Cr.
SACRAMENTO
FAIRFIELD
Suisun Bay
Calistoga
San Francisco
CHESTER
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DRAINAGE BASIN BOUNDARY
LEVEE
SCALE IN MILES
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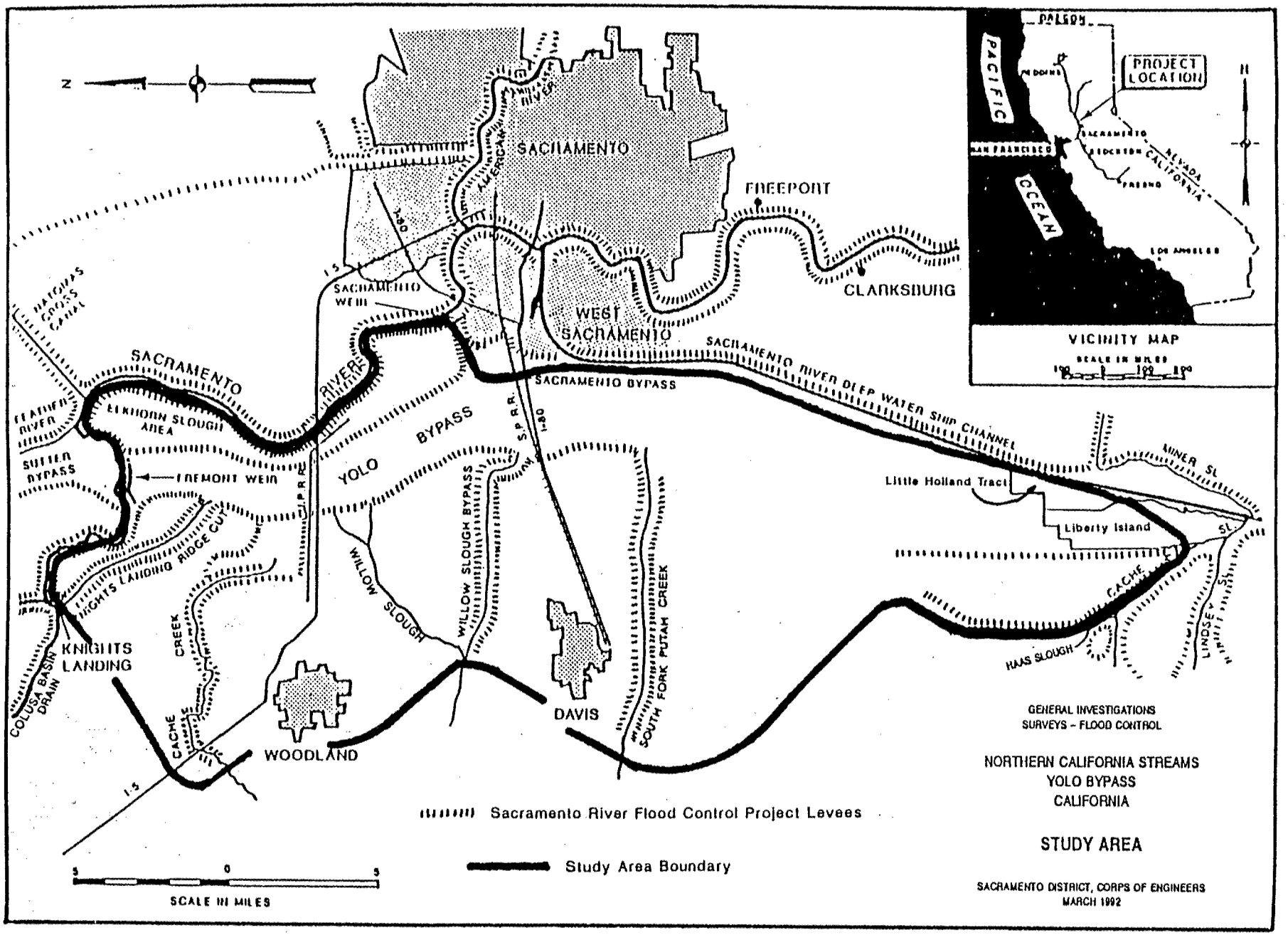
LAKE TAHOE
GENERAL INVESTIGATIONS
SURVEYS – FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS
CALIFORNIA
SACRAMENTO RIVER BASIN
GENERAL MAP
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 2


N
SACRAMENTO
AMERICAN
I-80
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SACRAMENTO WEIR
FREEPORT
CLARKSBURG
WEST SACRAMENTO
HAGGINS GROSS CANAL
SACRAMENTO RIVER
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
YOLO BYPASS
SP R.R.
MINER SL
Little Holland Tract
Liberty Island
SL
CACHE
LINDSEY SL
KNIGHTS LANDING RIDGE CUT
KNIGHTS LANDING
COLUSA BASIN DRAIN
CACHE CREEK
WILLOW SLOUGH
WILLOW SLOUGH BYPASS
SOUTH FORK PUTAH CREEK
DAVIS
WOODLAND
HAAS SLOUGH
PACIFIC
OCEAN
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NEVADA
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Sacramento River Flood Control Project Levees
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MARCH 1992

Figure 3

Cache Creek, Willow Slough Bypass and South Fork Putah Creek. The Yolo Bypass directs the flood water south, eventually emptying the water into the Sacramento River south of the study area.

Geology and Soils. - The study area is geologically part of the Great Valley Geomorphic province of California. The broad valley was filled with erosion debris that originated in the surrounding mountains. Most soils in the area are recent alluvial flood plain soils. They consist of unconsolidated deposits of clay, silt, and sand and occur as flood plain deposits. Fresh alluvium is deposited (particularly within the bypasses) with each floodflow.

Topography. - The Yolo Bypass is generally flat and open with little relief, sloping gradually downward from the Fremont Weir to the Delta. Lands to the west of the bypass rise in elevation above the bypass as one moves to the west, toward the coastal mountain range. The Elkhorn Slough area east of the bypass is also relatively flat. Levees constructed for flood control and land reclamation purposes in the 1800's and 1900's provide barriers to floodflows as well as topographic relief.

Climate. - The Sacramento area has a mediterranean climate characterized by hot, dry summers and mild, rainy winters. Precipitation averages 17 inches per year. Most of this precipitation occurs during the months of November to April. During the summer, daytime temperatures occasionally exceed 100 degrees Fahrenheit. The winter temperatures are mild and rarely drop below 20 degrees Fahrenheit.

Local meteorological conditions result from the topography of the valley. Winds are channelled by the mountain ranges that surround the valley so prevailing winds are from the southwest. Air flow passes from San Pablo Bay to Suisun Bay through the Carquinez Strait, a natural break in the coastal range, bringing cool southerly winds from the ocean in the summer and rainstorms in the winter.

Air Quality. - The study area lies within the Sacramento Valley Air Basin. Federal air quality standards for ozone are being exceeded several times each year. Contributors to the regional ozone problem include motor vehicle emissions, pesticide use and non-highway mobile sources (boats, off-road vehicles and aircraft). Major air pollution problems in the basin also include high concentrations of oxidants and suspended particulate matter. Both pollutants frequently exceed air quality standards. The largest source of oxidants is motor vehicles. The major sources of suspended particulates are the agriculture and lumber industries.

Water Quality. - The overall water quality of the Sacramento River and tributaries is generally good, but the quality varies at specific sites due to the effects of variable streamflows and the

quantity of local waste discharges and irrigation return flows. Higher sediment loads and extensive irrigated agriculture tend to degrade water quality. during the spring and fall, irrigation tailwaters are discharged into drainage canals that flow to the river. In the winter, runoff flows over these same areas. In both instances, flows are highly turbid and introduce herbicides and pesticides into the drainage canals.

Vegetation. - Vegetation in the study area includes various habitat types: mixed riparian forest, riparian scrub/shrub, valley grassland, oak woodland, agricultural land, shaded riverine aquatic, and freshwater marsh.

Riparian forest forms narrow, linear bands adjacent to the Sacramento River, Tule Canal, and various toe drains adjacent to the waterside of the levees. Trees include valley oaks, sycamores, willows and cottonwoods. Undisturbed areas may also have a woody understory consisting of box elder, black walnut, white alder, Oregon ash, elderberry, poison oak, and smaller cottonwoods. California grape, blackberry, and various grasses and forbs are also frequently present. Near the Sacramento Bypass are areas of open water that contain some emergent marsh vegetation. The central part of the Yolo Bypass is farmed, and riparian vegetation is confined to canals and toe drains.

Fish. - Within portions of the study area, the Sacramento River provides important habitat for an abundant and diverse variety of both anadromous and resident species. The Sacramento River supports striped bass, steelhead trout, American shad and four races of chinook salmon. Resident species in the river include catfish, black bass, largemouth bass, black crappie, warmouth, Sacramento squawfish and Sacramento sucker.

When floodflows of the Sacramento River are diverted into the Yolo Bypass and Sacramento Bypass at the weirs, fish species that inhabit the river are diverted into the bypasses. When flows recede, depressions within the bypasses form temporary pools, and fish not flushed out are stranded. Because of the intermittent nature, the bypass areas do not support permanent fish populations. However, the canals and toe drains of the Yolo Bypass do provide year-round habitat for warm water species such as carp and catfish.

Wildlife. - Wildlife species are associated with the type of habitat available for food, cover and nesting. Riparian forest, valley oak woodland and freshwater marsh areas are highly productive wildlife areas. Species found in these areas include house finch, scrub jay, acorn woodpecker, egret, owl, red-tailed hawk, Swainson's hawk, Virginia opossum, gray fox, raccoon, western gray squirrel and muskrat. During the winter months the Yolo Bypass is used by migratory waterfowl and raptors.

The open grassland and riparian scrub areas are used by species that feed on seeds and vegetation. Examples include the California ground squirrel, California vole, California quail and American goldfinch. Vertebrate predators include the gopher snake, red-tailed hawk and striped skunk.

Agricultural fields provide foraging areas for species such as the red-tailed hawk, Brewer's blackbird and black-tailed hare. These species often nest in nearby riparian areas and use agricultural fields and annual grassland for feeding.

Rare, Threatened and Endangered Species. - Three Federally-listed species, one species proposed for Federal listing, and eight Candidate species are described as possibly occurring within the study area. The palmate-bracted bird's beak is the only endangered species listed. Both winter-run chinook salmon and valley elderberry longhorn beetle are listed as threatened. The giant garter snake has been proposed for listing as endangered. The Candidate species are Sacramento splittail, Delta smelt, California tiger salamander, tricolored blackbird, white-faced ibis, Pacific western bigeared bat, Sacramento anthicid beetle, and valley spearscale. Species recognized by the State as endangered, threatened, or rare which may occur in the study area include the giant garter snake, Swainson's hawk, and bank swallow.

Socioeconomic Conditions

With the exceptions of Davis and Woodland, the study area is sparsely populated. The cities of Davis, Woodland and Knights Landing have a combined population of over 80,000.

The study area is serviced by a number of regional and local roadways and railroads. Regional highway access is provided by Interstate 5 (I-5) and I-80. Railroads include the Southern Pacific Railroad (SPRR) and Union Pacific Railroad (UPRR).

Land Use

Land use in the study area is predominantly agricultural. Row and grain crops are grown on much of the land. Urban areas include the cities of Woodland and Davis west of the bypass. The unincorporated town of Knights Landing is at the northwest corner of the study area. These urban areas include residential, commercial, and industrial development. The city of West Sacramento, which is outside the study area, lies east of the bypass. Other developed areas include the Yolo County Landfill and the City of Davis Water Pollution Control Plant, both located north of Willow Slough Bypass. Inside the Yolo Bypass, land use includes farming, cattle grazing, management for wildlife, duck hunting, and management for flood control operations.

Cultural Resources

Although data from elsewhere in western North America suggests substantially longer occupation, data from the study area firmly establishes human presence for only the last 10,000 years.

Anglo-Europeans first visited the study area in the late 1700's. However, it was not until the early part of the 19th century that western culture began to exert a strong and lasting influence on the character of the region: initially as a result of exploration parties, later as a result of trading expeditions, and subsequently as a result of mining activity in the 1800's that led to substantial settlements and agricultural development.

For much of the study area, no archeological sites, surveys or reports are on file with the Northwest Information Center of the California Archeological Inventory, Sonoma State University. For many areas surveyed as part of other Corps projects and other studies, no sites have been recorded. However, records indicate that one archeological site exists in the vicinity of South Fork Putah Creek, 13 archeological sites in the vicinity of the Sacramento River, and two potential historic sites in the southernmost portion of the study area. One site eligible for the National Register of Historic Places and 16 California Historical Landmarks were noted in or close to the study area, but do not appear to be near areas that could be affected by any construction alternatives in this reconnaissance study.

Recreation

Along both the Yolo and Sacramento Bypasses, recreational activities are limited to fishing for warm water resident fish and hunting at private duck hunting clubs. These areas are characterized by flat, agricultural landscapes with manmade modifications including levees and farm equipment. Existing natural vegetation is limited to small, scattered areas along irrigation canals and toe drains.

In portions of the study area, the Sacramento River provides a variety of seasonal and year-round recreation activities, including fishing, boating, water skiing, picnicking, and bird watching. The river supports large runs of anadromous fishes, mainly salmon, striped bass, steelhead trout and American shad. The sport fishery that these runs provide is probably the largest single recreational resource of the river.

FUTURE CONDITIONS

Future conditions in the study area are expected to remain essentially the same. During nonflooding times of the year, the

bypasses will continue to be managed for their current uses. Areas outside the bypasses immediately adjacent to the levees are either mapped by the Federal Emergency Management Agency (FEMA) as being within the 100-year flood plain, the 100- to 500-year flood plain, or are prone to flooding. Proposed future development in the Elkhorn Slough area includes a 224-acre industrial and commercial park adjacent to I-5 (I-5 Metro Project) sponsored by a local developer. The I-5 Metro Project is still in a preliminary planning stage. At present, the area is under a construction moratorium. The moratorium, which allows building to proceed within the 100-year flood plain without flood proofing, ends in November 1992. Development seems unlikely by this date, since a formal draft environmental impact report has not yet been submitted to Yolo County.

CHAPTER III - PROBLEMS AND OPPORTUNITIES

FLOOD PROBLEMS

Historical Flooding

The climate and geography of the North Central Valley combine to produce an area where regular flooding is natural. Prior to levee construction in the 1800's, the Sacramento River channel in the valley area had insufficient capacity to carry the heavy winter and spring flows generated by precipitation and snowmelt. The natural topography of the countryside formed six large flood basins in the valley downstream of about Chico Landing. Once flow exceeded channel capacity, channels overflowed into the surrounding basins, which acted as large detention areas for the flood waters. At the same time, eroded material from the mountain and foothill areas was deposited on the riverbed and valley floor.

Once agricultural development began in the valley, flood problems became apparent. Landowners built private levees to protect specific tracts of land. These levees tended to increase depths of floodwater in other areas, which were further increased by the millions of cubic yards of hydraulic mining debris washed into valley streams between 1853 and 1884. By the end of the 19th century, it was clear that flood protection was needed for the valley.

Flooding during this time was common and widespread. Indian folklore and newspaper accounts mention at least nine major floods prior to 1900. The U.S. Geological Survey (USGS) kept gaged records of discharge during major flooding in March 1907 and January 1909, and the Corps used this information to make estimates of total discharges and flooded areas during these events. The 1907 flood was considered the greatest flood experienced since the flood of 1862, and the design of the Sacramento River Flood Control Project was based primarily on this 1907 flood. Based on high water marks in the upper tributary basins, however, the peak flows of 1862 actually exceeded those of 1907 and 1909 at various locations in the Sacramento River watershed. These estimates also indicated that the 1862 storm had a greater intensity and duration than the two later events.

The losses throughout the valley due to these early floods were large. Rivers everywhere overflowed their banks, and water, mud, sand and gravel swept over unprotected farmland and communities. Dry creeks became raging watercourses that converted lowland areas into shoreless lakes. Until flood waters subsided, transportation, business and farming came to a standstill. Estimated losses in 41 reclamation districts during the flood of January 1909 were over $4.5 million; losses during the March 1907 flood were somewhat larger. It was estimated that losses due to

the floods of 1904, 1907 and 1909 amounted to be at least $11 million.

The Sacramento River Flood Control Project, constructed primarily between 1918 and 1958, allowed potential flood waters to be contained between levees on various river channels and sloughs, and to be diverted into the Butte Basin and Sutter and Yolo Bypasses.

Recent large floods in the Sacramento Valley include those in 1955, 1958, 1964, 1969, 1970, 1974 and 1983, and the flood-of-record in 1986. Damages from those flood events occurred outside the study area when tributaries overflowed their banks, restricted flows backed up, and levees were overtopped and/or failed. Although there were no major flood damages in the study area during these events due to the absence of flood control project levee failures, high water conditions threatened to overtop levees and transportation lines, and eroded and weakened the structure of levee embankments. On-site emergency work, including sandbagging and the laying of plastic sheets, was required to prevent levee overtopping and erosion of levee embankment material due to wind-induced wave action and floodflows.

Flooding has also occurred historically on some westside tributaries of the Yolo Bypass upstream of the flood control project levees. In addition, flooding of the area between the Knights Landing Ridge Cut and Cache Creek occurred in 1940 and 1983 due to overflow from the Colusa Basin.

Flood of Record

Regional Impacts. - The series of storms that struck California in February of 1986 resulted in the flood-of-record for many parts of northern and central California (for records generally dating back to the early 1900's). Record high flows saturated many of the levees of the Sacramento River Flood Control Project, compromising their structural integrity, while winds often drove waves into the tops of the levee embankments. Emergency levee work prevented catastrophic flooding in many places along the Sutter Bypass levees and Yolo Bypass levees. However, in spite of diligent levee patrolling and emergency levee work, there were levee failures in other areas.

Statewide flood damage estimates indicated that 12 deaths were attributed to the February 1986 storm along with 67 injuries. More than 50,000 people were forced from their homes. Property damage included approximately 12,500 houses and 1,000 businesses damaged, and 1,400 houses and 200 businesses destroyed. When the storm was finished, the Governor had proclaimed emergencies in 39 counties and damages totaled more than $500 million.

Study Area Impacts. - The study area is a portion of the Sacramento River Flood Control Project. Many of the northern tributaries to the flood control project had peak flows that were lower than the flow of record during the February 1986 flood event. Upstream of the study area, the Sacramento, Feather and American Rivers had peak flows that indicated 10-year, 80-year and 70-year events, respectively. When these flows and local tributary inflows nearly coincided in the study area, peak flows and stages approached or exceeded the flood control project's design levels.

The weirs and bypasses were built to direct reservoir releases and uncontrolled runoff around main population centers in the Sacramento Valley. Within the study area, the Fremont Weir directs flood waters from the Sacramento and Feather Rivers and the Sutter Bypass to the Yolo Bypass, to avoid the metropolitan areas of Sacramento and West Sacramento. In 1986, the estimated peak flow over the Fremont Weir of 341,000 cfs nearly exceeded the design flow of the weir (343,000 cfs). During large floods, a portion of the American River flow moves upstream from the mouth of the American River along the Sacramento River channel to the Sacramento Weir, where it along with a portion of the Sacramento River flow is diverted into the Yolo Bypass. In 1986, the estimated peak flow over the Sacramento Weir of 128,000 cfs exceeded the design flow of the weir (112,000 cfs).

In 1986, the Sacramento Bypass and Yolo Bypass flows approached or exceeded design flows. Gaging station data for the Sacramento River, Sacramento Bypass and Yolo Bypass indicate record high stages occurred for the 1986 flood event (for records generally dating back to the early 1900's). Based on preliminary information from the Sacramento River Flood Control System Evaluation and using stage-frequency relationships based on current physical conditions, the 1986 water surface elevations (the static water surface elevations plus wind setup) represent about a 60-year recurrence interval on the Sacramento River near Knights Landing, a 100-year recurrence interval on the Sacramento River at Fremont Weir, a 120-year recurrence interval on the Sacramento River near the Natomas Cross Canal, a 50-year recurrence interval on the Sacramento River near Sacramento Bypass, a 100-year recurrence interval on the Sutter Bypass just upstream of the Sacramento River, a 55-year recurrence interval on the Yolo Bypass just downstream of Cache Creek, a 65-year recurrence interval on the Yolo Bypass near Lisbon, a 70-year recurrence interval on the Yolo Bypass at Cache Slough, and a 60-year recurrence interval on Haas Slough at Cache Slough.

Future Flood Threat

Although the February 1986 flood was a major flood event, problems that occurred during that flood indicate that similar or larger floods could produce catastrophic damages and loss of life

in the future. Wave action in the Yolo Bypass during the flood required emergency sandbagging to prevent water from moving over the levee embankment. In addition, emergency efforts were required to prevent continued loss of levee embankment material from wave action. Since wind velocities were not severe during the 1986 event, future floods of similar magnitude, but with severe wind conditions, could compound problems in the study area. Future floods with peak flows identical to the February event, but with longer durations, could also compound problems. The longer durations increase the potential for structural failure because levee embankment material is subjected to pressure flow for longer periods. The longer durations also increase the potential for levee embankment erosion due to flow and wave action. Also, if project levee failure were to occur in the study area, flooding would tend to be rapid rather than gradual. Close to the Yolo Bypass levees and Sacramento River levees, there is the potential for deep flood depths.

RECREATION

Along the Yolo Bypass, recreational activities are limited to fishing for warmwater resident fish and duck hunting. Although demand for recreational facilities is expected to increase in the future as local and regional populations increase, recreational opportunities in the study area are limited due to seasonal flooding of the bypass and limited public access.

In portions of the study area the Sacramento River provides a variety of seasonal and year-round recreation activities, including fishing, boating, water skiing, picnicking, and bird watching. However, public access to the Sacramento River is limited by the amount of public lands and access sites along the river. Wherever it is accessible, the river is heavily used for recreation.

A number of entities including Yolo County, and the cities of Woodland, Davis, and West Sacramento are in the process of developing plans for hiking, biking and equestrian trails. In concept the plans would connect existing trails in Woodland and Davis and develop trails to connect up with West Sacramento and Sacramento. There is additional interest in providing biking access to proposed wetland sites in, and adjacent to, the Yolo Bypass and a proposed wetlands visitor center. Should a plan or plans for flood control be determined to have a Federal interest, recreation elements could be incorporated.

CHAPTER IV - PLAN FORMULATION

PLANNING OBJECTIVE

The primary purpose of the reconnaissance level study was to determine if there is a Federal interest in at least one flood control alternative that would reduce the flood damages in the study area. The objective of this study was to investigate the flood problems within the study area and to develop potential solutions to these problems. The objective was established to address the problems and realize the opportunities identified by the Corps and local interests and to serve as a guideline for the formulation and evaluation of alternative plans.

DEVELOPMENT OF ALTERNATIVE PLANS

Planning Assumptions

Formulation and evaluation of alternative flood control plans were based on the most likely conditions expected to exist in the future with and without a project. The without-project condition was the condition expected to prevail if no action (no Federal participation in a flood control alternative) was taken. The with-project condition was the condition expected to prevail with a proposed project in place.

Period of Analysis. - The period of analysis for this study included the 50-year period from 2000 to 2050, the effective life for alternative plans. In addition, the period of analysis included the time required for project construction. Construction of a project could potentially begin in 1997 and be completed by 2000, the base year. The actual base year would depend on Congressional authorization, funding and other factors.

Without-Project (Base Condition) Assumptions. - The without-project assumptions included the following:

a. Improvements identified in the American River Watershed Investigation and the Sacramento Metropolitan Area Investigation were assumed to be in place. Feasibility reports for the two investigations have been finalized. The likelihood of both projects being authorized is very high, because the areas to be protected have levels of flood protection significantly below 100 years, and both areas are highly developed urban areas.

b. Portions of the levee embankments of the Sacramento River Flood Control Project are assumed to be structurally stable at the existing design water surface elevation. Work proposed in Phases I and II of the Sacramento River Flood Control System Evaluation is considered to be in place. Phase I construction is underway and scheduled for completion in 1992, bringing the levees up to

recommended design standards. Phase II work includes stabilizing levees in the Marysville-Yuba City area. Since Phase II work will ultimately provide increased protection to an urbanized area that would sustain potentially significant flood damages, there is a very high likelihood that this work will be completed.

c. Evaluations for Phases III-V of the Sacramento River Flood Control System Evaluation are currently underway, and the Corps is in the process of preparing the required environmental documentation. Therefore, because of the uncertainties associated with Phases III-V, this work was not assumed to be in place. This meant that current levee height and structural and piping stability problems identified by these evaluations were assumed to exist. Costs for any of the improvements identified to date in Phases III-V were incorporated, if available and as needed, into overall costs for alternatives to provide increased levels of flood protection.

d. Currently, the State has an ongoing maintenance program to remove sediment from the area in the vicinity of the Fremont Weir. Work began in about August 1991 to remove sediment downstream and approximately in the middle of Fremont Weir. Previous work was completed in the spring of 1988. The additional removal of sediment upstream of the Fremont Weir was assumed to be completed by the State. This sediment removal would allow the weir to function at its design crest of 30.5 feet. This allows for more water to enter the Yolo Bypass and less water to move downstream of the weir in the Sacramento River.

e. The Colusa Basin Project, which includes improvements to the Colusa Basin Drain and Knights Landing Ridge Cut levees, was assumed not to be in place. Although the project is currently authorized, a preliminary examination of the Colusa system indicates that work on the Colusa Basin Drain and Knights Landing Ridge Cut levees may not be economically justified independently of work on the west levee of the Sacramento River proposed under the Sacramento River Flood Control System Evaluation. Construction of the project is being delayed pending further studies. It was also assumed that there would be no levee failures upstream of the Knights Landing Ridge Cut on the Colusa Basin Drain for the 100-year event. These assumptions provided an estimate for flow into the Knights Landing Ridge Cut and provided existing levee heights, and structural and piping stability problems for the Knights Landing Ridge Cut.

f. Currently under construction, the Cache Creek Settling Basin Project was assumed to be in place. This project includes improvements to, and raising of, the settling basin levees and weir.

With-Project Condition. - The with-project condition involved the implementation of one or more flood control alternative plans. Each alternative plan would provide an increase in the level of

flood protection. As specified in the authorization, the emphasis was to provide a high level (at least 100-year level) of flood protection.

Flood Control Measures

Possible flood control measures were identified by the Corps and local interests at the onset of, and during, the study. These measures included modifying existing levees, implementing channel work, excavating within the flood bypasses, constructing cross levees, removing flow obstructions, implementing nonstructural measures, and constructing ring levees and flood walls. For one area, constructing a new levee was considered. These measures were evaluated with respect to technical, economic, environmental and local acceptance criteria.

Modify Existing Levees. - The purposes of modifying existing levees were to protect areas on the landside of the levees from flood inundation and to better transport flood water through the flood control project without causing damage. Modifications consisted of insuring structural and piping stability of levees and raising levees to provide required freeboard where needed. This measure was considered further in this report.

Implement Channel Work. - The purpose of this measure was to improve the carrying capacity of channels. Earthwork would be completed and vegetation removed to enlarge flowage areas and improve the carrying capacity of channels. Due to the large flow discharges, large amounts of sediment that would have to be removed, high costs of the sediment removal, adverse environmental impacts, and small effect on the resulting flood stages, this measure was eliminated from further consideration in this report.

Excavate within the Flood Bypasses. - The purpose of this measure was to improve the carrying capacity of the bypasses. Earthwork would be completed to remove sediment to deepen or enlarge the flowage area. Due to the large flow discharges, large amounts of sediment that would have to be removed, high costs of the sediment removal, adverse environmental impacts, and small effect on the resulting flood stages, this measure was eliminated from further consideration in this report.

Construct Cross Levees. - This measure was used in combination with the measure of modifying existing levees. In certain instances, rather than modifying levees around an entire area, cross levees were provided to try and protect smaller areas and obtain a better benefit-to-cost ratio (BCR). This measure was considered further in this report.

Remove Flow Obstructions. - Certain levees within the lower end of the Yolo Bypass may create obstructions to the flow in the bypass. These levees, located at the northern end of Liberty

Island and Little Holland Tract, run east to west, perpendicular to bypass flood flows. Removal of these levees could potentially lower water surface elevations upstream and remove acreage from the 100-year and other frequency flood plains along the western unleveed portion of the Yolo Bypass. However, the necessary hydrologic and hydraulic modeling required to evaluate the levee removal was beyond the scope of the reconnaissance study. Preliminary analysis from an existing hydraulic model, the Dynamic Wave Operational (DWOPER) model, suggested that complete removal of the obstructions would drop the water surface elevation (from existing conditions) in the Yolo Bypass downstream of the I-80 causeway. Additionally, accurate costs could not be developed due to ongoing legal action currently underway to attempt to partially degrade the levees. Because of these reasons, this measure was eliminated as a viable option.

Implement Nonstructural Measures. - Nonstructural measures consisted of floodproofing structures, constructing small ring levees and flood walls, raising structures, and relocating structures. Flood plains for most areas provided deep flood depths at relatively infrequent events and potentially high residual damages, and non-structural measures were considered too costly and were eliminated from further consideration for these areas. For other areas with only a few isolated structures, nonstructural measures were not evaluated. Finally, this measure was initially considered for four groups of structures: a landfill, a water pollution control plant, a transmitter site and a migrant housing center. These were the only groups of structures that appeared to be amenable to this measure in the study area. Each of these groups had a single owner, and based on the most current engineering regulation, Engineering Regulation 1165-2-123, Federal Participation in Proposed Projects in Single-Owner Situations, dated 31 August 1989, there is no Federal interest in nonstructural measures for developments with single beneficiaries. Therefore, nonstructural measures were not considered further in this report.

Construct Ring Levees and Flood Walls. - The purpose of this measure was to minimize damage to groups of structures when modifications to existing levees were not economically feasible. This measure differed from the nonstructural measure, which concentrated on protecting individual structures. Ring levees and flood walls were considered for four groups of structures; a landfill, a water pollution control plant, a transmitter site and a migrant housing center; the only groups of structures that appeared to be amenable to this measure. However, since each of these groups had a single owner, based on the most current engineering regulations (Engineering Regulation 1165-2-123) there was no Federal interest in flood control measures for these developments. Therefore, this measure was not considered further in this report.

Construct New Levees. - The purpose of this measure was to provide flood protection to presently unprotected areas. A new levee was proposed in the unleveed area along the west side of the Yolo Bypass south of Putah Creek. This measure was considered further in this report.

Methodology for Developing and Screening Preliminary Alternative Plans

Based on the measures, preliminary alternative plans were developed. Preliminary alternative plans were developed to provide flood control benefits to five areas. The five areas were the Knights Landing area, the Elkhorn Slough area, the Willow Slough Bypass area, the unleveed portion of the Yolo Bypass south of Putah Creek, and the area west of Liberty Island and north of Cache and Haas Sloughs. The Knights Landing area is bordered by the Sacramento River on the north, the Yolo Bypass on the east, the Knights Landing Ridge Cut on the south and the Colusa Basin Drainage Canal on the west. The Elkhorn Slough area is bordered by the Sacramento River on the north and east, the Sacramento Bypass on the south, and the Yolo Bypass on the west. The Willow Slough Bypass area is the area adjacent to the Willow Slough Bypass and bordered on the east by the Yolo Bypass. The titles of the two remaining areas provide their approximate locations and boundaries.

Preliminary designs and costs were completed for the alternative plans. The BCR for each plan was computed. If the BCR was markedly less than 1.0, the preliminary alternative plan was eliminated from further consideration. If the BCR was greater than, or close to, 1.0, the preliminary alternative plan was carried forward as a final alternative plan and evaluated in more detail.

Technical Studies for Preliminary Alternative Plans

Hydrology. - Hydrology was developed assuming the base condition assumptions listed in the previous section titled "Without-Project (Base Condition) Assumptions." Water surface profiles were determined based on an event with the greatest contribution from the Sacramento River system. In addition, stage-frequency data were used for the Sacramento River and the Yolo Bypass to take into account historic flows. Water surface profiles for the 100-, 200-, and 400-year events were developed for the Yolo Bypass and the Sacramento River. Concurrent flows for the 100-year event were developed for the westside tributaries.

Flood Plains. - Flood plain analyses were completed within flood control project levee reaches only. For this study, levee failure was assumed to occur when the water surface encroached to a point halfway into the design freeboard, or to the 1986 flood profile, whichever was higher. Design freeboard was assumed to be

6 feet for the Yolo Bypass levees and 3 feet for the Sacramento River, the westside tributary levees and the Cache Slough levees. Interior features such as railroad embankments in flooded areas were evaluated individually. USGS 7-1/2 minute quadrangle maps and California Department of Water Resources levee profile data were used for sources of existing topographic data. Additional surveyed cross-sections were available for the Willow Slough Bypass and the Knights Landing Ridge Cut. Information from the Sacramento River Flood Control System Evaluation and the Colusa Basin Project was also used in determining the existence and locations of levee structural and piping stability problems, the frequency of nondamaging events, and the extent of flooding. Hydrologic and flood plain information from the American River Watershed and the Sacramento Metropolitan Area Investigations was also used. Flood plain information is provided in Table 1.

Water surface profile information indicated that a 400-year Yolo Bypass flow and a concurrent 100-year South Fork Putah Creek flow would not encroach into the assumed half of the freeboard for the South Fork Putah Creek levees. Therefore, based on the study assumptions and available data, there was assumed to be no flooding associated with the project levees along South Fork Putah Creek. Because the Cache Creek Settling Basin Project will raise the settling basin weir and levees, no Yolo Bypass flows could enter the settling basin. Therefore, the Yolo Bypass did not affect flows or water surface elevations in Cache Creek. Also, any flooding on Cache Creek would be due solely to the creek and would not be affected by the Yolo Bypass. For these reasons both South Fork Putah Creek and Cache Creek were eliminated from further consideration in this report.

Flood plains were identified for the five areas: the Knights Landing area, the Elkhorn Slough area, the Willow Slough Bypass area, the unleveed area south of Putah Creek, and the area west of Liberty Island and north of Cache and Haas Sloughs (see Figure 4). No flood plains were shown for West Sacramento or areas to the south along the east side of the Yolo Bypass. Levee failure and subsequent flooding in these areas from the Yolo Bypass could not be claimed for the 400-year event, based on the base condition assumptions. These areas were also outside the study area.

Knights Landing Area. - Flooding of the Knights Landing area could occur either by failure of the left bank Knights Landing Ridge Cut (Ridge Cut) levee or failure of the right bank Sacramento River levee. Because of the Ridge Cut's flat slope, flows entering the Ridge Cut were affected by stages in the Yolo Bypass. Once failure occurs, the Knights Landing area would fill to a level flood plain elevation. The worst case flood plain was developed using a 400-year stage in the Yolo Bypass and a 100-year concurrent flow in the Ridge Cut. This flood plain produced an average flood depth of about 7 feet. The nondamaging point was approximately a 40-year event based on preliminary information from the Colusa

Table 1
Flood Plain Data

Area and/or Source of Flooding	Average Depth for 400-year Flood Plain (feet)	Non-damaging Event (years)
Knights Landing	7	40
Elkhorn Slough	14	55
Willow Slough Bypass		
Flooding From Willow Slough Bypass	4-6 1/	20 2/
Flooding From Yolo Bypass	8-12 3/	100 3/
Unleveed Area South of Putah Creek	2	10 4/
Area West of Liberty Island and North of Cache and Haas Sloughs		
Flooding from Outflanking of Levee West of Liberty Island (Yolo Bypass)	< 2	70
Flooding from Haas Slough	9	70

1/ Average depths vary for different ponding areas north and south of Willow Slough Bypass. Depths are for a 100-year event prior to a failure of the Yolo Bypass levee. The average depth of additional areas with overland flow from levee failures was $\leq$ 3 feet.

2/ The non-damaging event was assumed based on upstream flooding. See following paragraph on "Willow Slough Bypass Area."

3/ Depths vary for ponding areas north and south of Willow Slough Bypass and north of South Fork Putah Creek. Failure occurs at events slightly less frequent than the 100-year event. A 100-year nondamaging event was assumed for the analysis.

4/ The 20-year event floods a portion of the area. A 10-year event was used as an estimate of the nondamaging event.

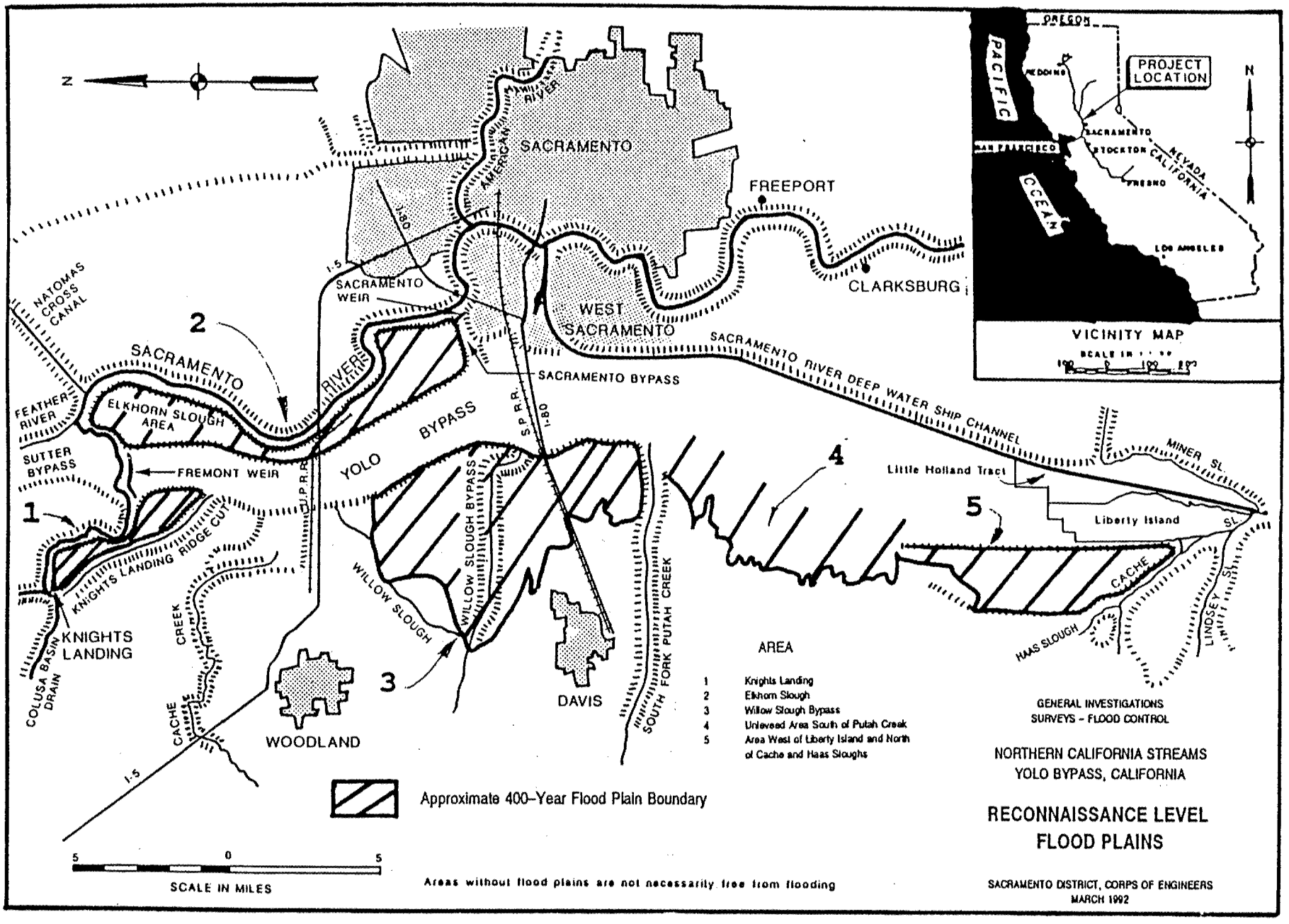

N
SACRAMENTO
AMERICAN RIVER
FREEPORT
CLARKSBURG
I-80
I-5
SACRAMENTO WEIR
NATOMAS CROSS CANAL
2
SACRAMENTO RIVER
WEST SACRAMENTO
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
U.P.R.R.
YOLO BYPASS
S.P.R.R.
MINER SL.
Little Holland Tract
4
5
Liberty Island
SL.
1
KNIGHTS LANDING RIDGE CUT
WILLOW SLOUGH BYPASS
WILLOW SLOUGH
CACHE CREEK
KNIGHTS LANDING
COLUSA BASIN DRAIN
3
DAVIS
SOUTH FORK PUTAH CREEK
CACHE
HAAS SLOUGH
LINDSEY SL.
WOODLAND
I-5
AREA
1 Knights Landing
2 Elkhorn Slough
3 Willow Slough Bypass
4 Unleveed Area South of Putah Creek
5 Area West of Liberty Island and North of Cache and Haas Sloughs
Approximate 400–Year Flood Plain Boundary
5 0 5
SCALE IN MILES
Areas without flood plains are not necessarily free from flooding
OREGON
PACIFIC
PROJECT LOCATION
N
SACRAMENTO
STOCKTON
NEVADA
CALIFORNIA
FRESNO
OCEAN
LOS ANGELES
VICINITY MAP
GENERAL INVESTIGATIONS
SURVEYS – FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
RECONNAISSANCE LEVEL
FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 4

Basin Project and the Sacramento River Flood Control System Evaluation, Phase III. This event failed the levee on the Knights Landing Ridge Cut into the area. (The levee on the Sacramento River side had a nondamaging event with a recurrence interval of about a 60-year event.)

In addition, the area between the Knights Landing Ridge Cut and Cache Creek would flood; this flooding was due to natural overflow from the Colusa Basin Drain. This overflow potentially provided a large volume of water to the area. The right bank levee of the Ridge Cut could also fail, providing some additional flood waters. The left bank levee of Cache Creek could fail, providing some additional flood waters. However, the primary source of flooding appeared to be from the Colusa Basin Drain, which was upstream of the project levees under study. Although flows in the Colusa Basin may be affected by stages in the Yolo Bypass under certain conditions, the area between the Ridge Cut and Cache Creek could be flooded by Colusa Basin flows regardless of the stage in the Yolo Bypass. This flooding was not addressed further in this reconnaissance study and was not shown on Figure 4. Flood water ponding in this area, however, may affect water surface profiles in the Knights Landing Ridge Cut for rare events.

Elkhorn Slough Area. - Flooding of the Elkhorn Slough area could occur either by failure of the left bank Yolo Bypass levee from the west or failure of the right bank Sacramento River levee from the north and east. Once failure occurred, the Elkhorn Slough area also fills to a level flood plain elevation, with average depths of about 14 feet for a 400-year event. The nondamaging point was approximately a 55-year event for a levee failure on the Yolo Bypass, based on preliminary information from the Sacramento River Flood Control System Evaluation, Phase III.

Willow Slough Bypass Area. - This section includes (1) a description of the flood plains in the Willow Slough Bypass area and (2) a discussion of potential flooding between Willow Slough and the Cache Creek Settling Basin.

The Willow Slough Bypass area flood plains were a composite of two different levee failure conditions. Neither condition included portions of urbanized areas. The urbanized areas of Woodland and Davis were both outside of the flood plain.

The first condition involved flooding due to failures along the Willow Slough Bypass levees. Hydrologic information was limited for the watershed affecting Willow Slough Bypass. Flooding has occurred historically along Willow Slough at a frequency of about the 20-year event upstream of the project levees. This frequency was assumed as the nondamaging event for the project levee reach. The slope of the Willow Slough Bypass is relatively flat at the lower end, and stages in the Yolo Bypass affect the water surface elevations in this reach. Flood plains were

generated using a 100-year flow in Willow Slough Bypass and assuming no levee failures for the Yolo Bypass. Levee failures along Willow Slough Bypass occurred upstream of the reach influenced by the Yolo Bypass. For this event average depths for the ponding areas north and south of the Willow Slough Bypass were 4 feet and 6 feet, respectively. Areas with overland flow from levee failures had average depths of $\leq$ 3 feet for less than 3 days.

The second condition involved flooding due to failures along the Yolo Bypass levee. Due to low areas at various locations along the levee, the Yolo Bypass levee fails into the Willow Slough Bypass area in several places with a frequency ranging from a 100- to 200-year nondamaging event. For the analysis a 100-year nondamaging event was used. Flooding from the Yolo Bypass was much deeper and covered a greater area than the flooding from the Willow Slough Bypass. Average flood depths for a 400-year event in the Yolo Bypass for floodwater ponding areas north and south of Willow Slough Bypass and north of South Fork Putah Creek were 12 feet, 8 feet, and 9 feet, respectively.

Based on the without-project assumptions, no potential flooding of the area between Willow Slough and the Cache Creek Settling Basin is shown in Figure 4. No flood damages could be claimed for this area. However, flooding could occur if levee failure occurs along lower Willow Slough or Cache Creek.

Along the lower reach of Willow Slough where it intersects with the Yolo Bypass, there are local levees that are not a part of the Sacramento River Flood Control Project. Based on topographic data from USGS's quadrangle maps and the without-project study assumptions, these levees were assumed not to fail for either of the two flood conditions for the Willow Slough Bypass area. Additional analysis beyond the scope of this study would be required to insure that the structural and piping stabilities and freeboard were adequate to prevent such failure and potential flooding of the lands to the north.

The area between Willow Slough and the Cache Creek Settling Basin may be flooded by levee failures along Cache Creek. An analysis of this flooding condition was also beyond the scope of this study.

Based on the study assumptions and existing operation and maintenance agreements, local interests were assumed to raise localized low areas, flood fight and/or provide closures at road crossings during floods. If local interests are unable to execute these actions in time to prevent Yolo Bypass levee overtopping or failure, flooding of the area between Willow Slough and the settling basin could occur.

Unleveed Area South of Putah Creek. - Flooding occurred in the unleveed area south of Putah Creek and north of the levee running

north to south along the western edge of Liberty Island. This reach of the Yolo Bypass is unleveed. Flood plains were available from the Sacramento Metropolitan Area Investigation. The 20-year event floods a portion of the area. A 10-year event was used as an estimate of the nondamaging event. An average depth for the 400-year event for the western portion of the area was about 2 feet.

Area West of Liberty Island and North of Cache and Haas Sloughs. - Water surface profile information indicated that flows in the Yolo Bypass outflank the levee running north to south along the western edge of Liberty Island. The levee itself did not fail for the 400-year event based on the levee failure criteria and available water surface profile data. Most of the lands to the west of this levee would be flooded due to downstream failures and/or overtopping of other levees and are designated by FEMA as being within the 100-year flood plain.

Flood plains were developed for the area based on levee failures on Haas Slough and the outflanking of the levee along the western edge of Liberty Island. The overwhelming majority of the depth, duration and extent of the resulting flood plain was due to a Haas Slough levee failure. Duration, flood volumes and depths in the area from the overland flow due to outflanking in the north were very small relative to the flooding from Haas Slough in the south. Based on information from the 1986 flood event and preliminary information from the Sacramento River Flood Control System Evaluation, Phase IV, both the Haas Slough levee and the outflanking of the levee west of Liberty Island were estimated to have a nondamaging point of about the 70-year event. The average depth for the 400-year flood plain for the levee failures was 9 feet, and depths were less than 2 feet for the overland flow from the outflanking.

Economics. - Inventories were completed for the Knights Landing, Elkhorn Slough and Willow Slough Bypass areas, and the majority of the area west of Liberty Island and north of Cache and Haas Sloughs. Economic experience and judgement were then used to develop per-acre damages, which were applied to develop estimates for the remaining flood plains.

Flood plain inventories were conducted which identified the location, value, and number of structures within the land use categories, including residential, commercial, industrial, public, and agriculture (see Table 2). For each structure, information was obtained on size (square feet), foundation height, type of construction, and number of floors.

Water surface elevations corresponding to a maximum flood depth based on a 400-year flood event were used to estimate total potential flood damages for each area. The benefit analysis assumed October 1991 price levels, a 50-year project life, an 8-3/4 percent interest rate, and a base year of 2000. Using this

Table 2
Without-Project Damages for Selected Areas 1/
(October 1991 Prices)

Knights Landing Area	
Residential Structures	$ 6,539,000
Farm Buildings	80,000
Commercial Structures	487,000
Industrial Structures	3,625,000
Public Structure	3,623,000
Agriculture	1,855,000
Total	16,209,000
Elkhorn Slough Area	
Residential Structures	$ 1,975,000
Farm Buildings	397,000
Commercial Structures	-
Industrial Structures	238,000
Public Structures	7,356,000
Agriculture	6,367,000
Total	16,333,000
Willow Slough Bypass Area 2/	
Residential Structures	$ 289,000
Farm Buildings	446,000
Commercial Structures	50,000
Industrial Structures	-
Public Structures	1,241,000
Agriculture	5,195,000
Total	7,221,000
Area West of Liberty Island and North of Cache and Haas Sloughs 3/	
Residential Structures	$ 224,000
Farm Buildings	954,000
Commercial Structures	-
Industrial Structures	-
Public Structures	1,867,000
Agriculture	4,700,000
Total	7,745,000

1/ Damages are total damages for the 400-year flood except for the Willow Slough Bypass area. Damages for the Willow Slough Bypass area are total damages for the 100-year flood. Damages include structures and contents. Public damages include public structures and contents, automobiles, traffic disruption, emergency costs, and levee repair.

2/ Damages are from flooding from Willow Slough Bypass only. Damages did not include flooding from the Yolo Bypass.

3/ Based on preliminary information from the Sacramento River Flood Control System Evaluation, Phase IV. The damages are from flooding from Haas Slough levee failures only and do not include outflanking of the north-to-south levee west of Liberty Island.

information, average annual damages were developed for the without-project condition. Levee failure frequencies were provided for each designated area.

Preliminary alternative plans were created to protect portions of the Knights Landing and Elkhorn Slough areas, as well as the entire area. At this point in the plan formulation process, additional detailed economic information was not developed for the Knights Landing area. For the Elkhorn Slough area, preliminary alternative plans included plans that provided a cross levee and only protected partial areas. To facilitate the evaluation of these Elkhorn Slough area plans, damages for the areas on either side of the cross levee were developed. The cross levee alignment was approximately at the existing railroad track alignment just north of I-5.

The estimated maximum possible flood inundation reduction benefits for each of the inventoried areas were developed. The estimates were used as a sensitivity technique to indicate the maximum cost possible for economically feasible levee improvements. For the analysis of the preliminary alternative plans, complete flood protection was assumed to be provided. Zero residual damages were assumed. Therefore, with-project benefits equalled without-project damages. Without-project damages for each of the areas are shown in Table 3.

Damages for the preliminary alternative plan to construct a new levee south of Putah Creek were developed by measuring the area from the edge of the 400-year flood plain to the new levee alignment. This area was assumed to be provided with complete flood protection. Benefits were developed by developing per-acre damages from total maximum damages for a similar adjacent area, the flood plain for the area west of Liberty Island and north of Cache and Haas Sloughs due to the Haas Slough levee failures. Land use and development in both of the areas was about the same. The area of interest and the area flooded by Haas Slough had average depths of 2 feet and 9 feet, respectively. This approach only provided an estimate of potential damages for protection from flood flows in the Yolo Bypass and ignored any residual damages and flood damages due to local drainage from the west.

The flood plain damages for the outflanking of the north to south levee west of Liberty Island were developed in the same manner as the damages for the unleveed area south of Putah Creek. Data for the area flooded by the Haas Slough levee failure were again used. Land use and development in both of the areas was about the same. The outflanking area flood plain had an average depth of less than 2 feet, and the area flooded by Haas Slough had an average depth of 9 feet.

Table 3
Average Annual Economic Data
for Preliminary Alternative Plans
($) 1/

Area	Without-Project Damages
Knights Landing	405,000
Elkhorn Slough	
Entire Area	294,000
Area North of Railroad Tracks	128,000
Area South of Railroad Tracks	166,000
Willow Slough Bypass	534,000
Unleveed Area South of Putah Creek	224,000
Area West of Liberty Island and North of Cache and Haas Sloughs	113,000

1/ The analysis assumed 1 October 1991 price levels, an 8-3/4 percent interest rate, and a 50-year project life. The analysis also assumed that complete flood protection would be provided and that residual damages would be zero.

Description of Preliminary Alternative Plans

Based on the measures, preliminary alternative plans were developed to provide 100-year design level of flood protection. Since the focus of the study was to evaluate flooding problems caused or aggravated by flows in the Yolo Bypass, no new levee construction was considered upstream of the existing project levees along the westside tributaries. Cross levees were considered for the Knights Landing and Elkhorn Slough areas. Cross levees were considered where it appeared economically practical to protect only part of an area. The primary measure considered was modifying existing levees. One new levee was proposed for construction along the unleveed west side of the Yolo Bypass. Figure 5 shows the locations of the preliminary alternative plans. Additional design information is provided in Appendix C: Basis of Design.

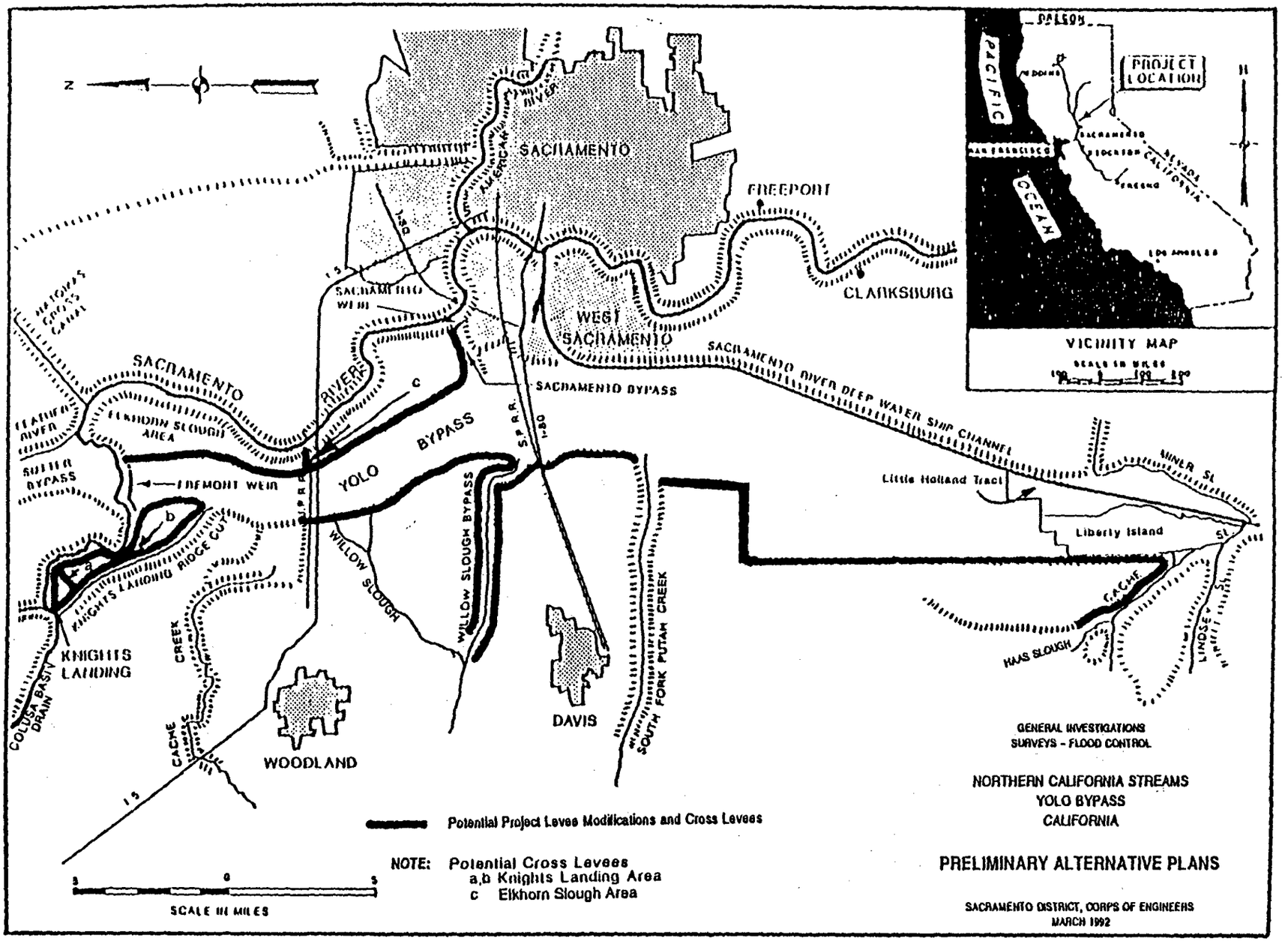

SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO RIVER
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
YOLO BYPASS
FREMONT WEIR
KNIGHTS LANDING
KNIGHTS LANDING RIDGE CUT
WILLOW SLOUGH
WILLOW SLOUGH BYPASS
SOUTH FORK PUTAH CREEK
DAVIS
WOODLAND
COLUSA BASIN DRAIN
CACHE CREEK
CACHE SLOUGH
HASS SLOUGH
LINDSEY SLOUGH
Little Holland Tract
Liberty Island
MINER SL
SUTTER BYPASS
FEATHER RIVER
ELKHORN SLOUGH AREA
NATOMAS CROSS CANAL
AMERICAN RIVER
I-5
I-80
S.P.R.R.
PACIFIC
OCEAN
PROJECT LOCATION
VICINITY MAP
Potential Project Levee Modifications and Cross Levees
NOTE: Potential Cross Levees
a,b Knights Landing Area
c Elkhorn Slough Area
SCALE IN MILES
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS
CALIFORNIA
PRELIMINARY ALTERNATIVE PLANS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 5

No Action. - For the no action plan, there would be no Federal participation in flood control alternatives for increased levels of flood protection. Levels of protection provided by the existing levees would remain the same. Potential damages due to flooding would also remain at current levels. The no action preliminary alternative plan was assumed to be analogous to the without-project condition.

Knights Landing Area. - Plans were developed to raise and strengthen existing levees and/or construct cross levees. A 100-year level of flood protection would be provided to the entire area or portions of the entire area. Three different levee alignments were developed. Alignment 1 involved work on existing levees around the entire area. Alignment 2 involved work on existing levees around the town of Knights Landing in the northwestern portion of the area and construction of a cross levee close to the southeast side of town (cross levee "a" in Figure 5). Alignment 3 involved work on a larger amount of the existing levees in the northwestern portion of the area and construction of a cross levee where the existing Sacramento River and Knights Landing Ridge Cut levees come close together, a location referred to as "the neck" (cross levee "b" in Figure 5). Costs to construct new levees were high, and the location at the neck helped to minimize these costs.

To meet freeboard requirements, the levees were raised in several locations for all three alignments. The preliminary alternative plans also incorporated construction to correct structural and piping stability problems identified by the Sacramento River Flood Control System Evaluation, Phase III, and the Colusa Basin Project along the Sacramento River and the Knights Landing Ridge Cut, respectively.

For alignment 1, levee modifications occur over about 22,400 linear feet (LF) of the Sacramento River west levee and 32,200 LF of the Knights Landing Ridge Cut east levee. Maximum levee raising along the Sacramento River and Knights Landing Ridge Cut levees is 2.3 feet and 3.0 feet, respectively.

For alignment 2, levee modifications occur over about 3,500 LF of levee around the western part of the town of Knights Landing, and a new 4,800 LF cross levee is constructed. The maximum levee raising is 1.5 feet and the maximum cross levee height is 18 feet.

For alignment 3, levee modifications occur over about 16,700 LF of the Knights landing Ridge Cut east levee, 12,700 LF of the Sacramento River west levee, and a new 1,900 LF cross levee is constructed. Maximum levee raising along the Sacramento River and Knights Landing Ridge Cut levees is 1.2 feet and 2.2 feet, respectively. The maximum cross levee height is 18 feet.

Elkhorn Slough Area. - Plans were developed to raise and strengthen existing levees and/or construct cross levees. A 100-

year level of flood protection would be provided to the entire area or portions of the entire area from the Yolo Bypass. Designs and costs were only developed for the Yolo Bypass and Sacramento Bypass sides of the area. Since costs did not account for any levee improvements along the Sacramento River side, the costs to provide complete 100-year level protection from all sources of flooding would be greater and would require additional work along the Sacramento River side to insure that flooding would not occur due to flood control project levee failure.

Three different levee alignments were developed. Alignment 1 involved work on existing levees along the entire Yolo Bypass and Sacramento Bypass sides of the area. Alignment 2 involved work only on existing Yolo Bypass levees to the north of the railroad tracks by I-5 and providing a cross levee by the railroad track alignment (cross levee "c" in Figure 5). Alignment 3 involved work only on existing Yolo Bypass and Sacramento Bypass levees to the south of the railroad tracks and providing a cross levee by the railroad track alignment.

To meet freeboard requirements, the levees were raised in several locations for all three alignments. For alignment 1, levee modifications occur over about 66,000 LF of the Yolo Bypass east levee. Maximum levee raising is 4.4 feet.

For alignment 2, levee modifications occur over about 32,600 LF of the Yolo Bypass east levee, and a new 4,000 LF cross levee is constructed. Maximum levee raising is 2.6 feet. The proposed cross levee provides construction parallel to the Union Pacific Railroad (UPRR) track. The maximum raising of the railroad embankment is 9.7 feet.

For alignment 3, levee modifications occur over about 35,900 LF of the Yolo Bypass east levee, and a new 4,000 LF cross levee is constructed. Maximum levee raising is 4.4 feet. The proposed cross levee provides construction to raise Highway 16 (which runs parallel and south of the railroad tracks) to the proposed levee height. The maximum cross levee height is 20.5 feet.

Willow Slough Bypass Area. - Originally, two plans were considered: one to primarily benefit the area north of Willow Slough Bypass and the other to primarily benefit the area south of Willow Slough Bypass. Because of the close proximity of these plans, a plan for one area could not be constructed separately without creating major hydraulic impacts to the other area. In essence, the hydraulic mitigation required would constitute construction of the other plan. Therefore, both plans were combined into a single plan.

A preliminary alternative plan for the Willow Slough Bypass area was developed to raise and strengthen existing levees in the

area. A 100-year level of flood protection would be provided to the area from the Yolo Bypass only. To provide complete 100-year level flood protection from all sources of flooding would require any additional work to insure that flooding would not occur due to interior drainage problems, failure of flood control project levees along South Fork Putah Creek or Cache Creek, or upstream flooding from westside tributaries. Protection would be provided by raising existing levees along the Willow Slough Bypass and the Yolo Bypass to meet freeboard requirements. Based on the most current information, System Evaluation geotechnical studies indicated no apparent structural and piping stability problems along Yolo Bypass and Willow Slough Bypass.

Levee modifications occur over 40,000 LF of levee along the Yolo Bypass west levee from the Cache Creek Settling Basin to Willow Slough Bypass with a maximum levee raising of 3.2 feet. Levee modifications occur over 30,400 LF of levee along the Willow Slough Bypass north levee with a maximum levee raising of 5.3 feet. Levee modifications occur over 28,500 LF of levee along the Willow Slough Bypass south levee with a maximum levee raising of 5.5 feet. Levee modifications occur over 19,000 LF of levee along the Yolo Bypass west levee from the Willow Slough Bypass to South Fork Putah Creek with a maximum levee raising of 2.2 feet.

Unleveed Portion of Yolo Bypass South of Putah Creek. - A plan was developed to construct a new levee with an alignment extending from the South Fork Putah Creek levee to the north-to-south levee west of Liberty Island. A 100-year level of flood protection would be provided to areas west of the new levee alignment from the Yolo Bypass. This levee would be about 8.7 miles long with heights varying from 3 to 10 feet and an average height of about 5 feet. The plan included two pumping plants for potential interior drainage. To provide complete 100-year level flood protection would require any additional work to insure that flooding would not occur due to failure of flood control project levees along South Fork Putah Creek.

Area West of Liberty Island and North of Cache and Haas Sloughs. - A plan was developed to raise and strengthen existing levees in the area. Protection would be provided by raising existing flood control project levees around the east and south sides of the area and extending one levee to prevent outflanking of Yolo Bypass flood waters. A 100-year level of flood protection would be provided to the area from the Yolo Bypass, Cache Slough and Haas Slough. Designs and costs were only developed for the Yolo Bypass, Cache Slough and Haas Slough sides of the area. To provide complete 100-year level of flood protection from all sources of flooding would require additional design work for the flood control project levee along the west side of the area.

To meet freeboard requirements, the levees were raised in several locations. System Evaluation reconstruction work along

Haas and Cache Sloughs and this portion of the Yolo Bypass is presently being studied under Phase IV and was not available for incorporation into this reconnaissance study.

Levee modifications occur over 63,100 LF of levees along the Yolo Bypass west levee, Cache Slough north levee, and Haas Slough north levee. The maximum levee raising is 2.6 feet.

Screening of Preliminary Alternative Plans

Designs and costs were developed for the preliminary alternative plans. Only sufficient design and cost work was completed to determine economic feasibility to reduce and simplify the amount of required engineering, economic and environmental work. All cost estimates are reconnaissance level and include only construction costs.

The costs were compared to the economic benefits, and BCRs were calculated. Table 4 includes the results of the economic analysis. As noted, all of the preliminary alternative plans have BCRs of less than 1.0 except for one of the plans for the Knights Landing area. This plan, alignment 2, was carried forward as a final alternative plan. To provide a comparison between other flood control options for the Knights Landing area, the other two plans for the area, alignments 1 and 3, were carried forward as well.

Sensitivity Analysis. - The sensitivity analyses information for the Knights Landing area is presented in the section entitled "Final Alternative Plans." Sensitivity analyses information for plans for the other four areas follows. Three different sensitivity analyses were performed.

The first analysis was to determine if higher levels of flood protection than 100-year might be feasible. Based on generalized benefit-to-cost analyses, designs above a 100-year level of protection for the four areas would not be economically feasible.

The second analysis was done at the request of non-Federal interests to determine the effects of modified base conditions. State and local flood control personnel requested an evaluation of study results with the work identified in Phases III-V of the System Evaluation in place.

Preliminary information from Phase III of the System Evaluation was available for the Elkhorn Slough area. If the work identified by the System Evaluation was considered to be in place, including work to correct structural and piping stability problems and freeboard deficiencies, the area would have a new nondamaging event of approximately 100 years, based on preliminary information.

Table 4
Economic Evaluation of Preliminary Alternative Plans 1/

Area	Flooding Problem	Preliminary Alternative Plan	Economic Evaluation			
			First Costs ($)	Annual Costs ($)	Average Annual Benefits ($)	Benefit to Cost Ratio
Knights Landing	Levee failures on Knights Landing Ridge Cut and Sacramento River	Modify levees around entire area	5,510,000	600,000	405,000	0.7
		Modify levees around the town and provide cross levee close to town	3,420,000	360,000	405,000	1.1
		Modify levees around northwestern area and provide cross levee where Ridge Cut and Sacramento River are close together	4,910,000	530,000	405,000	0.8
Elkhorn Slough	Levee failures on Yolo Bypass and Sacramento River	Modify levees along entire Yolo Bypass and Sacramento Bypass sides of area	11,090,000	1,210,000	294,000	0.2
		Modify levees along Yolo Bypass north of the railroad tracks by I-5 and provide a cross levee at or by the railroad track alignment	4,330,000	460,000	128,000	0.3
		Modify levees along Yolo Bypass and Sacramento Bypass south of the railroad tracks by I-5 and provide cross levee at or by the railroad track alignment	11,310,000	1,230,000	166,000	0.1
Willow Slough Bypass	Levee failures on Willow Slough Bypass and Yolo Bypass	Modify levees along Willow Slough Bypass and Yolo Bypass	13,740,000	1,500,000	534,000	0.4
Unleveed portion of Yolo Bypass south of South Fork Putah Creek	Overland flooding from Yolo Bypass	Construct new levee	6,070,000	660,000	224,000	0.3
Area west of Liberty Island and north of Cache and Haas Sloughs	Levee failures on Haas Slough and outflanking of Yolo Bypass levee	Modify levees around area and extend existing Yolo Bypass levee to prevent outflanking	5,850,000	640,000	113,000	0.2

1/ The analysis assumed 1 October 1991 price levels, an 8-3/4 percent interest rate, a 50-year project life, and 100-year levels of flood protection to be provided by the plans. First costs include construction costs only. Only sufficient design and cost work was completed to determine economic feasibility. Additional design work may be required for some plans to provide complete 100-year level of flood protection.

Average annual benefits for increased levels of flood protection (assuming zero residual damages) for the entire area, the northern portion of the area only, and the southern portion of the area only would be $161,000, $70,000, and $91,000, respectively. Revised first costs for alignments 1, 2, and 3 in the Elkhorn Slough area would be $8,320,000, $2,940,000, and $9,930,000, respectively; annual costs would be $930,000, $330,000, $1,100,000, respectively; and BCRs would be 0.2, 0.2, and 0.1, respectively. As noted, all of the alignments had BCRs less than 1.0.

Limited information from the System Evaluation was available for the Willow Slough Bypass area. Under Phase III there was no work identified on the Yolo Bypass levee. Based on the most current information, geotechnical work on the Willow Slough Bypass revealed no apparent structural or piping problems, but studies did reveal freeboard deficiencies. For this analysis, the work identified by the System Evaluation was considered to be in place. There was no change in the nondamaging event for the Yolo Bypass. Sufficient information was lacking to revise the nondamaging event for the Willow Slough Bypass. The previous nondamaging events were used. The previous average annual benefits of $534,000 were also used. The revised first costs, annual costs, and BCR were $11,540,000, $1,280,000, and 0.4, respectively.

For this level of analysis, there would be no change in the preliminary alternative plan for the area south of Putah Creek. At this time there is no potential System Evaluation work in this unleveed area. In addition, due to the timing of this reconnaissance study relative to Phase IV of the System Evaluation, sufficient information was not available to complete this type of sensitivity analysis for the area west of Liberty Island and north of Cache and Haas Sloughs.

The third analysis was to determine if higher levels of flood protection could be feasible based on these modified conditions noted in the second sensitivity analysis for the Elkhorn Slough and Willow Slough Bypass areas. Based on generalized benefit-to-cost analyses, designs above a 100-year level of protection for these areas would not be economically feasible.

FINAL ALTERNATIVE PLANS

Description

Based on the screening of the preliminary alternative plans, four final alternative plans were identified. Additional detailed engineering, environmental, and economic analyses were completed for the final alternative plans to refine the information. All three alignments for the Knights Landing area were analyzed in order to provide a comparison between flood control options for the area. Summarized descriptions for each of the plans follow. Details of the required construction work for the final

alternatives are presented in Figures 6, 7, and 8. Additional information is provided in Appendix C: Basis of Design

No Action. - For the no action alternative, there would be no Federal participation in flood control alternatives for increased levels of flood protection. Levels of protection provided by the existing levees would remain the same. Potential damages due to flooding would also remain at current levels. The no action alternative was assumed to be analogous to the without-project condition.

Knights Landing Area - Alignment 1. - Alignment 1 involved modifications to existing levees around the entire area (see Figure 6). The purpose was to provide 100-year levels of flood protection to the entire Knights Landing area.

Knights Landing Area - Alignment 2. - Alignment 2 involved modifications to existing levees around the town of Knights Landing in the northwestern portion of the area and construction of a cross levee close to the southeast side of town (see Figure 7). The purpose was to provide 100-year levels of flood protection only to the town of Knights Landing.

Knights Landing Area - Alignment 3. - Alignment 3 involved modifications to existing levees around the northwestern portion of the area and construction of a cross levee where the existing Sacramento River and the Knights Landing Ridge Cut levees come close together at the location known as the "neck" (see Figure 8). This plan represented a combination of the other two alignments. The purpose was to provide 100-year levels of flood protection to the town of Knights Landing and as much additional area as possible, while minimizing costs for cross levee construction.

Environmental Concerns

For the no action alternative, environmental resources would remain approximately the same in the Knights Landing area. The remainder of this discussion focuses on alignments 1, 2 and 3. Additional information is provided in the Environmental Evaluation appendix.

For the three alignments, all construction would be on the crown or the landside of the levee. Landside construction would directly impact grasses on the levee slopes, trees and shrubs growing along the levee, and wetland habitats along existing toe drains. Direct impacts on vegetation would be significantly less than waterside construction. Landside construction in general eliminates or reduces any adverse project effects on riparian vegetation and shaded riverine aquatic cover on the waterside of levees along the Sacramento River, the Knights Landing Ridge Cut and the Colusa Basin Drain. Alignments 1, 2, and 3 would require about 32 acres, 17 acres and 28 acres, respectively, of mitigation

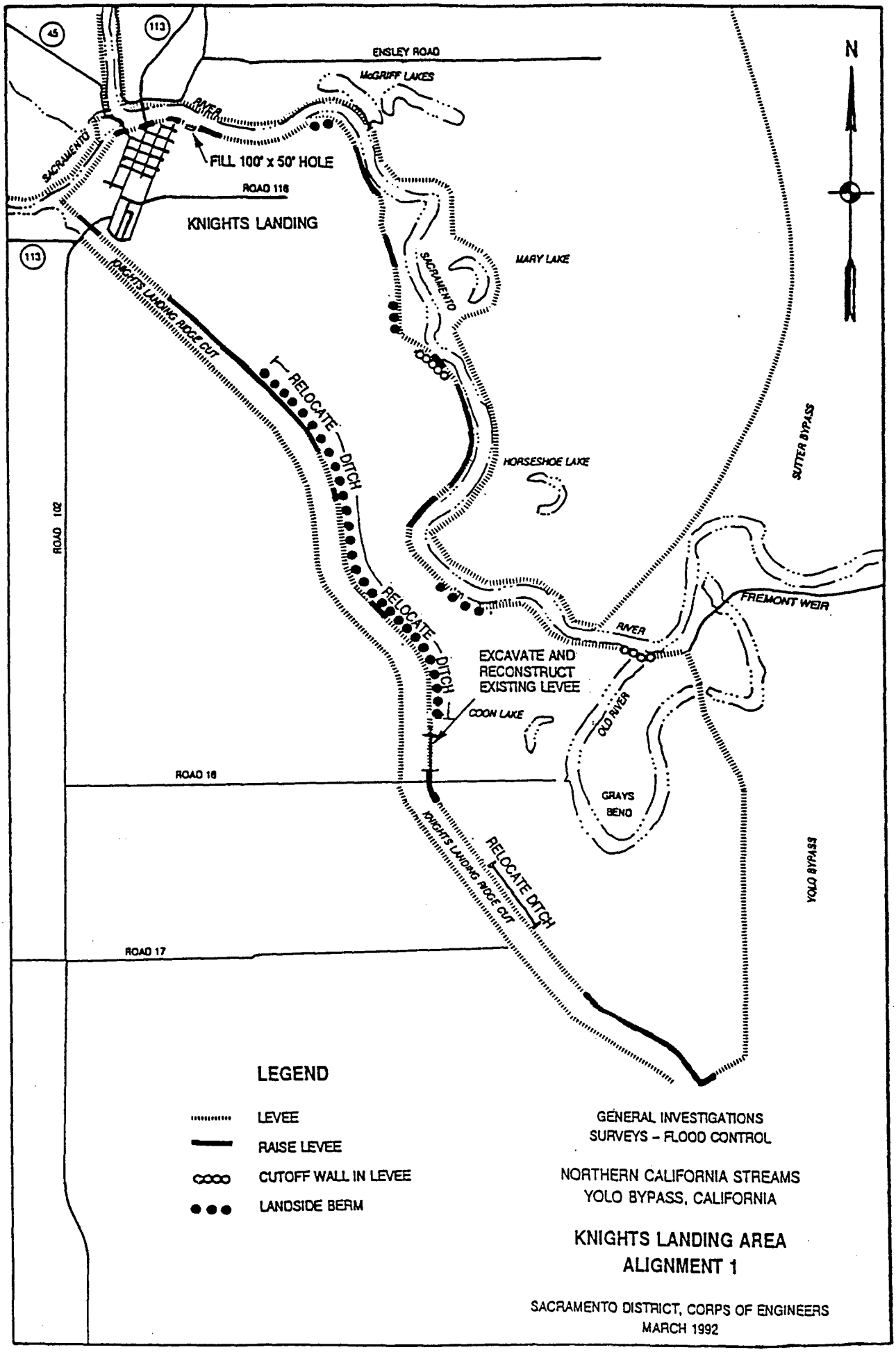

45
113
ENSLEY ROAD
McGRIFF LAKES
RIVER
SACRAMENTO
FILL 100' x 50' HOLE
ROAD 116
KNIGHTS LANDING
113
KNIGHTS LANDING RIDGE CUT
MARY LAKE
SACRAMENTO
RELOCATE DITCH
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
FREMONT WEIR
RIVER
RELOCATE DITCH
EXCAVATE AND
RECONSTRUCT
EXISTING LEVEE
COON LAKE
OLD RIVER
ROAD 18
GRAYS
BEND
KNIGHTS LANDING RIDGE CUT
RELOCATE DITCH
YOLO BYPASS
ROAD 17
N
LEGEND
LEVEE
RAISE LEVEE
CUTOFF WALL IN LEVEE
LANDSIDE BERM
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 1
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 6

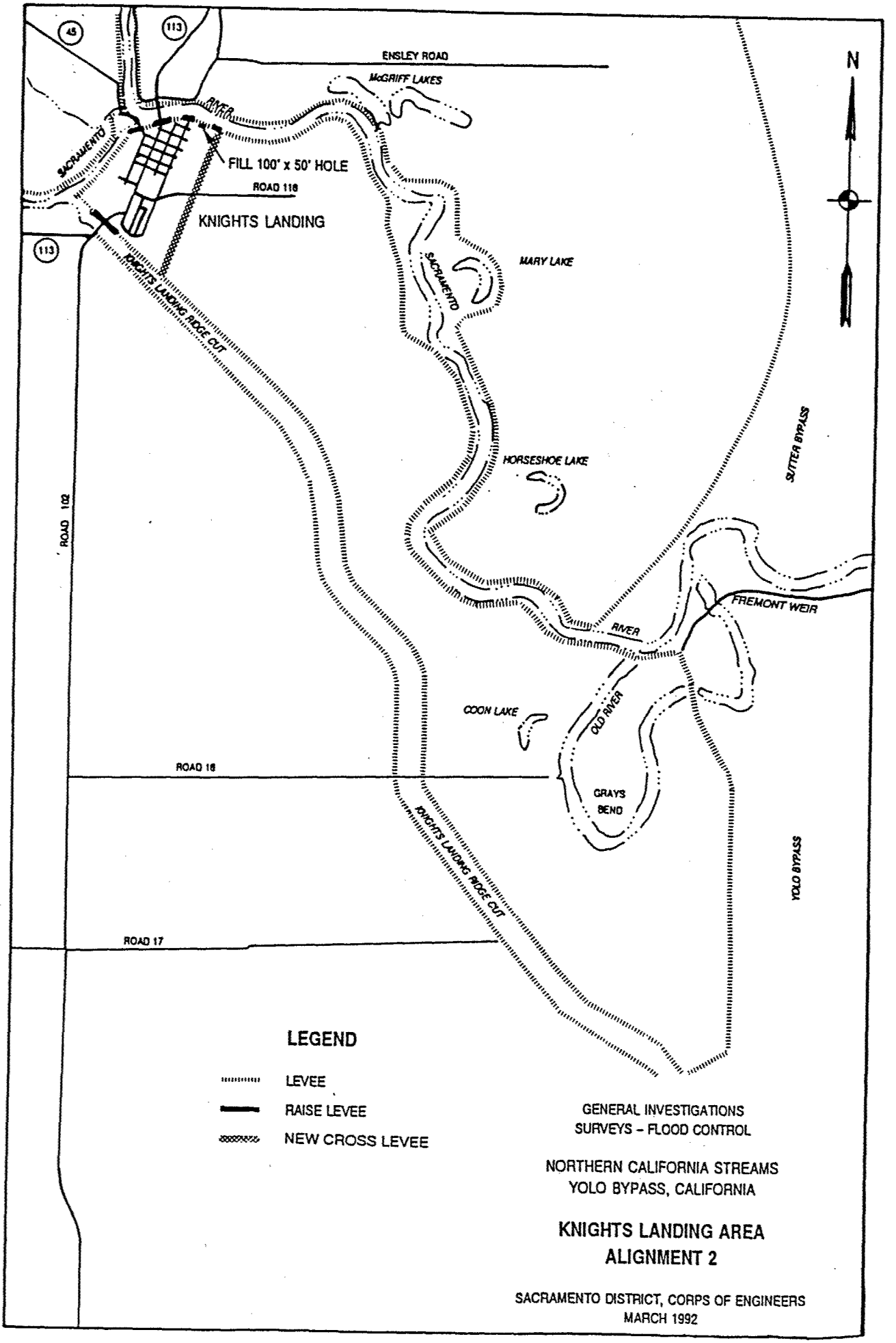
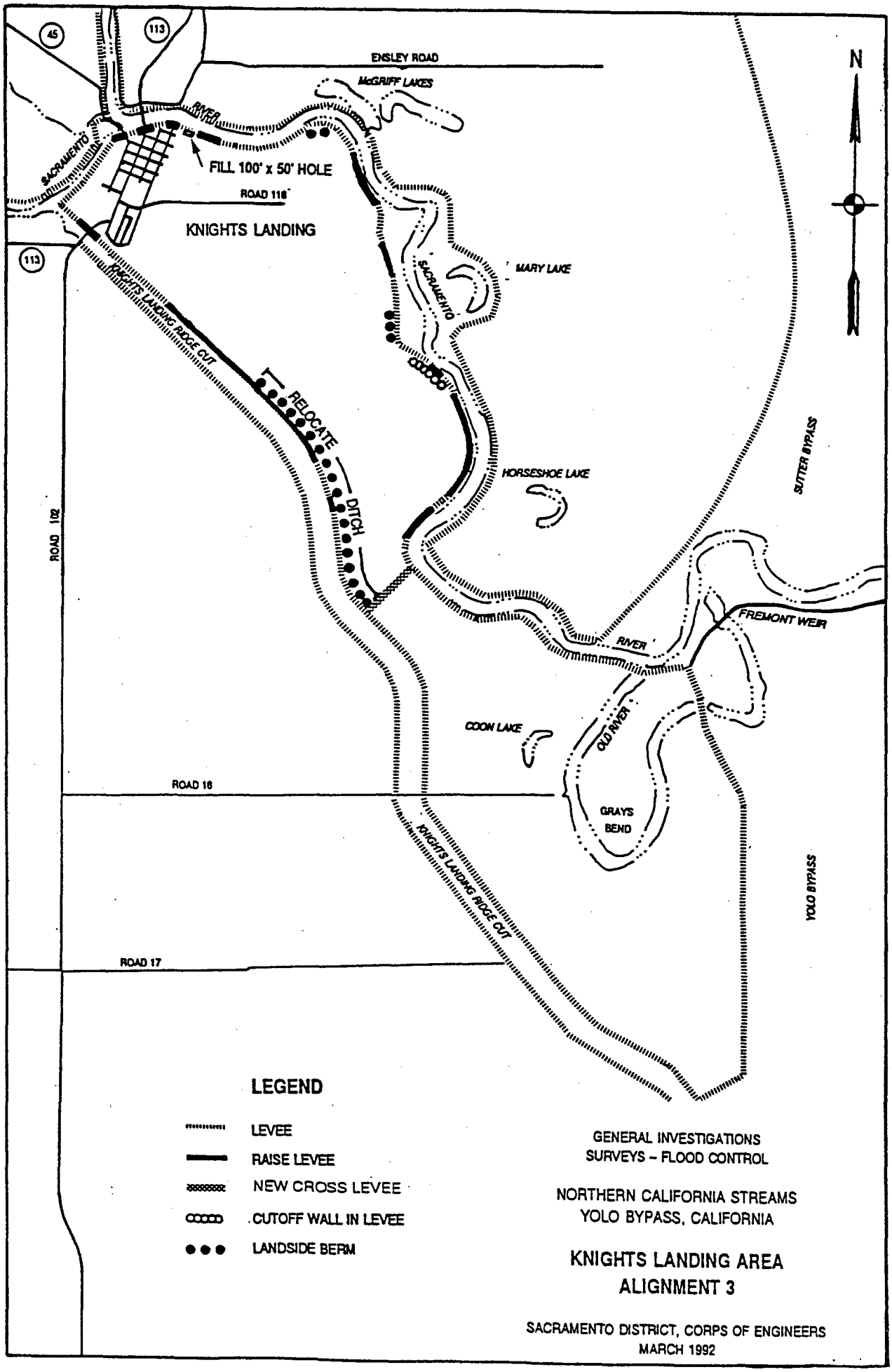

45
113
ENSLEY ROAD
McGRIFF LAKES
SACRAMENTO RIVER
FILL 100' x 50' HOLE
ROAD 116
KNIGHTS LANDING
113
KNIGHTS LANDING RIDGE CUT
SACRAMENTO
MARY LAKE
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
FREMONT WEIR
RIVER
COON LAKE
OLD RIVER
ROAD 16
GRAYS BEND
KNIGHTS LANDING RIDGE CUT
YOLO BYPASS
ROAD 17
N
LEGEND
LEVEE
RAISE LEVEE
NEW CROSS LEVEE
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 2
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 7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ENSLEY ROAD
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RIVER
SACRAMENTO
FILL 100' x 50' HOLE
ROAD 11B
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KNIGHTS LANDING RIDGE CUT
SACRAMENTO
MARY LAKE
RELOCATE
DITCH
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
FREMONT WEIR
RIVER
COON LAKE
OLD RIVER
ROAD 18
GRAYS BEND
KNIGHTS LANDING RIDGE CUT
YOLO BYPASS
ROAD 17
N
LEGEND
LEVEE
RAISE LEVEE
NEW CROSS LEVEE
CUTOFF WALL IN LEVEE
LANDSIDE BERM
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 3
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 8

lands to compensate for adverse impacts. These lands would be replanted to provide various types of habitat including riparian forest, scrub/shrub, emergent marsh and woodland-type habitat.

The existing land use of the Knights Landing area includes the urbanized area of the town, with the remainder of the area being primarily agricultural. Land use could potentially change with implementation of any of the three alignments, as 100-year level of flood protection would be provided to the areas inside the alignments. New development could occur within these protected areas. This change would be an indirect impact of each of the alignment alternatives. Land use of the areas outside the protected areas for alignments 2 and 3 would remain primarily agricultural. There could be additional impacts to environmental resources from such potential future growth.

Whether future growth would occur, however, is uncertain. This uncertainty is due to significant future growth projected in other areas and limited road access to the Knights Landing area. A regional analysis would be required to determine if any future development could reasonably be assumed to occur.

Economic Considerations

Economic benefit information was refined for the final alternative plans to provide a better estimate of the actual with-project benefits. Benefits are consistent with the level of protection provided, and credit was given for benefits in the freeboard range. In addition, benefits for alignment 2 were reduced by subtracting the damages for 90 percent of the agricultural flood damages. Alignment 2 provided flood protection to less than 10 percent of the total agricultural area; therefore, 90 percent of the agricultural area would continue to be flooded with a nondamaging event of 40 years even with alignment 2 in place. In a similar manner, benefits for alignment 3 were reduced by subtracting the damages for 40 percent of the agricultural flood damages. Alignment 3 provided flood protection to less than 60 percent of the total agricultural area. Table 5 presents this information.

In addition to construction costs, additional work was completed to develop land costs, and fish and wildlife mitigation costs for the three alignments. Cultural resources preservation costs were estimated at 1 percent of the total estimated costs for the project. Costs for the final alternative plans are presented in Table 6.

Table 5
Economic Information for
Final Alternative Plans 1/

Knights Landing Area Plans	Without-Project Damages ($)	Residual Damages ($)	With-Project Benefits ($)
Alignment 1 - Modify levees around entire area	405,000	40,000	365,000
Alignment 2 - Modify levees around the town and provide cross levee close to town	405,000	81,000	324,000
Alignment 3 - Modify levees around northwestern area and provide cross levee where Ridge Cut and Sacramento River are close together	405,000	59,000	346,000

1/ Average annual economic data are presented. The analysis assumed 1 October 1991 price levels, an 8-3/4 percent interest rate, and a 50-year project life.

Table 6
Estimated First and Annual Costs for Final Alternative Plans ($) 1/

	Feature	Knights Landing Area		
		Alignment 1: Modify levees around entire area	Alignment 2: Modify levees around the town and provide cross levee close to town	Alignment 3: Modify levees around northwestern area and provide cross levee where Knights Landing Ridge Cut and Sacramento River are close together
01	Lands and Damages	2,392,000	1,293,000	1,980,000
02	Relocations	329,000	30,000	223,000
06	Fish and Wildlife Facilities	800,000	425,000	700,000
11	Levee Modifications and Drainage Facilities	3,457,000	2,813,000	3,481,000
18	Cultural Resources Preservation	87,000	51,000	76,000
30	Planning, Engineering, and Design	1,418,000	341,000	895,000
31	Construction Management	310,000	231,000	310,000
	TOTAL PROJECT FIRST COST	8,793,000	5,184,000	7,665,000
	INTEREST DURING CONSTRUCTION	1,130,000	670,000	990,000
	TOTAL PROJECT INVESTMENT COST	9,923,000	5,854,000	8,655,000
	INTEREST AND AMORTIZATION	880,000	520,000	770,000
	O, M & R	80,000	50,000	70,000
	TOTAL ANNUAL COST	960,000	570,000	840,000

1/ The analysis assumed 1 October 1991 price levels, an 8-3/4 percent interest rate, a three-year construction period and a 50-year project life.

Evaluation of Final Alternative Plans

The economic evaluation data for the final alternative plans are provided in Table 7. None of the alternatives have BCRs greater than 1.0.

Table 7
Economic Evaluation of
Final Alternative Plans 1/

Knights Landing Area Plans	First Costs ($)	Total Annual Costs ($) 2/	Average Annual Benefits ($)	Benefit-to-Cost Ratio
Alignment 1 - Modify levees around entire area	8,793,000	960,000	365,000	0.4
Alignment 2 - Modify levees around the town and provide cross levee close to town	5,184,000	570,000	324,000	0.6
Alignment 3 - Modify levees around northwestern area and provide cross levee where Ridge Cut and Sacramento River are close together	7,665,000	840,000	346,000	0.4

1/ The analysis assumed 1 October 1991 price levels, an 8-3/4 percent interest rate, and a 50-year project life.

2/ Total annual costs include operations and maintenance costs.

Sensitivity Analysis

Three different sensitivity analyses were done on the final alternative plans. The first analysis was to determine if higher levels of flood protection than 100-year might be feasible. Based on generalized benefit-to-cost analyses, designs above a 100-year level of protection for all three alignments would not be economically feasible.

The second analysis was done at the request of non-Federal interests to determine the effects of modified base conditions. State and local flood control personnel requested an evaluation of study results with the work identified by the System Evaluation and the Colusa Basin Project in place. If the identified work was considered to be in place, including work to correct structural and piping stability problems, the area would have a new without-project nondamaging event of approximately 100 years, based on preliminary information from the System Evaluation and the Colusa Basin Project. (No design freeboard deficiencies were identified by the System Evaluation or the Colusa Basin Project for the Knights Landing area.) This reduced the overall project benefits. For the analysis, zero residual damages were assumed, resulting in with-project benefits equaling total without-project damages for alignment 1. For alignments 2 and 3, benefits were again reduced by subtracting damages for 90 percent and 40 percent, respectively, of the agricultural flood damages. These assumptions provided average annual project benefits for alignments 1, 2, and 3 of $162,000, $144,000, and $154,000, respectively. Costs for the 100-year plans were reduced to reflect completed work. Costs for alignment 1 were reduced significantly because all work shown in Figure 6 except for levee raising was assumed to be completed. Costs for alignment 2 remained constant since the completed work would have a minimal effect on this alternative. Costs for alignment 3 were also reduced. However, since alignment 3 modified less linear footage of the existing levees than alignment 1, there was less of a reduction in the costs due to the completed work (see Figure 8). The revised first costs for alignments 1, 2, and 3 were $4,440,000, $5,184,000, and $5,431,000, respectively; total annual costs were $490,000, $570,000, and $590,000, respectively; and the resulting BCRs were 0.3, 0.3, and 0.3, respectively. As noted, all of the alternatives had BCRs less than 1.0. The reduction in benefits relative to the original analysis and the high remaining costs for cross levee construction contributed to the reduction of the BCRs for alignments 2 and 3.

The third analysis was to determine if higher levels of flood protection could be feasible based on the modifications noted in the second sensitivity analysis. Based on generalized benefit-to-cost analyses, designs above a 100-year level of protection for all three alignments would not be economically feasible.

Recreation

As noted in Chapter III, Problems and Opportunities, there was local interest in recreation development. Under the current guidance regarding Federal participation, such development must be completed in conjunction with a feasible flood control plan. Since there were no feasible flood control plans, there is no opportunity for recreation development at this time.

CHAPTER V - DISCUSSION AND CONCLUSIONS

During the flood of 1986, the Yolo Bypass flows approached or exceeded design flows. Although no levee failures occurred in the study area, wave action in the bypass required emergency actions to prevent levee overtopping and continued loss of levee embankment material. Future floods of a similar magnitude, but with more severe wind conditions or longer durations, or floods of greater magnitude could compound problems, resulting in levee failures and flooding.

The objective of this study was to investigate the flood problems within the study area and to develop potential solutions to these problems. The analysis focused on the following five areas: Knights Landing, Elkhorn Slough, Willow Slough Bypass, the unleveed area south of Putah Creek, and the area west of Liberty Island and north of Cache and Haas Sloughs. Preliminary and final alternative plans for flood control were developed for the areas to modify existing Sacramento River Flood Control Project levees and construct a new levee on the unleveed west side of the Yolo Bypass south of Putah Creek.

Several of the preliminary alternative plans were found to have BCRs of less than 1.0 and were eliminated. Upon more detailed study, the remaining final alternative plans also had BCRs of less than 1.0. No economically feasible plans were found.

Based on preliminary analyses and existing information, potential flood impacts to urbanized areas of Woodland and Davis in Yolo County may exist that were beyond the scope of this reconnaissance investigation. Yolo County has requested that the Corps conduct a new reconnaissance study on the potential for flooding to these areas from westside tributaries of the Yolo Bypass.

CHAPTER VI - RECOMMENDATIONS

Since no economically feasible plan can be identified, I recommend that participation in further studies for a flood control project not be pursued at this time for the Yolo Bypass.

Laurence R. Sadoff
Colonel, Corps of Engineers
District Engineer

APPENDIX A: ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

af	acre-feet
BCR	benefit-to-cost ratio
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
CVP	Central Valley Project
DWOPER	Dynamic Wave Operational Model
EIS	Environmental Impact Statement
EIR	Environmental Impact Report
FEMA	Federal Emergency Management Agency
I-80	Interstate 80
I-5	Interstate 5
LF	linear feet
SPRR	Southern Pacific Railroad
State	State of California
SWP	State Water Project
UPRR	Union Pacific Railroad
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

APPENDIX B: ECONOMIC ANALYSIS

ECONOMIC ANALYSIS
YOLO BYPASS RECONNAISSANCE

INTRODUCTION

This section provides information used in estimating average annual flood damages. The analysis is based on, a 50-year project life, October 1991 price levels, and 8-3/4% interest rate, and existing conditions of development. Future development was looked at in the Knights Landing area and the Elkhorn Slough area, but was not incorporated in the study. The 1980 flood insurance rate maps identify Knights Landing as zone B (areas between limits of the 100-year flood and 500-year flood). Conditions have changed in the area since the publication of the these maps. As a result, current zoning may not be appropriate since it does not address the flood problem. Also, the flooding problem is not addressed in the Comprehensive General Plan for the Town of Knights Landing. Proposed future growth for the Elkhorn Slough area is to develop 224 acres of industrial and commercial park off I-5. The I-5 Metro Project is still in a preliminary stage. At present, the area is under a moratorium which ends in November of 1992; development may occur without flood proofing until the moratorium ends. Development seems unlikely since a formal draft of the Environmental Impact Report has not been submitted to Yolo County. Average annual damages and benefits are estimated in accordance with the guidelines of ER 1105-2-100, 28 December 1990. The estimation of average annual damages under without and with project conditions is described in the following paragraphs.

The following describes the analyses used in evaluating flood protection for the Knights Landing area (Area 1), Elkhorn Slough area (Area 2), Willow Slough Bypass area (Area 3) , the unleveed area south of Putah Creek (Area 4), and the area west of Liberty Island and North of Cache Creek and Haas Sloughs (Area 5). First, an analysis was completed for the preliminary alternative plans. Secondly, preliminary alternative plan sensitivity analyses were performed for Areas 2-5. Thirdly, final alternative plan analyses and final alternative plan sensitivity analyses for the Knights Landing area (Area 1) were conducted.

All analyses had certain assumptions in common. The analyses assumed that the improvements identified by the American River Watershed Investigation, Sacramento Metropolitan Area Investigation, and the Sacramento River Flood Control System Evaluation Phase I and II are in place.

The analysis for the preliminary alternative plans assumed that the system evaluation, Phases III-V and the Colusa Basin Project are not in place. This analysis was assumed to provide 100-year level of flood protection.

There were three different types of sensitivity analyses completed for the preliminary plans. Sensitivity analysis 1 assumed 200-year level of protection was provided, and the system evaluation Phases III-V and the Colusa Basin Project are not in place. Sensitivity analysis 2 and 3 provided 100-year and 200-year levels of flood protection, respectively. Both sensitivity analyses 2 and 3 assumed that the system evaluation Phases III-V and the Colusa Basin Project were in place.

For the analysis of the final alternative plans, 100-year level of flood protection was assumed and the system evaluation Phases III-V and the Colusa Basin Project were assumed not to be in place. The assumptions for the three final alternative plan sensitivity analyses were the same respectively as for the three sensitivity analyses for the preliminary plans.

FLOOD PLAIN DESCRIPTION

Flood plains delineating potential flooding from levee failures were provided (Figure 1). An inventory of the flood-plains was conducted.

Knights Landing Area (Area 1)

Knights Landing is a small town located within Northern California's agricultural lands. The town is surrounded by levees, the Knights Landing Ridge Cut on the south boundary, Colusa Basin Drain on the west boundary, the Sacramento River on the north boundary, and the Yolo Bypass on the east boundary (Figure 1). The structures located in the flood plain include; residential, multiple residential, public, commercial, and an industrial facility, the Oakland Bean Cleaning and Storage Company. The Oakland Bean Cleaning and Storage Company processes all varieties of beans and also cleans, removes defects, and bags beans, safflower, rice, grain, etc.

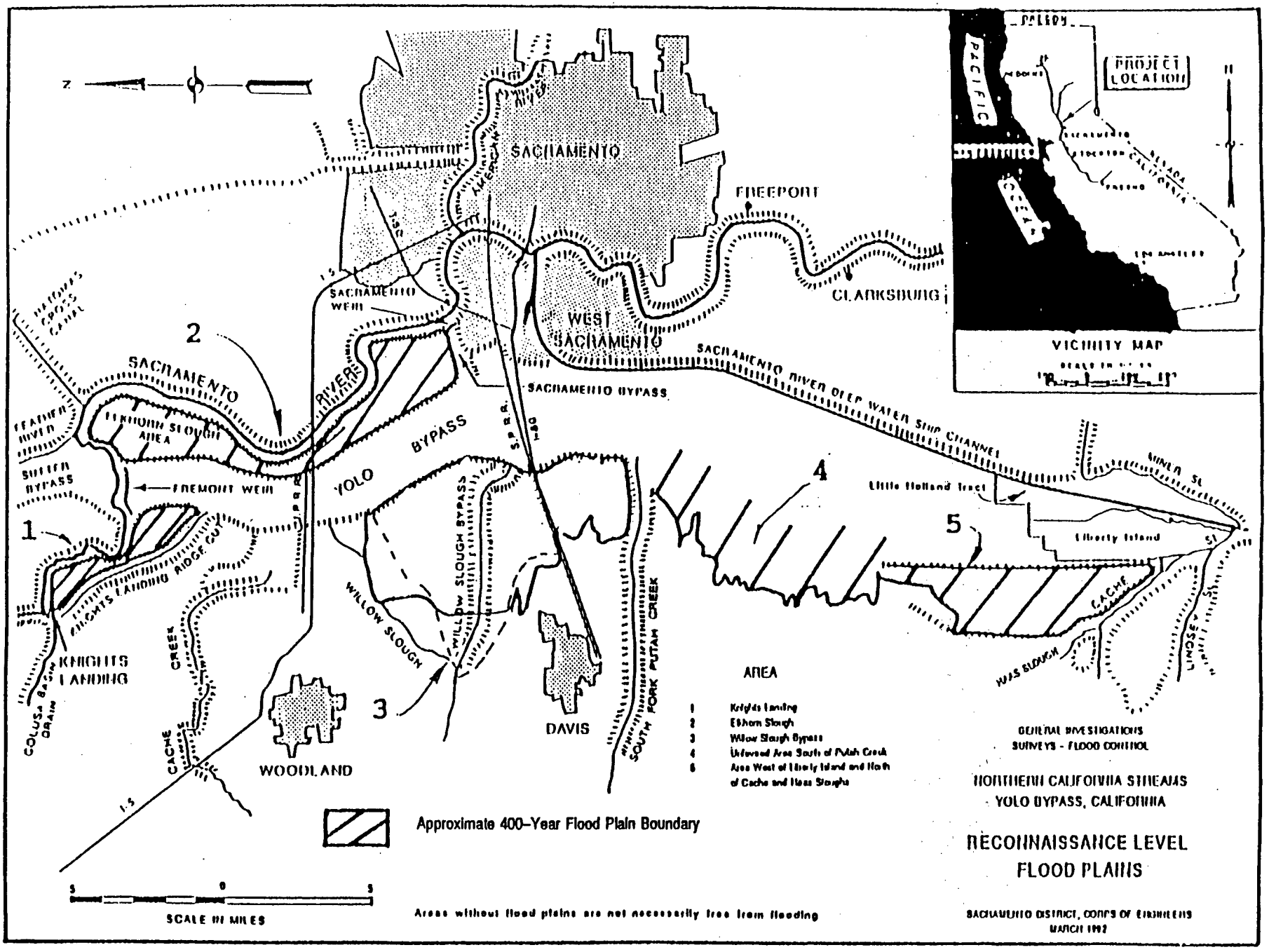
SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO WEIR
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
FEATHER RIVER
SUTTER BYPASS
FREMONT WEIR
YOLO BYPASS
WILLOW SLOUGH BYPASS
WILLOW SLOUGH
KNIGHTS LANDING
KNIGHTS LANDING RIDGE CUT
COLUSA BASIN DRAIN
CACHE CREEK
WOODLAND
DAVIS
SOUTH FORK PUTAH CREEK
Little Holland Tract
Liberty Island
CACHE SLOUGH
LINDSEY SLOUGH
MINER SLOUGH
1
2
3
4
5
I-5
S.P.R.R.
PROJECT LOCATION
PACIFIC OCEAN
VICINITY MAP
AREA
1 Knights Landing
2 Elkhorn Slough
3 Willow Slough Bypass
4 Unleveed Area South of Putah Creek
5 Area West of Liberty Island and North of Cache and Miner Sloughs
Approximate 400-Year Flood Plain Boundary
SCALE IN MILES
Areas without flood plains are not necessarily free from flooding
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
RECONNAISSANCE LEVEL
FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1962

FIGURE 1

Elkhorn Slough Area (Area 2)

The area of Elkhorn Slough is predominately agriculture and designated agriculture preserve. Crops grown in the area include corn, tomatoes, sugar beets, and walnuts. The Elkhorn Slough area is surrounded by levees. The boundaries from the north and east are the Sacramento River, from the south the Sacramento Bypass and from the west the Yolo Bypass (Figure 1). The area was looked at in two different ways. First, the area was divided into two flood plains, the dividing line being the railroad embankment close to I-5. The areas will be referred to as North Elkhorn Slough and South Elkhorn Slough. Secondly, the two areas were combined and analyzed.

Willow Slough Bypass Area (Area 3)

Area 3 is comprised of two separate flood plains. The first flood plain is from the Willow Slough Bypass which is designated by the dashed line (Figure 1). The second flood plain is from the Yolo Bypass and is designated by the solid line (Figure 1). The flood plains consist primarily of agricultural lands with some structures, mostly farmsteads (houses, barns, sheds). Two notable structures in the flood plains are the City of Davis Water Pollution Control Plant, and the Yolo County Land Fill, which receive major flooding from potential levee failures from the Yolo Bypass.

Unleveed Portion of Yolo Bypass South of Putah Creek (Area 4)

This area is predominantly agricultural and native pasture. Structures in the area include farmsteads (houses, barns, sheds). Notable structures in the flood plain are a military reservation and a migrant farm workers camp (Figure 1).

Area West of Liberty Island and North of Cache & Haas Sloughs (Area 5)

The area is comprised of agriculture (predominant crops are safflower, sugar beets, wheat, and alfalfa), native pasture, and farmsteads (houses, barns, sheds) Figure 1.

DAMAGEABLE PROPERTY

Damageable property consist of structures and the contents within the structures. The value of damageable property was estimated at replacement cost less depreciation. Replacement cost is the cost of physically replacing (reconstructing) the structure. Depreciation is that portion of the structure value that is diminished due to wear and age. Estimates of replacement cost were obtained from the Marshall and Swift appraisal handbook. The percentage of depreciation applied to structure value was obtained from county appraisers. A percentage of the structure value after depreciation is applied to the value of damageable contents. These values were determined for areas 1, 2, and for Area 3 from the Willow Slough Bypass, but not for Area 3 from the Yolo Bypass and areas 4 and 5. The reason for this difference follows. The Yolo Bypass flood plain in Area 3 was added late in the study. Due to the similarity of the additional flood plain areas, total damages on the North side of Willow Slough Bypass were divided by the amount of acres in that area. Then the dollar per acre value was multiplied by the new acreage from the additional flood plain of the Yolo Bypass to arrive at damages for this new area. The same procedure was used for the additional flooded area south of Willow Slough Bypass to South Fork Putah Creek. For areas 4 and 5, damages from the Sacramento River Flood Control System Evaluation Phase IV were used to come up with per-acre damages. The without project damages for the portion of area 5 evaluated in Phase IV are $7,744,200. The per-acre damage data were used in areas 4 and the remainder of area 5 due to the similarity of topography and development. The value of damageable property is presented in Table 1.

TABLE 1
VALUE OF DAMAGEABLE PROPERTY
(OCT. 1991 PRICE LEVELS)

KNIGHTS LANDING AREA 1	
RESIDENTIAL	$23,457,000
FARM BUILDINGS	258,000
COMMERCIAL	1,215,000
INDUSTRIAL	6,214,000
PUBLIC	654,000
TOTAL	31,798,000
ELKHORN SLOUGH AREA 2	
(NORTH ELKHORN)	
RESIDENTIAL	$1,165,000
FARM BUILDINGS	113,000
COMMERCIAL	N/A
INDUSTRIAL	425,000
PUBLIC	13,000
TOTAL	1,716,000
(SOUTH ELKHORN)	
RESIDENTIAL	$2,968,000
FARM BUILDINGS	425,000
COMMERCIAL	N/A
INDUSTRIAL	N/A
PUBLIC	87,000
TOTAL	3,480,000
WILLOW SLOUGH AREA 3	
RESIDENTIAL	$941,000
FARM BUILDINGS	1,635,000
COMMERCIAL	163,000
INDUSTRIAL	N/A
PUBLIC	233,000
TOTAL	2,972,000

FLOOD DAMAGES

Flood damages were estimated based on depths and duration of flooding. Damages were estimated for the following categories: residential, farm buildings, commercial, industrial, public, agriculture, automobiles, emergency costs, traffic disruption, and levee repairs.

Residential Damages. Residential damages were comprised of two separate categories: (1) physical damages to dwelling units (single-family, multi-family, and mobile homes); (2) damages to residential contents, including household items and personal property.

Farm Building Damages-Damages to barns, sheds, utility and equipment buildings and other miscellaneous structures used for agricultural purposes.

Commercial Damages-Structural damages to office buildings and retail establishments and content damages, which includes equipment and furniture, supplies, and merchandise.

Industrial Damages-Losses and destruction of industrial properties from inundation consists of three categories: (1) fixtures and equipment; (2) inventory; and (3) structure.

Public Damages-The tangible damages associated with inundation to churches, libraries, schools, government facilities, (including equipment and furnishings) and roads.

Agricultural Damages-Agricultural damages were divided into two categories: (1) crop losses and (2) non-crop cleanup costs, which include debris removal, land leveling, soil mixing, disking the land, and repairing ditches for irrigation systems.

Automobile Damages-Auto damages are the damages to automobiles which are not removed prior to flooding.

Emergency Costs-Emergency costs are the costs that are incurred during flood emergencies for evacuation and re-occupation, flood fighting, disaster relief, and increased police and fire protection. A cost of $35 per person day was assumed in this analysis.

Other Damages-In addition, damages also occurred as a result of traffic disruption, levee breaks, and erosion of a railroad embankment.

DEPTH - DAMAGE RELATIONSHIPS

Depth-Damage relationships describe the probable damages that will occur under different depths of flooding conditions, either as a percentage of the total value of damageable property or in the probable loss expected. The depth-damage relationships used for all damage categories except for agricultural damages and automobile damages came from The 1988 Federal Insurance Administration, Tennessee Valley Authority Study, and studies from other Corps Districts. Historical damages were used to derive crop damages; while, non-crop cleanup costs and automobile depth-damage relationships were obtained from the Soil Conservation Service.

DAMAGE - FLOW RELATIONSHIPS

Damage-flow relationships describe the probable flood damages expected for various streamflows. They are derived by estimating the probable flood damages of several hypothetical floods of given streamflows. The probable flood damages that would result from a particular flow are estimated by describing the flood plain area associated with that flow, inventorying this area by damage category and depth of flooding, and applying the appropriate depth-damage relationships for each damage category.

AVERAGE ANNUAL DAMAGES AND BENEFITS

Average annual damages were estimated under without and with project conditions. The without project condition levee failure frequencies are presented below.

WITHOUT PROJECT LEVEE FAILURE FREQUENCIES

Knights Landing (Area 1)	40 Year
Elkhorn Slough Area (Area 2)	
North Elkhorn Slough	55 Year
South Elkhorn Slough	55 Year
Willow Slough Bypass (Area 3)	
Levee Failures on Willow Slough Bypass	20 Year
Levee Failures on Yolo Bypass	100 Year
Unleveed Area South of Putah Creek (Area 4)	10 Year
Area West of Liberty Island & North of Cache & Haas Sloughs (Area 5)	70 Year

PRELIMINARY ALTERNATIVE PLAN ANALYSIS

Water surface elevations corresponding to a maximum flood depth were used to estimate total potential flood damages for each area. Using this information, average annual damages were estimated under without and with project conditions.

For example under the without project condition a levee break occurs in Area 1, flood waters fill the area to a maximum possible flood depth. All of the without project damages are captured from the 40-year event to the 1000-year event and the damages attributable to these occurrences are $16,209,000. The above procedure was used for Area 2. Damages were captured for North Elkhorn Slough and South Elkhorn Slough from the 55-year event to the 1000-year event and then the damages were added for the entire Elkhorn area. The without project damages for North Elkhorn Slough are $7,106,000 and for South Elkhorn Slough $9,227,000. The without project damages for the entire area are $16,333,000. All possible damages for Area 3 are $24,665,000. Damages from the Willow Slough Bypass flood plain from a 20-year event to a 100-year event $7,221,000 and damages from the Yolo Bypass flood plain from a 100-year event to a 1000-year event are $17,444,000. The without project damages for area 4 (based on the per acre damages developed from Phase IV for area 5) were $2,240,000. The without project damages for area 5 were $7,910,000. These damages consisted of two different flooded areas: Damages for the first flooded area ($7,745,000) were derived from the Sacramento River Flood Control System Evaluation

Phase IV. Damages for the second flooded area ($165,800) were based on per acre damages developed from the first flooded area. The without project damages for the selected areas are presented in Table 2. Because of the per acre procedure used in Area 3 (Yolo Bypass) and Area 4, a breakdown of damages by land use category are not presented in Table 2.

For economic purposes, the with project conditions assumes complete flood protection to the flood plain areas and benefits have been claimed to the 1000 year event. The assumption results in no average annual residual damages. Thus the average annual without project damages and with project benefits are the same. For Area 1, the average annual flood inundation reduction benefits are $405,000. The average annual benefits for Area 2 are estimated using the same procedure, but in addition to that, the north and south areas were treated separately and later combined. The average annual benefits for North Elkhorn Slough are $128,000 and for the South Elkhorn Slough are $166,000, the combined average annual benefits for both areas is $294,000. For Area 3, the Willow Slough Bypass flood plain fails at a 20-year event and the Yolo Bypass flood plain fails at a 100-year event. Average annual benefits for Area 3 were $360,000, for benefits from the 20-year to the 100-year event. From the 100-year to the 1000-year event, the average annual benefits for the Area 3 are $174,000. The aforementioned analysis was used for Area 3 to prevent double counting of benefits and yet be able to claim the maximum possible benefits. The benefits were added to arrive at $534,000 for the total average annual inundation reduction benefit for Area 3. The average annual with project benefits for Area 4 and Area 5 are $224,000 and $113,000, respectively. The average annual equivalent damages and benefits are presented in Table 3.

Table 2
Without-Project Damages for Selected Areas 1/
(October 1991 Prices)

Knights Landing Area	
Residential Structures	$ 6,539,000
Farm Buildings	80,000
Commercial Structures	487,000
Industrial Structures	3,625,000
Public Structure	3,623,000
Agriculture	1,855,000
Total	16,209,000
Elkhorn Slough Area	
Residential Structures	$ 1,975,000
Farm Buildings	397,000
Commercial Structures	-
Industrial Structures	238,000
Public Structures	7,356,000
Agriculture	6,367,000
Total	16,333,000
Willow Slough Bypass Area 2/	
Residential Structures	$ 289,000
Farm Buildings	446,000
Commercial Structures	50,000
Industrial Structures	-
Public Structures	1,241,000
Agriculture	5,195,000
Total	7,221,000
Area West of Liberty Island and North of Cache and Haas Sloughs 3/	
Residential Structures	$ 224,000
Farm Buildings	954,000
Commercial Structures	-
Industrial Structures	-
Public Structures	1,867,000
Agriculture	4,700,000
Total	7,745,000

1/ Damages are total damages for the 400-year flood except for the Willow Slough Bypass area. Damages for the Willow Slough Bypass area are total damages for the 100-year flood. Damages include structures and contents. Public damages include public structures and contents, automobiles, traffic disruption, emergency costs, and levee repair.

2/ Damages are from flooding from Willow Slough Bypass only. Damages did not include flooding from the Yolo Bypass.

3/ Based on preliminary information from the Sacramento River Flood Control System Evaluation, Phase IV. The damages are from flooding from Haas Slough levee failures only and do not include outflanking of the north-to-south levee west of Liberty Island.

TABLE 3
AVERAGE ANNUAL DAMAGES AND BENEFITS

Area	Without Project Damages	Residual Damages	Benefits
Knights Landing	$405,000	0	$405,000
Elkhorn Slough			
Entire Area	$294,000	0	$294,000
North Elkhorn	$128,000	0	$128,000
South Elkhorn	$166,000	0	$166,000
Willow Slough Bypass	$534,000	0	$534,000
Unleveed Area South of Putah Creek	$224,000	0	$224,000
Area West of Liberty Island & North of Cache & Haas Sloughs	$113,000	0	$113,000

BENEFIT EVALUATION

The above method was used in an effort to estimate maximum possible flood inundation reduction benefits that might be attributed to levee reconstruction for each of the specified areas and combinations cited. The estimation of maximum possible inundation reduction benefits is used as a sensitivity technique to indicate the maximum cost that could be incurred for remedial repairs. If an area has a benefit-to-cost ratio greater than or equal to one, a more detailed analysis is needed. The areas which have a benefit-to-cost ratio less than one are not incrementally justified and further analysis is not warranted.

PRELIMINARY ALTERNATIVE SENSITIVITY ANALYSIS PLAN

After the preliminary alternatives were addressed, sensitivity analyses were provided for each of the following areas: Elkhorn Slough (Area 2), Willow Slough Bypass (Area 3), the unleveed area south of Putah Creek (Area 4), and the area west of Liberty Island and north of Cache and Haas Sloughs (Area 5).

For Area 2 (Elkhorn Slough) three different sensitivity analyses were developed. For the three sensitivity analyses the without project damages are the same. The entire Elkhorn Slough area has $16,333,000 in damages, that of which $7,106,000 are for the area north of the railroad embankment, and $9,227,000 for the area south of the railroad embankment.

For sensitivity analysis 1, no modification was made to average annual with project benefits. The only difference between the previous analysis for this preliminary alternative and sensitivity analysis is that different cost data were used. Sensitivity analysis 2 and 3 had a new without project non-damaging event of 100 years. The resulting average annual with project benefits, assuming no residual damages, were $70,000 for the North Elkhorn Slough area, $91,000 for the South Elkhorn Slough area, and for the entire Elkhorn Slough area, $161,000. The only difference between sensitivity analysis 2 and 3 is different cost data was used.

All three sensitivity analyses for Area 3 involve differences in cost data only. The average annual damages and benefits used are identical to the preliminary alternative plan analysis.

The last two flood plains analyzed were Area 4 and Area 5. Only sensitivity analysis 1 was completed for each area. For each area the difference between the analysis for the preliminary alternative and this sensitivity analysis involves differences in cost data only. The average annual damages and benefits are the same as those in the preliminary alternative plans.

FINAL ALTERNATIVE PLAN ANALYSIS

The final analyses were performed on the Knights Landing area for three alignment plans. These alignments are describe below.

Alignment 1 would modify levees around the entire Knights Landing area.

Alignment 2 would modify levees around the town and provide a cross levee close to town.

Alignment 3 would modify levees around the northwestern portion of the area and provide a cross levee where the Knights Landing Ridge Cut and Sacramento River come close together.

This analysis assumes that the American River Watershed Investigation, Sacramento Metropolitan Area Investigation, and the Sacramento River System Evaluation Phase I and II area projects are in place; while, the Sacramento River Flood Control System Evaluation Phase III-V and the Colusa Basin Project are not in place. All alignments were assumed to have the same average annual without project damages, but for all three alignments benefits will only be claimed from a 40-year without project non-damaging up to a 400-year with project non-damaging event. For Alignment 2, 90% of the agriculture damages were taken out in this analysis because 90% of the agricultural area was outside the area to be protected, the town of Knights Landing. In addition, 40% of the agriculture damages were taken out in this analysis for Alignment 3 because 40% of the agricultural area was outside the area to be protected. The average annual without project damages, residual damages, and benefits are presented below in Table 4.

TABLE 4
Alignment Plans
Average Annual Without Project Damages and Benefits ($)

Alignment	Without Project Damages	Residual Damages	Project Damages
Alignment 1	405,000	40,000	365,000
Alignment 2	405,000	81,000	324,000
Alignment 3	405,000	59,000	346,000

FINAL ALTERNATIVE PLAN SENSITIVITY ANALYSES

Under the three final sensitivity analyses, it was assumed that the American River Watershed Investigation, Sacramento Metropolitan Area Investigation, and Sacramento River Flood Control System Evaluation Phases I and II are all in place.

For sensitivity analysis 1, Phases III-V for the system evaluation and the Colusa Basin Project were assumed not to be in place. For sensitivity analyses 2 and 3, Phases III-V of the system evaluation and the Colusa Basin Project were assumed to be in place.

All three sensitivity analyses considered are for the Knights Landing area. Sensitivity analysis 1 assumes a 40-year non-damaging event and provides 200-year level of protection. Complete flood protection is assumed to be provided up to the 1000-year event. For sensitivity analysis 1, zero residual damages were assumed for Alignment 1, making the resulting average annual without project damages equal to the with project benefits. For Alignment 2, 90% of the agricultural damages were subtracted. For Alignment 3, 40% of the agricultural damages were subtracted. The average annual without project damages, residual damages, and with project benefits for alignments 1, 2, and 3 are presented below in Table 5.

TABLE 5
Sensitivity #1
Average Annual Without Project Damages and Benefits ($)

Alignment	Without Project Damages	Residual Damages	Project Damages
Alignment 1	405,000	0	405,000
Alignment 2	405,000	45,000	360,000
Alignment 3	405,000	20,000	385,000

Sensitivity plan 2 assumes a 100-year without project non-damaging event, claims benefits from this event up to a 1000-year with project non-damaging event, and provides a 100-year design level of protection. Finally, sensitivity plan 3 also claims benefits from a 100-year without project non-damaging event up to a 1000-year with project non-damaging event and provides 200-year design level of protection. The economic data for these two sensitivity analyses are the same. The differences between the two analyses involves differences in the cost data only. Average annual with project benefits were calculated assuming no residual damages for alignment 1. The 90% reduction for agricultural damages was again completed for alignment 2. Alignment 3, assumes a 40% reduction to agricultural damages. The without project damages, residual damages, and with project benefits for sensitivity analyses 2 and 3 are presented below in Table 6.

TABLE 6
Sensitivity #2 & #3
Average Annual Without Project Damages and Benefits ($)

Alignment	Without Project Damages	Residual Damages	Project Damages
Alignment 1	162,000	0	162,000
Alignment 2	162,000	18,000	144,000
Alignment 3	162,000	8,000	154,000

APPENDIX C: BASIS OF DESIGN

YOLO BYPASS, NORTHERN CALIFORNIA

STREAMS INVESTIGATION

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

FOR

RECONNAISSANCE REPORT

FEBRUARY 1992

PREPARED BY

CENTRAL VALLEY SECTION, CIVIL PROJECTS BRANCH

ENGINEERING DIVISION

U. S. ARMY ENGINEER DISTRICT, SACRAMENTO

CORPS OF ENGINEERS

YOLO BYPASS, NORTHERN CALIFORNIA
STREAMS INVESTIGATION

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES
FOR
RECONNAISSANCE REPORT

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YOLO BYPASS, NORTHERN CALIFORNIA
STREAMS INVESTIGATION

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES
FOR RECONNAISSANCE REPORT

1. GENERAL

The purpose of this Basis of Design is to address design aspects and cost estimates for increased levels of flood protection by increasing the heights of approximately 61.5 miles of existing flood control levees, and by constructing new levees in the areas identified below. See Plate 1. The Basis of Design and cost estimates are prepared for 100-year level of flood protection and for 1 October 1991 price level.

A. The urban areas of Davis, Woodland, and Knights Landing.

B. The agricultural area between the Sacramento River and the Yolo Bypass with the Sacramento Bypass as its southern boundary (Elkhorn Slough area).

C. The agricultural areas along Willow Slough, Willow Slough Bypass, Cache Creek, Putah Creek, South Fork Putah Creek, and Knights Landing Ridge Cut.

D. The agricultural area to the west of Liberty Island, north of Cache Slough, and East of Haas Slough.

This report will describe the information used in determining alignment, freeboard, quantities, and costs for different alternatives.

The design work was based on the following assumptions:

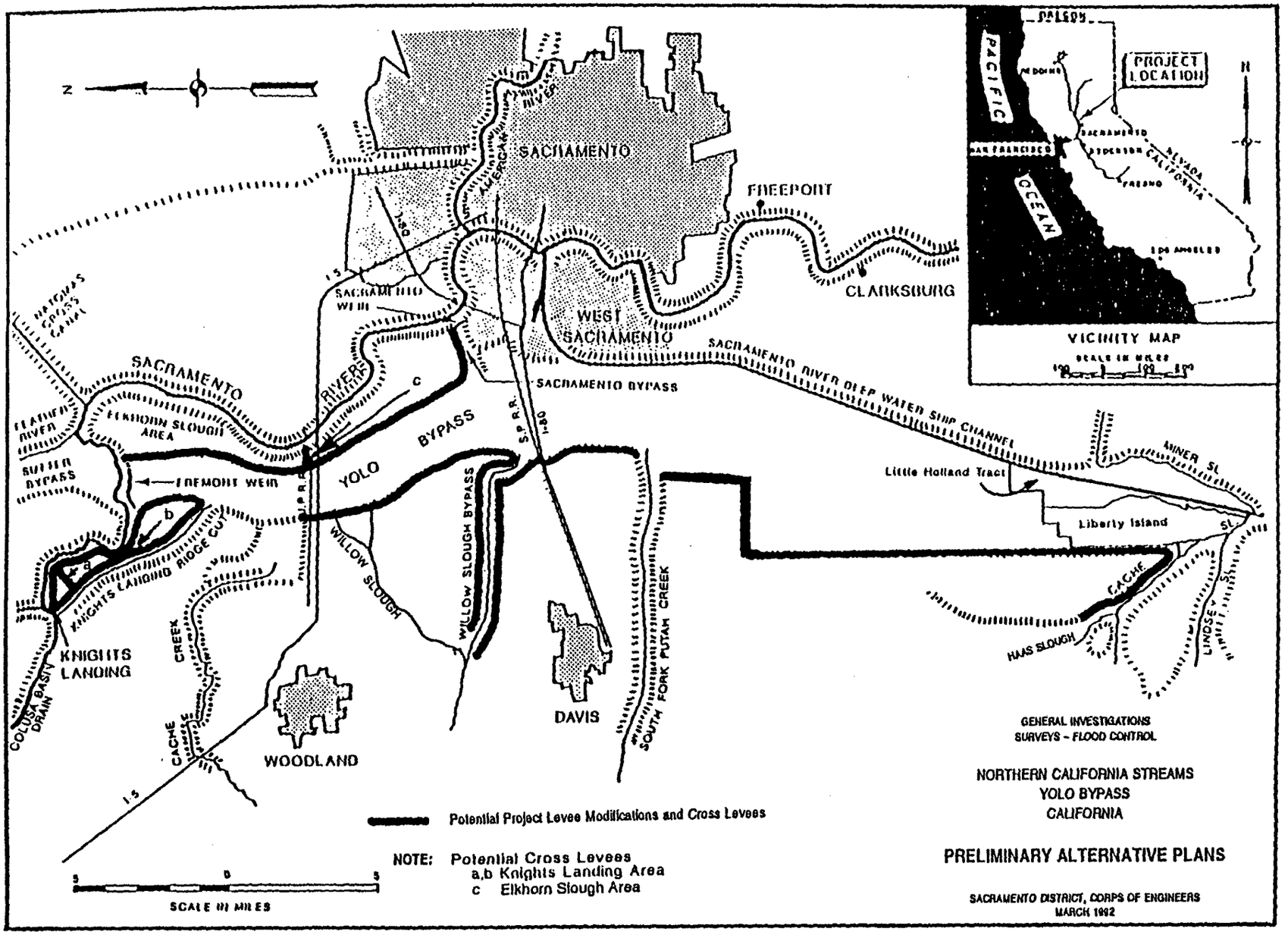
(1) The Sacramento River Flood Control System Evaluation, Phase I and II are in place. Phases III through V are not in place.

(2) The Colusa Basin Project is not in place.

(3) Improvements identified in the American River Watershed and Sacramento Metropolitan Area Investigations are in place.

(4) The Cache Creek Settling Basin Project is in place.

Based on available data and at the request of non Federal interests, limited sensivity analysis were completed for selected preliminary and final alternative plans. These analysis modified the above assumptions as follows:


SACRAMENTO
AMERICAN RIVER
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO WEIR
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
YOLO BYPASS
WILLOW SLOUGH BYPASS
WILLOW SLOUGH
KNIGHTS LANDING RIDGE CUT
KNIGHTS LANDING
COLUSA BASIN DRAIN
CACHE CREEK
WOODLAND
DAVIS
SOUTH FORK PUTAH CREEK
Little Holland Tract
Liberty Island
MINER SL
CACHE SL
HASS SLOUGH
LINDSEY SL
PACIFIC OCEAN
PROJECT LOCATION
VICINITY MAP
SCALE IN MILES
Potential Project Levee Modifications and Cross Levees
NOTE: Potential Cross Levees
a,b Knights Landing Area
c Elkhorn Slough Area
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS
CALIFORNIA
PRELIMINARY ALTERNATIVE PLANS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

4A

PLATE 1

(1A) Phases III through V of the System Evaluation were considered to be in Place.

(2A) The Colusa Basin Project was considered to be in place.

2. ALIGNMENT

Most levee work consists of raising existing levees with the alignment being determined by the existing alignment. Plate 1 shows the levees which currently exist in the areas under consideration. Plate 1 also shows alignment of the new cross levees in the Elkhorn Slough and the Knights Landing areas, and the new levee in the unleveed area south of Putah Creek.

3. MAPPING AND TOPOGRAPHY

Levee topography was determined from recently surveyed levee profiles, and recent levee cross sections. In those reaches where cross sections were not available for existing levees, top widths were field verified and side slopes were assumed to be the same as used for the original design. These side slopes are: in the case of Yolo Bypass 3:1 landside and 4:1 waterside, and in all other cases 2:1 landside and 3:1 waterside. Where regularly spaced cross sections were not available, schematic sections were developed consistent in shape with field investigations. Field observations determined that most of the levees are consistent in shape. Therefore, the few sections that are provided serve to adequately represent long reaches of levee. Table 1 presents information on existing levee topography and sources of information. Department of Water Resources levee profile survey data of 1988, 1989, and 1990 was used for Haas Slough, Cache Slough, South Fork Putah Creek, Willow Slough Bypass, Knights Landing Ridge Cut, Sacramento River Right Bank, and Yolo Bypass Right (West) levee. 1989 Corps of Engineers cross section survey data was used for Yolo Bypass Left (East) levee, and Sacramento Bypass Right (North) levee.

4. DESIGN DETAILS

Design levee sections were chosen to remain the same as used in the past designs for the existing levees. These sections have performed adequately and a stability analysis has determined that the levees would be stable after being raised to the elevations proposed for the reconstruction, see Geotech office report on Levee Enlargement Investigation For Yolo Bypass Levees, Sacramento Metropolitan Area, May 1990. In some cases the existing levees were constructed with top widths wider than the original design widths. In these locations the raised levee section will be confined to the top of the existing levees. In other cases work will extend past the existing toes of the levees. There are reaches of levees which have public roads on top of the levees. Where there are public roads and the levee must be modified, top widths of the levee will be the minimum safe roadway widths of 28-feet or current roadway widths if they exceed minimum roadway widths. In determining

whether new levee fill would be on the landside or waterside, consideration was given to the quality of fill that was being placed and to impacts on utilities, relocations, and development. Excessive fill in the waterway could significantly reduce conveyance with a resultant rise in design water profiles. Table 2 lists the levee design details for the different levee reaches.

5. FREEBOARD

Design water surface profiles were developed which were based upon hydraulic and hydrologic model studies and were calibrated for the 1986 flood of record in most reaches. Because of this, the design profiles are considered to be reliable for the design flows being considered. No additional freeboard above the minimum freeboard is considered necessary to account for uncertainties in design profile calculations.

The main objective of levee freeboard is to convey the design flows with a high degree of safety through the area of protection. Another objective is to design the levee in such a manner that flows exceeding the design flows will fail the levee in an area or in a manner that will cause the least amount of damage and have the least likelihood of causing loss of life, often referred to as levee superiority.

The freeboard adopted for the different levee reaches are: 3-feet for the Sacramento River West levee; the Willow Slough Bypass levees; the Cache Slough, the Haas Slough, and the Knights Landing Ridge Cut levees; 6-feet for the Yolo Bypass East levee from the Fremont Weir to the Sacramento Bypass, the Yolo Bypass West levee from the Fremont Weir to the Cache Slough, and the Sacramento Bypass North levee from the Yolo Bypass to the Sacramento Weir. The additional three feet over normal freeboard for the bypass is provided for wave runup. Because of the width of the Yolo Bypass, substantial waves have been and can be generated by winds during floods. The additional freeboard will prevent these waves from overtopping the levees and causing a wave erosion failure.

Table 3 lists the design freeboards adopted for the alternatives for different levee reaches.

6. SEDIMENTATION

Information developed from the sediment transport studies for "Sacramento River and Tributaries Bank Protection and Erosion Control Investigation, California," Corps of Engineers, August 1983, indicates that sediment deposition within the Yolo Bypass could have an adverse impact on flood stages and design flow requirements. Based on the sediment budgets contained in this report, long term averages of about 580,000 tons and 150,000 tons of sediment are discharged annually over the Fremont and Sacramento Weirs, respectively, into the Yolo Bypass. Of the 730,000 tons of sediment discharged over the two weirs, about 429,000 tons (318,000 cy) are deposited annually in the Yolo bypass.

TABLE 1

EXISTING LEVEE INFORMATION AND SOURCES

REACH	TOP WIDTH (FT)	LEVEE PROFILE SOURCES	SIDESLOPES LAND SIDE	SIDESLOPES WATER SIDE	LEVEE HEIGHT (FT)
SACRAMENTO RIVER WEST LEVEE, FREMONT WEIR AT RM 84 TO RM 90	20-30	1/	2:1	3:1	10-14
KNIGHTS LANDING RIDGE CUT, EAST LEVEE	20-30	1/	2:1	3:1	10-14
SACRAMENTO BYPASS, NORTH LEVEE	25-30	1/	2:1	3:1	10-27
YOLO BYPASS EAST LEVEE, FREMONT WEIR TO SACRAMENTO BYPASS	20-30	2/	3:1	4:1	17-24
YOLO BYPASS WEST LEVEE, FREMONT WEIR TO KNIGHTS LANDING RI CUT	12-20	3/	2:1	3:1	13-18
YOLO BYPASS WEST LEVEE, KNIGHTS LANDING RI CUT TO SETTLING BASIN	12-20	3/	2:1	3:1	13-20
YOLO BYPASS WEST LEVEE, CACHE CR SETTLING BASIN TO WILLOW SL BYPASS NORTH LEVEE	12-20	3/	2:1	3:1	9-20
YOLO BYPASS WEST LEVEE, WILLOW SL BYPASS TO SOUTH FORK PUTAH CR	12-20	3/	2:1	3:1	15-23
WILLOW SL BYPASS NORTH LEVEE	12	4/	2:1	3:1	3-17
WILLOW SL BYPASS SOUTH LEVEE	12	4/	2:1	3:1	3-16
YOLO BYPASS WEST LEVEE, KING & COUNTY ROAD 104 INTERSECTION TO CACHE SLOUGH	12-20	5/	2:1	3:1	12-21
CACHE SLOUGH LEFT LEVEE	12-20	5/	2:1	3:1	16-20
HAAS SLOUGH LEFT LEVEE	12-20	5/	2:1	3:1	11-16

1/ From levee profile surveyed in October 1989 by the California Department of Water Resources.
2/ From levee cross sections surveyed by the Corps of Engineers in November 1989 and from levee profile surveyed in June 1988 by the California Department of Water Resources.
3/ From levee profile surveyed in June 1988 by the California Department of Water Resources.
4/ From levee profile surveyed in August and September 1989 by the California Department of Water Resources.
5/ From levee profile surveyed in May 1990 by the California Department of Water Resources.

TABLE 2

DESIGN DETAILS FOR LEVEE REACHES

REACH	TOP WIDTH (FT)	SIDESLOPES LAND SIDE	SIDESLOPES WATER SIDE	SIDE OF FILL (FT)
SACRAMENTO RIVER WEST LEVEE, FREMONT WEIR AT RM 84 TO RM 90	20	2:1	3:1	LANDSIDE
KNIGHTS LANDING RIDGE CUT, EAST LEVEE	20	2:1	3:1	LANDSIDE
SACRAMENTO BYPASS, NORTH LEVEE	30	2:1	3:1	LANDSIDE
YOLO BYPASS EAST LEVEE, FREMONT WEIR TO SACRAMENTO BYPASS	20	3:1	4:1	LANDSIDE
YOLO BYPASS WEST LEVEE, FREMONT WEIR TO KNIGHTS LANDING RIDGE CUT	20	2:1	3:1	LANDSIDE
YOLO BYPASS WEST LEVEE, KNIGHTS LANDING RIDGE CUT TO SETTLING BASIN	20	2:1	3:1	LANDSIDE
YOLO BYPASS WEST LEVEE, CACHE CR SETTLING BASIN TO WILLOW SL BYPASS NORTH LEVEE	20	2:1	3:1	LANDSIDE
YOLO BYPASS WEST LEVEE, WILLOW SL BYPASS TO SOUTH FORK PUTAH CR	12	2:1	3:1	WATERSIDE
WILLOW SL BYPASS NORTH LEVEE	12	2:1	3:1	LANDSIDE
WILLOW SL BYPASS SOUTH LEVEE	12	2:1	3:1	LANDSIDE
YOLO BYPASS WEST LEVEE, KING & COUNTY ROAD 104 INTERSECTION TO CACHE SLOUGH	20	2:1	3:1	LANDSIDE
CACHE SLOUGH LEFT LEVEE	12	2:1	3:1	LANDSIDE
HAAS SLOUGH LEFT LEVEE	12	2:1	3:1	LANDSIDE

Currently, about 200,000 tons of sediment are deposited in the Yolo Bypass by Cache Creek. The majority of this material is deposited in an area just downstream of the existing cobble weir. After the Cache Creek Settling Basin is modified, sediments from Cache Creek are not expected to deposit in the bypass, as noted in the report, "Cache Creek Basin, California," Corps of Engineers, February 1979. Work on this project is expected to start in March 1992 and this project should be completed by the middle of 1992. Additional sediments are transported into the Yolo Bypass from smaller tributaries and from agricultural return water.

Under existing conditions (no improvements at the Cache Creek Settling Basin), about 466,000 cy of sediment are deposited annually into the Yolo Bypass from Sacramento River overflow and from Cache Creek. If spread uniformly over the surface area of the bypass, 466,000 cy of sediment would represent a depth of about 0.05 inch of deposited material per year (2.5 inches of deposited material in a 50-year period). The effect of sediment deposition on flood stages in the Yolo Bypass could be more significant than indicated because the sediments probably accumulate in specific areas. At present, there is no procedure for monitoring sediment deposition and sediment deposits are not being removed from the Yolo Bypass. However, the 6-feet of freeboard used for the Yolo Bypass design is adequate to accommodate any changes in design flood stages caused by future sedimentation.

7. RELOCATIONS

Six major transportation routes cross the project levees in the reach where modifications are proposed, a Southern Pacific Railroad (SPRR) line, Interstate Highway 80 (I-80), Union Pacific Railroad (UPRR) line, Interstate Highway 5 (I-5) and Highway 16 across the Yolo Bypass; and SPRR railroad line and Highway 113 across the Knights Landing area. Plate 1 shows the location of these crossings. Major modifications would be necessary to these lines if they were raised to the proposed elevations of the new levees.

The UPRR railroad grade is approximately one foot above the investigated design water surfaces. If this railroad were modified to pass over the proposed increased levee heights, miles of railroad would have to be raised at great expense. Instead of raising the railroad, it is proposed to install a flood gate structure at the railroad crossing. This structure would have concrete walls on both sides, parallel to the tracks. These walls would abut the levee. Between the walls, a gate would be constructed, which would be closed and sealed during floods. This gate would remain open until flood elevations reached a predetermined critical elevation. At that time, the gate would be closed and remain closed until flood elevations dropped below the critical elevation. This critical elevation would be as high as the existing railroad grade. The crossing would require careful monitoring during the passage of a flood and a monitoring system would be installed which would alert local flood officials when flood elevations reached the critical elevation. The use of a flood gate could interrupt railroad traffic for several days. However, this would occur very infrequently. These type of flood gates are currently in use in other reaches of the Sacramento River Flood Control Project.

TABLE 3

DESIGN FREEBOARD FOR LEVEE REACHES

REACH	DESIGN FREEBOARD (FT)
SACRAMENTO RIVER WEST LEVEE, FREMONT WEIR AT RM 84 TO RM 90	3
KNIGHTS LANDING RIDGE CUT, EAST LEVEE	3
YOLO BYPASS EAST LEVEE, FREMONT WEIR TO SACRAMENTO BYPASS	6
SACRAMENTO BYPASS, NORTH LEVEE	6
YOLO BYPASS WEST LEVEE, FREMONT WEIR TO KNIGHTS LANDING RIDGE CUT	6
YOLO BYPASS WEST LEVEE, KNIGHTS LANDING RIDGE CUT TO SETTLING BASIN	6
YOLO BYPASS WEST LEVEE, CACHE CREEK SETTLING BASIN TO WILLOW SLOUGH BYPASS NORTH LEVEE	6
YOLO BYPASS WEST LEVEE, WILLOW SLOUGH BYPASS TO SOUTH FORK PUTAH CREEK	6
WILLOW SL BYPASS NORTH LEVEE	3
WILLOW SL BYPASS SOUTH LEVEE	3
YOLO BYPASS WEST LEVEE, KING & COUNTY ROAD 104 INTERSECTION TO CACHE SLOUGH	6
CACHE SLOUGH LEFT LEVEE	3
HASS SLOUGH LEFT LEVEE	3

The grade of I-80 is approximately 4 feet above the proposed design water surface elevations. As with the SPRR, modification of this crossing to go over the proposed levee raising would be expensive. The existing crossing is a wide concrete bridge. The existing four feet of freeboard is adequate for most unknowns. The only freeboard that is lacking is design freeboard added to prevent overtopping due to waves. The concrete roadway would serve to prevent any wave wash from passing over the levee at this crossing. Where the modified levee abuts the roadway, riprap or concrete would be placed to prevent erosion of the ends of the levees where wave wash could occur. This low point in the levee reach would not jeopardize the integrity of the levee system.

For Highway 16 and the UPRR railroad a flood gate structure as described above is proposed. The proposed treatment for I-5 is similar to that discussed for I-80 above.

In the Knights Landing area, for Highway 113 and the SPRR railroad, a flood gate structure is proposed.

For the protection of the southern Elkhorn Slough Area, one alternative proposed is to raise the present Highway 16 to the designed elevation for 100 year level of flood protection. This will constitute a relocation.

Most alternatives indicate there would be some minor relocations. These relocations would be: telephone poles, power poles, cable poles, chain link fence, earth drainage ditches, pipe gates, and gate valves.

8. HYDRAULIC MITIGATION

In a levee system as complex as the one under investigation, any change in levee heights in one area can very likely cause impacts on the other levees in the system. These impacts can be caused by reduced conveyance due to levee fill or by loss of flood storage due to prevention of levee failure. These impacts generally take the form of increased water surface elevations for a particular design flow and must be mitigated. This is called hydraulic mitigation to differentiate from fish and wildlife mitigation. One approach used in hydraulic mitigation is to assure that no area's flood frequency, for an impacted reach of levee, would be worse after the proposed levee modifications were done. This would be assured by raising low areas of impacted levees so as to restore the flood frequency to the protected area to at least the same level as existed before levee modifications. In the case of the Yolo Bypass Streams Investigation no modifications are proposed.

Another method of providing hydraulic mitigation is to raise any opposing levee to the same height as the proposed modified levee. This method is based

on the opinion that any significant raising of a levee would be perceived by owners of opposing levees as a definite threat to the integrity of their levee. To not raise opposing levees to equal heights would be inviting law suits should the opposing levees fail during a flood. Also by raising a levee which is currently lower than an opposing levee, the argument can be made that you have shifted the weak point in the levee system from one side of a channel to the other and the only way to ensure mitigation is to raise the levees to equal height. This same argument can be made for reaches where the opposing levees are close together and already at equal heights, such as the Willow Slough Bypass levees, the Knights Landing Ridge Cut levee, and the Sacramento River levee in the Knights Landing area. The problem with this approach is twofold. First is determining where to stop mitigation. Is the levee raised to the point where impacts do not occur or continued completely around the protected areas? It would look questionable to have a levee grade suddenly drop three to four feet simply because the area of impact has been covered. This approach can increase an area's flood protection even though the area's benefits would not justify this protection based on an incremental economic analysis. This comes to the second problem of this approach. The project sponsor can and probably will object to paying for what they perceive as improvements to another's levee. The project sponsor would object to this approach unless the beneficiaries of this extra mitigation would agree to cost share in the project.

Because of the complexity of this project - the different reaches for higher levels of flood protection, and the different alternatives - the approach recommended for hydraulic mitigation for the Yolo Bypass Streams Investigation is to raise the levees so as to preserve but not increase existing flood protection for impacted areas. Therefore, other levees impacted by the proposed levee modifications would have lower elevation reaches raised to the level to restore their previous flood protection.

9. PRELIMINARY ALTERNATIVE PLAN DESIGNS:

The area under investigation is divided into five segments as given below:

(a) Knights Landing Area.

(b) Elkhorn Slough Area.

(c) Willow Slough Bypass Area.

(d) Unleveed portion of Yolo Bypass Area, south of Putah Creek.

(e) Area west of Liberty Island and north of Cache and Haas Sloughs.

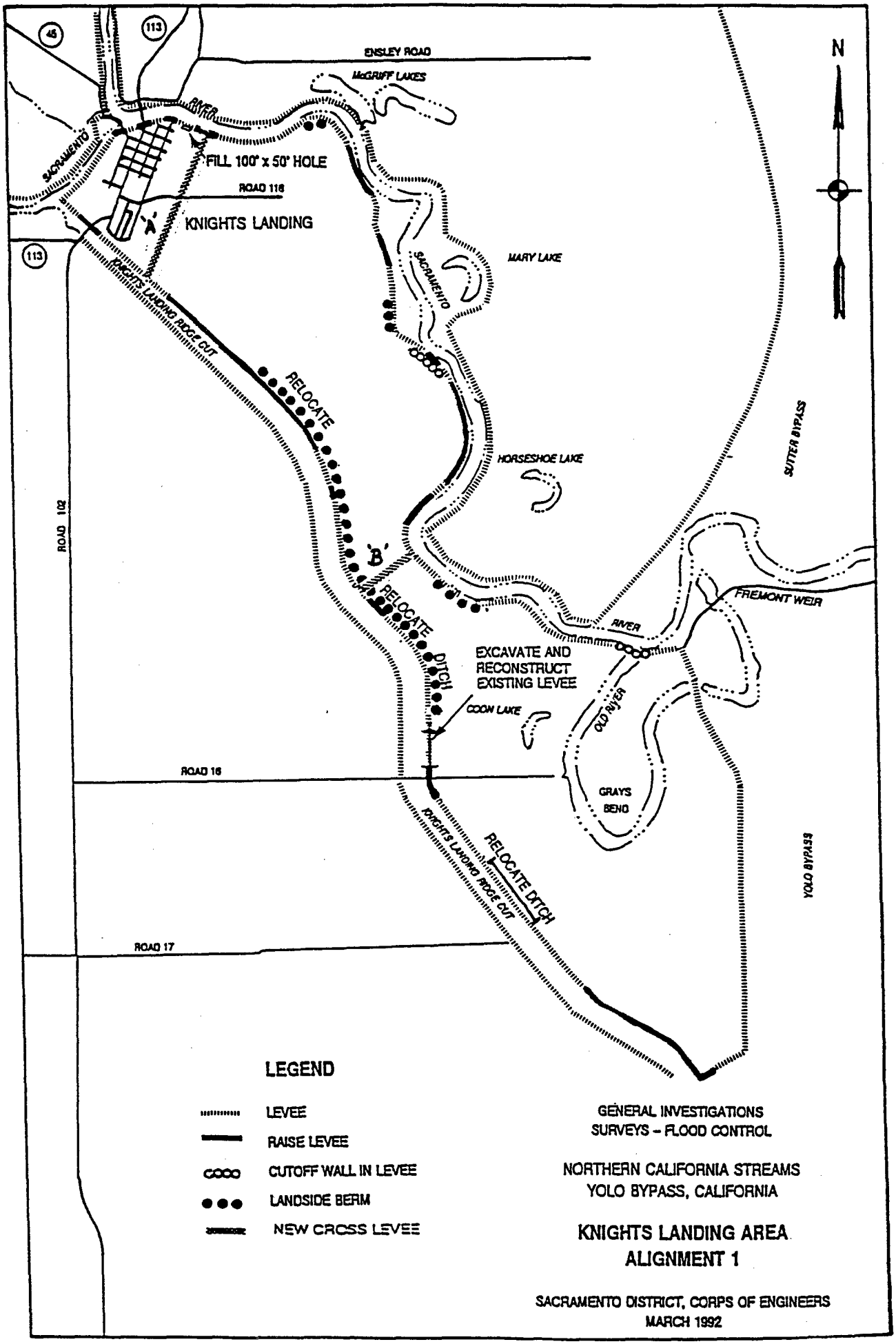

45
113
ENSLEY ROAD
McGRIFF LAKES
SACRAMENTO RIVER
FILL 100' x 50' HOLE
ROAD 116
'A'
KNIGHTS LANDING
113
MARY LAKE
SACRAMENTO
KNIGHTS LANDING RIDGE CUT
RELOCATE
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
'B'
RELOCATE
DITCH
FREMONT WEIR
RIVER
EXCAVATE AND
RECONSTRUCT
EXISTING LEVEE
COON LAKE
OLD RIVER
ROAD 16
GRAYS
BEND
KNIGHTS LANDING RIDGE CUT
RELOCATE DITCH
YOLO BYPASS
ROAD 17
N
LEGEND
LEVEE
RAISE LEVEE
CUTOFF WALL IN LEVEE
LANDSIDE BERM
NEW CROSS LEVEE
GENERAL INVESTIGATIONS
SURVEYS – FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 1
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 1

9.1 KNIGHTS LANDING AREA:

Three alternative designs for 100-year level of flood protection were considered for the Knights Landing Area, which is bounded by the Sacramento River on the north side, the Knights Landing Ridge Cut on the south side, the Yolo Bypass on the east side, and the Colusa Basin Drainage Canal on the west side (Figurel). The most levee work is required for raising the levees around the entire Knights Landing Area - Alignment 1. The least levee work is required for raising levees around the town of Knights Landing and by providing a new cross levee about 1,000 feet east of the SPRR tracks, which are to the east of the town - Alignment 2 with Cross Levee A. The third alternative is to raise levees around northwestern area of Knights Landing and providing a cross levee where the Knights Landing Ridge Cut and the Sacramento River are close together, roughly midway between the entire Knights Landing Area - Alignment 3, with Cross Levee B (Figure 1). This portion will be referred to as "the neck" at the Knights Landing Area.

9.2 ELKHORN SLOUGH AREA:

Three alternative designs for 100-year level of flood protection were considered for the agricultural area between the Sacramento River on the north and east side, the Yolo Bypass on the West Side, with Sacramento Bypass as its southern boundary (Figure 2). The most levee work is required for raising the levees around the entire area - Alignment 1. The least levee work is required for raising the levees north of I-5 and by building a cross levee along the Union Pacific Railroad (UPRR) track - Alignment 2, with Cross Levee C. The third alternative is to raise the levees around the southern Elkhorn Slough area and by building a cross levee by raising Highway 16 to the designed level for 100-year protection - Alignment 3, with Cross Levee C.

9.3 WILLOW SLOUGH BYPASS AREA:

The 100-year protection for the area is provided by the Yolo Bypass west levee from the Cache Creek Settling Basin to the Willow slough Bypass north levee, the Willow Slough Bypass north levee, the Willow Slough Bypass south levee, and the Yolo Bypass west levee from the Willow Slough Bypass south levee to the South Fork Putak Creek north levee (Figure 2).

9.4 UNLEVEED PORTION OF YOLO BYPASS, SOUTH OF PUTAH CREEK:

The 100-year protection for the unleveed portion of the Yolo Bypass south of Putah Creek is provided by building a new levee to join the existing levee at the intersection of King Road and County Road 104 (Figure 3).

9.5 AREA WEST OF LIBERTY ISLAND AND NORTH OF CACHE AND HAAS SLOUGHS:

The 100-year protection for the area west of Liberty Island, north of Cache slough, and Haas Slough is provided by raising Yolo Bypass West levee, Cache Slough and Haas Slough north levees (Figure 4, Circled area"A").

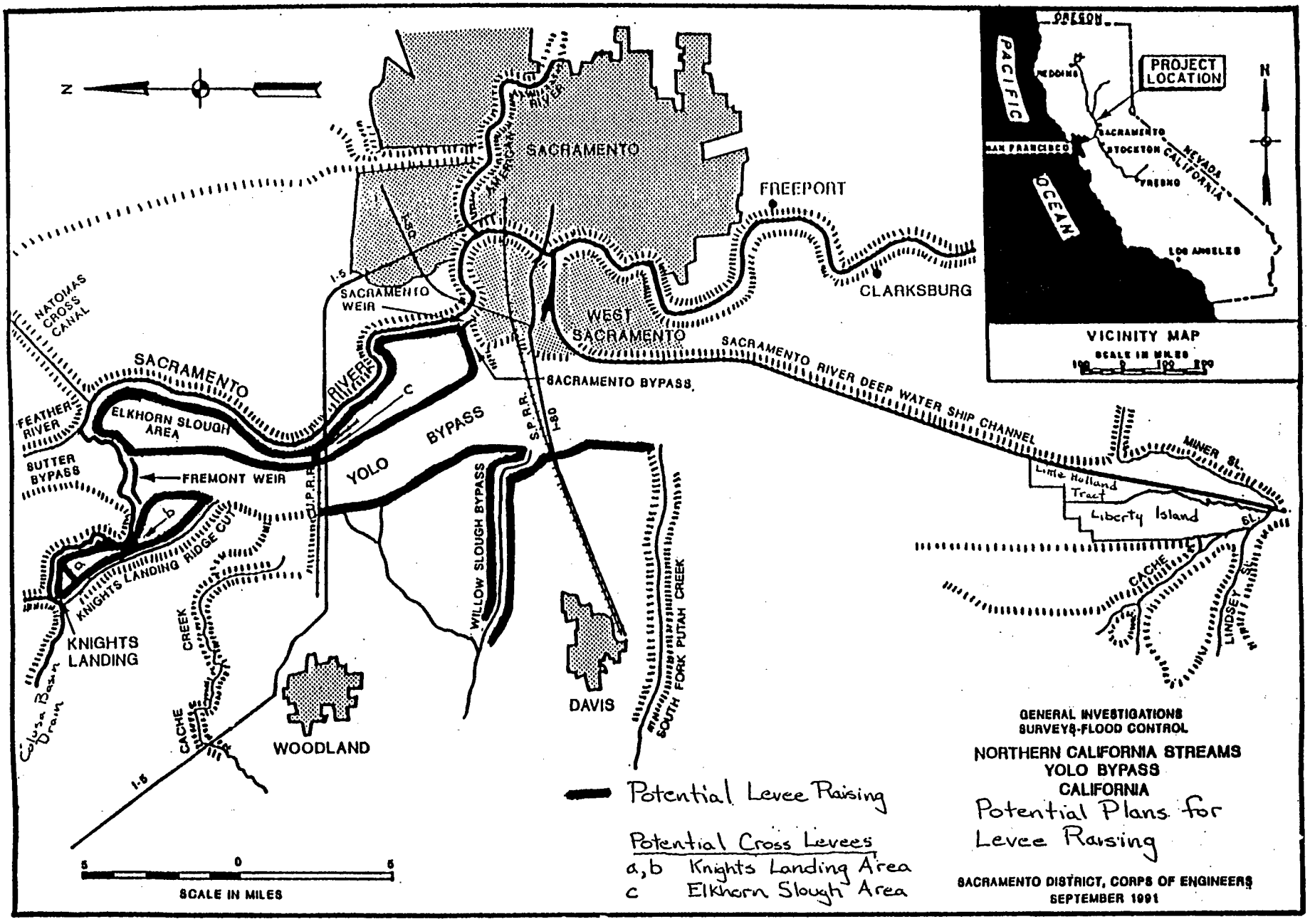

N
SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
NATOMAS CROSS CANAL
SACRAMENTO WEIR
I-5
I-80
SACRAMENTO RIVER
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
YOLO BYPASS
C.P.R.R.
S.P.R.R.
WILLOW SLOUGH BYPASS
KNIGHTS LANDING RIDGE CUT
KNIGHTS LANDING
COLUSA BASIN DRAIN
CACHE CREEK
WOODLAND
DAVIS
SOUTH FORK PUTAH CREEK
MINER SL.
Little Holland Tract
Liberty Island
CACHE SL.
LINDSEY SL.
5 0 5
SCALE IN MILES
Potential Levee Raising
Potential Cross Levees
a,b Knights Landing Area
c Elkhorn Slough Area
PACIFIC
OCEAN
OREGON
REDDING
PROJECT LOCATION
SACRAMENTO
STOCKTON
SAN FRANCISCO
NEVADA
CALIFORNIA
FRESNO
LOS ANGELES
VICINITY MAP
SCALE IN MILES
GENERAL INVESTIGATIONS
SURVEYS-FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS
CALIFORNIA
Potential Plans for Levee Raising
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1991

Figure 2

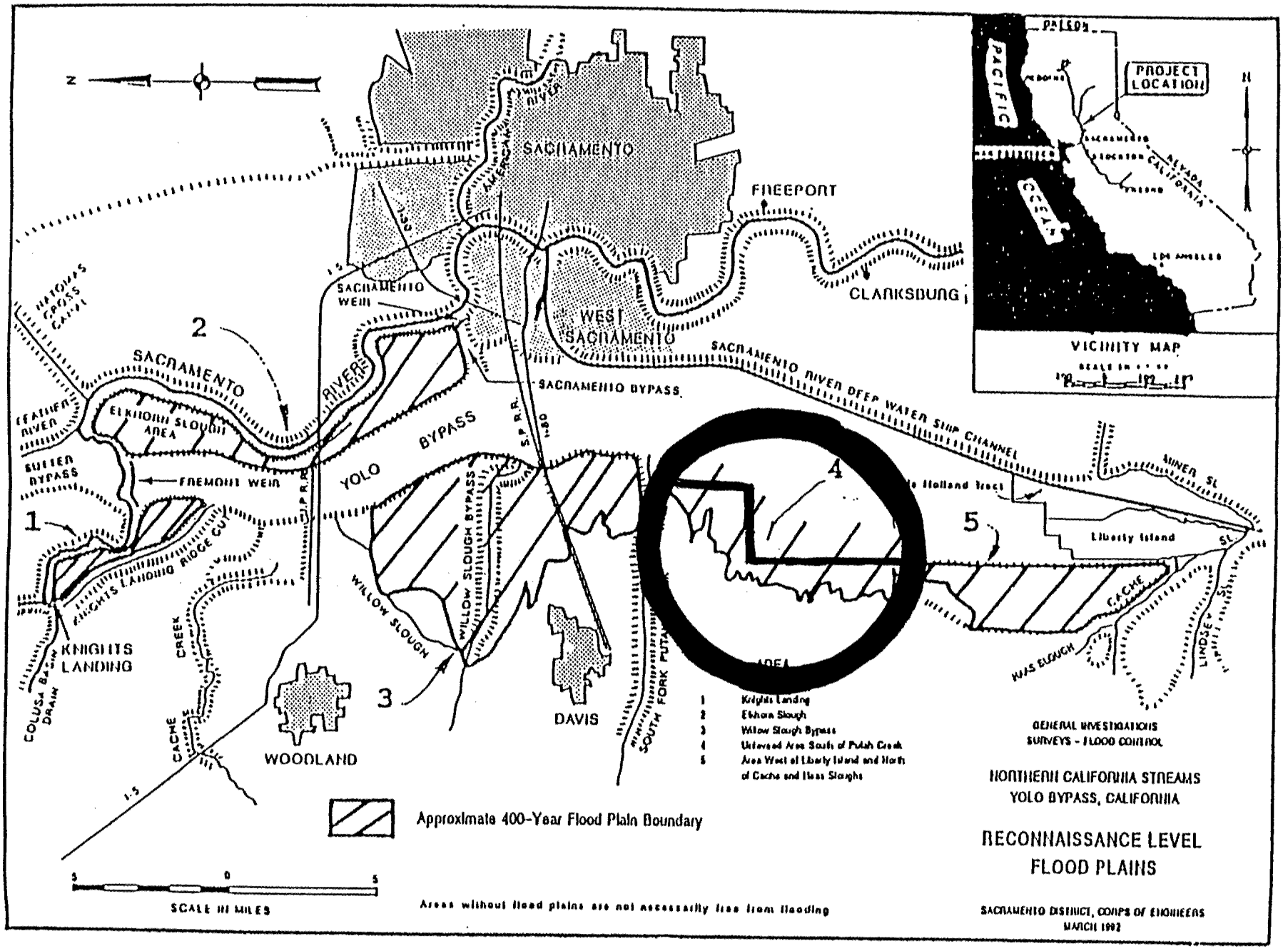

SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO BYPASS
YOLO BYPASS
SACRAMENTO WEIR
NATOMAS CROSS CANAL
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
KNIGHTS LANDING
KNIGHTS LANDING RIDGE CUT
COLUSA BASIN DRAIN
CACHE CREEK
WILLOW SLOUGH
WILLOW SLOUGH BYPASS
DAVIS
WOODLAND
SOUTH FORK PUTAH
Liberty Island
CACHE SL
LINDSEY SL
MINER SL
MAS SLOUGH
I-5
I-80
S.P.R.R.
N
PACIFIC
OCEAN
PROJECT LOCATION
VICINITY MAP
1 Knights Landing
2 Elkhorn Slough
3 Willow Slough Bypass
4 Unleveed Area South of Putah Creek
5 Area West of Liberty Island and North of Cache and Mas Sloughs
Approximate 400-Year Flood Plain Boundary
SCALE IN MILES
Areas without flood plains are not necessarily free from flooding
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
RECONNAISSANCE LEVEL
FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 3

9.6 ADDITIONAL DESIGN WORK:

Additional work was completed as a part of this study. 100-year designs were developed for the Knights Landing Ridge Cut west levee and the Yolo Bypass west levee from the Knights Landing Ridge Cut west levee to the Cache Creek Settling Basin north levee.

10. PRELIMINARY ALTERNATIVE PLANS - DESCRIPTIONS AND COSTS:

Costs for the preliminary alternative plans were computed by developing detailed quantities. However, it does not include costs of Lands and Damages (02 account); Fish and Wildlife Facilities (06 account); and, Cultural Resources (18 account). Description of levee work and costs required for the different areas are given below.

10.1 KNIGHTS LANDING AREA:

10.1.1 KNIGHTS LANDING - THE ENTIRE AREA - ALIGNMENT 1:

Levee modifications occur over 54,640 feet of levee around the entire area of Knights Landing. Out of the above footage, 22,440 feet of levee reconstruction occurs above Fremont Weir on the Sacramento River West Levee, and 32,200 feet of reconstruction occurs on the Knights Landing Ridge Cut East Levee from the Yolo Bypass West Levee to Highway 113 (Figure 1). The existing levee crown width varies from 20 feet to 30 feet, and the proposed levee crown width is 20 feet. The maximum levee raising along the Sacramento River is 2.3 feet and the maximum existing levee height is 14.2 feet. Along the Knights Landing Ridge Cut, the maximum levee raising is 3.0 feet and the maximum existing levee height is 17.3 feet. A flood gate structure will be provided for the SPRR railroad and Highway 113 (Figure 1). Relocations include telephone poles, power poles, and chain link fence. Design costs for the above reaches are shown in Table 4.

10.1.2 KNIGHTS LANDING - LEVEES AROUND THE TOWN & A CROSS LEVEE - ALIGNMENT 2:

Levee modifications include the raising of 3,500 feet of levee around the western part of the town of Knights Landing and the construction of a new levee of 4,800 feet, about 1,000 feet east of the SPRR railroad tracks which are located east of the town (Figure 1). Existing levee crown width varies from 20 to 30 feet, and the proposed levee crown width is 20 feet. The maximum levee raising is 1.5 feet and the maximum levee height is 15 feet. The proposed crown width of the new levee is 28 feet, and the maximum height is 18 feet. The 28 feet width is according to the current design standards for minimum safe roadway widths. Relocations include telephone poles, power and cable poles. Design costs for this alternative are shown in Table 5.

TABLE 4

COSTS FOR **KNIGHTS LANDING** - THE ENTIRE AREA
ALIGNMENT 1
100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	SACRAMENTO RIVER WEST LEVEE		KNIGHTS LANDING RIDGE CUT EAST LEVEE	
	PHASE III MID VALLEY COSTS	YOLO BYPASS RECON COSTS	COLUSA BASIN COSTS	YOLO BYPASS RECON COSTS
02 RELOCATIONS	197,000	21,000	80,000	31,000
11 LEVEES	745,000	573,000	900,000	1,239,000
30 ENGINEERING & DESIGN	397,000	74,000	800,000	147,000
31 SUPERVISION & ADMIN	93,000	42,000	70,000	105,000
TOTAL FIRST COST	$ 1,432,000	$ 710,000	$ 1,850,000	$ 1,522,000
	-----(a)-----	-----(b)-----	-----(c)-----	-----(d)----
COMBINED FIRST COST	(a) + (b) = $ 2,142,000		(c) + (d) = $ 3,372,000	

TABLE 5

COSTS FOR **KNIGHTS LANDING** - LEVEES AROUND THE TOWN
AND A CROSS LEVEE CLOSE TO TOWN
ALIGNMENT 2
100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	LEVEES AROUND THE TOWN	CROSS LEVEE
02 RELOCATIONS	10,000	20,000
11 LEVEES	83,000	2,730,000
30 ENGINEERING & DESIGN	11,000	330,000
31 SUPERVISION & ADMIN.	11,000	220,000
TOTAL FIRST COST	$ 115,000	$ 3,300,000

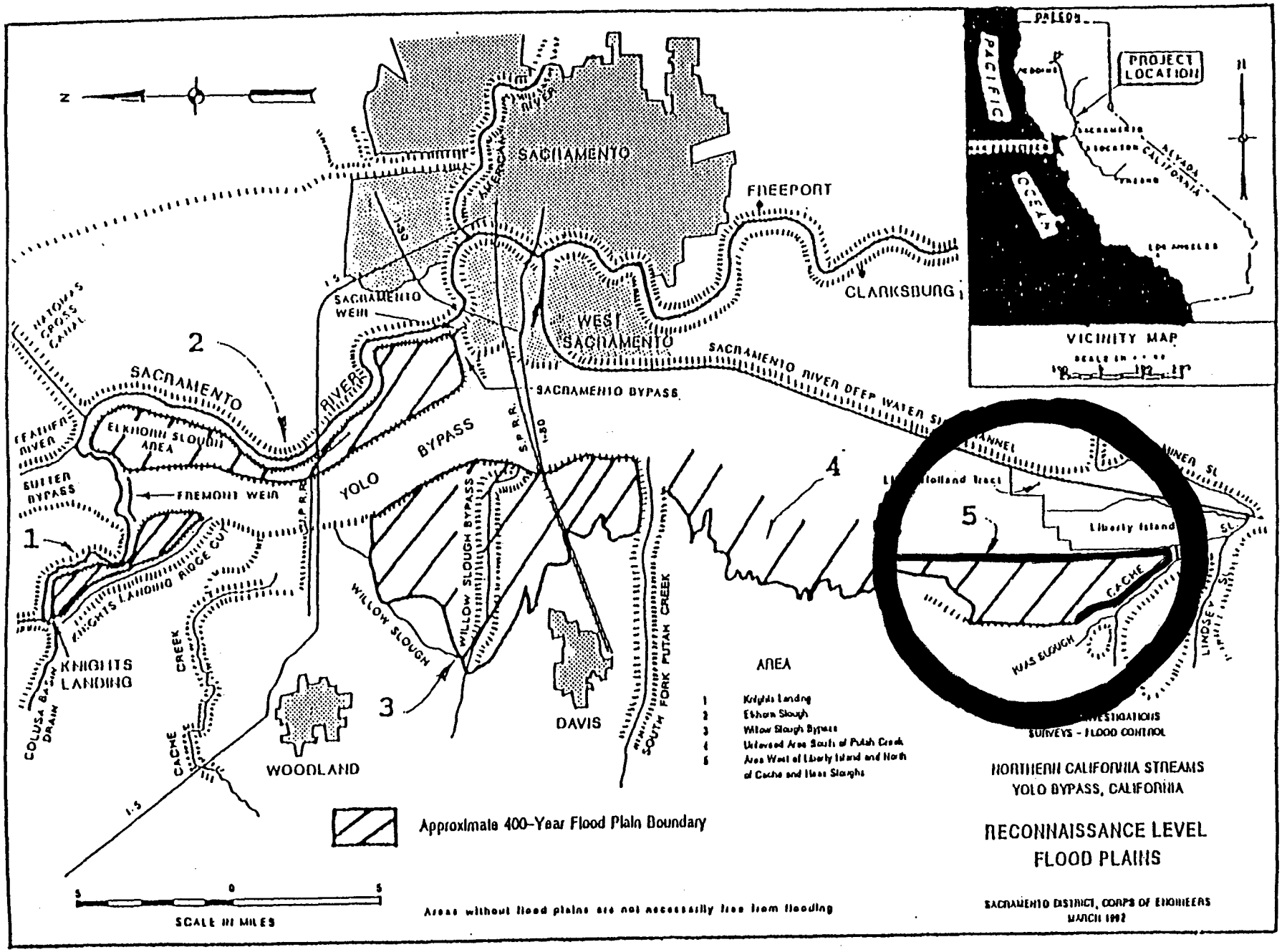

SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
YOLO BYPASS
ELKHORN SLOUGH AREA
FREMONT WEIR
FEATHER RIVER
SUTTER BYPASS
KNIGHTS LANDING RIDGE CUT
KNIGHTS LANDING
COLUSA BASIN DRAIN
CACHE CREEK
WILLOW SLOUGH
WILLOW SLOUGH BYPASS
SOUTH FORK PUTAH CREEK
DAVIS
WOODLAND
NATOMAS CROSS CANAL
AMERICAN RIVER
I-5
I-80
S.P. R.R.
Holland Tract
Liberty Island
CACHE
LINDSEY SLOUGH
MAS SLOUGH
1
2
3
4
5
AREA
1 Knights Landing
2 Elkhorn Slough
3 Willow Slough Bypass
4 Unleveed Area South of Putah Creek
5 Area West of Liberty Island and North of Cache and Hass Sloughs
PACIFIC OCEAN
PROJECT LOCATION
VICINITY MAP
Approximate 400-Year Flood Plain Boundary
Areas without flood plains are not necessarily free from flooding
SCALE IN MILES
INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
RECONNAISSANCE LEVEL
FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 4

10.1.3 KNIGHTS LANDING - LEVEES AROUND NORTHWESTERN AREA & A CROSS LEVEE AT "THE NECK" - ALIGNMENT 3:

Levee modifications occur over 16,700 feet of levee along Knights Landing Ridge Cut East Levee, 12,680 feet along Sacramento River West Levee, and the construction of a 1,900 feet cross levee at "the neck", the area where the two levees come close together. The maximum levee raising is 2.2 feet and the maximum levee height is 17.3 feet for the Knights Landing Ridge Cut East Levee. For the Sacramento River West Levee, the maximum levee raising is 1.2 feet and the maximum levee height is 13.7 feet. The proposed crown width of the new levee is 28 feet, and the maximum height is 18 feet (Figure 1). Relocations include telephone poles, power poles, and ditches. Design costs for this alternative is shown in Table 6.

Limited Sensitivity Analyses were completed regarding all three alternative plans for the Knights Landing area. Discussion of these analyses is included under the Final Alternatives Section.

10.2 ELKHORN SLOUGH AREA:

10.2.1 ELKHORN SLOUGH - THE ENTIRE AREA - ALIGNMENT 1:

Levee modifications occur over 66,000 feet of levee from the Yolo Bypass mile 0 to mile 12.5 (Figure 2). The existing levee width varies from 20 feet to 30 feet, and the proposed levee width is 20 feet. The maximum levee raising is 4.4 feet and the maximum levee height is 24.5 feet. Relocations include telephone poles, cable poles, power poles, and chain link fences. Design costs for this reach are shown in Table 7.

10.2.2 ELKHORN SLOUGH - FREMONT WEIR TO INTERSTATE 5 - ALIGNMENT 2:

Levee modifications occur over 32,580 feet of levee from Yolo Bypass mile 0.33 to mile 6.5 (Figure 2). The existing levee crown width varies from 20 feet to 30 feet, and the proposed levee crown width is 20 feet. The maximum levee raising is 2.6 feet, and the maximum levee height is 23.2 feet. The proposed crown width of the cross levee is 20 feet, the maximum raising of the existing railroad embankment is 9.7 feet, and the maximum levee height is 11.0 feet. Flood gate structure will not be necessary because the embankment raising will be done on the northern side of the UPRR railroad track. The railroad track will actually become berm on the southern slope of the levee embankment (Figure 5). Relocations include telephone poles, power poles, cable poles, and chain link fence. Railroad tracks will not be relocated. Design costs for the reach are shown in Table 8.

10.2.3 ELKHORN SLOUGH - INTERSTATE 5 TO SACRAMENTO WEIR - ALIGNMENT 3:

Levee modifications occur over 35,900 feet of levee from Yolo Bypass mile 6 to mile 12.7 (Figure 2). The existing levee crown width varies from 20 feet to 30 feet, and the proposed levee crown width is 20 feet. The maximum levee raising is 4.4 feet, and the maximum height of the levee is 24.5 feet. The proposed crown width of the cross levee is 28 feet, the maximum raising of highway 16 is 18.8 feet, and the maximum levee height is 20.5 feet. Highway 16 will not be relocated, but it will be raised to the designed elevation. Relocations include telephone poles, power poles, cable poles, and chain link fences. Design costs for this reach are shown in Table 9.

TABLE 6

COSTS FOR **KNIGHTS LANDING** - LEVEES AROUND NORTHWESTERN AREA AND CROSS LEVEE AT "THE NECK"
ALIGNMENT3
100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

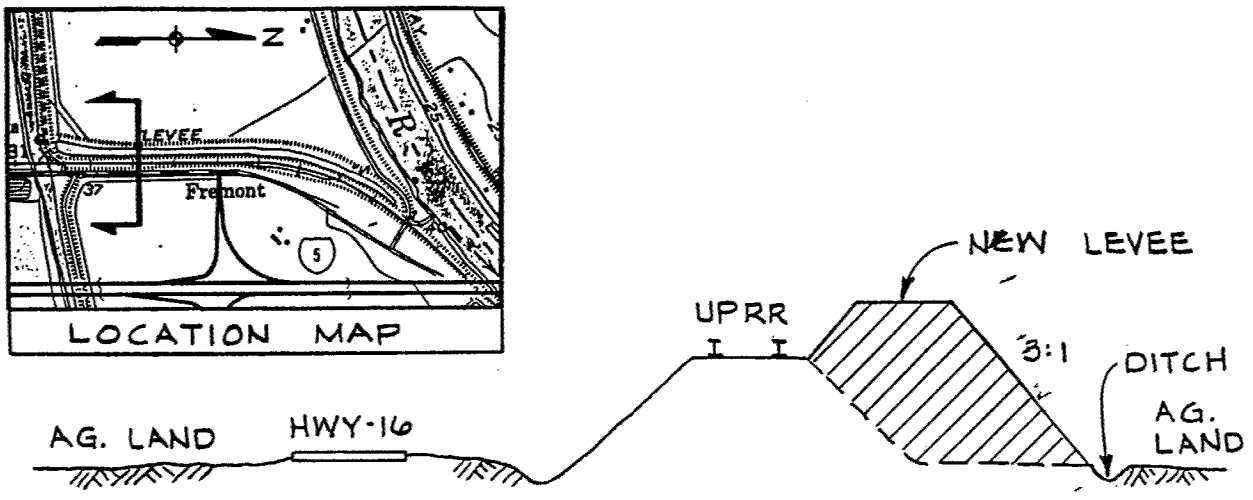
CODE ITEM	CROSS LEVEE NEAR "THE NECK"	SACRAMENTO RIVER WEST LEVEE		KNIGHTS LANDING RIDGE CUT EAST LEVEE	
		PHASE III MID VALLEY COSTS	YOLO BYPASS RECON COSTS	COLUSA BASIN COSTS	YOLO BYPASS RECON COSTS
02 RELOCATIONS	10,000	118,000	21,000	43,000	31,000
11 LEVEES	1,220,000	447,000	573,000	429,000	812,000
30 ENGINERG & DESIGN	150,000	248,000	74,000	328,000	95,000
31 SUPRVISN & ADMIN	100,000	56,000	42,000	38,000	74,000
TOTAL FIRST COST	$1,480,000	$ 869,000 (a)	$ 710,000 (b)	$ 838,000 (c)	$ 1,012,000 (d)
COMBINED FIRST COST	$1,480,000	(a) + (b) = $ 1,579,000		(c) + (d) = $ 1,850,000	

TABLE 7

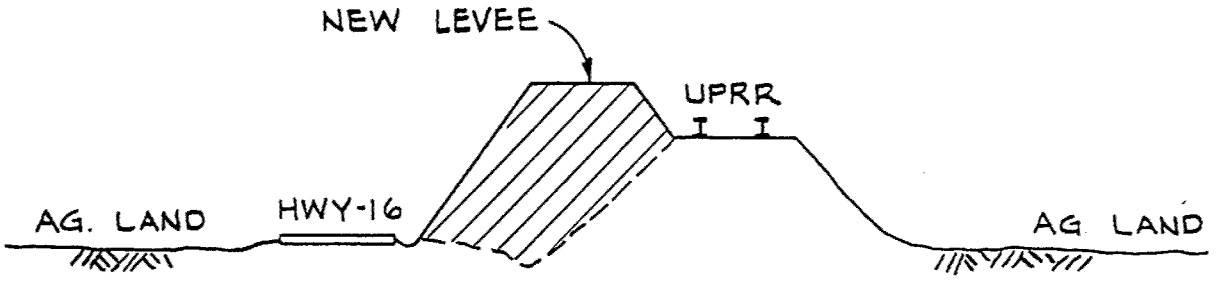
COSTS FOR **ELKHORN SLOUGH** - THE ENTIRE AREA *
ALIGNMENT 1
100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	YOLO BYPASS EAST LEVEE
02 RELOCATIONS	83,000
11 LEVEES	9,161,000
30 ENGINEERING & DESIGN	1,114,000
31 SUPERVISION & ADMIN.	736,000
TOTAL FIRST COST	$ 11,094,000

* The cost of Sacramento River West Levee was not developed because this alternative was found to be infeasible when only the cost of the Yolo Bypass East Levee was included.

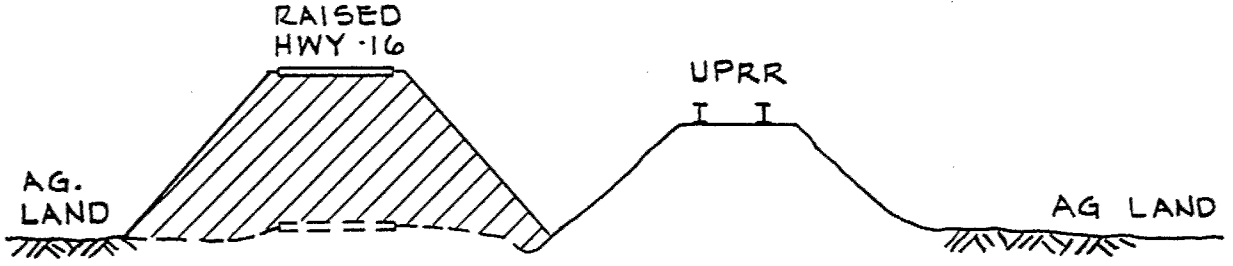


ALTERNATIVE 1-A



ALTERNATIVE 1-B

ALTERNATIVE 1



ALTERNATIVE 2

ELKHORN SLOUGH AREA
CROSS LEVEE ALTERNATIVES

Figure 5

TABLE 8

COSTS FOR **ELKHORN SLOUGH** - FREMONT WEIR TO INTERSTATE 5
AND A CROSS LEVEE BY RAISING UPRR EMBANKMENT
ALIGNMENT 2
100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE	ITEM	YOLO BYPASS EAST LEVEE NORTH OF I-5	CROSS LEVEE UPRR RAILROAD EMBANKMENT
02	RELOCATIONS	62,000	10,000
11	LEVEES	2,186,000	1,353,000
30	ENGINEERING & DESIGN	263,000	168,000
31	SUPERVISION & ADMIN.	179,000	105,000
	TOTAL FIRST COST	$ 2,690,000	$ 1,636,000

TABLE 9

COSTS FOR **ELKHORN SLOUGH** - INTERSTATE 5 TO SACRAMENTO
WEIR AND A CROSS LEVEE BY RAISING HIGHWAY 16
ALIGNMENT 3
100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE	ITEM	YOLO BYPASS EAST LEVEE SOUTH OF I-5	CROSS LEVEE HIGHWAY 16
02	RELOCATIONS	62,000	42,000
11	LEVEES	6,954,000	2,384,000
30	ENGINEERING & DESIGN	841,000	284,000
31	SUPERVISION & ADMIN.	557,000	189,000
	TOTAL FIRST COST	8,414,000	2,899,000

10.2.4 ELKHORN SLOUGH - CROSS LEVEES:

To provide 100-year protection to either the upper Elkhorn Slough Area, or the lower area, two cross levee alternatives are proposed. The first alternative is to construct a cross levee along and parallel to the UPRR railroad tracks, connecting the Yolo Bypass East Levee with the Sacramento

River West Levee. The construction of the levee could be either on the north side of the railroad tracks or on the south side of the railroad tracks. The proposed levee crown width is 20 feet, and the maximum raising of the embankment is 9.7 feet (Figure 2 & 5, Alternative 1). The length of this levee is approximately 3,965 feet and the design costs of this levee are shown in Table 8.

The second alternative is to construct a cross levee by raising Highway 16 to the proposed levee height. Highway 16 runs very close to the railroad tracks and is located south of the UPRR railroad tracks. The proposed levee crown width is 20 feet, and the maximum raising of Highway 16 is 18.8 feet (Figure 5, Alternative 2). The length of this levee is 3,965 feet. Design costs for this levee are shown in Table 9.

10.2.5 LIMITED SENSITIVITY ANALYSIS - ELKHORN SLOUGH AREA:

Limited sensitivity analyses were completed for the three alignments for the Elkhorn Slough area. The analyses considered system evaluation Phase III work to correct design freeboard deficiencies, and structural and piping stability problems to be in place. The result was a reduction in the amount and costs associated with raising of the existing Yolo Bypass levee. Costs for the cross levees , however, remained the same. The results are presented in Table 10.

TABLE 10

SENSITIVITY ANALYSIS - ELKHORN SLOUGH AREA

ALIGNMENT 1, ALIGNMENT 2, & ALIGNMENT 3

OCTOBER 1991 PRICE LEVEL

CODE ITEM	ALIGNMENT 1	ALIGNMENT 2		ALIGNMENT 3	
	YOLO BYPASS WEST LEVEE	YOLO BYPASS WEST LEVEE	*CROSS LEVEE UPRR RAILROAD	YOLO BYPASS WEST LEVEE	*CROSS LEVEE HIGHWAY 16
02 RELOCATIONS	21,000	31,000	10,000	31,000	42,000
11 LEVEES	6,902,000	1,057,000	1,353,000	5,825,000	2,384,000
30 ENGINERG & DESIGN	841,000	127,000	168,000	705,000	284,000
31 SUPRVISN & ADMIN	557,000	90,000	105,000	468,000	189,000
TOTAL FIRST COST	$8,321,000	$ 1,305,000	$ 1,636,000	$ 7,029,000	$ 2,899,000

* Costs for Cross Levee construction did not change.

10.3 WILLOW SLOUGH BYPASS AREA:

10.3.1 WILLOW SLOUGH BYPASS - YOLO BYPASS WEST LEVEE FROM CACHE CREEK SETTLING BASIN TO WILLOW SLOUGH BYPASS, AND WILLOW SLOUGH BYPASS NORTH LEVEE:

Levee modifications occur over 40,030 feet of levee along the Yolo Bypass West Levee south of the Cache Creek Settling Basin (Figure 3). The existing levee crown width varies from 20 to 30 feet, and the proposed levee crown width is 20 feet. The maximum levee raising is 3.2 feet and the maximum existing levee height is 20.0 feet. Levee modifications occur over 30,400 feet of levee from mile 0.8 to mile 6.55 of the Willow Slough Bypass North Levee. The existing levee crown width is 12 feet and the same width is proposed for reconstruction. The maximum levee raising is 5.3 feet and the maximum existing levee height is 17 feet. Relocations include telephone poles, power poles, drainage relocation, and chain link fences. Improvements in these reaches primarily provide flood protection to the area north of Willow Slough Bypass. Design costs for the reach are shown in Table 11.

TABLE 11

COSTS FOR **WILLOW SLOUGH BYPASS** - YOLO BYPASS WEST LEVEE FROM CACHE CREEK SETTLING BASIN TO WILLOW SLOUGH BYPASS, AND WILLOW SLOUGH BYPASS NORTH LEVEE

100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	YOLO BYPASS WEST LEVEE	WILLOW SLOUGH BYPASS NORTH LEVEE
02 RELOCATIONS	42,000	52,000
11 LEVEES	3,467,000	3,040,000
30 ENGINEERING & DESIGN	420,000	368,000
31 SUPERVISION & ADMIN.	284,000	242,000
TOTAL FIRST COST	$ 2,441,000	$ 3,702,000

10.3.2 WILLOW SLOUGH BYPASS - WILLOW SLOUGH BYPASS SOUTH LEVEE AND YOLO BYPASS WEST LEVEE FROM WILLOW SLOUGH BYPASS TO SOUTH FORK PUTAH CREEK NORTH LEVEE:

Levee modification occurs over 19,000 feet of levee along the Yolo Bypass West Levee from mile 14 to mile 17.6, the Willow Slough Bypass South Levee, to Putah Creek North Levee (Figure 3). The existing levee crown width of Yolo Bypass varies from 20 to 30 feet, and the proposed levee crown width

is 20 feet. The maximum levee raising is 2.2 feet and the maximum existing levee height is 22.5 feet. Levee modifications occur over 28,500 feet of levee from Willow Slough Bypass South Levee, mile 1.15 to mile 6.55, west of Yolo Bypass. The existing levee width is 12 feet and it is not changed for the reconstruction. The maximum levee raising is 5.5 feet and the maximum existing levee height is 16.0 feet. Relocations include telephone poles, power poles, and chain link fences. Improvements in these reaches primarily protect the area south of Willow Slough Bypass. Design costs for the reach are shown in Table 12.

TABLE 12

COSTS FOR **WILLOW SLOUGH BYPASS** - YOLO BYPASS WEST LEVEE FROM WILLOW SLOUGH BYPASS TO SOUTH FORK PUTAH CREEK NORTH LEVEE AND WILLOW SLOUGH BYPASS SOUTH LEVEE

100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	YOLO BYPASS WEST LEVEE	WILLOW SLOUGH BYPASS SOUTH LEVEE
02 RELOCATIONS	42,000	21,000
11 LEVEES	1,999,000	2,800,000
30 ENGINEERING & DESIGN	242,000	336,000
31 SUPERVISION & ADMIN.	158,000	231,000
TOTAL FIRST COST	$ 2,441,000	$ 3,388,000

10.3.3 LIMITED SENSITIVITY ANALYSIS - WILLOW SLOUGH BYPASS AREA:

A limited sensitivity analysis was completed for the plan for the Willow Slough Bypass area. Limited information from the system evaluation was available. Under Phase III no work would be required on the Yolo Bypass levee. Based on the most current information, geotechnical work on the Willow Slough Bypass revealed no apparent structural or piping problems, but studies did reveal design deficiencies. At this time, uncertainty exists regarding Federal involvement in construction to correct these problems due to potential local subsidence. Engineering Regulation 1165-2-119, Modification to Completed Projects, dated September 20, 1982, restricts Federal involvement in such a case. For this analysis, work to correct these freeboard deficiencies were considered to have been completed by either Federal or non-Federal construction actions. The cost information is presented in Table 13.

TABLE 13

SENSITIVITY ANALYSIS - WILLOW SLOUGH BYPASS AREA

OCTOBER 1991 PRICE LEVEL

CODE ITEM	*YOLO BYPASS CACHE CREEK TO WILLOW SLOUGH BYPASS	WILLOW SLOUGH BYPASS NORTH LEVEE	WILLOW SLOUGH BYPASS SOUTH LEVEE	*YOLO BYPASS WIL SL BP SO LEV TO SO FO PUTAH CREEK
02 RELOCATIONS	42,000	31,000	11,000	42,000
11 LEVEES	3,467,000	2,218,000	1,811,000	1,999,000
30 ENGINEERING & DESIGN	420,000	273,000	220,000	242,000
31 SUPRVISION & ADMIN.	284,000	179,000	147,000	158,000
TOTAL FIRST COST	$ 4,213,000	$ 2,701,000	$ 2,189,000	$ 2,441,000

* Costs for Yolo Bypass levees did not change.

10.4 UNLEVEED PORTION OF YOLO BYPASS - NEW YOLO BYPASS WEST LEVEE FROM PUTAH CREEK TO THE INTERSECTION OF KING ROAD AND COUNTY ROAD 104:

Currently no levee exists south of Putah Creek up to the intersection of King Road and County Road 104. A new levee along the west side of Yolo Bypass is proposed which would prevent the increased water surface elevations from further spreading over the agricultural land. This levee would be approximately 8.7 miles long and would follow the alignment shown in Figure 6. This alignment would be beside existing County Road 104. The levee would have a 15 feet crown width, 1 on 3 waterside slope, and 1 on 2 landside slope. There would be a 12 feet wide patrol road on top of the levee. Levee heights vary from 3 to 10 feet and average about 5 feet. This levee would enclose a considerable area and provisions must be made for interior drainage. The measure includes two pumping plants for this purpose. Cost estimates for this are shown in Table 14. Since there is no work proposed in this area by the system evaluation, no sensitivity analyses was possible.

10.5 AREA WEST OF LIBERTY ISLAND, NORTH OF CACHE SLOUGH, AND NORTH OF HAAS SLOUGH:

Levee modifications occur over 63,100 feet of levees from the Yolo Bypass West Levee, to Cache Slough, to Haas slough (Figure 4). The existing levee crown width varies from 12 to 20 feet. The proposed levee crown width is 20 feet. The maximum levee raising is 2.6 feet and the maximum levee height is 20.9 feet. The ground elevation at several places is zero (at Mean Sea Level). The costs for the levee reaches are shown in Table 15.

Due to the timing of the system evaluation, information was not available to complete a sensitivity analysis for this area.

TABLE 14

UNLEVEED PORTION OF YOLO BYPASS - NEW YOLO BYPASS WEST LEVEE FROM PUTAH CREEK TO THE INTERSECTION OF KING RD & COUNTY RD 104

100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	YOLO BYPASS WEST LEVEE
02 RELOCATIONS	40,000
11 LEVEES	3,231,000
13 PUMPING PLANTS	1,775,000
30 ENGINEERING & DESIGN	612,000
31 SUPERVISION & ADMIN.	414,000
TOTAL FIRST COST	$ 6,072,000

TABLE 15

AREA WEST OF LIBERTY ISLAND, NORTH OF CACHE SLOUGH, AND HAAS SLOUGH

100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	YOLO BP, CACHE SL, HAAS SL
02 RELOCATIONS	52,000
11 LEVEES	4,820,000
30 ENGINEERING & DESIGN	589,000
31 SUPERVISION & ADMIN.	389,000
TOTAL FIRST COST	$ 5,850,000

10.6 ADDITIONAL DESIGN WORK:

10.6.1 YOLO BYPASS WEST LEVEE FROM FROM KNIGHTS LANDING RIDGE CUT TO CACHE CREEK SETTLING BASIN:

Levee modifications occur over 23,020 feet of levee along Yolo Bypass West Levee south of Knights Landing Ridge Cut (Figure 3). The existing levee crown width varies from 12 to 20 feet, and the proposed levee crown width is 20 feet. The maximum levee raising is 2.4 feet and the maximum existing levee height is 20.3 feet. Relocations include telephone poles, power poles,and chain link fences. Design costs for the reach are shown in Table 16.

10.6.2 LEVEE EXTENSION FOR HALF MILE AT INTERSECTION OF COUNTY ROAD 104 AND KING ROAD IN RD 2068:

Existing levee to the south of King Road, at the intersection of County Road 104 and King Road is about 10 feet higher than the ground elevation. This results in flooding of the area west of County Road 104 and the property south of King Road, where some farm structures were flooded during 1986 flood. To stop the outflanking, it is proposed to provide one-half mile levee to tie with the present levee height to the ground elevation along County Road 104. The levee top width will be 20 feet, water side levee slope 3:1, and land side levee slope 2:1. Design costs for this levee extension are shown in Table 17.

TABLE 16

COSTS FOR **WILLOW SLOUGH BYPASS** - YOLO BYPASS WEST LEVEE
FROM KNIGHTS LANDING RIDGE CUT WEST LEVEE TO
CACHE CREEK SETTLING BASIN

100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	YOLO BYPASS WEST LEVEE
02 RELOCATIONS	21,000
11 LEVEES	489,000
30 ENGINEERING & DESIGN	63,000
31 SUPERVISION & ADMIN.	42,000
TOTAL FIRST COST	$ 615,000

TABLE 17

COSTS FOR **LEVEE EXTENSION - COUNTY ROAD 104** - HALF MILE

100-YEAR LEVEL OF FLOOD PROTECTION
OCTOBER 1991 PRICE LEVEL

CODE ITEM	LEVEE EXTENSION COUNTY ROAD 104
02 RELOCATIONS	10,000
11 LEVEES	206,000
30 ENGINEERING & DESIGN	22,000
31 SUPERVISION & ADMIN.	22,000
TOTAL FIRST COST	$ 260,000

11. INTERIOR DRAINAGE

The current interior drainage system has operated adequately in the past. Raising the levees around the different areas, and providing cross levees for different alternatives, would not change the current operation of the existing systems and no modifications are proposed. For the New Levee (para 10.4), two pumps are provided for the interior drainage.

12. TOTAL FIRST COSTS AND TOTAL ANNUAL COSTS FOR PRELIMINARY ALTERNATIVE PLANS:

Based on the analysis of the preliminary alternative plans, all plans hold BCRs of less than 1.0 except for the Knights Landing area, Alignment 2 plan. The Alignment 2 plan was carried forward as a final alternative and analyzed in more detail. In addition, Alignments 1 and 3 for the Knights Landing area were carried forward to provide a more complete comparison of flood control options for the area.

The Total First Cost which includes the Relocations, Levee Raising, Engineering & Design, and Supervision & Administration costs for different reaches and alternatives and the Total Annual Cost are given in Table 18 for the preliminary alternative plans and Table 19 for the sensitivity analysis.

13. FINAL ALTERNATIVE PLANS - DESCRIPTION & COSTS:

The Final Alternative Plans were the alignments 1, 2, and 3 for the Knights Landing area. Additional design and cost work was completed to develop land, fish and wildlife facility, and cultural resource preservation costs. Cultural resource preservation costs were estimated at 1% of the total of all other costs. The Total First Cost and the Total Annual Cost for the final three, Final Alternative Plans are given in Table 20.

Limited Sensitivity Analysis were completed for the three alignmnets for the Knights Landing area. The analysis considered the work to correct structural and piping stability problems identified by the system evaluation, Phase III on the Sacramento River and the Colusa Basin Project on the Knights Landing Ridge Cut to be in place. The result was a reduction in the amount of work and the costs associated with these plans. Costs for the cross levees, however, remained the same. The results are presented in Table 21.

* * * * *

YOLO BYPASS, STREAMS INVESTIGATION - RECON STUDY
100 YEAR LEVEL OF FLOOD PROTECTION

TABLE 18
TOTAL PROJECT (FIRST) COST FOR EACH ALTERNATIVE

TOTAL PROJECT COST FOR EACH ALTERNATIVE
OCTOBER 1991 PRICE LEVEL

PRELIMINARY ALTERNATIVE PLANS

COST ITEMS	KNIGHTS LANDG ALIGNMENT 1	KNIGHTS LANDG ALIGNMENT 2	KNIGHTS LANDG ALIGNMENT 3	ELKHORN SLOUGH ALIGNMENT 1	ELKHORN SLOUGH ALIGNMENT 2	ELKHORN SLOUGH ALIGNMENT 3	WILLOW SLOUGH BYPASS AREA	UNLEVEED AREA S OF PUTAH CR	AREA W OF LIBERTY ISL & N OF CACH..
02 RELOCATIONS	329,000	30,000	223,000	83,000	72,000	104,000	157,000	40,000	52,000
11 LEVEES	3,457,000	2,813,000	3,481,000	9,161,000	3,539,000	9,338,000	11,306,000	3,231,000	4,820,000
13 PUMPING PLANTS	0	0	0	0	0	0	0	1,775,000	0
30 ENGINEERING & DESIGN	1,418,000	341,000	895,000	1,114,000	431,000	1,125,000	1,366,000	612,000	589,000
31 SUPERVISION & ADMINIS.	310,000	231,000	310,000	736,000	284,000	746,000	915,000	414,000	389,000
TOTAL FIRST COST	5,514,000	3,415,000	4,909,000	11,094,000	4,326,000	11,313,000	13,744,000	6,072,000	5,850,000

ANNUAL COST FOR EACH ALTERNATIVE

TOTAL ANNUAL COST FOR EACH ALTERNATIVE
OCTOBER 1991 PRICE LEVEL

TOTAL FIRST COSTS	5,514,000	3,415,000	4,909,000	11,094,000	4,326,000	11,313,000	13,744,000	6,072,000	5,850,000
INTEREST DURING CONSTRUCTION	710,000	440,000	630,000	1,430,000	560,000	1,460,000	1,770,000	780,000	750,000
TOTAL FIRST INVESTMENT	6,224,000	3,855,000	5,539,000	12,524,000	4,886,000	12,773,000	15,514,000	6,852,000	6,600,000
INTEREST RATE	8.750%	8.750%	8.750%	8.750%	8.750%	8.750%	8.750%	8.750%	8.750%
ANALYSIS PERIOD (YEARS)	50	50	50	50	50	50	50	50	50
INTEREST & AMORTIZATION ANNUAL COSTS	550,000	340,000	490,000	1,110,000	430,000	1,130,000	1,380,000	610,000	590,000
O,M & R COSTS	50,000	20,000	40,000	100,000	30,000	100,000	120,000	50,000	50,000
TOTAL ANNUAL COST	600,000	360,000	530,000	1,210,000	460,000	1,230,000	1,500,000	660,000	640,000

YOLO BYPASS, STREAMS INVESTIGATION - RECON STUDY
100 YEAR LEVEL OF FLOOD PROTECTION

TABLE 19
TOTAL PROJECT (FIRST) COST FOR EACH ALTERNATIVE

TOTAL PROJECT COST FOR EACH ALTERNATIVE
OCTOBER 1991 PRICE LEVEL

SENSITIVITY ANALYSIS

PRELIMINARY ALTERNATIVE PLANS

COST ITEMS	KNIGHTS LANDG ALIGNMENT 1	KNIGHTS LANDG ALIGNMENT 2	KNIGHTS LANDG ALIGNMENT 3	ELKHORN SLOUGH ALIGNMENT 1	ELKHORN SLOUGH ALIGNMENT 2	ELKHORN SLOUGH ALIGNMENT 3	WILLOW SLOUGH BYPASS AREA
02 RELOCATIONS	52,000	30,000	62,000	21,000	41,000	73,000	126,000
11 LEVEES	1,812,000	2,813,000	2,605,000	6,902,000	2,410,000	8,209,000	9,495,000
13 PUMPING PLANTS	0	0	0	0	0	0	0
30 ENGINEERING & DESIGN	221,000	341,000	319,000	841,000	295,000	989,000	1,155,000
31 SUPERVISION & ADMINIS.	147,000	231,000	216,000	557,000	195,000	657,000	768,000
TOTAL FIRST COST	2,232,000	3,415,000	3,202,000	8,321,000	2,941,000	9,928,000	11,544,000

ANNUAL COST FOR EACH ALTERNATIVE

TOTAL ANNUAL COST FOR EACH ALTERNATIVE
OCTOBER 1991 PRICE LEVEL

SENSITIVITY ANALYSIS

TOTAL FIRST COSTS	2,232,000	3,415,000	3,202,000	8,321,000	2,941,000	9,928,000	11,544,000
INTEREST DURING CONSTRUCTION	710,000	440,000	630,000	1,070,000	380,000	1,280,000	1,490,000
TOTAL FIRST INVESTMENT	2,942,000	3,855,000	3,832,000	9,391,000	3,321,000	11,208,000	13,034,000
INTEREST RATE	8.750%	8.750%	8.750%	8.750%	8.750%	8.750%	8.750%
ANALYSIS PERIOD (YEARS)	50	50	50	50	50	50	50
INTEREST & AMORTIZATION ANNUAL COSTS	260,000	340,000	340,000	830,000	300,000	1,000,000	1,160,000
O,M & R COSTS	50,000	20,000	40,000	100,000	30,000	100,000	120,000
TOTAL ANNUAL COST	310,000	360,000	380,000	930,000	330,000	1,100,000	1,280,000

TABLE 20

TOTAL PROJECT (FIRST) COST FOR FINAL ALTERNATIVE
YOLO BYPASS, STREAMS INVESTIGATION - RECON STUDY
100 YEAR LEVEL OF FLOOD PROTECTION

OCTOBER 1991 PRICE LEVEL

FINAL ALTERNATIVE PLANS

COST ITEMS	KNIGHTS LANDG ALIGNMENT 1	KNIGHTS LANDG ALIGNMENT 2	KNIGHTS LANDG ALIGNMENT 3
01 LANDS & DAMAGES	2,392,000	1,293,000	1,980,000
02 RELOCATIONS	329,000	30,000	223,000
06 FISH & WILDLIFE	800,000	425,000	700,000
11 LEVEES	3,457,000	2,813,000	3,481,000
18 CULTURAL RESOURCES	87,000	51,000	76,000
30 ENGINEERING & DESIGN	1,418,000	341,000	895,000
31 SUPERVISION & ADMINIS.	310,000	231,000	310,000
TOTAL FIRST COST	8,793,000	5,184,000	7,665,000

ANNUAL COST FOR FINAL ALTERNATIVE

OCTOBER 1991 PRICE LEVEL

TOTAL FIRST COSTS	8,793,000	5,184,000	7,665,000
INTEREST DURING CONSTRUCTION	1,130,000	670,000	990,000
TOTAL FIRST INVESTMENT	9,923,000	5,854,000	8,655,000
INTEREST RATE	8.750%	8.750%	8.750%
ANALYSIS PERIOD (YEARS)	50	50	50
INTEREST & AMORTIZATION ANNUAL COSTS	880,000	520,000	770,000
O,M & R COSTS	80,000	50,000	70,000
TOTAL ANNUAL COST	960,000	570,000	840,000

TABLE 21

TOTAL PROJECT (FIRST) COST FOR FINAL ALTERNATIVE
YOLO BYPASS, STREAMS INVESTIGATION - RECON STUDY
100 YEAR LEVEL OF FLOOD PROTECTION

SENSITIVITY ANALYSIS

OCTOBER 1991 PRICE LEVEL

FINAL ALTERNATIVE PLANS

COST ITEMS	KNIGHTS LANDG ALIGNMENT 1	KNIGHTS LANDG ALIGNMENT 2 ***	KNIGHTS LANDG ALIGNMENT 3
01 LANDS & DAMAGES	1,764,000	1,293,000	1,700,000
02 RELOCATIONS	52,000	30,000	62,000
06 FISH & WILDLIFE	400,000	425,000	475,000
11 LEVEES	1,812,000	2,813,000	2,605,000
18 CULTURAL RESOURCES	44,000	51,000	54,000
30 ENGINEERING & DESIGN	221,000	341,000	319,000
31 SUPERVISION & ADMINIS.	147,000	231,000	216,000
TOTAL FIRST COST	4,440,000	5,184,000	5,431,000

*** Costs for Alignment 2 did not change.

ANNUAL COST FOR FINAL ALTERNATIVE

SENSITIVITY ANALYSIS

OCTOBER 1991 PRICE LEVEL

TOTAL FIRST COSTS	4,440,000	5,184,000	5,431,000
INTEREST DURING CONSTRUCTION	570,000	670,000	700,000
TOTAL FIRST INVESTMENT	5,010,000	5,854,000	6,131,000
INTEREST RATE	8.750%	8.750%	8.750%
ANALYSIS PERIOD (YEARS)	50	50	50
INTEREST & AMORTIZATION ANNUAL COSTS	450,000	520,000	540,000
O,M & R COSTS	40,000	50,000	50,000
TOTAL ANNUAL COST	490,000	570,000	590,000

****

APPENDIX D: ENVIRONMENTAL EVALUATION

ENVIRONMENTAL EVALUATION

YOLO BYPASS

RECONNAISSANCE STUDY

FOR

FLOOD CONTROL

MARCH 1992

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

ENVIRONMENTAL EVALUATION
YOLO BYPASS RECONNAISSANCE STUDY FOR FLOOD CONTROL

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ACRONYMS AND ABREVIATIONS

APCD	Air Pollution Control District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COE	U.S. Army Corps of Engineers
Corps	U.S. Army Corps of Engineers
EIS	Environmental Impact Statement
FWARG	Far Western Anthropological Research Group
GLO	Government Land Office
HEP	Habitat Evaluation Procedure
HTW	Hazardous and Toxic Wastes
Service	U.S. Fish and Wildlife Service
SHPO	State Historic Preservation Office
USFWS	U.S. Fish and Wildlife Service
VELB	Valley Elderberry Longhorn Beetle

ENVIRONMENTAL EVALUATION
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA

1.0 INTRODUCTION

This environmental evaluation (EE) was prepared to determine whether significant environmental impacts would occur if any of the proposed final flood control alternatives were selected, to identify opportunities for fish and wildlife habitat restoration, to identify recreation opportunities, and to identify environmental, cultural, and recreation studies which would be required if a feasibility phase investigation were initiated in the future. It has been determined that significant environmental impacts could result from the final flood control alternatives. Therefore, an Environmental Impact Statement (EIS) would be required as part of any further feasibility-level studies.

1.1 **Study Purpose.** The purpose of the reconnaissance study was to determine the potential for Federal participation in development and construction for high levels of flood control protection (100-year level) primarily along the west side of the Yolo Bypass in Yolo and Solano Counties. The investigation was requested in August 1989 by the Yolo County Board of Supervisors.

Consistent with the U.S. Army Corps of Engineers (Corps) environmental mission, an additional objective of this investigation was to identify potential environmental features in the study area which might be carried out under new directives of the Water Resources Development Act of 1986, Sections 704, 906, and 1135. Recreation opportunities consistent with the flood control project were also identified.

1.2 **Study Authority.** Under authority provided in the Flood Control Act of 1962 (P.L. 87-874), the Corps of Engineers was directed by Congress in the Conference Report, dated September 7, 1989, (Public Law 101-235) to initiate a reconnaissance study of flood protection for the west side of the Yolo Bypass in Yolo and Solano Counties, California. This study was to evaluate the existing levees and other flood control facilities on the west side of the bypass and adjacent streams, including Cache Creek, Putah Creek and Willow Slough, and suggest appropriate measures for providing a high level of flood protection in the area west of the bypass, particularly near the cities of Woodland, California and Davis, California.

1.3 **Project Description.** The Sacramento District conducted a reconnaissance study of flood control alternatives and fish and wildlife habitat restoration opportunities primarily along the west side of the Yolo Bypass and its west side tributaries in Yolo and Solano Counties. Possibilities for increased flood protection to the Elkhorn Slough area and Knights Landing area were also

considered. Flood control and wildlife habitat restoration opportunities which might be achieved through modification or removal of the northern levees of Liberty Island and Little Holland Tract in the Sacramento-San Joaquin Delta were investigated. Other fish and wildlife habitat restoration opportunities explored are discussed in Section 2.0.

2.0 NEED FOR THE STUDY AND OPPORTUNITIES

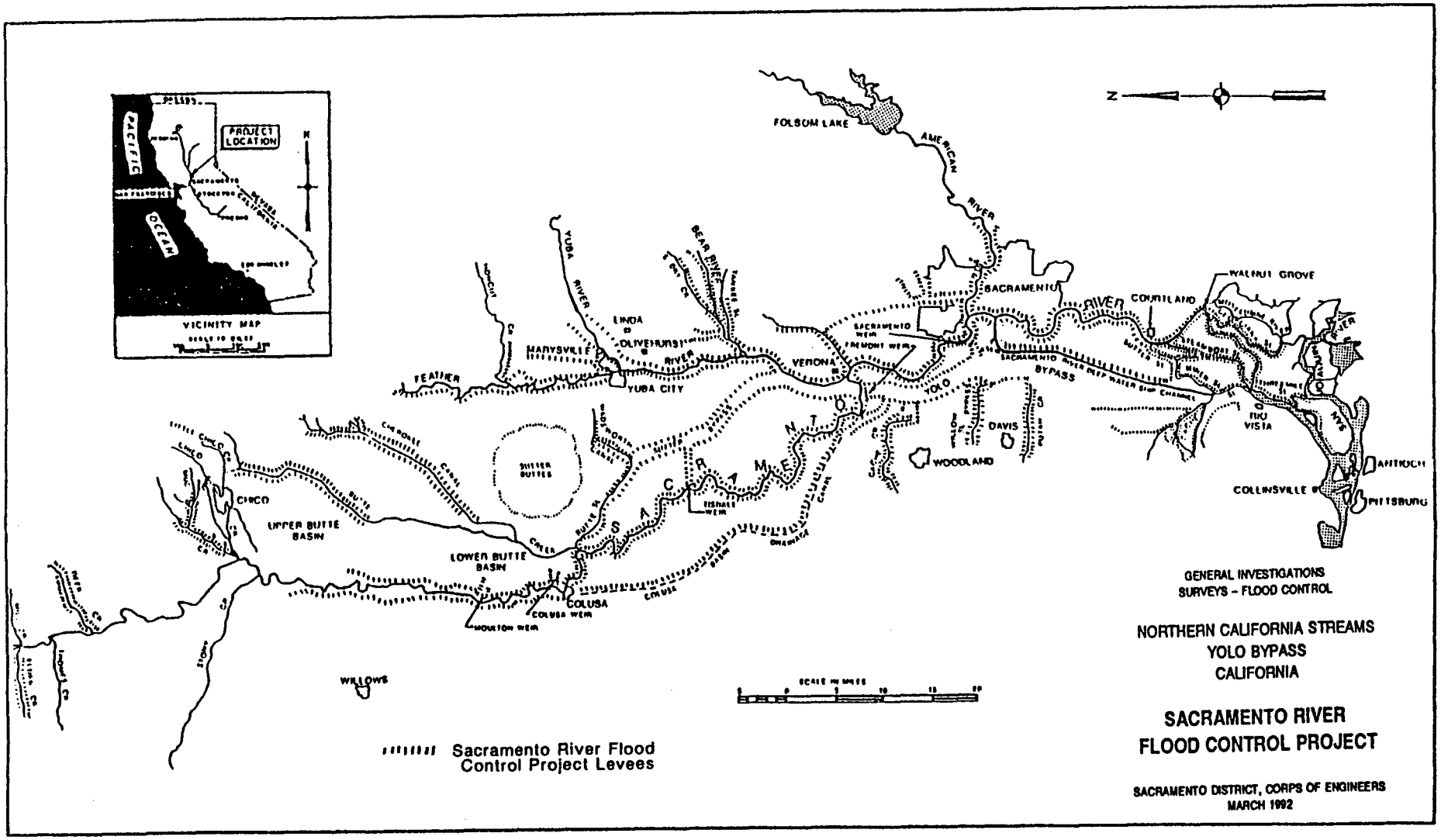
The reconnaissance study was needed to evaluate, and develop solutions to, problems identified during high river flows of 1983 and February 1986. During the winter storms in 1983-84 and February 1986, freeboard was less than 3 feet along the Yolo Bypass levees south of Interstate 5 and southwest of Elkhorn Park. During the flood of 1986, the Yolo Bypass flows approached or exceeded design flows. Although no levee failures occurred in the study area, wave action in the bypass required emergency actions to prevent levee overtopping and continued loss of levee embankment material. Future floods of a greater magnitude or duration could result in levee failures and flooding. The major metropolitan centers within the area are the cities of Davis and Woodland. Of particular concern are the wastewater treatment plants serving both cities, and the Yolo County landfill.

Environmental problems are also present in the study area. The existing joint local, State, and Federal levee system has contributed to the intensive land reclamation in the area. Reclamation has destroyed many valuable fish and wildlife habitats including wetlands, riparian forest, and the habitats of species currently listed as endangered, threatened, or rare. There is opportunity for, and considerable public interest in, restoring selected portions of these important former fish and wildlife habitats.

3.0 STUDY AREA

The study area is within the Sacramento River Basin (Figure 1). It is located within the bounds of the Sacramento River Flood Control Project in Yolo and Solano Counties. The area is about five miles west of Sacramento and about 100 miles northeast of San Francisco.

In a north-south direction, the study area covers lands on the west side of the Yolo Bypass from the Fremont Weir to the areas south of South Fork Putah Creek near Liberty Island, north of Cache Slough. In the east-west direction, the study area covers from the Yolo Bypass on the east, to lands west of the cities of Davis and Woodland. Watercourses within the area include the Yolo Bypass, Knights Landing Ridge Cut, Cache Creek, Willow Slough, Willow Slough Bypass, Putah Creek, and South Fork Putah Creek. The Knights Landing area was included, because the Yolo Bypass forms the eastern boundary of the area and the bypass influences the


PACIFIC
OCEAN
PROJECT LOCATION
VICINITY MAP
FOLSOM LAKE
AMERICAN RIVER
SACRAMENTO
WALNUT GROVE
COURTLAND
YUBA RIVER
BEAR RIVER
LINDA
OLIVEHURST
MARYSVILLE
YUBA CITY
FEATHER RIVER
VERONA
SACRAMENTO RIVER
YOLO BYPASS
DAVIS
WOODLAND
RIO VISTA
ANTIOCH
COLLINSVILLE
PITTSBURG
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CALIFORNIA
SACRAMENTO RIVER
FLOOD CONTROL PROJECT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992
Sacramento River Flood Control Project Levees

Figure 1

Knights Landing Ridge Cut. At the request of Yolo County the studyincluded a re-examination of the Elkhorn area to the east of the Yolo Bypass and north of the Sacramento Bypass. Portions of the Sacramento River bordering these two latter areas were also included. The study area is divided into the following five major study units (Figure 2):

3.1 **Area 1 - Knights Landing Area.** Knights Landing is located in the northern part of the study area just to the west of the Fremont Weir. It is bounded on the north by the Sacramento River and on the east by the Yolo Bypass. The Knights Landing Ridge Cut forms the southern boundary of this area and the Colusa Basin Drainage Canal, the western boundary.

3.2 **Area 2 - Elkhorn Slough Area.** The Elkhorn Slough area is also located in the northern part of the study area. It extends from the Fremont Weir in the north to West Sacramento in the south. It is bounded on the west by the eastern edge of the Yolo Bypass, on the north and east by the Sacramento River, and on the south by the Sacramento Bypass.

3.3 **Area 3 - Willow Slough Bypass Area.** The Willow Slough Bypass is a human constructed flood control channel which was designed to route flood flows from Willow Slough and Dry Slough to the Yolo Bypass (Larry Walker Associates:Section 3-3). Levees are maintained free of woody vegetation along most of their length. Within the Willow Slough Bypass emergent wetland vegetation is present. The Yolo County Landfill is located just north of the Willow Slough Bypass, between the City of Davis and the Yolo Bypass. The City of Davis Water Pollution Control Plant is located north of the Willow Slough Bypass and east of the landfill.

3.4 **Area 4 - Unleveed Area South of South Fork Putah Creek.** This area consists of the unleveed portion of the Yolo Bypass between South Fork Putah Creek, in the north, and the northern end of the north-to-south levee located along the west side of Liberty Island. In the east-west direction, the area covers lands west of the Yolo Bypass. For the purpose of this EE, Liberty Island and Little Holland Track were also included in Area 4.

3.5 **Area 5 - Area West of Liberty Island and North of Cache and Haas Sloughs.** Most of this area is in agriculture. There are a few homes and farm buildings scattered across the land.

3.6 **Staging, Access, Borrow, and Disposal Areas.** Staging areas are locations where equipment and materials are assembled prior to, and during, new construction work. Activities that may take place at staging areas include vehicle and equipment parking, office trailer parking and material storage. Access areas provide entrances to the construction sites. Borrow areas are areas where material (earth or gravel) is excavated to be used as fill at the construction sites. Disposal areas are locations designated for

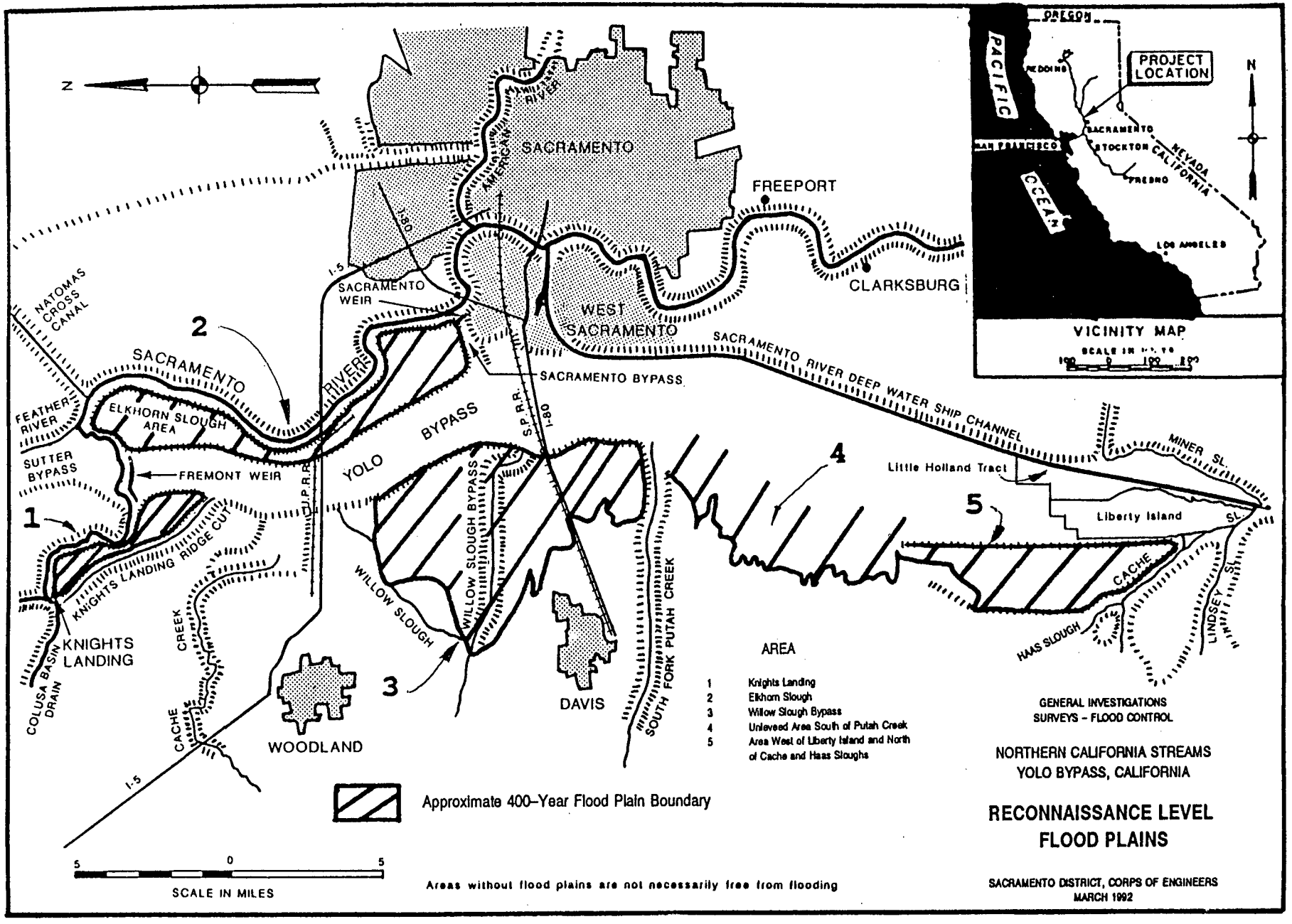

N
SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
AMERICAN RIVER
I-80
I-5
SACRAMENTO WEIR
NATOMAS CROSS CANAL
SACRAMENTO RIVER
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
U.P.R.R.
S.P.R.R.
YOLO BYPASS
WILLOW SLOUGH BYPASS
WILLOW SLOUGH
KNIGHTS LANDING RIDGE CUT
KNIGHTS LANDING
COLUSA BASIN DRAIN
CACHE CREEK
WOODLAND
DAVIS
SOUTH FORK PUTAH CREEK
Little Holland Tract
MINER SL.
Liberty Island
SL.
CACHE SLOUGH
HAAS SLOUGH
LINDSEY SLOUGH
1
2
3
4
5
AREA
1 Knights Landing
2 Elkhorn Slough
3 Willow Slough Bypass
4 Unleveed Area South of Putah Creek
5 Area West of Liberty Island and North of Cache and Haas Sloughs
Approximate 400-Year Flood Plain Boundary
5 0 5
SCALE IN MILES
Areas without flood plains are not necessarily free from flooding
PACIFIC OCEAN
OREGON
REDDING
PROJECT LOCATION
SACRAMENTO
STOCKTON
SAN FRANCISCO
NEVADA
CALIFORNIA
FRESNO
LOS ANGELES
VICINITY MAP
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
RECONNAISSANCE LEVEL
FLOOD PLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 2

the contractor to stockpile excess material; these areas may betemporary or permanent sites. These areas are not identified in this EE. Identification and evaluation of these areas would be required during any future feasibility investigations.

4.0 FLOOD CONTROL MEASURES CONSIDERED

Possible flood control measures identified by the Corps and local interests included: (1) no action; (2) modifying existing levees, (3) implementing channel work, (4) excavating within the flood bypasses, (5) constructing cross levees, (6) removing flow obstructions, (7) implementing nonstructural measures, (8) constructing ring levees and flood walls, and (9) for one area, constructing a new levee was considered.

4.1 **Measure 1 - Modify Existing Levees.** The purposes of modifying existing levees were to protect areas on the landside of the levees from flood inundation and to better transport flood water throughout the flood control project without causing damage. Modifications consisted of insuring structural and piping stability of levees and raising levees to provide required freeboard where needed. This measure was considered further.

4.2 **Measure 2 - Implement Channel Work.** The purpose of this measure was to improve the carrying capacity of channels. Earthwork would be completed and vegetation removed to enlarge flowage areas and improve the carrying capacity of channels. Due to the large amounts of sediment that would have to be removed, high cost of the sediment removal, adverse environmental impacts, and small effect on the resulting flood stages, this measure was eliminated from further consideration.

4.3 **Measure 3 - Excavate within the Flood Bypasses.** The purpose of this measure was to improve the carrying capacity of the bypasses. Earthwork would be completed to remove sediment to deepen or enlarge the flowage area. Due to the large flow discharges, large amounts of sediment that would have to be removed, high cost of the sediment removal, adverse environmental impacts, and small effect on the resulting flood stages, this measure was eliminated from further consideration.

4.4 **Measure 4 - Construct Cross Levees.** This measure was used in combination with the measure of modifying existing levees. In certain instances, rather than modifying levees around an entire area, cross levees were provided to try and protect smaller areas and obtain a better benefit-to-cost ratio. This measure was considered further.

4.5 **Measure 5 - Remove Flow Obstructions.** Certain levees within the lower end of the Yolo Bypass may create obstructions to the flow in the bypass. These levees, located at the northern end of Liberty Island and Little Holland Tract, run east to west,

perpendicular to bypass flood flows. Removal of these levees could potentially lower water surface elevations upstream and remove acreage from the 100-year and other flood plains along the western unleveed portion of the Yolo Bypass. However, the necessary hydrologic and hydraulic modeling required to evaluate the levee removal was beyond the scope of the reconnaissance study. Preliminary analysis from an existing hydraulic (DWOPER) model suggests that complete removal of the obstructions may potentially drop the water surface elevation (from existing conditions) in the Yolo Bypass downstream of the Interstate 80 causeway. Additionally, accurate costs could not be developed due to ongoing legal action currently underway to attempt to partially degrade the levees. Because of these reasons, this measure was eliminated as a viable option.

4.7 **Measure 6 - Implement Nonstructural Measures.** The purpose of the nonstructural measures was to minimize damage to individual structures in areas where structural measures were found to be infeasible. Nonstructural measures consisted of floodproofing structures, constructing small ring levees and flood walls, raising structures, and relocating structures. For areas with deep flood depths at relatively infrequent events and potentially high residual damages, non-structural measures were considered too costly and were eliminated from further consideration. Nonstructural measures were not evaluated for areas with only a few isolated structures. Although initially considered for four groups of structures, each of the groups had a single owner. Based on the most current engineering regulations, Federal participation is restricted in such circumstances. Therefore, nonstructural measures were not considered further.

4.8 **Measure 7 - Construct Ring Levees and Flood Walls.** The purpose of this measure was to minimize damage to groups of structures when modifications to existing levees were not economically feasible. This measure differed from the nonstructural measure which concentrated on protecting individual structures. For the same reasons noted for the measure to implement nonstructural measures, this measure was not considered further.

4.9 **Measure 9 - Construct New Levees.** The purpose of this measure was to provide flood protection to presently unprotected areas. In certain instances, rather than modifying levees around an entire area, cross levees were provided to try and protect smaller areas and obtain a better benefit-to-cost ratio. The measure is considered further.

5.0 STUDY AREA ENVIRONMENTAL SETTING - ABIOTIC ENVIRONMENT

5.1 **Climate.** The study area has a mediterranean climate characterized by hot, dry summers and mild, rainy winters. The dry season extends from May through October, followed by a rainy season which lasts from November through April. Normal annual rainfall for the area is around 17 inches, most of which falls from December through March. During the summer, daytime temperatures occasionally exceed 100 degrees Fahrenheit. The winter temperatures are mild and rarely drop below 20 degrees Fahrenheit.

Local meteorological conditions result from the topography of the valley. Winds are channelled by the mountain ranges that surround the valley so prevailing winds are from the southwest. Air flow passes from San Pablo Bay to Suisun Bay through the Carquinez Strait, a natural break in the coastal range, bringing cool southerly winds from the ocean in the summer and rainstorms in the winter. Clear skies predominate throughout most of the year, but storms and fog frequently occur during the winter months.

5.2 **Topography.** The Sacramento River Basin is bounded by the Trinity Mountains on the north, the Sierra nevada on the east, the North Coast Range on the west, and joins the San Joaquin Valley on the south. The Sacramento Valley is the central portion of the basin and extends 150 miles from Red Bluff in the north to Suisun Bay in the south. The valley varies 10 to 40 miles in width and ranges in elevation from about 300 feet above sea level to about 5 feet below sea level. Near the center of the valley, the Sutter Buttes, an old volcanic formation, rise abruptly to more than 2,100 feet and cover approximately 80 square miles of northern Sutter County.

The Yolo Bypass is generally flat and open with little relief, sloping gradually downward from the Fremont Weir to the Delta. Lands to the west of the Bypass rise in elevation above the bypass as one moves to the west, toward the coastal mountain range. The Elkhorn area east of the bypass is also relatively flat. Levees constructed for flood control and land reclamation purposes in the 1800's and 1900's provide barriers to flood flows as well as topographic relief.

5.3 **Geology.** The study area is geologically part of the Great Valley Geomorphic province of California. Geologic formations underlying the Sacramento Valley include igneous, metamorphic, and sedimentary rock types, which range in age from pre-Cretaceous to Recent. The project area is situated on vast alluvial deposits that have slowly accumulated over the last 100 million years. The materials have been derived from the surrounding uplands, transported by major streams, and deposited in successive clay, silt, sand and gravel layers on the river flood plains, in local sinks, or within the shallow sea that periodically covered the valley floor. The surface sediments associated with the Sacramento

River are primarily of three kinds: the older Victor formation, recent flood deposits, and recent basin deposits.

5.4 **Soils.** The floor of the Sacramento Valley is composed of mixed sedimentary and igneous alluvium deposited during the Holocene and late Pleistocene age. Along the Sacramento River, soils are characteristic of river channels, recent alluvial flood plains, basin areas, and reclaimed Delta islands. Riverwash, found in the river channel and vicinity, consists of drained sandy, gravelly, or cobble deposits. Recent alluvial flood plain soils are found in alluvial flood plain areas that are often transversed by channels and subject to overflow. These are poor to moderately drained soils and are suited for a variety of agricultural uses. Basin soils, which are used to grow rice and cereal grains, are found farther inland than the flood plain soils and are poorly drained with a clay to clay-loam surface underlain by clay subsoils. Organic Delta soils average 10 feet in depth and were originally built up from alluvial deposits and later covered by peat and other organic matter. They are excellent agricultural soils because of their high organic content.

5.5 **Air Quality.** The study area lies within the Sacramento Valley Air Basin. The topographic boundaries of the basin, coupled with light winds and atmospheric stability, make the basin highly favorable for the accumulation of air pollutants. The typical summer circulation system allows transport of pollutants for long distances up and down the valley.

The major air pollution problems in the basin are high concentrations of oxidants and suspended particulate matter. Both pollutants frequently exceed air quality standards. The largest source of oxidants is motor vehicles, and the major sources of suspended particulates are agriculture and lumber industries.

The study area is located within the jurisdiction of the Yolo-Solano Air Pollution Control District (APCD). This agency operates several monitoring stations that measure ozone, carbon monoxide, suspended particulate matter, nitrogen dioxide, and sulphur dioxide.

5.6 **Hydrology and Flow Regimen.** Throughout most of the study area, natural flow and drainage patterns have been altered by the Sacramento River Flood Control Project. This project includes a comprehensive system of levees, overflow weirs, drainage pumping plants, and flood bypass channels.

5.7 **Water Quality.** The overall water quality of the Sacramento River and tributaries is generally good, but the quality varies at specific sites due to the effects of variable streamflows and the quantity of local waste discharges and irrigation return flows. Higher sediment loads and extensive irrigated agriculture tend to degrade water quality. During the spring and fall, irrigation

tailwaters are discharged into drainage canals that flow to the river. In the winter, runoff flows over these same areas. In both instances, flows are highly turbid and introduce herbicides and pesticides into the drainage canals.

5.8 **Noise.** Noise is often defined simply as unwanted sound, and noise levels and impacts are interpreted in relation to noise standards for each county. Existing dominant noise sources in these areas range from birdsong and wind to roadway and railroad activities. Noise levels near existing communities are typical of low-density urban areas and are primarily traffic related.

6.0 STUDY AREA ENVIRONMENTAL SETTING - BIOTIC ENVIRONMENT

Most of the information provided in this section is taken directly from the Planning Aid Letter provided to the Corps by the U. S. Fish and Wildlife Service (USFWS) for this reconnaissance study (May 28, 1991).

6.1 **Vegetation.** The study area includes the following types of habitat: freshwater marsh, woody riparian forest, riparian scrub/shrub, oak woodland, grassland (upland), shaded riverine aquatic cover, and agricultural lands.

Sacramento River. Vegetation along the Sacramento River within the study area varies in density, width, and species composition depending on physical parameters such as land use, placement of riprap, location of levees, and levee maintenance.

Generally, stands of riparian vegetation occur along the rivers within the levees, while vegetation on the levee slopes and at the outside toe of the levee consists primarily of grasses and forbs, with a scattering of singular or small stands of oaks, willows or cottonwoods. Land use on the landward side of the levees is primarily agricultural.

Within the riparian corridor, tree canopy consists primarily of valley oak, sycamore, cottonwood, and various species of willow. Grape or mistletoe are sometimes present. A well-defined woody understory typically consisting of box elder, black walnut, white alder, Oregon ash, elderberry, poison oak, and smaller cottonwood occurs in most undisturbed areas. California grape, blackberry, raspberry mugwort, western ragweed, pigweed, clover, cocklebur, several thistles, grasses and forbs form an often dense ground cover. Non-native woody species which may be commonly found include eucalyptus, acacia, giant reed, and honey locust.

Yolo Bypass. In the project area, vegetation waterward of the levee consists primarily of very narrow strips of riparian habitat dominated by willows, alders, and oaks. Emergent marsh vegetation occurs sporadically along the toe drain of the levee. A dense stand of trees occurs on the west bank while the east bank, having

undergone substantial revetment work, supports only a very sparse scattering of trees.

Agricultural crops within the bypass are primarily small grains such as rice, wheat, barley, corn, safflower and sunflower and truck crops such as tomatoes, melons, and cucumbers. Many of these crops are also grown outside the bypass.

West Side Tributaries to the Yolo Bypass. The vegetation growing in and along these waterways is similar to that previously described. Willow species dominate the woody overstory while mixtures of blackberry, grasses, and forbs dominate the understory. Cache Creek supports relatively dense riparian vegetation within the channel. However, the vegetation is degraded in some areas by off-road vehicle use and clearing activities in and along the channel. The south levee of South Fork Putah Creek is generally devoid of woody vegetation as are both levees of Willow Slough Bypass.

Agricultural lands within these channels consist of a few cleared areas for crops. Lands adjacent to the channels are primarily in row crops and wheat fields.

Knights Landing Ridge Cut. Vegetation along this waterway consists of a riparian corridor along the east and west banks with the east bank more heavily vegetated. Willows are the dominant woody species. Within the channel there are berms which support scattered woody vegetation, primarily willows, and dense stands of grasses, forbs, and reeds. There are no agricultural lands within the leveed channel.

Lands outside the levee are predominately agricultural (row crops and wheat).

Liberty Island and Little Holland Tract. The levees bordering these areas are vegetated with dense stands of grasses, forbs, and scrub-shrub species. Shaded Riverine Aquatic habitat also may be present.

6.2 **Fish.**

Sacramento River. The Sacramento River supports an array of anadromous and resident fish species. Anadromous fishes in the project area include chinook salmon, steelhead trout, striped bass, American shad and white sturgeon. Resident warmwater fish include largemouth bass, crappie, white and channel catfish, bluegill, tule perch, Sacramento squawfish, Sacramento sucker and various sculpins and minnows.

Chinook salmon constitute the most important fisheries resource in California. The Sacramento River supports the largest chinook salmon population in the state. Four genetically distinct

species of chinooks presently use the river: fall-; late fall-; winter-; and spring-run. According to Hallock (1987), total numbers of salmon that spawn in the upper Sacramento River system have declined more than 75 percent since the 1950's. Winter-run salmon have experienced the most precipitous decline and were listed as threatened species in 1989 by the National Marine Fisheries Service. Between the four races of salmon and the related steelhead trout, one or more life stages of salmonids occur in the Sacramento River system at essentially all times of the year.

Steelhead trout, most of California's American shad and striped bass spawn in the Sacramento River and its tributaries. Juvenile steelhead spend 2 or more years in upstream areas before migrating downstream. The populations of all of these species have experienced a decline over the past several few decades.

Backwater areas and Shaded Riverine Aquatic Cover habitat provide important habitat to fish like largemouth bass, crappie, bluegill, white catfish, and channel catfish (USFWS 1991). Large, deep, well-shaded, sand- or rock-bottomed pools provide habitat for Sacramento squawfish, hardhead and Sacramento sucker.

Yolo Bypass, Sacramento Bypass, Knights Landing Ridge Cut. Fish from the Sacramento River system enter the Yolo Bypass when it is flooded during large storm events. As the water recedes some of these fish become stranded in the borrow ditches within the Yolo Bypass. This is true of the Tule Canal and the Knights Landing Ridge Cut as well. As a result, the same anadromous fish species identified in the Sacramento River system may also be present, at times, present in the Yolo Bypass, Sacramento Bypass, and Knights Landing Ridge Cut. Largemouth bass, crappie, catfish and bluegill compose a significant warmwater fishery in these areas. Nongame fish like carp, suckers, minnows, and mosquitofish are also present.

Cache Creek, Willow Slough, Willow Slough Bypass, South Fork Putah Creek. The characteristics of the west side tributaries vary and therefore the type of fish they are likely to support may be expected to vary as well. Cache Creek and South Fork Putah Creek are perennial in most years, since their flows are controlled by various dams and diversions. The flow in Putah Creek is controlled by Monticello Dam and Putah Creek Diversion Dam. Because these streams are somewhat perennial in nature (flows sustained by reservoir releases) they support a greater species diversity in aquatic fauna, particularly fish, than if they were intermittent streams. Three anadromous species: Pacific lamprey, chinook salmon, and steelhead trout utilize Putah Creek in wet years. Chinook salmon spawning and emerging fry have been observed in Putah Creek in the vicinity of the University of California, Davis (Moyle, personal communication to FWS).

Willow Slough and Willow Slough Bypass are watercourses generally maintained in more or less a perennial state through human intervention. The stream channels are used to deliver irrigation water and/or drain agricultural lands. These streams have been channelized to various degrees.

The fisheries of Willow Slough Bypass are generally unknown but can be expected to be limited to species adapted to turbid, warmwater conditions. Such species include carp, goldfish, Sacramento sucker, Sacramento squawfish, channel catfish, and green sunfish. Channel configuration, streamflow velocity, water depth, water temperature, chemical composition of the water, presence of cover, and availability of food are only a few of the factors influencing the success of fish species in these streams. The seasonality of irrigation deliveries may result in significant changes in available habitat with consequent adverse impacts on the fishery. At present, these stream are of relatively limited fishery value.

6.3 **Wildlife.** Wildlife resources are generally associated with the type of vegetative habitat available for food, cover and nesting. Vegetation types are described in section 6.1. Wildlife species associated with these habitats are described below. Agricultural development has generally reduced the numbers and types of wildlife present within the study area.

Riparian corridors provide habitat for many native mammal species. Audubon cottontail, brush rabbit, blacktail hare, gray squirrel, red and gray foxes, bobcat, raccoon, opossum, mink, weasel, striped and spotted skunks, badger, muskrat, river otter and beaver are found in the study area. Many of these animals are also found in other habitat types in the study area.

There are four classes of birds that use riparian ecosystems: (1) summer (breeding) residents; (2) winter residents; (3) transients (migratory); and (4) permanent residents (non-migratory). As a result, bird populations are distinctly different from season to season.

The Sacramento River system is part of the Pacific Flyway and provides important resting and feeding areas for migratory waterfowl, shorebirds, and other water associated birds. Other common bird species found in the project area include California quail, ring-necked pheasant, mourning dove, common merganser, mallard, herons, egrets, kingfisher, marsh wren, song sparrow, various owls, woodpeckers, red-tailed hawk and Swainson's hawk.

Waterfowl use of the Yolo Bypass is extensive in the study area particularly when flooded by control weirs during floods or by waterfowl hunting clubs. The wetlands and agricultural lands provide important food and resting areas for waterfowl.

Amphibians and reptiles found along the Sacramento River include gopher snake, western fence lizard, garter snake, western pond turtle, and Pacific tree frog. A variety of aquatic and terrestrial invertebrates also inhabit the study area.

Riparian forest, valley oak woodland and freshwater marsh areas found along the toe drains of the bypasses and the Sacramento River are highly productive wildlife areas. They provide food, cover, and nesting habitat for both resident and migratory species.

6.4 **Rare, Threatened, and Endangered Species.** A list of threatened and endangered species that may occur within the study area was requested and received from the U.S. Fish and Wildlife Service (Appendix 1). Three federally-listed species, one species proposed for listing, eight candidate species, and five species recommended for candidate status are described as possibly occurring within the study area.

The palmate-bracted bird's beak is the only endangered species listed. Both winter-run chinook salmon and valley elderberry longhorn beetle are listed as threatened. The winter-run chinook salmon is found throughout the Sacramento River and tributaries, (and the Yolo Bypass when flooded) during its migration to and from spawning grounds upstream in the Sacramento River from Red Bluff to Redding, California. In their letter of April 24, 1991, the National Marine Fisheries Service confirmed the presence of winter-run chinook salmon in the study area (see Appendix 2). Elderberry shrubs, which are necessary habitat for the Valley elderberry longhorn beetle to complete its life cycle, occur within the study area. These shrubs are mainly located on the waterward sides of the levees and along toe drains throughout the study area. The giant garter snake, proposed for listing, may be present in agricultural supply or drainage canals, or toe drains.

Eight federal Candidate species are identified as possibly occurring within the study area. These include: Sacramento splittail, delta smelt, California tiger salamander, tricolored blackbird, white-faced ibis, Pacific western big-eared bat, Sacramento anthicid beetle, and valley spearscale. An additional five species have been recommended for federal Candidate status. These are: vernal pool branchinecta, California linderiella, Conservancy fairy shrimp, Sacramento valley tiger beetle, and Sacramento Valley milk-vetch.

Species recognized by the State as endangered, threatened, or rare which may occur in the study area include the giant garter snake, Swainson's hawk, and the bank swallow. The swallow is protected under the Migratory Bird Treaty Act. The giant garter snake has been documented as occurring in the Yolo Bypass (USFWS May 28, 1991).

7.0 STUDY AREA ENVIRONMENTAL SETTING - SOCIOLOGICAL ENVIRONMENT

7.1 **Socioeconomic Conditions.** The study area includes parts of two counties; Yolo and Solano. These counties are primarily rural and sparsely populated. The largest urban center in the study area is Davis. No residential, commercial or industrial development is allowed in either of the flood bypass areas. Yolo County has a population of 139,200 and Solano County has a population of 339,800 (California State Department of Finance 1990).

Agriculture is the main source of employment and tax revenue in both of these counties. In 1988, the per capita income for Yolo ($17,166) and Solano ($15,639) Counties was below the State average of $18,763. However, they were not below the State poverty level.

Public services in the study area are provided by the counties and cities. These services include schools, libraries, roads, utilities, and emergency services. The major transportation routes are I-5 and State Highways 99, 45, 20 and 160.

7.2 **Hazardous and Toxic Waste Sites.** Not evaluated at this time.

7.3 **Land Use.** Urban areas include the cities of Woodland and Davis west of the Yolo Bypass. The unincorporated town of Knights Landing is situated in the northwest corner of the study area. These urban areas include residential, commercial, and industrial development. The City of West Sacramento, which is outside the study area, lies just east of the bypass. Other developed areas include the Yolo County Landfill and the City of Davis Water Pollution Control Plant, both located north of Willow Slough Bypass; the Department of the Air Force's Davis Transmitter Site, a small military installation, and the Yolo County Housing Authority's Davis Migrant Center, a migrant farm worker housing complex, both located south of South Fork Putah Creek. Inside the Yolo Bypass, land use includes farming, cattle grazing, management for wildlife, duck hunting, and management for flood control operations.

Agriculture is the predominant land use in the study area (Table 1). Row crops, orchards, and grain crops are grown on much of the land, and many irrigation diversions are made from the rivers. Land in the northern portion of the Yolo Bypass near the Fremont Weir is maintained in a relatively natural state. Deposited material is removed as required to maintain the flood control operations in a manner so as to minimize impact to vegetation. The land just south of the weir is managed as a private refuge. As such, neither of these areas is farmed nor hunted, and cattle grazing takes place only in the area south of the weir. Along the rest of the Yolo Bypass south to South Fork Putah Creek, land is used for farming. Typical crops include rice, corn, and safflower.

Table 1 1/

Land Use in Yolo and Solano Counties

County	Important Farm Land	Grazing Land	Urban	Other Land	Water Area	Total
Solano	172,334	443,636	58,460	333,657	17,329	1,025,416
Yolo	432,169	134,707	21,814	54,765	6,796	652,251

1/ Source: California Department of Conservation. 1990. California Department of Conservation. September 1990.

The central portion of the Sacramento Bypass is not farmed. Because of high velocities during floodflows, the eastern end is generally scoured and somewhat devoid of vegetation as part of project maintenance. The bypass has been designated by the State of California as the Sacramento Bypass Wildlife Area and is managed for wildlife habitat within constraints of the area's primary purpose, which is flood control. Toe drains waterward of the north and south levees contain riparian scrub and mature riparian vegetation. The landside of the north levee is farmed.

7.4 **Cultural Resources.** Prior to European contact, much of the study area was occupied by the Patwin Indians (Johnson 1978:350). Settlement and development of the Sacramento Valley by Europeans began with the arrival of John Sutter in 1839.

Archeological site records and reports for the study area are located at the Northwest Information Center of the California Archeological Inventory, Sonoma State University. A records check was conducted in May 1991. Findings are summarized below:

Knights Landing Ridge Cut. Two historic sites have been identified along the Knights Landing Ridge Cut in the Knights Landing area.

Elkhorn Slough and West Side of Sacramento River upstream of the Sacramento Weir. At least thirteen prehistoric archeological sites have been recorded within this portion of the study area. The majority of these were first documented in the 1930's and the site locations cannot be considered reliable.

Yolo Bypass. Much of the land within the confines of the lower Yolo Bypass was historically designated as "impassable tule swamp" or "swamp and overflow land" (GLO Records). One archeological site, a lithic scatter, was recorded in the Yolo Bypass near South Fork Putah Creek (FWARG n.d.).

Westside Tributaries to Yolo Bypass. No archeological sites were recorded for the westside tributaries.

Liberty Island and Little Holland Tract. No archeological sites were recorded for this area. An historical overview completed for the Corps' Sacramento-San Joaquin Delta study (Owens 1990a, 1990b) shows two potential historical site locations near the current study alternative. The first is Camp 9 at Liberty Farms, dating to 1931 or earlier. The second site is a removable span bridge, also from the same time period, on Shag Slough just north of Liberty Farms. Neither of these sites has been verified in the field.

7.5 **Recreation.** Along both the Yolo and Sacramento Bypasses, recreational activities are limited to fishing for warm water resident fish and duck hunting in private duck clubs. These areas are characterized by flat, agricultural landscapes with human made modifications including levees and farm equipment. Existing natural vegetation is limited to small, scattered areas along irrigation canals and toe drains.

In portions of the study area the Sacramento River provides a variety of seasonal and year-round recreation activities, including fishing, boating, water skiing, picnicking, and bird watching. The river supports large runs of anadromous fishes, mainly salmon, striped bass, steelhead trout and American shad. The sport fishery that these runs provide is probably the largest single recreational resource of the river.

Representatives from several local entities have produced a draft regional plan for walking and bicycling trails, and associated basic public health and safety facilities. This plan shown in Appendix 3.

7.6 **Public Safety.** Not evaluated at this time.

8.0 GENERAL DISCUSSION OF FLOOD CONTROL MEASURE IMPACTS

8.1 **Modify Existing Levees.** The proposed raising of the levees would adversely affect grasses and other herbaceous vegetation growing on the existing levee slope and beyond the toe of the berm to the limit of the construction footprint (including temporary and permanent easements, staging and access areas). Depending on the location of the work (waterside, landside, or straddle), the impacts would differ greatly.

Waterside Construction. Waterside construction would adversely affect Shaded Riverine Aquatic Cover, riparian vegetation, and grasses along the levee slope where it occurs. Any adverse effect on Shaded Riverine Aquatic Cover and riparian habitat would adversely impact fish and wildlife, including anadromous (adults and smolts) and resident fish species, and the threatened valley longhorn elderberry beetle if elderberries, its host plant, are removed. Loss of these habitat types would also reduce cover and food for fish, and nutrient input to the aquatic system; local water temperatures could also be increased due to a reduction of shading of water. Any adverse effect on anadromous fish would be significant because Sacramento River system populations are already severely depressed.

Any loss of riparian vegetation along the watercourses within the study area would adversely affect many wildlife species. The riparian forest, with its multi-layered vegetation and high plant species density, supports the largest populations and most diverse wildlife along the Sacramento River. The high diversity of tree species with varying growth rates, cover conditions and layers, and close proximity to water provides a wide variety of ecological niches. Any loss of plant area or diversity would adversely affect those species inhabiting the area.

Losses of Shaded Riverine Aquatic Cover and riparian habitats could have a significant adverse impact on many species of fish and wildlife including resident and anadromous fish, water-related birds, and small mammal species that use these areas to meet part or all of their life needs. Cover and food sources for anadromous and resident fish would be lost, nesting habitat for raptors would be eliminated or greatly reduced. Cover and nesting habitat for songbirds would be lost, and cover, food and a portion of the migration corridor for small mammals would be eliminated.

Any disturbance and loss of riparian vegetation, and construction activity would adversely affect nesting raptors, including the Swainson's hawk. Loss or disturbance of nesting habitat could severely impact these species.

The impact on grassland habitat on the levee slopes would be minimal and temporary. Disturbance or loss of this habitat would adversely impact some mammals, raptors, and other species.

However, reseeded grasses should recover quickly after project construction allowing the area to be relatively quickly repopulated by similar wildlife species.

Landside Construction. Landside construction would impact grasses on the levee slopes, trees and shrubs growing along the levee, and wetland habitats along and within existing toe drains. In areas where agricultural lands with value to wildlife are adjacent to construction sites, impacts may be sustained in these agricultural lands by losses of food and cover. Also, construction activity during raptor nesting periods could lead to nesting failure.

The impacts on fish, wildlife, and vegetation would be significantly reduced with landside construction. Landside construction would primarily eliminate or reduce any adverse project effects on riparian vegetation and Shaded Riverine Aquatic Cover.

Straddle Construction. Straddle construction would impact the grassy levee slopes, some riparian vegetation, and trees and shrubs found immediately adjacent to the levee toe on both land and watersides of the levee. Also, depending on the locations of the toe drains, impacts to wetland habitats could be reduced or eliminated. The impacts to Shaded Riverine Aquatic Cover could occur; however, they would probably be significantly less than with a waterside construction alternative.

If a landside berm is constructed with straddle construction, the impacts would be similar to landside construction.

A significant amount of borrow material would be required to raise and reinforce the levees. The impacts on vegetation and wildlife could be adverse. However, the magnitude of the impacts would vary with site location and amount of borrow material required.

8.2 **Implement Channel work.** Channelization of the watercourses in the study area would adversely affect vegetation growing within the channel (all areas between the levees). The effect of these losses on fish and wildlife would be similar to that described in 8.1. Losses of Shaded Aquatic Cover would also be likely to occur, resulting in adverse impacts to fish and other species that utilize these areas to meet part or all of their life requisites.

Clearing and snagging activities greatly reduce or eliminate habitat value for fish by removing cover, reducing substrate material for aquatic invertebrates, and reducing flow and current diversity. Terrestrial wildlife are also adversely affected when streamside vegetation is lost through removal of perching and nesting sites for birds, and cover and food sources for small mammals. Fish would lose instream and overhead cover, aquatic

insects and insect drop from overhanging vegetation for food, and may experience increased summer water temperatures from loss of shading.

Excavation of the channel would also adversely affect vegetation growing within these areas. The effect of these losses has been generally described. This alternative would potentially impact all habitats discussed in 8.1.

8.3 **Excavation within the Flood Bypass.** Excavation within the Yolo bypass would also adversely affect vegetation growing within these areas. The effect of these losses has been generally described in 8.2. Most of the land in the bypass is in agriculture, with strips of riparian forest or shrub/scrub occurring along parts of the toe drains. Emergent marsh and seasonal and permanent wetlands are also present in the bypass. Excavation within the bypass would potentially impact all habitats discussed in 8.1.

8.4 **Construct Cross Levees.** All vegetation within the construction footprint would be removed and any wildlife in the immediate vicinity would be displaced. Large quantities of borrow would be obtained from another area and placed at the construction site. Where the levees crossed toe drains, canals, or ditches, aquatic species could be adversely affected. Since the cross levees would be aligned approximately perpendicular to major waterways (like the Sacramento River) which already possess peripheral levees, impact to riparian forests and shrub/scrub, and shaded riverine aquatic vegetation should be minimal. No impact to instream aquatic resources would be expected.

8.5 **Remove Flow Obstructions.** Complete removal of levees would adversely affect vegetation growing on the levee. Breaching would adversely affect vegetation in the area where breaching occurs. Some of the wildlife in the area would be displaced, at least temporarily, or drowned. Impacts from breaching at intervals would be less than with complete removal of the levee. Areas considered for flood control measure were primarily agricultural lands surrounded by artificial levees. Agricultural lands provide important habitat for some wildlife. However, levee removal could result in restoration of scarce native wetland habitat which could produce higher value habitat for fish and wildlife.

8.6 **Implement Nonstructural Measures.** The construction actions should have only minimal adverse effects on vegetation and wildlife in the study area. Few, if any, impacts are expected to fish resources. Construction activities could adversely affect raptor nesting success if it is conducted during the nesting periods.

Location of construction staging areas could have an adverse impact on vegetation and wildlife if they were located in sensitive areas.

8.7 **Construct Ring Levees and Flood Walls.** Impacts would be similar to those discussed in 8.4.

8.8 **Construct New Levees.** Impacts would be similar to those discussed in 8.4.

9.0 DETAILED EVALUATION FINAL ALTERNATIVE PLANS - KNIGHTS LANDING AREA

9.1 Existing Conditions.

9.1.1 Abiotic Environment.

Climate, Topography, Geology, Air Quality, and Noise. The Knights Landing area experiences the same mediterranean climate as the rest of the study area (see Section 5.1). It is located in a flood plain and is relatively flat. Descriptions of topography, geology, air quality, and noise provided in sections 5.2, 5.3, 5.5, and 5.8, respectively, also apply to the Knights Landing area.

Soils. Soils are characteristic of recent alluvial flood plains. Most of the soils in the Knights Landing area are classified as "Prime Farmland" (California Department of Conservation June 1990: map). The U.S. Department of Agriculture defines Prime Farmland as "land which has the best combination of physical and chemical characteristics for the production of crops" (California Department of Conservation September, 1990:61).

Water Quality. The water quality of the toe drains in the Knights Landing area is unknown, but it is probably similar to that of other agricultural toe drains in the region. The temperature and chemical composition of the water is likely to vary widely depending upon rainfall and agricultural practices like irrigation, cultivation, and fertilizer and pesticide application.

9.1.2 Biotic Environment.

Vegetation. Patches of relatively high quality riparian forest exist along the water side of the Sacramento River levee and in places along the Colusa Basin Drainage Canal. Linear strips of riparian forest cover exist along the waterside of the Knights Landing Ridge Cut levees. Levee faces throughout most of the Knights Landing area are maintained free of woody vegetation. Occasional berry bushes and tree seedlings interrupt expanses of grasses and forbs. In places, mature trees, both native and introduced (ornamental or orchard trees) occur quite close to the Sacramento River levee on the landside. These are usually near homes or along roads. Thick strips of trees and shrubs are present in and along the landside toe drain of the Knights Landing Ridge Cut.

Fish. Section 6.2 provides a description of fisheries waterside of the Knights Landing area levees. Within the Knights Landing area, waterways capable of supporting fish consist of toe drains and agricultural supply and drainage canals. The fishery resources of these areas are unknown, but expected to be composed primarily of introduced species adapted to turbid, warm water, low oxygen conditions, like carp, goldfish, and green sunfish.

Wildlife. Wildlife presence and abundance varies with the type of habitat available for food, cover, and nesting. Section 6.3 describes wildlife which may be present in the Knights Landing Area.

Rare, Threatened, and Endangered Species. The FWS identified three federally-listed species, 1 species proposed for listing, eight candidate species, and five species recommended for candidate status (Appendix 1). These include: the endangered palmate-bracted bird's beak; the threatened winter-run chinook salmon and valley elderberry longhorn beetle; the giant garter snake, which is proposed for listing as endangered; candidates Sacramento splittail, delta smelt, California tiger salamander, tricolored blackbird, white-faced ibis, Pacific western big-eared bat, Sacramento anthicid beetle, and valley spearscale. Five additional species have been recommended for federal candidate status. These are: vernal pool branchinecta, California linderiella, conservancy fairy shrimp, Sacramento tiger beetle, and Sacramento anthicid beetle.

The State recognized the following species which may occur in the study area as endangered, threatened, or rare: giant garter snake, Swainson's hawk, and the bank swallow.

Surveys have not been conducted to determine which of these species is actually present in the Knights Landing area.

9.1.3 Sociological Environment.

Socioeconomic Conditions. The Knights Landing area is sparsely populated. The largest concentration of people, structures, and services is found in the unincorporated town of Knights Landing. County road 102 joins State Highway 113, which passes through Knights Landing. State Highway 45 joins 113 in Knights Landing.

Hazardous and Toxic Waste Sites. Not evaluated at this time.

Land Use. Most of the Knights Landing area is in agricultural lands; mainly row and grain crops, with a few orchards. The only population concentration is in the northwestern part of the area in the unincorporated town of Knights Landing. Scattered homes and farm buildings are located close to the Sacramento River levee on the northeastern side of the Knights Landing area.

Cultural Resources. The National Register of Historic Places contains no listings for the Knights Landing area (see Appendix 5). However, two historic sites have been identified along the Knights Landing Ridge Cut. No California Historical Landmarks have been identified in the Knights Landing area.

Recreation. The Sacramento River provides opportunities for boating, fishing, picnicking, water skiing, and nature study. The river supports large runs of anadromous fishes, mainly salmon, striped bass, steelhead trout and American shad. Waterways within the Knights Landing area (toe drains, agricultural supply and drainage canals) are unlikely to support much recreational fishing. Hunting may occur on private agricultural lands in the area. There is a public recreation facility across from the town of Knights Landing, on the Colusa Basin Drain, which provides access to the Sacramento River. A parking lot, boat ramp, and restrooms are available for public use.

Public Safety. Flooding of the Knights Landing area could occur either by failure of the left bank Knights Landing Ridge Cut (Ridge Cut) levee or failure of the right bank Sacramento River levee. Because of the Ridge Cut's flat slope, flows entering the Ridge Cut were affected by stages in the Yolo Bypass. Once failure occurs, the Knights Landing area would fill to a level flood plain elevation. The worst case flood plain was developed using a 400-year state in the Yolo Bypass and a 100-year concurrent flow in the Ridge Cut. This flood plain produced an average flood depth of about 7 feet. The nondamaging point was approximately a 40-year event based on preliminary information from the Colusa Basin Project and the Sacramento River Flood Control System Evaluation, Phase III. This event failed the levee on the Knights Landing Ridge Cut into the area. (The levee on the Sacramento River side had a nondamaging event with a recurrence interval of about a 60-year event.)

9.2 Description of Final Alternative Plans.

Alternative A is the No Action alternative. It is described in Section 9.2.1. Alternatives B, C, and D are shown in Figure 3 and are described in Sections 9.2.2, 9.2.3, and 9.2.4.

9.2.1 **Alternative A: No Action.** For the no action alternative, there would be no Federal participation in flood control alternatives for increased levels of flood protection. Levels of protection provided by the existing levees would remain the same. Potential damages due to flooding would also remain at current levels. The no action alternative was assumed to be analogous to the without-project condition.

9.2.2 **Alternative B: Knights Landing Area - Alignment 1.** Alignment 1 involved modifications to existing levees around the entire area. The purpose was to provide 100-year levels of flood protection to the entire Knights Landing area (Figure 4).

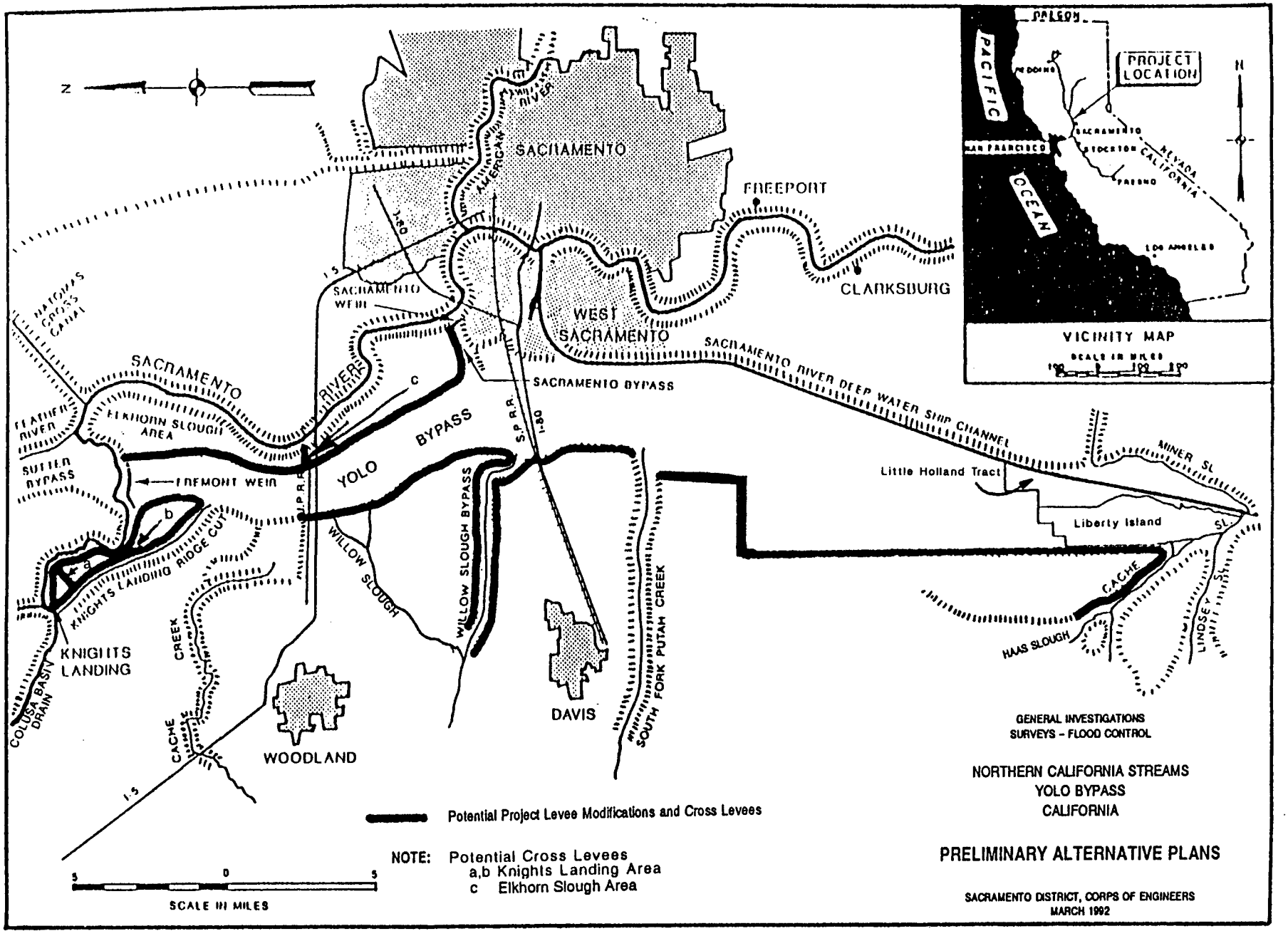
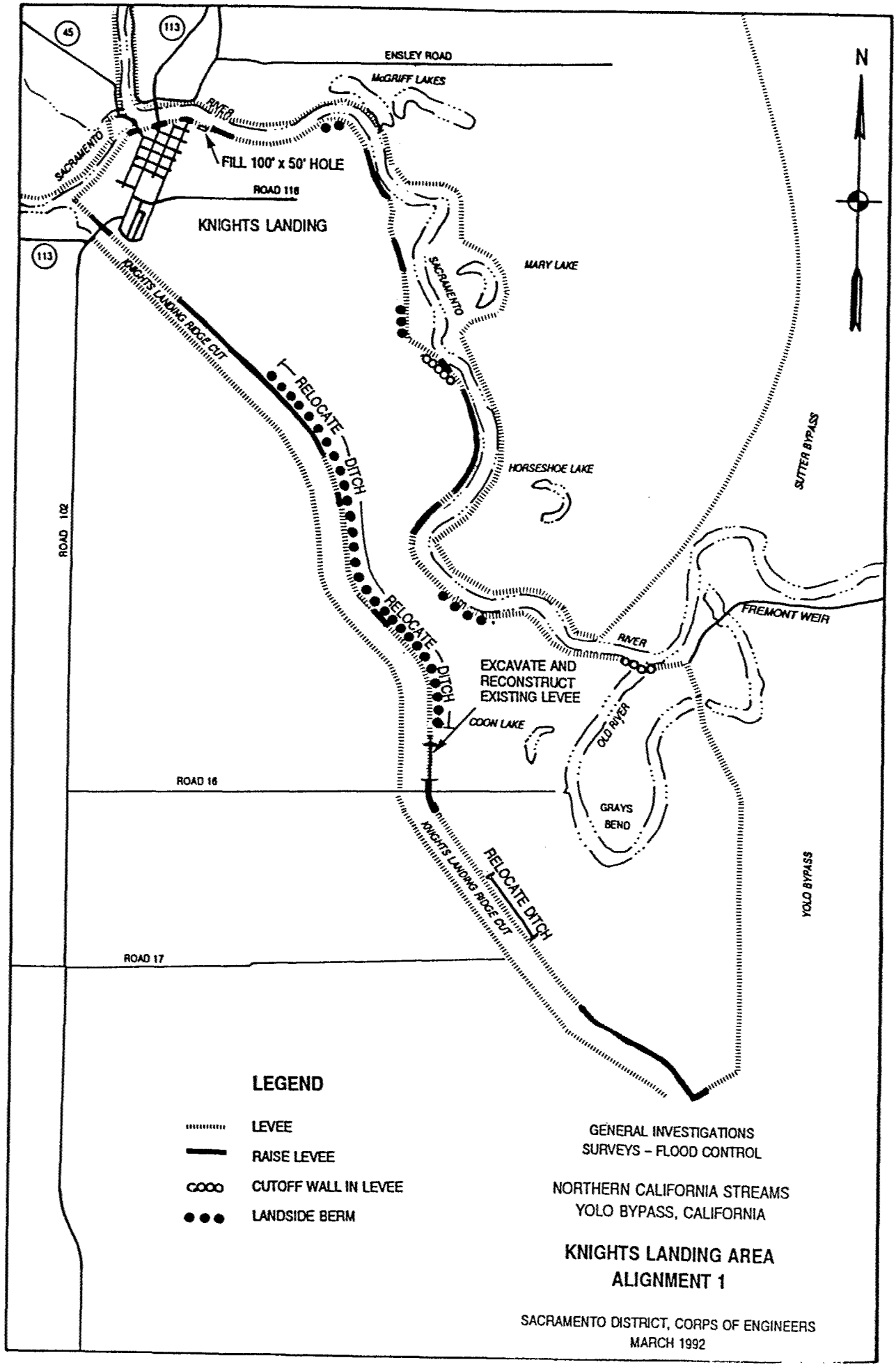

SACRAMENTO
AMERICAN RIVER
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO WEIR
SACRAMENTO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
NATOMAS CROSS CANAL
SACRAMENTO RIVER
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
YOLO BYPASS
U.P.R.R.
S.P.R.R.
I-80
I-5
WILLOW SLOUGH
WILLOW SLOUGH BYPASS
KNIGHTS LANDING RIDGE CUT
KNIGHTS LANDING
COLUSA BASIN DRAIN
CACHE CREEK
WOODLAND
DAVIS
SOUTH FORK PUTAH CREEK
Little Holland Tract
MINER SL
Liberty Island
SL
CACHE
HAAS SLOUGH
LINDSEY SL
N
PACIFIC
OCEAN
PROJECT LOCATION
NEVADA
CALIFORNIA
VICINITY MAP
SCALE IN MILES
5 0 5
SCALE IN MILES
Potential Project Levee Modifications and Cross Levees
NOTE: Potential Cross Levees
a,b Knights Landing Area
c Elkhorn Slough Area
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS
CALIFORNIA
PRELIMINARY ALTERNATIVE PLANS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 3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113
ENSLEY ROAD
McGRIFF LAKES
SACRAMENTO RIVER
FILL 100' x 50' HOLE
ROAD 116
KNIGHTS LANDING
113
MARY LAKE
SACRAMENTO
KNIGHTS LANDING RIDGE CUT
RELOCATE DITCH
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
FREMONT WEIR
RIVER
EXCAVATE AND RECONSTRUCT EXISTING LEVEE
RELOCATE DITCH
COON LAKE
OLD RIVER
ROAD 16
GRAYS BEND
KNIGHTS LANDING RIDGE CUT
RELOCATE DITCH
YOLO BYPASS
ROAD 17
N
LEGEND
LEVEE
RAISE LEVEE
CUTOFF WALL IN LEVEE
LANDSIDE BERM
GENERAL INVESTIGATIONS
SURVEYS – FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 1
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 4

9.2.3 **Alternative C: Knights Landing Area - Alignment 2.** Alignment 2 involved modifications to existing levees around the town of Knights Landing in the northwestern portion of the area and construction of a cross levee close to the southeast side of town (Figure 5). The purpose was to provide 100-year levels of flood protection only to the town Knights Landing area.

9.2.4 **Alternative D: Knights Landing Area - Alignment 3.** Alignment 3 involved modifications to existing levees around the northwestern portion of the area and construction of a cross levee where the existing Sacramento River and the Knights Landing Ridge Cut levees come close together at the location known as the "neck" (Figure 6). This plan represented a combination of Alternatives B and C. The purpose was to provide 100-year levels of flood protection to the town Knights Landing area and as much additional area as possible, while minimizing costs for cross levee construction.

9.3 **Impacts of Final Alternative Plans.** Estimates of the amount of land affected by the final flood control alternatives are shown in Tables 2 and 3.

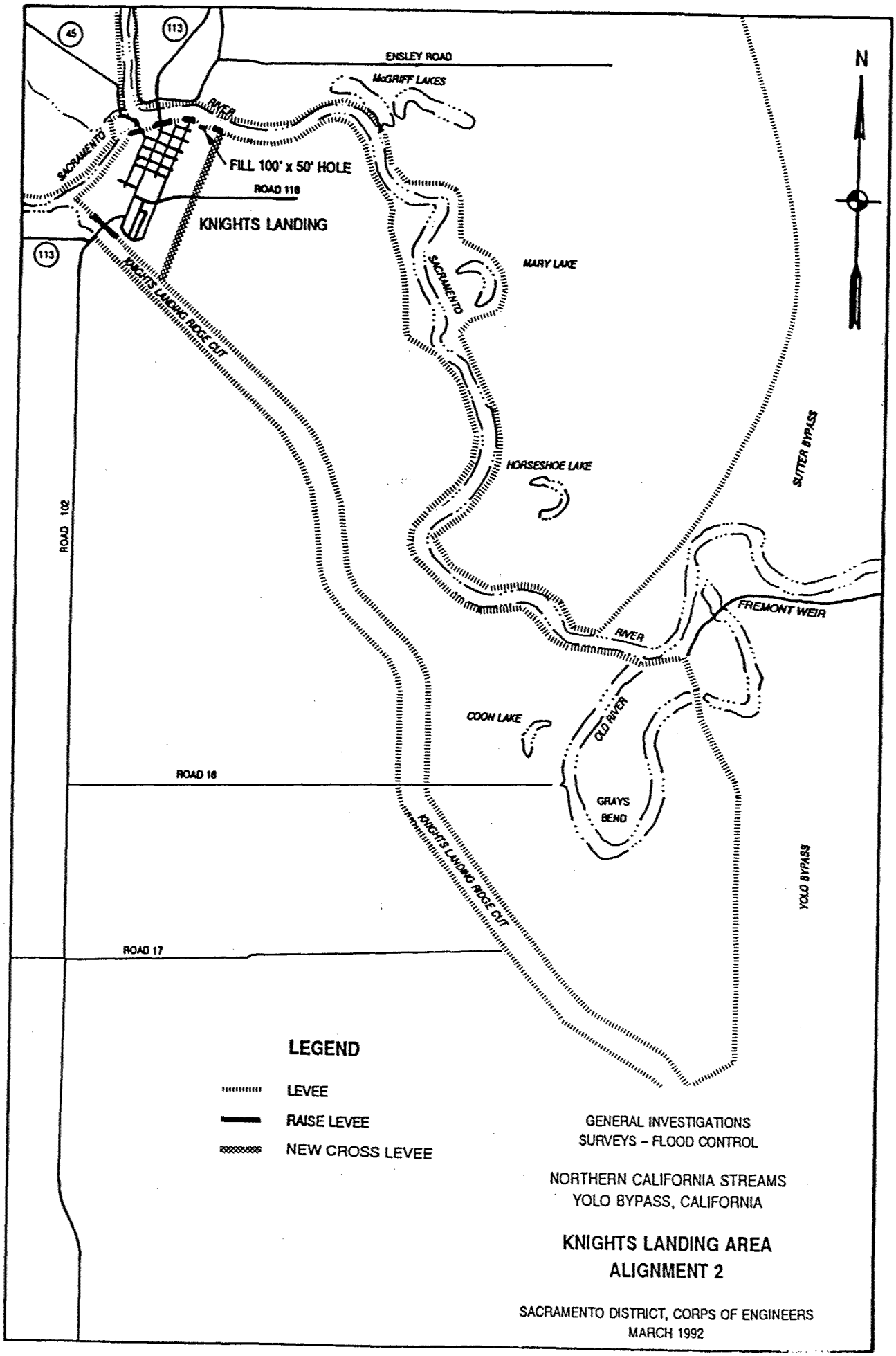
9.3.1 **Abiotic Environment.**

Flood Control Alternative A: No Action. The No Action alternative would have no significant impact upon climate, topography, geology, soils, or water quality. Intensification of urban and built-up land use would be likely to continue under the No Action alternative. This could result in increased air quality problems due to automobile exhaust. Given the size of the urban areas, and Yolo County's commitment to prohibiting urban development on agricultural land (Yolo County General Plan July 17, 1983), the impact on air quality would be expected to be insignificant. Intensification of urban and built-up land use could also result in localized increases in urban-generated noise. This impact would probably be less-than-significant.

Flood Control Alternatives B, C, and D.

Climate. Climate would be unaffected by any of the Flood Control Alternatives.

Topography. Local topography would be affected by flood control alternatives B, C, and D since levee height and width would increase in some areas. However, this affect would be considered insignificant. Alternatives C and D also involve construction of cross levees which would add height in areas which had previously been flat. This would constitute a relatively significant change in local topography, but would be insignificant at a regional level.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ENSLEY ROAD
McGRIFF LAKES
SACRAMENTO RIVER
FILL 100' x 50' HOLE
ROAD 11B
KNIGHTS LANDING
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KNIGHTS LANDING RIDGE CUT
SACRAMENTO
MARY LAKE
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
FREMONT WEIR
RIVER
COON LAKE
OLD RIVER
ROAD 16
GRAYS BEND
KNIGHTS LANDING RIDGE CUT
YOLO BYPASS
ROAD 17
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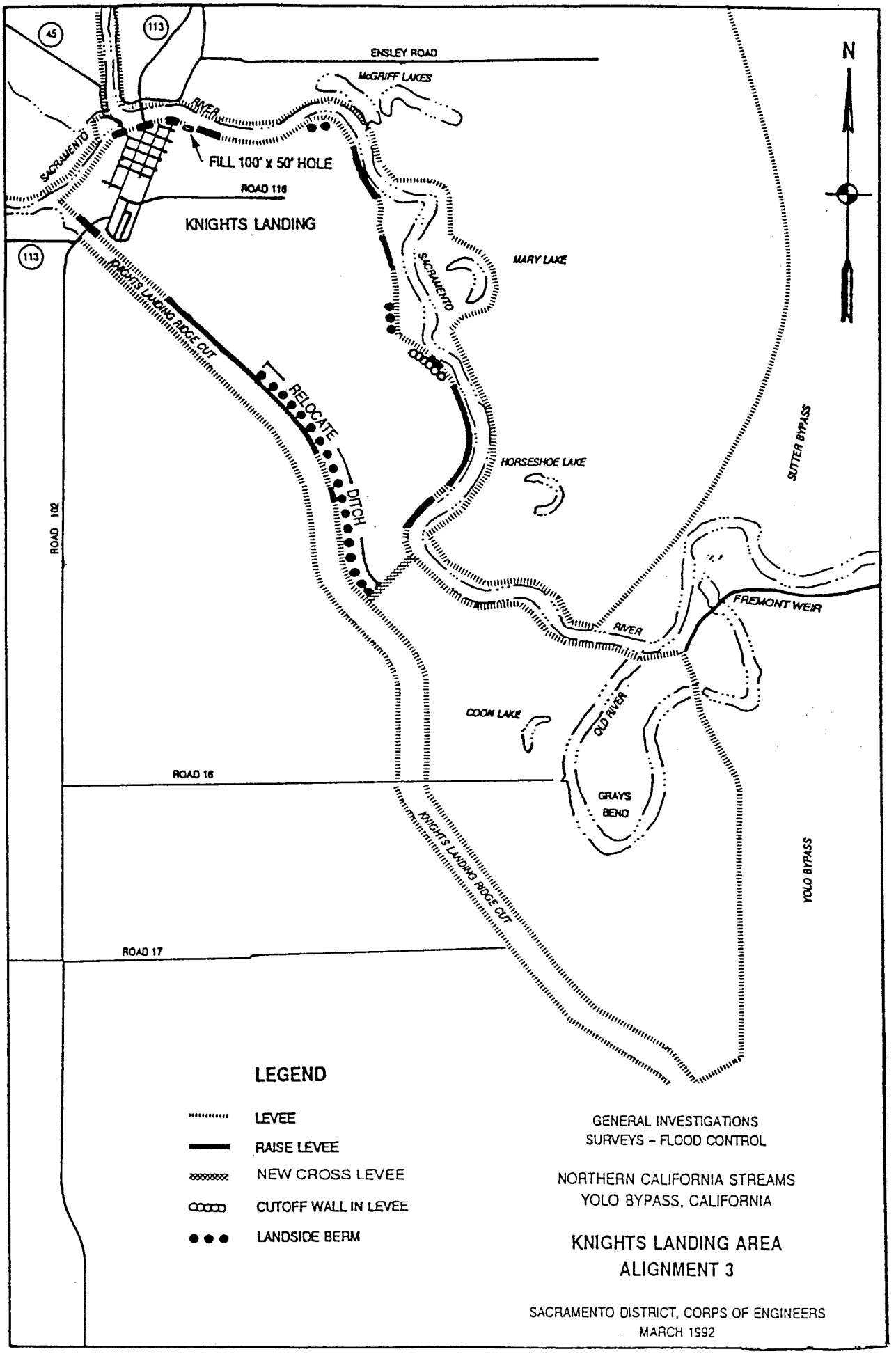
LEVEE
RAISE LEVEE
NEW CROSS LEVEE
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 2
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 5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ENSLEY ROAD
McGRIFF LAKES
RIVER
SACRAMENTO
FILL 100' x 50' HOLE
ROAD 11E
KNIGHTS LANDING
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KNIGHTS LANDING RIDGE CUT
SACRAMENTO
MARY LAKE
RELOCATE
DITCH
HORSESHOE LAKE
SUTTER BYPASS
ROAD 102
FREMONT WEIR
RIVER
COON LAKE
OLD RIVER
ROAD 16
GRAYS BEND
KNIGHTS LANDING RIDGE CUT
YOLO BYPASS
ROAD 17
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LEGEND
LEVEE
RAISE LEVEE
NEW CROSS LEVEE
CUTOFF WALL IN LEVEE
LANDSIDE BERM
GENERAL INVESTIGATIONS
SURVEYS - FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS, CALIFORNIA
KNIGHTS LANDING AREA
ALIGNMENT 3
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH 1992

Figure 6

Table 2. Permanent and Temporary Easements for Final Flood Control Alternatives Under Scenario 1.*

Alternative	Permanent Easement	Temporary Easement
A: No Action	0 acres	0 acres
B: Knights Landing - Alignment 1	13.71 acres	8.23 acres
C: Knights Landing - Alignment 2	15.66 acres	3.82 acres
D: Knights Landing - Alignment 3	17.05 acres	7.51 acres

*Assumes that Sacramento Systems Evaluation Phases III-V and the Colusa Basin Project are in place.

Table 3. Permanent and Temporary Easements for Final Flood Control Alternatives Under Scenario 2.*

Alternative	Permanent Easement	Temporary Easement
A: No Action	0 acres	0 acres
B: Knights Landing - Alignment 1	27.48 acres	16.22 acres
C: Knights Landing - Alignment 2	15.66 acres	4.17 acres
D: Knights Landing - Alignment 3	24.84 acres	10.29 acres

*Assumes that Sacramento Systems Evaluation Phases III-V and the Colusa Basin Project are not in place.

Geology. Geology would be unaffected by any of the Flood Control Alternatives.

Soils. Soils within the construction footprints would be removed, compacted, or otherwise disturbed. Soils outside of the immediate construction area would be unaffected. Therefore, no significant impacts on soils in the Knights Landing area would be anticipated.

Air Quality. Minor, short-term increases in dust from construction activities would be expected. This would not be a significant impact since construction contractors are required to maintain all construction areas free from dust or other air emissions that would cause the local standards for air pollution to be exceeded, or would cause a hazard or nuisance to others.

Water quality. The proposed alternatives include landside construction only, therefore, the Sacramento River, Colusa Basin Drain, Knights Landing Ridge Cut, and Yolo Bypass would experience no significant impact as a result of the flood control alternatives.

The water quality of toe drains located adjacent to construction activities would be likely to experience temporary decreases in water quality, primarily due to increased turbidity. Some toe drains would be relocated. Accidental spills of fuel or other hazardous material from heavy equipment used in construction could contaminate the toe drains. Appropriate precautions should be taken throughout construction to minimize the risk of accidental spills and to deal promptly and effectively with any spills should they occur.

Noise. Direct noise impacts associated with alternatives B, C, and D include temporary construction activities. Construction equipment would be used at work sites, and truck traffic would transport material and equipment on area roads. Noise activities would be of short duration and would occur only during daylight hours. Construction would take place in both populated and unpopulated areas.

Some wildlife species might relocate to other areas to avoid construction noise; however, they would likely return to the project vicinity when construction ceases, as they presently do after major agricultural activities (tilling and harvesting). Also, construction noise during the breeding seasons of some wildlife species (like Swainson's hawk) could adversely affect reproductive rates.

9.3.2 Biotic Environment.

Flood Control Alternative A: No Action. The No Action alternative would be expected to have no significant impact on the biotic environment (vegetation, fish, wildlife, rare, threatened and endangered species).

Flood Control Alternatives B, C, and D.

Vegetation. All vegetation within the construction footprints (including temporary and permanent easements, staging areas, and access) would be affected by the flood control alternatives. Vegetation along the levee faces (mainly grasses, forbs, black berries, and some isolated trees), adjacent toe drains (riparian forest and shrub/scrub cover, and emergent marsh vegetation), and at the proposed cross levee locations (agricultural field crops) would be removed during construction.

Fish. Flood Control Alternatives B, C, and D focus on landside or straddle construction which would include construction procedures for avoiding waterside impacts. Therefore, no impact on fisheries in the Sacramento River, Yolo Bypass, Colusa Basin Drain, or Knights Landing Ridge Cut would be anticipated. Realignment of the toe drains would affect the aquatic resources in those drains. Most, or all, of the fish present in the toe drains and agricultural supply and drainage canals are probably exotics. No significant impact to fisheries would be anticipated as a result of any of the alternatives.

Wildlife. Loss of riparian and emergent marsh habitats would produce the most significant impact upon wildlife. These habitats are scarce in the region, and provide valuable nesting, resting, and foraging habitat. Isolated, mature trees may also provide important raptor habitat. Construction activities and noise could frighten off some wildlife. This impact would probably be temporary, particularly given the location of these areas within or adjacent to actively farmed lands.

Rare, Threatened, and Endangered Species. Potential impacts to rare, threatened, and endangered species cannot be evaluated at this time. A search of the California Natural Diversity Data Base (Department of Fish and Game) is recommended. The areas must be surveyed for the presence of the species listed by the USFWS as possibly occurring in the vicinity.

9.3.3 **Sociological Environment.**

Flood Control Alternative A: No Action. The No Action alternative was assumed to be the same as existing conditions and was not evaluated in detail at this time.

Flood Control Alternatives B, C, and D.

Socioeconomic Conditions. Any proposed levee work in sparsely populated areas would be expected to have minimal impact on current socioeconomic conditions.

Hazardous and Toxic Waste Sites. Not evaluated at this time.

Land Use. Changes in land use are not anticipated as a result of this project.

Cultural Resources. Not evaluated at this time.

Recreation. Not evaluated at this time.

Public Safety. Plans were developed to raise and strengthen existing levees and/or construct cross levees. A 100-year level of flood protection would be provided to the entire area or portions of the entire area. Three different levee alignments were developed. Alignment 1 involved work on existing levees around the entire area. Alignment 2 involved work on existing levees around the town of Knights Landing in the northwestern portion of the area and construction of a cross levee close to the southeast side of town (cross levee "a" in Figure 5). Alignment 3 involved work on a larger amount of the existing levees in the northwestern portion of the area and construction of a cross levee where the existing Sacramento River and Knights Landing Ridge Cut levees come close together, a location referred to as "the neck" (cross levee "b" in Figure 6). Costs to construct new levees were high, and the location at the neck helped to minimize these costs.

10.0 POTENTIAL MITIGATION AND/OR ENHANCEMENT MEASURES

This section provides a general discussion of USFWS mitigation planning goals for mitigation of impacts to specific habitat types. Also included are the FWS recommendations provided to the COE based upon the original study area and set of alternatives which the COE provided to them. Finally, a general description of the amount of mitigation lands and costs of mitigation for each of the three Knights Landing flood control alternatives is presented. Information in sections 12.1 and 12.2 is taken from the Planning Aid Letter prepared by the FWS for this study (May 28, 1991).

Should the study proceed into feasibility phase, impacts and mitigation needs would need to be assessed with a Habitat Evaluation Procedure (HEP) analysis.

10.1 **U.S. Fish and Wildlife Mitigation Planning Goals.** Table 4 summarizes the material in this section.

10.1.1 **Impacts to Freshwater Marsh, Woody Riparian Forest, and Scrub/Shrub Habitats.** To mitigate adverse impacts to freshwater marsh, woody riparian forest, and scrub/shrub habitats, an area (or areas) without these attributes and of sufficient size (as determined by the HEP), should be provided for management. Plantings of indigenous species (trees and shrubs) would likely be required in the area(s) to provide habitat compensation values. Estimated cost to create these habitat types is currently averaging about $25,000 per acre, excluding land acquisition and maintenance costs. Irrigation would be required for a minimum of several years, depending on conditions, or until the plantings were well established and self-sustaining. Any dead or decadent trees and shrubs would need to be replaced and maintained until self-sufficient. A detailed mitigation monitoring study would be required. This plan would have to be developed jointly by the COE, USFWS, and California Department of Fish and Game once specific impacts and mitigation sites are identified. At a minimum the plan should identify specific attributes of the site that would be monitored, sampling procedures, and reporting requirements.

10.1.2 **Impacts to Instream Aquatic Habitat Values.** To offset the loss of instream aquatic habitat values, a planting program, coordinated with riparian plantings, would be required. Dense plantings of select indigenous trees and shrubs would be required along the shoreline to provide the attributes associated with overhanging and in-water cover. In addition, the placement of tree trunks and tree root balls anchored to the river bank, could be necessary for providing full habitat value replacement.

Table 4. U.S. Fish and Wildlife Mitigation Planning Goals

Habitat Type	Mitigation Planning Goals	Mitigation Requirements
Freshwater marsh	No net loss of in-kind habitat value	In-kind replacement of lost habitat values
Woody riparian forest	No net loss of in-kind habitat value	In-kind replacement of lost habitat values
Riparian scrub/shrub	No net loss of in-kind habitat value	In-kind replacement of lost habitat values
Oak woodland	No net loss of habitat value, while minimizing the loss of in-kind habitat value	Replacement of habitat value, but not necessarily in-kind value
Grassland (upland)	No net loss of habitat value, while minimizing the loss of in-kind habitat value	Replacement of habitat value, but not necessarily in-kind value
Shaded riverine aquatic cover	No net loss of in-kind habitat value	In-kind replacement of lost habitat values
Agricultural lands	No net loss of habitat value, while minimizing the loss of in-kind habitat value	In-kind replacement of lost habitat values

10.1.3 **Impacts to Wetland Vegetation.** The loss of wetland vegetation along the toe drains and seeps could be offset through the construction of new toe drains and ponding areas. To further minimize any losses, toe drain construction could be initiated, water provided, and vegetation planted (transplanted from old drain), at least 6 months prior to covering old toe drains and seeps. This would essentially eliminate any adverse impacts on such habitat types.

10.1.4 **Other.** Scattered trees and shrubs lost on levee slopes or the landside toes of levees could require replacement at a ratio as high as 5:1. Due to lower soil moisture conditions, such plantings could require watering and maintenance for up to 6 years.

Any loss of grassland habitat values due to project construction could be offset relatively quickly and easily by reseeding the disturbed areas with native grasses and forbs. Seedlings would need to be done just prior to the rainy season, to provide adequate germination and establishment of these species.

10.2 **U.S. Fish and Wildlife Service Recommendations.**

(1) If the study moves into the feasibility phase, funding should be provided so that the Fish and Wildlife Service can prepare a Section 2(b) Fish and Wildlife Coordination Act Report.

(2) The study and any resulting project should be coordinated closely with the planning efforts of the Central Valley Joint Habitat Venture to establish a wetland complex to be known as the Yolo Basin Wildlife Refuge.

(3) Based on its lowest overall impacts to fish and wildlife habitat values, the FWS recommends Alternative E (nonstructural measures) be selected for further investigation or implementation to provide flood protection to the study area. The USFWS believes that Alternative E would have the least adverse effect on fish and wildlife followed by Alternatives D (excavation within channel bypasses), C (channel work), and B (raise levees). With regard to waterside, landside, and straddle construction, the USFWS believes that waterside construction would be the most detrimental of the three, followed by landside and straddle construction. The Service recommends that waterside construction be avoided if at all feasible.

(4) To mitigate any adverse impacts of the proposed alternative on riparian vegetation, instream aquatic habitat, wetland vegetation, grassland, and landside trees and shrubs, measures as indicated in the Discussion Section should be planned early on in the process. A determination of impacts and mitigation requirements should be accomplished through the use of the Service's Habitat Evaluation Procedures. The Service's estimated

cost to conduct the procedure could be determined after construction measures and specific work sites have been identified.

(5) To avoid construction activity impacts to Swainson's hawk and other raptors, construction should not be conducted during the late March to early August period.

(6) To minimize the loss of wetland vegetation (toe drains, seeps) with project construction, open toe drains should be included in lieu of culverts. The toe drains should be designed to allow growth of wetland and other vegetation in and adjacent to the drain. Also, as a possible wetland restoration measure, depressions be excavated in adjacent farmlands and drain water be directed to these areas. Such depressions could be a source of borrow material for levee construction. This would promote the growth of wetland and other vegetation.

(7) After completion of repair work, the levees and surrounding areas should be revegetated to restore wildlife habitat and overall environmental quality.

10.3 **Knights Landing Mitigation Needs.** The acreages developed for permanent and temporary easements were assumed to be the amounts of land to be directly affected by the Knights Landing Alternatives. Three alignments and two scenarios were considered. The levee alignments are shown in Figures 4, 5, and 6. Scenario 1 assumes that the Colusa Basin Project and the Sacramento River Flood control System Evaluation work are in place. It was developed to provide sensitivity analysis using modified without-project condition assumptions as discussed in the reconnaissance report. Scenario 2 represents the without-project assumptions of the reconnaissance study. It assumes that neither the Colusa Basin Project nor the Sacramento River Flood Control System Evaluation work are in place. The kind and extent of existing cover types were estimated based upon review of field notes collected in January, 1992, aerial photos (scale 1 inch equals 1000 feet) taken in November, 1986. Additional more detailed fieldwork will be required to refine these data.

The amount of mitigation land needed was estimated by assuming a replacement rate of 3 to 1 for relatively high value fish and wildlife habitat (riparian forest, riparian shrub/scrub, emergent marsh, and woodland like vegetation), and a replacement rate of 0.3 to 1 for lower value habitat (agricultural field crop cover type) affected by permanent easements. A 0.3 to 1 replacement rate was assumed for all cover types affected by temporary easements. About 25 percent of the land was considered to have high value habitat. About 75 percent of the land was considered to be in lower value agricultural crops.

For the purposes of this analysis, the mitigation site was identified as lands located in the southeast portion of the Knights Landing area, near where the western Yolo Bypass levees are joined by the northern levee of the Knights Landing Ridge Cut. An average cost per acre of $25,000 was assumed for establishment of all cover types at the mitigation site. Additional costs were developed to acquire and purchase lands that are not presented here. Required mitigation acres and estimated cost of mitigation, excluding the cost of lands and maintenance, are shown in Tables 5 and 6.

Table 5. Final Alternatives - Knights Landing Area
Mitigation Acres Required and Cost Under Scenario 1.*

Alignment	Mitigation Acres Required	Cost per Acre	Total Cost
1	16	$25,000	$400,000
2	17	$25,000	$425,000
3	19	$25,000	$475,000

*Data for sensitivity analysis using modified without-project condition assumptions.

Table 6. Final Alternatives - Knights Landing Area
Mitigation Acres Required and Cost Under Scenario 2.*

Alignment	Mitigation Acres Required	Cost per Acre	Total Cost
1	32	$25,000	$800,000
2	17	$25,000	$425,000
3	28	$25,000	$700,000

*Data for analysis using without-project condition assumptions stated in the Reconnaissance Report.

11.0 ADDITIONAL STUDIES NEEDED

11.1 Fish and Wildlife Studies. Additional fish and wildlife studies have been recommended by the USFWS (May 28, 1991) should additional planning studies be undertaken for the flood control alternatives. These recommendations are based upon the original study boundaries and project alternatives. These studies are described below.

1. Conduct surveys of existing winter-, spring-, fall-, or late fall-run salmon as well as other anadromous fishes if water side construction is proposed for the middle Sacramento River and associated tributaries. As part of this study, determine the acreage and value of aquatic habitat (shaded riverine aquatic) along the river or associated tributaries.

2. Conduct population surveys for species of special concern, such as the Swainson's hawk and bank swallow. Include information about nesting sites and territories.

3. Inventory fish resources of the Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, and South Fork Putah Creek. This would be particularly important if channel work (channelization or excavation) is proposed.

4. Complete a mapping inventory of Shaded Riverine Aquatic Cover for parts of the study area which have not yet been mapped.

5. Complete a land-use analysis addressing future with and without project scenarios for the life of the project. Provide this analysis to the USFWS prior to their conducting any detailed evaluations.

6. Identify borrow sources and analyze them for potential contaminant and toxics problems.

7. Identify jurisdictional wetlands within the study area and provide this information to the Service prior to initiation of any Habitat Evaluation Procedures (HEP's).

If any part of this study enters the feasibility stage, an updated list of endangered and threatened species would need to be requested from the U. S. Fish and Wildlife Service. A list of state protected species would be obtained from the California Department of Fish and Game. An assessment of impacts would then be prepared.

11.2 **Cultural Resources Studies.** If the study proceeds into the feasibility phase, additional cultural resources studies will be required. The scope of these will be developed in consultation with the State Historic Preservation Officer (SHPO) and may include but not be limited to the following:

1. Further archival research using historic maps, Government Land Office (GLO) records, ethnographies, and other documents to more accurately ascertain the likelihood of locating additional archeological, historical and ethnographic sites.

2. Information on sites of ceremonial or religious concern to Native Americans.

3. Public involvement including Native Americans, historical societies and other interested persons or groups.

4. Examine all areas not previously surveyed and areas surveyed prior to 1980 for cultural resources. Revisit previously recorded sites.

5. National Register evaluation of cultural resources within the Area of Potential Effect.

6. Determination of effect in consultation with the SHPO.

11.3 **Recreation Studies.** Not evaluated at this time.

11.4 **Hazardous and Toxic Wastes.** Any hazardous and toxic waste (HTW) sites located in the study area could require special design or construction considerations for the restoration work. To determine the extent of known HTW sites located in the study area, Federal, State and local lists should be identified and reviewed. The Environmental Protection Agency maintains and updates the Federal "National Priorities List" for uncontrolled hazardous waste sites as required by the Comprehensive Environmental Response, Compensation and Liability Act for 1980" (CERCLA). The latest updated list was published in the Federal Register, August 30, 1990. The State Office of Permit Assistance in the Office of Planning and Research maintains and updates the Hazardous Waste and/or Substance Sites List (AB 3750 list). The State Water Resources Control Board, California Waste Management Board, and Department of Health Services Agency maintains and updates the Hazardous Material Site and Underground Tank Files, which lists the local HTW sites.

The Corps recently developed agency policy in response to CERCLA, which holds certain categories of individuals strictly liable for all clean up and response costs of any hazardous substances regulated under CERCLA. This policy states that between the Government and the local sponsor, it will generally be the local sponsor's responsibility to assure clean up and pay all

response costs of any HTW sites located on a Civil Works project. However, if HTW material exists within the construction area, the Government will determine as soon as possible the extent and nature of the contaminated material prior to construction. If already in construction, the Government and local sponsor shall decide whether to continue construction, terminate construction, or, if possible, redesign the project. In any event, should the Government and local sponsor decide to proceed or continue with construction after considering any liability that may arise under CERCLA, the local sponsor shall be responsible for any studies, investigations, clean up and response costs. In addition, the local sponsor shall operate, maintain, repair, replace, and rehabilitate the project in a manner so that liability will not arise under CERCLA.

12.0 COORDINATION

A "Notice of Initiation of a Reconnaissance Study for Flood Control" was sent to Federal, State, county and city agencies and other interested parties in December 1990. Where appropriate, the comments received were considered in this EE. Letters of comment are provided in Appendix 5.

Development of this Environmental Evaluation has been coordinated with in-house staff of the Environmental Resources Branch, the study manager, and relevant COE technical staff. Coordination with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and local recreation interests has also been important to the development of this report.

13.0 FINDINGS AND CONCLUSIONS

Implementation of any of the final Knights Landing area flood control alternatives would be likely to have a significant impact on the environment. Therefore, if the study continues into the feasibility phase, an EIS should be prepared.

Abiotic resources not likely to be significantly affected by the Knights Landing area alternatives include: climate, topography, geology, and soils. Short-term impacts on air quality and noise would be minimized through appropriate construction practices. Water quality in the Sacramento River, Colusa Basin Drain, Knights Landing Ridge Cut, Yolo Bypass are not likely to be affected since all of the final alternatives call for landside construction. However, water quality in the toe drains would be affected by some construction activities.

All biotic resources - vegetation, fish, wildlife, and rare, threatened, and endangered species - would be affected by the final alternatives. The extent of the impact would need to be determined during the feasibility phase. Impacts on terrestrial resources include the removal of riparian forest, riparian scrub/shrub, freshwater emergent marsh, valley grassland, open water habitats, and scattered individual trees. Removal or alteration of these habitats could adversely affect wildlife dependent on these habitats for food, cover, and nesting. Wildlife potentially affected by the alternatives include: the endangered valley elderberry longhorn beetle (VELB); the giant garter snake, which has been proposed for listing; species of special concern, like the tricolored blackbird, and the state listed Swainson's hawk.

With the exception of the No Action alternative, all of the final flood control alternatives for Knights Landing would create conditions which could result in increased urbanization in the Knights Landing area. However, whether such development would occur is uncertain, based on projected future growth in other areas and limited road access to the Knights Landing area. Additional studies

would be needed during the feasibility phase in order to evaluate potential impacts on cultural resources. In addition, hazardous and toxic waste sites would need to be identified and evaluated. No significant impacts on recreation would be expected, although there may be local interest in developing bicycle and walking trails on or alongside the levees.

14.0 **EFFECT OF RECONNAISSANCE STUDY FINDINGS ON EE.** Since the reconnaissance study determined that all alternative plans were economically infeasible, some environmental studies and work were terminated prior to completion. The EE reflects this decision and includes the results of all studies to date.

15.0 **LIST OF PREPARERS AND REVIEWERS**

Name Discipline/ Expertise	Experience	Role in Preparation
Barry Jarvis Civil Engineer/ Study Manager	6 yrs Planning Studies, COE	Management review
Fred Kindel Wildlife Biologist/ Environmental Planner	27 yrs Environmental Planning Studies, COE; 8 yrs State and Private Wildlife Mgt.	Review and editing
Sannie Osborn	10 yrs Archeologist, COE	Cultural Resources Report, review
Sean Sou Student Aid	2 yrs COE	Graphics
Lynne Stevenson Technical Writer/ Water Res. Planner	7 yrs Planning Studies, COE: 10 yrs Professional Librarian	Editing
Tanis Toland Ecologist/ Environmental Planner	1 1/2 yrs Planning Studies, COE	Research and Writing
Mike Welsh General Biologist/ Environmental Planner	13 yrs Engineering and Planning Studies, COE	Review and editing

APPENDIX 1

U.S. Fish and Wildlife Service Endangered Species Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Fish and Wildlife Enhancement
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

In Reply Refer To:
1-1-91-SP-212

February 8, 1991

Mr. Walter Yep
Chief, Planning Division
Sacramento District Corps of Engineers
650 Capitol Mall
Sacramento, California 95814-4794

Subject: Species List for the Reconnaissance Study for Flood Control Northern California Streams, Yolo Bypass, Yolo County, California

Dear Mr. Yep:

As requested by letter from your agency dated January 15, 1991, you will find attached a list of the listed endangered and threatened species that may be present in the subject project area. (See Attachment A.) To the best of our knowledge, no proposed species occur within the area. This list fulfills the requirement of the Fish and Wildlife Service to provide a species list pursuant to Section 7(c) of the Endangered Species Act, as amended.

Some pertinent information concerning the distribution, life history, habitat requirements, and published references for the listed species is also attached. This information may be helpful in preparing the biological assessment for this project, if one is required. Please see Attachment B for a discussion of the responsibilities Federal agencies have under Section 7(c) of the Act and the conditions under which a biological assessment must be prepared by the lead Federal agency or its designated non-Federal representative.

Formal consultation, pursuant to 50 CFR § 402.14, should be initiated if you determine that a listed species may be affected by the proposed project. Informal consultation may be utilized prior to a written request for formal consultation to exchange information and resolve conflicts with respect to a listed species. If a biological assessment is required, and it is not initiated within 90 days of your receipt of this letter, you should informally verify the accuracy of this list with our office.

Also, for your consideration, we have included a list of the candidate species that may be present in the project area. (See Attachment A.) These species are currently being reviewed by our Service and are under consideration for possible listing as endangered or threatened. Candidate species have no protection under the Endangered Species Act, but are included for your consideration as it is possible that one or more of these candidates could be proposed and listed before the subject project is completed. Should the biological assessment reveal that candidate species may be adversely affected,

you may wish to contact our office for technical assistance. One of the potential benefits from such technical assistance is that by exploring alternatives early in the planning process, it may be possible to avoid conflicts that could otherwise develop, should a candidate species become listed before the project is completed.

Please contact Peggie Kohl at 916/978-4866 (FTS 460-4866) if you have any questions regarding the attached list or your responsibilities under the Endangered Species Act.

Sincerely,

Wayne S. White
Field Supervisor

Attachments

ATTACHMENT A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE RECONNAISSANCE STUDY FOR FLOOD CONTROL NORTHERN CALIFORNIA STREAMS, YOLO BYPASS, YOLO COUNTY, CALIFORNIA
(1-1-91-SP-212, FEBRUARY 8, 1991)

Listed Species

Fish
winter-run chinook salmon, *Oncorhynchus tshawytscha* (T)

Invertebrates
valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

Plants
palmate-bracted bird's-beak, *Cordylanthus palmatus* (E)

Candidate Species

Fish
Sacramento splittail, *Pogonichthys macrolepidotus* (2)
delta smelt, *Hypomesus transpacificus* (1)

Amphibians
California tiger salamander, *Ambystoma tigrinum californiense* (2)

Reptiles
giant garter snake, *Thamnophis couchi gigas* (2)

Birds
tricolored blackbird, *Agelaius tricolor* (2)
white-faced ibis, *Plegadis chihi* (2)

Mammals
Pacific western big-eared bat, *Plecotus townsendii townsendii* (2)

Invertebrates
vernal pool branchinecta, *Branchinecta lynchi* (2R)
California linderiella, *Linderiella occidentalis* (2R)
Conservancy fairy shrimp, *Branchinecta conservatio* (2R)
Sacramento valley tiger beetle, *Cicindela hirhcollis abrupta* (2R)
Sacramento anthicid beetle, *Anthicus sacramento* (2)

Plants
Sacramento Valley milk-vetch, *Astragalus tener* var. *ferrisae* (2R)
valley spearscale, *Atriplex joaquiniana* (2)

(E)--Endangered (T)--Threatened (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(2R)-Recommended for Category 2 status.
(*)--Possibly extinct.

ATTACHMENT B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER
SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species; 2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and 3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment--Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat are present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirements; interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; an analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of indirect effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, any problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

---

[1] A construction project (or other undertaking having similar physical impacts) which is a major Federal action significantly affecting the quality of the human environment as referred to in NEPA (42 U.S.C. 4332(2)C).

[2] "Effects of the action" refers to the direct and indirect effects on an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

PALMATE-BRACTED BIRD'S-BEAK

(*Cordylanthus palmatus*)

CLASSIFICATION: Endangered 51 FR 23765

CRITICAL HABITAT: None designated

DESCRIPTION:

This annual herb of the snapdragon family (*Scrophulariaceae*) attains a height of 4 to 12 inches and produces several to many spreading ascending branches from near the base of the main stem. The pale stems are sparsely to densely hairy, often with glandular excretions of salt crystals evident on the herbage. The leaves and stems are grayish green and often very pale. The small pale whitish flowers, 1/2-inch to 1 inch long, are arranged in dense clusters (spikes) and densely surrounded by herbaceous leaflike bracts. Seedlings in late March or April. The species flowers in late spring through the summer.

DISTRIBUTION:

Historically the species was collected from seven scattered locations in Fresno, Madera, San Joaquin, Yolo, and Colusa Counties. In 1982 a new location was discovered near Livermore in Alameda County and in 1987 a colony was discovered on the Colusa National Wildlife Refuge in Colusa County. The latter stand may represent a remnant of the former populations to occur in the general area. At present four extant populations are known. These include the Livermore and Colusa NWR colonies, one near Woodland, Yolo County, and one on the Mendota State Wildlife Area, Fresno County. Additional colonies may occur in appropriate alkali sink habitats in these regions of the Central Valley and inner coast range valleys.

SPECIAL CONSIDERATIONS:

Population fluctuations are common in the palmate-bracted bird's-beak. These oscillations may be a result of changes in pollination success, rainfall patterns, freshwater influence, and marsh pollution. Consequently, researchers should take into account the unreliability of a single-season survey.

REFERENCES FOR ADDITIONAL INFORMATION

Chuang, T. I., and L. R. Heckard. 1971. Observations on root-parasitism in *Cordylanthus* (Scrophulariaceae). Am. J. Bot. 58:218-228.

Chuang, T. I., and L. R. Heckard. 1973. Taxonomy of *Cordylanthus* subgenus *Hemistegia* (Scrophulariaceae). Brittonia 25:135-158.

Ferris, R. S. 1918. Taxonomy and distribution of *Adenostegia*. Bull. Torrey Bot. Club. 45:399-423.

Heckard, L. R. 1977. Rare Plant Status Report for *Cordylanthus palmatus*. Calif. Native Plant Society, Berkeley, California. Unpub. Rep. 4 pp.

Macbride, J. F. 1919. Reclassification of new spermatophytes, chiefly North American. Contrib. Gray Herb. 59:28-39.

Mason, H. L. 1975. A flora of the marshes of California. University of California press. Berkeley.

Ranwell, D. S. 1972. Ecology of salt marshes and sand dunes. Chapman and Hall. London.

Reimold, R. J., and W. H. Queen. 1974. Ecology of halophytes. Academic Press. New York.

VALLEY ELDERBERRY LONGHORN BEETLE

(Desmocerus californicus dimorphus)

CLASSIFICATION: Threatened - **Federal Register** 45:FR52803 August 8, 1980.

CRITICAL HABITAT: Federal Register 17.95(c), May 7, 1980.

California. Sacramento County.

(1) Sacramento Zone. An area in the city of Sacramento enclosed on the north by the Route 160 Freeway, on the west and southwest by the Western Pacific railroad tracks, and on the east by Commerce Circle and its extension southward to the railroad tracks.

(2) American River Parkway Zone. An area of the American River Parkway on the south bank of the American River, bounded on the north by latitude 38 37'30" N, and on the South and east by Ambassador Drive and its extension north to latitude 38 37'30" N, Goethe Park, and that portion of the American River Parkway northeast of Goethe Park, west of the Jedediah Smith Memorial Bicycle Trail, and north to a line extended eastward from Palm Drive.

(3) Putah Creek Zone. California. Solano County. R 2 W T. 8 N. Solano County portion of Section 26.

DESCRIPTION:

Horn described the valley elderberry longhorn beetle in 1881 and it was redescribed in 1921 by Fisher. Morphological description: In general, longhorn beetles are characterized by somewhat elongate and cylindrical bodies with long antennae, often in excess of 2/3 of the body length. In contrast, males of VELB are stout-bodied and their elytra (thickened, hardened forewings) are coarsely punctured, with a metallic-green pattern of 4 oblong maculations, surrounded by a bright red- orange border. The border eventually fades to yellow on museum specimens. The maculations are fused on some males, more closely resembling the nominate subspecies. Antennae are about as long as the body or slightly shorter. Body length is about 13-21 mm.

Females are more robust, elytra are subparallel, and the dark pattern is not reduced. Antennae reach to about the middle of the elytra and body length is about 18-25 mm. Both sexes of VELB are readily identified due to their distinctive appearance. As noted earlier, males with fused maculations resemble the nominate subspecies, *Desmocerus californicus dimorphus*, Fisher, 1921.

DISTRIBUTION:

VELB is endemic to moist valley oak woodlands along the margins of rivers and streams in the lower Sacramento and upper San Joaquin Valley of California, where elderberry (*Sambucus* spp.), its foodplant, grows. During the past 150 years over 90

percent of the riparian habitat in California has been destroyed by agricultural and urban development. Although the entire historical distribution of VELB is unknown, the extensive destruction or riparian forests of the Central Valley of California strongly suggests that the beetle's range may have shrunk and become greatly fragmented.

Due to the limited knowledge about the VELB's life history, and its ecological requirements, precise threats to its survival are difficult to enumerate. Clearly the primary threat to survival of the VELB has been and continues to be loss and alteration of habitat by agricultural conversion, grazing, levee construction, stream and river channelization, removal of riparian vegetation, rip-rapping of shoreline, plus recreational, industrial and urban development. Insecticide and herbicide use in agricultural areas may be factors limiting the beetle's distribution. The age and quality of individual elderberry shrubs/trees and stands as a foodplant for VELB may also be a factor in the beetle's limited distribution.

There is little information on former abundance of VELB for comparison with current population levels. A. T. McClay collected 51 adults during May 1947. Dr. John A. Chemsak, a cerambycid specialist from the University of California, Berkeley, believes that VELB has probably always been rather rare and of limited abundance.

SPECIAL CONSIDERATION:

The riparian habitat of the beetle is still being degraded by urban development and levee repair work along the rivers. There has been some successful elderberry transplantings in specific areas along the rivers. This has increased the viable habitat for the beetle.

Special recovery efforts needed: Protect the only known VELB colonies; conduct further research on life history and habitat requirements of VELB; survey areas in Central Valley of California to locate additional colonies; formulate management plans as appropriate information on VELB's biology becomes available; establish VELB at rehabilitated habitat sites within present-day range; monitor VELB colonies to determine population status and success of management actions as implemented; increase public awareness of VELB through educational and information programs. Studies on the physiological requirements of the beetle and of the elderberry plants are needed.

REFERENCES FOR ADDITIONAL INFORMATION:

Arnold, R. A. 1984. Interim report for contract C-616 with the California Department of Fish and Game. 14 pp.

Burke, H.E. 1921. Biological notes on *Desmocerus*, a genus of roundhead borers, the species of which infests various elders. J. Econ. Ent. 14:450-452.

Craighead, F.C. 1923. North American cerambycid larvae. A clarification and the biology of North American cerambycid larvae. Can. Dept. Ag., Ottawa. Bull. 27. 239 pp.

APPENDIX 2

National Marine Fisheries Service Endangered Species Letter

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southwest Region
300 South Ferry Street
Terminal Island, CA 90731

April 24, 1991 F/SWR14:TDW

Colonel Lawrence R. Sadoff
District Engineer
Sacramento District
Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Dear Colonel Sadoff:

This letter is in response to your request for information regarding the presence of winter-run chinook salmon within the Yolo Bypass, Northern California Streams Flood Control Reconnaissance Study project area.

As we understand the project, the Corps will be preparing an Environmental Evaluation (EE) which will examine increased flood protection feasibility in Yolo and Solano Counties. A number of creeks, sloughs, and tributaries will be involved, with project alternatives including levee and channel work, flood bypass excavation and non-structural measures.

We confirm that winter-run salmon may occur within the project area. However, completion of the EE and associated reconnaissance study for the project proposal will not impact winter-run. Therefore, there is no need to proceed further with the consultation process relative to completion of the EE.

If it is determined through the EE that any of the project alternatives will involve in-water work (work that cannot be completed in-the-dry), further consultation will be required. The Corps may wish to re-initiate consultation when the EE is completed and more specific design information is available for our review.

If you have questions concerning these comments or wish to discuss the project further, please contact Diane Windham of my staff at: National Marine Fisheries Service, 777 Sonoma Avenue, Room 325, Santa Rosa, California 95404; telephone (707) 578-7513.

Sincerely,

E C Fullerton
E.C. Fullerton
Regional Director

APPENDIX 3

Recreation Letter

County of Yolo

GENERAL SERVICES AGENCY 625 Court Street, Room B-03 Woodland, California 95695 (916) 666-8075

Keith M. Ott
Director

July 10, 1991

Tanis Toland, Planning Division
Sacramento Basin Branch
U.S. Army Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814-4794

Dear Tanis:

Enclosed for your review is a map I prepared showing what resulted from our July 3rd meeting to layout a recommendation for inclusion of some recreation features in the Corps of Engineers Reconnaissance Study for Flood Control of the Yolo ByPass.

If you, as staff for your respective agency, have no objection to the layout attached, I intend to forward the recommendation to the Board of Supervisors for their approval. When, and if, the Board has approved this element I will forward the recommendation to the Corps for inclusion in the study. As you know, at this point there is no financial obligation on the part of local agencies to cost share in the study.

Unless you respond within the next 10 days with comments or concerns I will assume that I can proceed with presentation to the Board of Supervisors. Thanks for your help and support.

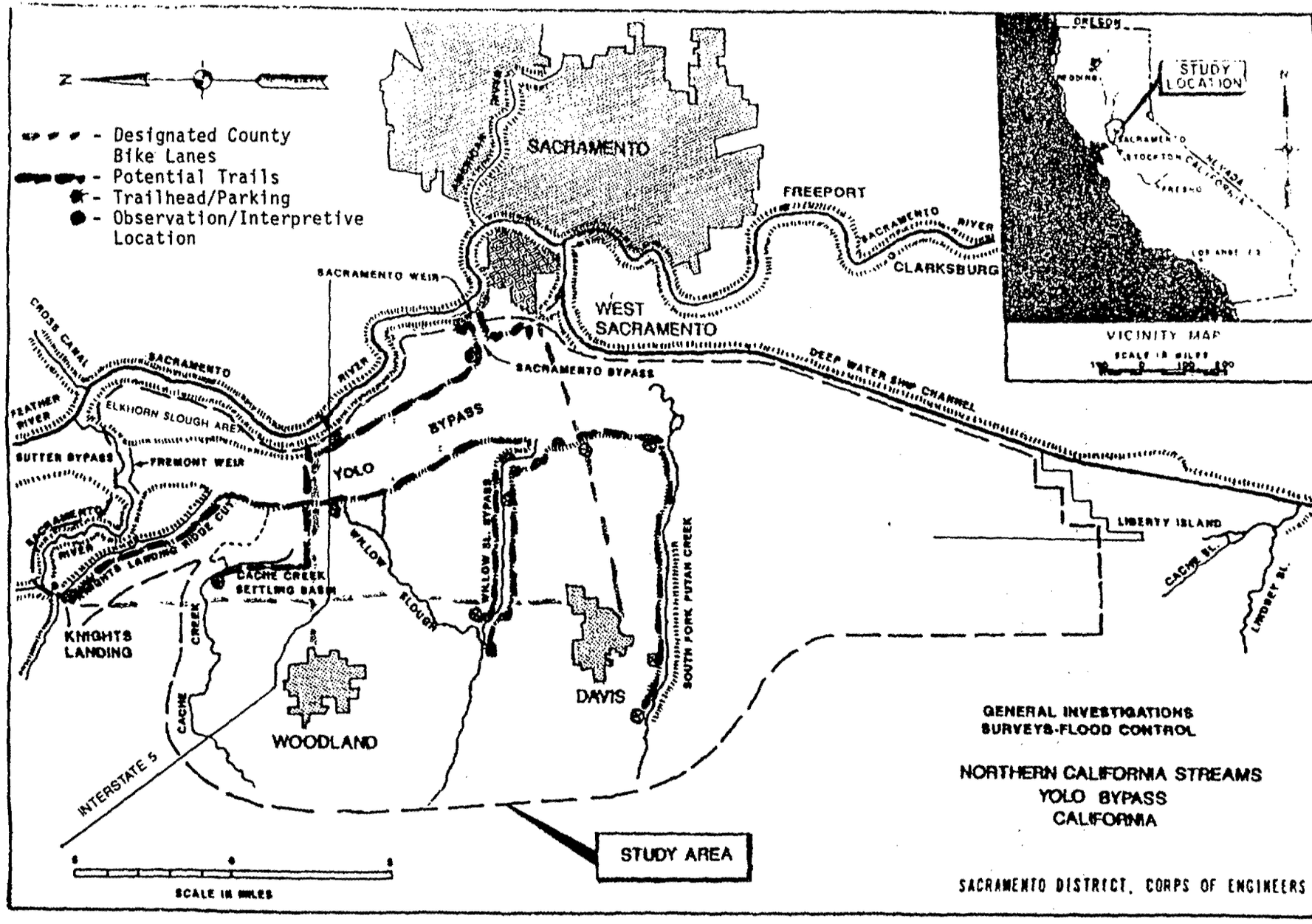
Sincerely,

Earl Balch, Director
Facilities and
Administrative Services

EB:tr

PARKS/corps

PRINTED ON RECYCLED PAPER


N
- Designated County Bike Lanes
- Potential Trails
- Trailhead/Parking
- Observation/Interpretive Location
SACRAMENTO
FREEPORT
CLARKSBURG
WEST SACRAMENTO
SACRAMENTO WEIR
SACRAMENTO BYPASS
DEEP WATER SHIP CHANNEL
CROSS CANAL
SACRAMENTO RIVER
FEATHER RIVER
ELKHORN SLOUGH AREA
SUTTER BYPASS
FREMONT WEIR
YOLO BYPASS
WILLOW SL. BYPASS
KNIGHTS LANDING RIDGE CUT
CACHE CREEK SETTLING BASIN
KNIGHTS LANDING
CACHE CREEK
WILLOW SLOUGH
SOUTH FORK PUTAH CREEK
LIBERTY ISLAND
CACHE SL.
LINDSEY SL.
WOODLAND
DAVIS
INTERSTATE 5
STUDY AREA
SCALE IN MILES
STUDY LOCATION
VICINITY MAP
GENERAL INVESTIGATIONS
SURVEYS-FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS
YOLO BYPASS
CALIFORNIA
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

Atach

APPENDIX 4

U.S. Fish and Wildlife Service Planning Aid Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Fish and Wildlife Enhancement
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

May 28, 1991

Colonel Laurence R. Sadoff
District Engineer
Sacramento District, Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: CE - Northern California Streams Flood Control, Yolo Bypass, California

Dear Colonel Sadoff:

This planning aid letter is provided pursuant to the scope of work for Fiscal Year 1991. It describes (1) fish and wildlife resources found in the project area, (2) potential impacts of the various alternatives being considered on these species, (3) data needs and studies for feasibility phase work, and (4) identification of a preferred alternative.

The information provided herein is preliminary in nature and is provided as technical assistance to aid your planning process. It does not constitute our detailed report as called for in Section 2 of the Fish and Wildlife Coordination Act.

Our recommendations are based on mitigation and compensation commensurate with the fish and wildlife values involved and adhere to the sequential levels identified by the Service and the Council on Environmental Quality.

This analysis is based on (1) preliminary project information provided by the Corps of Engineers through February, 1991, and (2) field reconnaissance trips on February 20, March 6, and May 20, 1991. The impact analysis will not remain valid if modifications are made in the described plan, if the resource base changes, or if anticipated future conditions based on preliminary Corps information are altered.

We have not applied the Fish and Wildlife Service's Habitat Evaluation Procedures (HEP) to this project. A HEP and Fish and Wildlife Coordination Act report will be required at the next phase (feasibility phase) of planning for this project.

This letter has been coordinated with the California Department of Fish and Game. All preliminary information presented herein regarding endangered, threatened, and candidate species has been coordinated with our Habitat Conservation staff.

INTRODUCTION

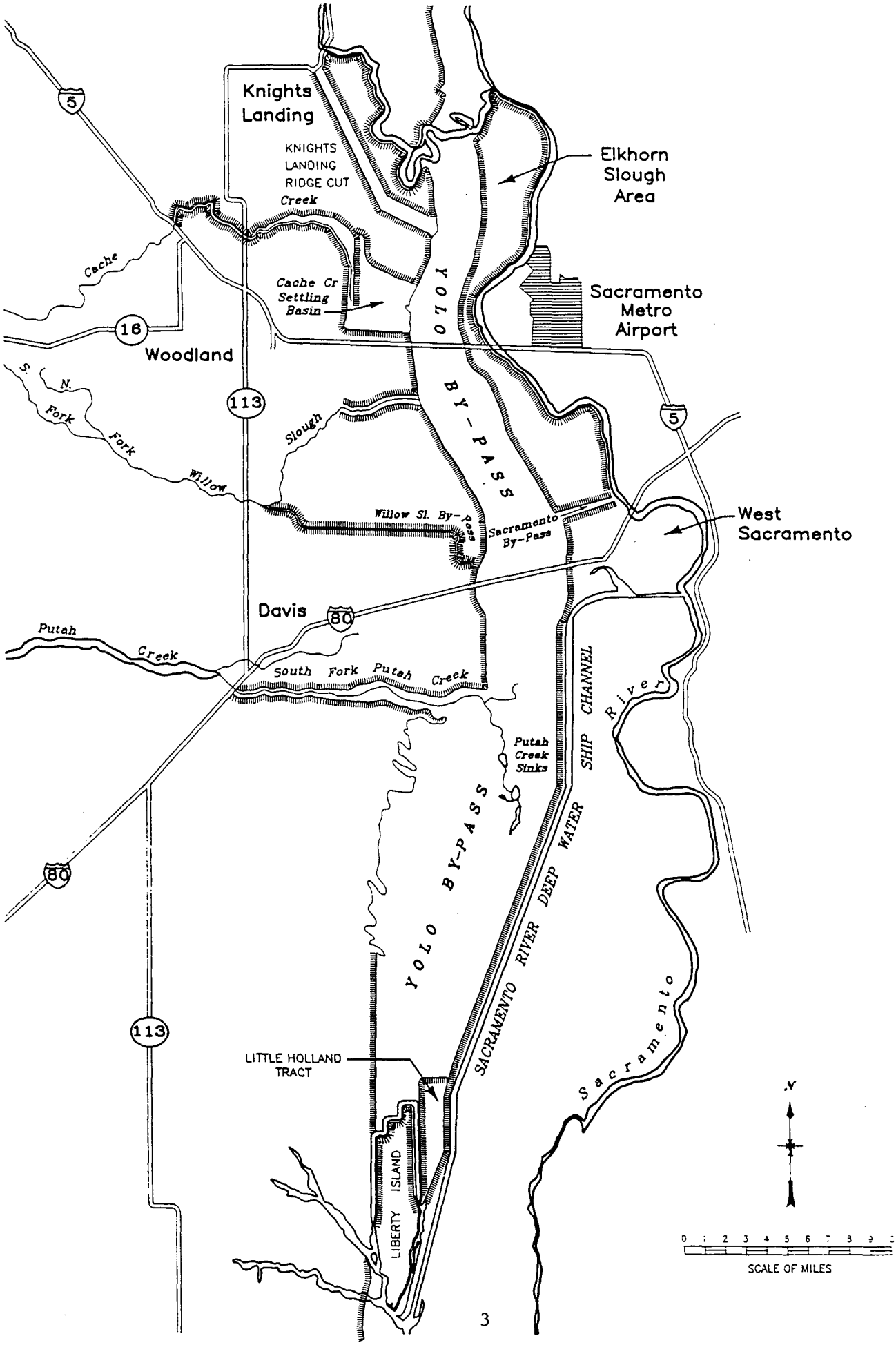
High river flows of 1983 and February 1986 caused freeboard to be less than 3 feet along the Yolo Bypass levees south of Interstate Highway 5. Wavewash erosion required about $900,000 in emergency repair by the Corps. Recent surveys indicate significant land subsidence in the area. This has raised questions about the elevations of flood control levees in the area and the impact upon flood protection levels. Flood protection needs for higher frequency flood events within the study area require evaluation.

The purpose of this reconnaissance study is to determine the potential for Federal participation in the development and construction of increased levels of flood control protection for the Yolo Bypass and tributaries along the west side of the Yolo Bypass including Cache Creek, Willow Slough, Willow Slough Bypass, Knights Landing Ridge Cut, Putah Creek, and South Fork Putah Creek, in Yolo and Solano Counties. In addition, the right bank levee of the Sacramento River from Knights Landing to Sacramento Bypass will be investigated. These levees protect areas on either side of the Yolo Bypass: the Knights Landing area and Elkhorn area. The investigation was requested in August, 1989 by the Yolo County Board of Supervisors and is authorized by the Flood Control Act of 1962, Northern California Streams, Public Law 87-874.

DESCRIPTION OF THE AREA

The Yolo Bypass study area covers lands on the west side of the Bypass from the Sacramento River by Knights Landing south to South Fork Putah Creek to the south end of Liberty Island and Little Holland Tract. In the east-west direction, the study area covers from the Sacramento River on the east, to lands west of the cities of Davis and Woodland. The study area is shown in Figure 1.

The Sacramento River system is the largest watershed in California, draining 26,300 square miles of the Central Valley and the Coast, Cascade and Sierra Nevada mountain ranges. A system of levees bounds much of the Sacramento River downstream from the city of Chico into the Delta. Flows are regulated by major dams and reservoirs, such as Shasta on the mainstem and Whiskeytown, Oroville, New Bullards Bar, Folsom, Black Butte, and Berryessa on the tributaries. In addition, water is transferred from the Trinity River to the Sacramento River via Whiskeytown and Keswick Reservoirs. Since the construction of these storage facilities, the river is used to transport this water to the Sacramento-San Joaquin Delta and the State and Federal export pump facilities in the south Delta. Two thousand square miles of fertile agricultural land and about fifty communities are located in the floodplain. The study area is located in the downstream, southerly end of the Sacramento River system.



NORTHERN CALIFORNIA STREAMS,
YOLO BY-PASS

DESCRIPTION OF PROJECT ALTERNATIVES

At the time of this report the Corps of Engineers has not completed surveying levees within the study area. Consequently, proposed actions for specific areas or sites have not been fully developed for all areas.

Generally, six alternatives are being considered however. These are:

Alternative A - No Action. In this alternative levees which have subsided would not be restored, no channelization or excavation of streambeds of tributaries to the Yolo Bypass would occur, and existing levees in constricted areas would not be breached or removed.

Alternative B - Raise levees. This option could be used to restore levee elevations where subsidence has occurred or to increase the level of flood protection by raising all levees. Specific dimensions of levee construction would likely vary. Construction might take place on the waterside or landside of the levee, or it might straddle the levee on both sides. It is assumed levee slopes would remain similar to existing levees. On May 2, 1991 the Corps advised the Service that this alternative was being considered in the Knights Landing and Elkhorn Slough areas, and project levees of Willow Slough Bypass and adjacent Yolo Bypass levees.

In the Knights Landing area three levee construction actions are being considered including: (1) raising levees all the around the island, (2) constructing a cut-off wall at the edge of the town of Knights Landing (along an old railroad alignment) and raising levees around the community, and (3) constructing a cut-off wall a short distance from the edge of town in conjunction with raising perimeter levees around the community.

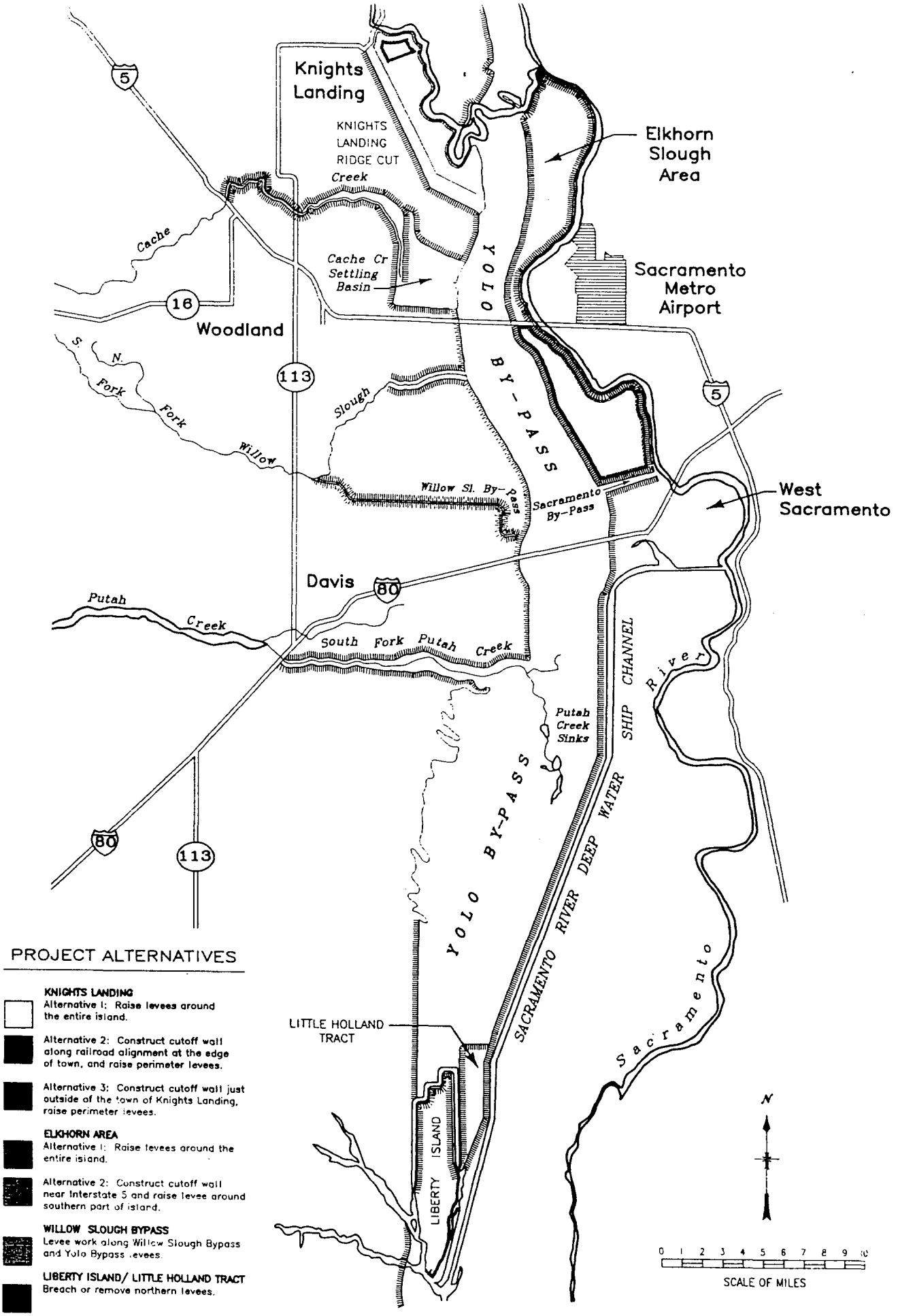
In the Elkhorn Slough area two levee construction actions are being considered including: (1) raising the levees all the way around the island, or (2) constructing a cut-off wall near Highway 5 and raising levees around the southern part of the Elkhorn Slough area.

The location for these proposals as well as the levee raising on Willow Slough Bypass and adjacent Yolo Bypass are shown on Figure 2.

Alternative C - Channel work. This option is identified primarily for the westside tributaries to the Yolo Bypass (Toland, personal communication). It is assumed this alternative would include channelization of segments or entire lengths and/or clearing of plant material and debris (referred to as clearing and snagging) in these tributaries.

Alternative D - Excavation within channel bypasses. This option was also identified for the westside tributaries to the Yolo Bypass. The extent of this proposed action in the study area is unknown.

Alternative E - Nonstructural measures. Included in this alternative is flood-proofing of existing structures in the floodplain and use of wetland buffer zones for flood damage reduction.



NORTHERN CALIFORNIA STREAMS,

Alternative F - Breach or remove levees. The northern levees of Liberty Island and Little Holland Tract would be breached or removed to facilitate floodflows through the narrow, southern part of the Yolo Bypass.

EXISTING BIOLOGICAL RESOURCES

VEGETATION

Many significant and diverse habitat types are found within the study area. Essentially seven different habitat types occur: (1) freshwater marsh; (2) woody riparian forest; (3) riparian scrub/shrub; (4) oak woodland; (5) grassland (upland); (6) Shaded Riverine Aquatic Cover; and (7) agricultural lands. A description of these habitats is contained in Attachment 1. These are the primary habitats used by fish and wildlife populations in the study area.

Historically, the constant meandering, seasonal flooding and sediment deposition by the Sacramento River and to a lesser extent, the Feather River, created extensive natural levees, numerous sloughs, islands and marsh areas. Many areas, once covered with extensive riparian forests and lakes which provided diverse habitats, supported high populations of numerous wildlife species. In recent times conversion of these native lands to agricultural and urban land uses has precipitated the decline of these populations, some to the point of threatened or endangered status. An estimated 90 to 98 percent of California's native wetland habitats such as riparian forests and permanent and seasonal marshes have been lost or extensively altered. A small percentage of the original acreage of native habitat now remains in the study area.

Sacramento River. Vegetation along the Sacramento River within the study area varies in density, width, and species composition depending on physical parameters such as land use, placement of riprap, location of levees, and levee maintenance.

Generally, stands of riparian vegetation occur along the rivers within the levees, while vegetation on the levee slopes and at the outside toe of the levee consists primarily of grasses and forbs, with a scattering of singular or small stands of oaks, willows or cottonwoods. Land use on the landward side of the levees is primarily agricultural.

Within the riparian corridor, tree canopy consists primarily of valley oak, sycamore, cottonwood, and various species of willow. Grape or mistletoe are sometimes present. A well-defined woody understory typically consisting of box elder, black walnut, white alder, Oregon ash, elderberry, poison oak, and smaller cottonwood occurs in most undisturbed areas. California grape, blackberry, raspberry mugwort, western ragweed, pigweed, clover, cocklebur, several thistles, grasses and forbs form an often dense ground cover. Non-native woody species which may be commonly found include eucalyptus, acacia, giant reed and honey locust.

Levee slopes and berms (relatively flat, bench-like areas, usually on the waterside of levees, just above the mean water level) may contain several varieties of grasses, forbs, and small woody species, such as cottonwood or willow. These areas provide valuable habitat for small mammals, such as ground squirrels, rabbits and mice, which in turn provide a food base for larger animals, such as coyotes and raptors.

Specifically, riparian vegetation along the banks of the Sacramento River occurs in varying conditions within the project area. Where vegetation is present, it usually occurs in narrow but dense bands along the banks. Set-back levees in some areas allow larger parcels of dense, high-value riparian habitat to occur adjacent to the river. Much of the Sacramento River between Verona and the city of Sacramento has undergone extensive bank protection work and levee maintenance. These practices have permanently eliminated or degraded much of the riparian vegetation in these areas, resulting in reduced habitat value for fish and wildlife species. However, the Service recognizes that vegetation is often lost through erosion of vegetated channel berms and that bank protection measures do protect some of these areas.

Yolo Bypass. In the project area, vegetation waterward of the levee consists primarily of very narrow strips of riparian habitat dominated by willows, alders, and oaks. Emergent marsh vegetation occurs sporadically along the toe drain of the levee. A dense stand of trees occurs on the west bank while the east bank, having undergone substantial revetment work, supports only a very sparse scattering of trees.

Agricultural lands within the Bypass are primarily small grains such as rice, wheat, barley, corn, safflower and sunflower and truck crops such as tomatoes, melons, and cucumbers. Agricultural lands outside the Bypass are generally quite similiar.

Knights Landing Ridge Cut. Vegetation along this waterway consists of a riparian corridor along the east and west banks with the east bank more heavily vegetated. Willows are the dominant woody species. Within the channel there are berms which support scattered woody vegetation, primarily willows, and dense stands of grasses, forbs, and reeds. There are no agricultural lands within the leveed channel.

Lands outside the levee are predominately agricultural (row crops and wheat), and the urban area of Knights Landing.

Cache Creek, Willow Slough, Willow Slough Bypass, South Fork Putah Creek, Sacramento Bypass Levees. The vegetation growing in and along these waterways is similar to that previously described. Willow species dominate the woody overstory while mixtures of blackberry, grasses, and forbs dominate the understory. Cache Creek supports relatively dense riparian vegetation within the channel. However, the vegetation is degraded in some areas by off-road vehicle use and clearing activities in and along the channel. The south levee of South Fork Putah Creek is generally devoid of woody vegetation as are both levees of Willow Slough Bypass.

Agricultural lands within these channels consist of a few cleared areas for crops. Lands adjacent the channels are primarily row crops and wheat fields.

Liberty Island and Little Holland Tract Levees.
Access was not available to the site for review on short notice. The levee was viewed from a distance and appears to be vegetated with dense stands of grasses, forbs, and scrub-shrub species. Shaded Riverine Aquatic habitat also may be present.

FISH

Sacramento River. The Sacramento River supports an array of anadromous and resident fish species. Anadromous fishes in the project area include chinook salmon, steelhead trout, striped bass, American shad and white sturgeon. Resident warmwater fish include largemouth bass, crappie, white and channel catfish, bluegill, tule perch, Sacramento squawfish, Sacramento sucker and various sculpins and minnows.

Of greatest economical importance to California fisheries is the chinook salmon. The Sacramento River supports the largest chinook salmon population in the state. Approximately 90 percent of the Central Valley salmon population spawn in this system (Kjelson 1982). Four genetically distinct species of chinooks presently use the river: fall-, late fall-, winter- and spring-run. Fall-run salmon are presently most abundant, comprising about 80 percent of the four runs (Kjelson 1982). According to Hallock (1987), total numbers of salmon that spawn in the upper Sacramento River system have declined more than 75 percent since the 1950's. Fall-run salmon, which make up more than 90 percent of the total, appear to be stabilized at a low level of 200,000 fish; 85 percent spawn naturally and 15 percent are spawned artificially at hatcheries. However, on certain tributaries where there are hatcheries, populations are increasing, which is masking the true picture, i.e., the natural spawning populations are declining in the upper Sacramento River system. Winter-run salmon have experienced the most precipitous decline and were listed as a threatened species in 1989 by the National Marine Fisheries Service. Counts of winter-run salmon passing the Red Bluff Diversion Dam from 1967 range from a high of 117,080 in 1969 to a low of 400 adults in 1989 (Hallock 1987, Pacific Fishery Mgmt. Council 1990). Documentation of the fall-run chinook salmon decline is extensive, indicating the 1985 population count is about 17 percent of the spawning population in the 1950's (Michny and Deibel 1986). Between the four races of salmon and the related steelhead trout, one or more life stages of salmonids occur in the Sacramento River system at essentially all times of the year.

Adult steelhead trout use the lower and middle Sacramento River as a migration corridor to the upper Sacramento River system during the late summer, fall, and winter. Spawning occurs from December through April in most tributaries with year-around flows. Juveniles migrate downstream primarily in the spring after 2 or more years of rearing in upstream areas. The current steelhead population is estimated at less than half their numbers in the 1950's (Hallock 1987), and recently, large additional population declines have been noted during the present 5-year drought period.

Most of California's American shad and striped bass spawn in the Sacramento River system. The overall American shad population had flourished in past decades, and was estimated to be several million fish, but is now experiencing an overall downward trend exacerbated by the present prolonged drought. Striped bass populations, however, are experiencing an even more severe decline. In the 1960's, the striped bass population for the Sacramento River was estimated to be 3.0 to 4.5 million; in the 1970's, the population declined to 1.7 million. In 1977 the population was between 0.8 to 1.2 million. It may be continuing to steadily decline. Recent indexes to numbers of young-of-the-year are the lowest ever recorded (4.3 in 1990 compared to 12.6 in 1987).

White sturgeon populations are also considered unstable. Over recent decades, the size of the sturgeon population has varied dramatically. From about 1967 to 1974, both the population and the sport fishery declined. A 1979 estimate put the population of legally catchable ($\geq$ 40-inches-total length) fish in the estuary at about 75,000. From about 1975 to 1985 a population increase occurred, with a 1984 estimate placing the population of legally catchable fish at about twice that of 1979. The present population appears to be either stable or declining.

Other fish species, including largemouth bass, crappie, bluegill, white catfish, and channel catfish are also common in the study area. Some of these species use river backwater areas where current velocities are slower and more conducive to habitat requirements. A number of species are found along vegetated shorelines of the river and associated sloughs where valuable cover is provided by overhanging and/or partially submerged shrubs or trees (this nearshore aquatic zone has been referred to as Shaded Riverine Aquatic Cover). Species such as the Sacramento squawfish, hardhead and Sacramento sucker are most abundant in the larger tributaries between the 300 to 2000 foot elevation. They generally prefer large, deep, well-shaded, sand- or rock-bottomed pools. Fish habitat is substantially enhanced by the diversity offered by this land-water interface with adjacent levee berms.

Yolo Bypass, Knights Landing Ridge Cut. The same anadromous fish species identified in the Sacramento River system are also occasionally present in several of the borrow ditches within the Yolo Bypass such as the Tule Canal and Knights Landing Ridge Cut. Some of the borrow ditches adjacent to the levees support a significant warmwater fishery consisting of largemouth bass, crappie, catfish and bluegill. Several nongame fish such as carp, suckers, minnows, and mosquitofish are also present. Shaded Riverine Aquatic Cover is scarce in these areas, and only occurs when an occasional shrub or tree is present in the nearshore area.

Most of the species found in the Sacramento River system enter the Yolo Bypass when it is flooded during large storm events. There is little information available on fish population levels, habitat conditions, and sportfishing effort and success in the Yolo Bypass, borrow ditches, and canals within the Yolo Bypass.

Cache Creek, Willow Slough, Willow Slough Bypass, South Fork Putah Creek, Sacramento Bypass. Cache Creek and South Fork Putah Creek are perennial in

most years since the flow in Putah Creek is controlled by Monticello Dam and Putah Creek Diversion Dam. Because these streams are somewhat perennial in nature (flows sustained by reservoir releases) they support a greater species diversity in aquatic fauna, particularly fish (Table 1) than if they were intermittent streams. Three anadramous species: Pacific lamprey, chinook

Table 1. Fish species and hydrologic conditions of westside tributaries to Yolo Bypass in project area.

NAME	HYDROLOGICAL CONDITIONS	FISH SPECIES	COMMENT
Cache Creek	Perennial, but greatly reduced summer flows due to diversions upstream	Hitch, squawfish, Sacramento blackfish, Sacramento sucker, bluegill, carp, green sunfish, white catfish, mosquitofish, goldfish, brown bullhead, channel catfish, roach, largemouth bass, smallmouth bass	Potential enhancement opportunities for fisheries
South Fork Willow Slough	Naturally intermittent in upper reaches but supplied with irrigation water from Cache Creek	goldfish, carp, mosquitofish, white catfish, channel catfish, striped bass	Channelized. Limited fishery value
South Fork Putah Creek	Perennial to intermittent depending upon seasonal rainfall below Putah Creek Diversion Dam (Lake Solano)	Green sunfish, blue gill, Sacramento blackfish, Sacramento squawfish, carp, goldfish, Sacramento sucker, bigscale logperch, American shad, threadfin shad, fathead minnow, white catfish, brown bullhead, golden shinner, mosquitofish, chinook salmon, striped bass, largemouth bass, channel catfish, Mississippi silverside, redear sunfish, hitch,	Excellent opportunity for fishery enhancement

Source: USFWS, 1980

salmon, and steelhead trout utilize Putah Creek in wet years. Chinook salmon spawning and emerging fry have been observed in Putah creek in the vicinity of the University of California, Davis (Moyle, personal communication).

Willow Slough and Willow Slough Bypass are watercourses generally maintained in more or less a perennial state by man. The stream channels are used to deliver irrigation water and/or drain agricultural lands. These streams have been channelized to various degrees.

The fisheries of Willow Slough and Willow Slough Bypass are generally unknown but can be expected to be limited to species adapted to turbid, warmwater conditions. Such species include carp, goldfish, Sacramento sucker, Sacramento squawfish, channel catfish, and green sunfish. Channel configuration, streamflow velocity, water depth, water temperature, chemical composition of the water, presence of cover, and availability of food are only a few of the factors influencing the success of fish species in these streams. The seasonality of irrigation deliveries may result in significant changes in available habitat with consequent adverse impacts on the fishery. At present, these streams are of relatively limited fishery value.

WILDLIFE

The abundance and distribution of wildlife resources in the study area is directly related to available habitat. Wildlife found in the study area is not as well represented as it was before agricultural development permanently removed much of the natural habitat. Many wildlife species are unable to adapt to other habitat types or altered habitat conditions. These specialists are therefore most susceptible to habitat loss and degradation. Species which were dependent on wetlands, riparian forest, oak scrub/shrub woodland, marsh and grassland habitats have been susceptable to decline.

Riparian forest with its multi-strata structure, dense cover, and high plant species diversity, is especially productive, supporting the highest percentages of wildlife species. Existing information indicates that, in California, approximately 25 percent of native land mammal species, 50 percent of reptile species, and 75 percent of amphibian species are dependent on riparian habitats (Leopold 1985). Invertebrates, both terrestrial and aquatic forms, are also supported in high numbers by riparian habitats. Invertebrates provide essential food sources for birds and other vertebrates. They regulate vegetative growth through feeding activity and assist in pollination of many flowering plant species. Restrictions in geographic movement make many invertebrates especially vulnerable to habitat alteration (Faber, et. al., 1989).

The existing native habitat, especially the riparian corridors occurring along the waterways, provides habitat for many native mammal species. Audubon cottontail, brush rabbit, blacktail hare, gray squirrel, red and gray foxes, bobcat, raccoon, opossum, mink, weasel, striped and spotted skunks, badger, muskrat, river otter and beaver are found in the study area.

Native habitat also provides nesting and feeding habitat for resident birds. Birds are probably the most common, conspicuous wildlife in riparian ecosystems. Birds using riparian ecosystems can be categorized into at least four groups based on their seasonal occurrence: (1) summer (breeding) residents, (2) winter residents, (3) transients (migratory), and (4) permanent residents (non-migratory). As a result, bird populations are distinctly different from season to season.

Riparian ecosystems are valuable as breeding habitats for birds everywhere in North America. Individual stands of high-value riparian woodland often have 10-50 breeding bird species with most having between 20 and 34. Population densities of birds breeding in riparian areas generally fall between 40-900 pairs per 40 ha. Table 2 shows values observed in California studies.

Table 2. Number of breeding bird species and breeding bird densities observed on riparian study areas in California.

Number of breeding bird species in riparian ecosystems

Community and location	No. of species	Source
Desert riparian, California	13	Berry 1977
Willow-cottonwood, California	20	Ingles 1950
Cottonwood-willow, California	27	Gaines 1977

Breeding bird densities in riparian ecosystems

Plant community type and location	Density (pairs per 40 ha)	Source
Cottonwood-willow forest, CA.	840	Gaines 1977
Willow-cottonwood streambotton, CA.	197	Ingles 1950
Sacramento Valley riparian, CA.	240-450	Gaines 1977
Desert riparian, CA.	863	Berry 1977

Breeding season is generally in spring and early summer months

The Sacramento River system is part of the Pacific Flyway and provides important resting and feeding areas for migratory waterfowl, shorebirds, and other water associated birds. Other common bird species found in the study

area include California quail, ring-necked pheasant, mourning dove, common merganser, mallard, herons, egrets, kingfisher, marsh wren, song sparrow, various owls, woodpeckers, red-tailed hawk and Swainson's hawk.

Waterfowl use of the Yolo Bypass is extensive in the study area particularly when flooded by control weirs or by waterfowl hunting clubs. The wetlands and agricultural lands provide important food and resting areas for waterfowl. Figures 3 and 4 contain waterfowl population data for the Yolo Bypass.

In 1986, the United States and Canadian governments, concerned over the decline in duck populations, developed and signed the North American Waterfowl Management Plan. This plan provides a broad framework for waterfowl conservation and management based on population and habitat goals needed to meet public demand.

Implementation of the North American Waterfowl Management Plan is the responsibility of designated joint ventures, in which agencies and private organizations collectively pool their resources to solve waterfowl habitat problems. The California Central Valley Habitat Joint Venture was formally established by a working agreement in 1988. The goal of the joint venture is to protect, maintain, and restore habitat to increase waterfowl populations to desired levels in the Central Valley. The Yolo Basin (Figure 5) is included in the Central Valley Habitat Joint Venture Plan. The current wetland restoration goal for the entire Yolo Basin is 10,000 acres.

The California Department of Fish and Game and the Corps of Engineers are currently working on acquisition and restoration of approximately 3,915 acres of lands within the Yolo Bypass and adjacent Willow Slough Bypass (Figure 6). Acquisition of the largest parcel (3,180 acres) is expected to be completed by summer, 1991 (Grenfell, personal communication). Restoration planning for these lands is in progress.

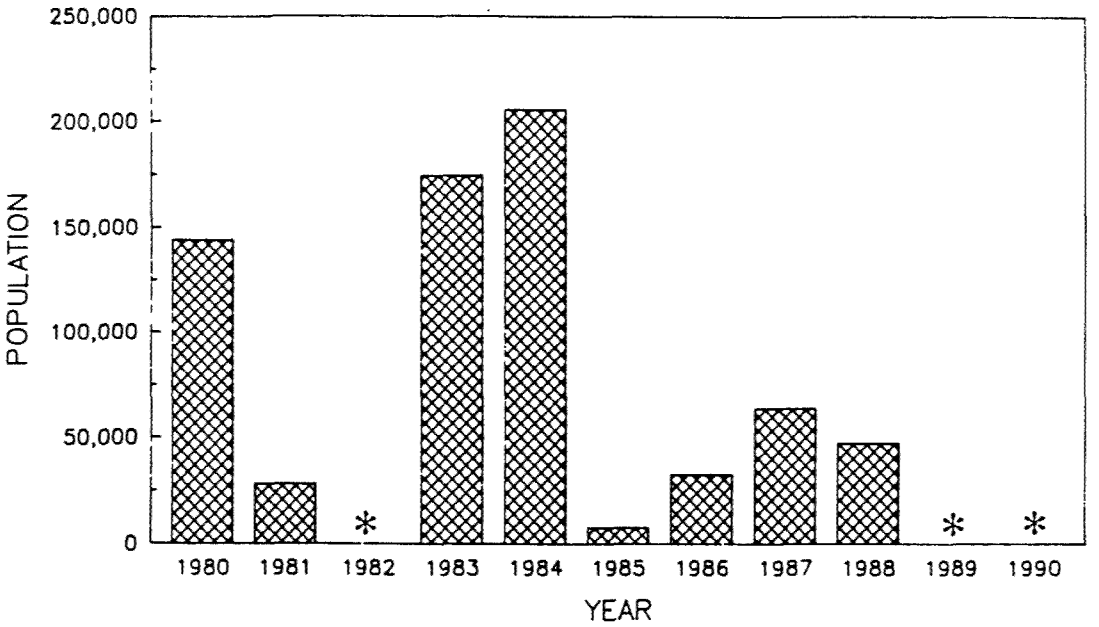
In addition, the Fish and Wildlife Service is preparing to establish an easement area which includes portions of Yolo County. Lands which eventually may be eligible for easements are also identified on Figure 6. The purpose of these easements is to preserve remaining wetland habitat for migratory waterfowl and other wetland dependent wildlife and plants.

Amphibians and reptiles found along the river include gopher snake, western fence lizard, garter snake, western pond turtle and Pacific tree frog. Nearly all amphibians depend on aquatic habitats for reproduction and overwintering, and many species are specifically adapted and restricted to riparian environments. Although reptiles are generally less restricted in relation to water, a clear preference for riparian ecosystems is displayed by various turtles and snakes.

A comprehensive list of fish and wildlife species likely found in the project area is contained in Attachment 2.

FIGURE 3

YOLO BYPASS MID-WINTER WATERFOWL COUNT
1980-1990 (ducks)

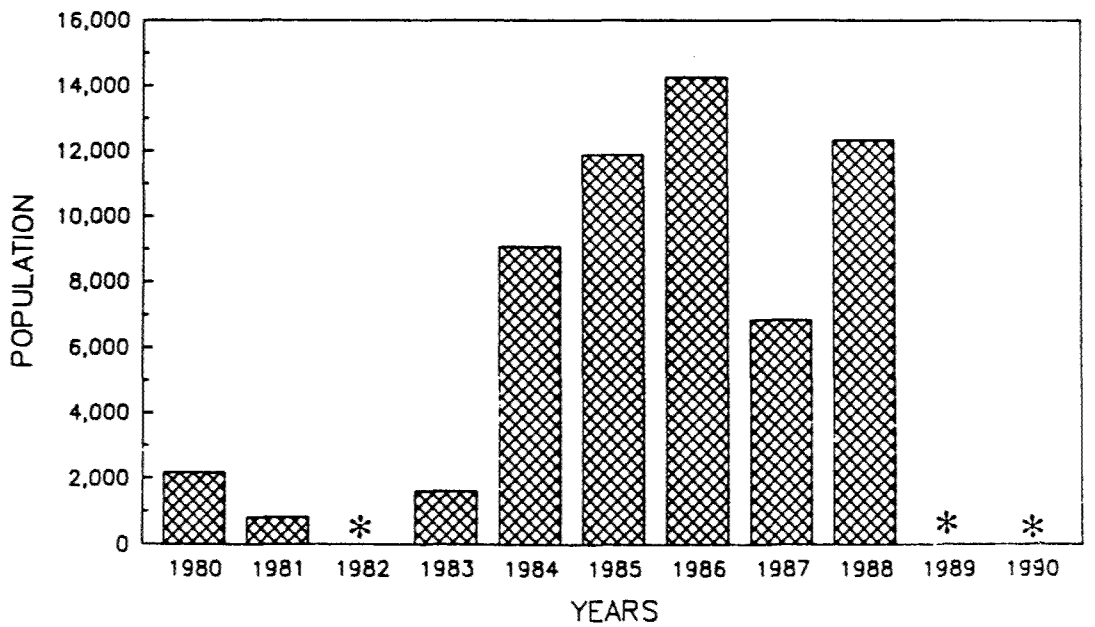


Source: CDFG Mid-Winter Waterfowl Surveys

* data missing

FIGURE 4

YOLO BYPASS MID-WINTER WATERFOWL COUNT
1980-1990 (geese, swans)



Source: CDFG Mid-Winter Waterfowl Surveys

* missing data

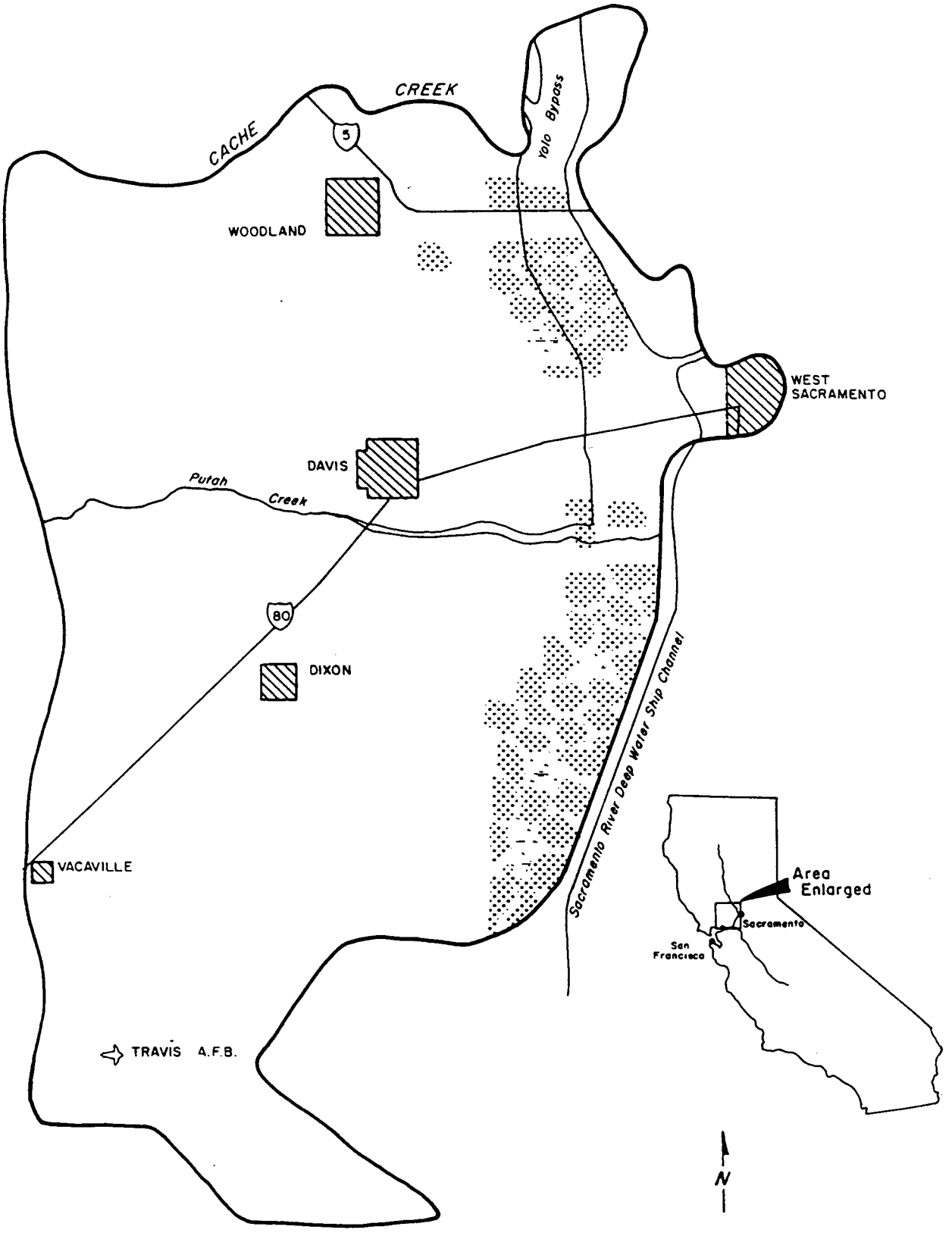
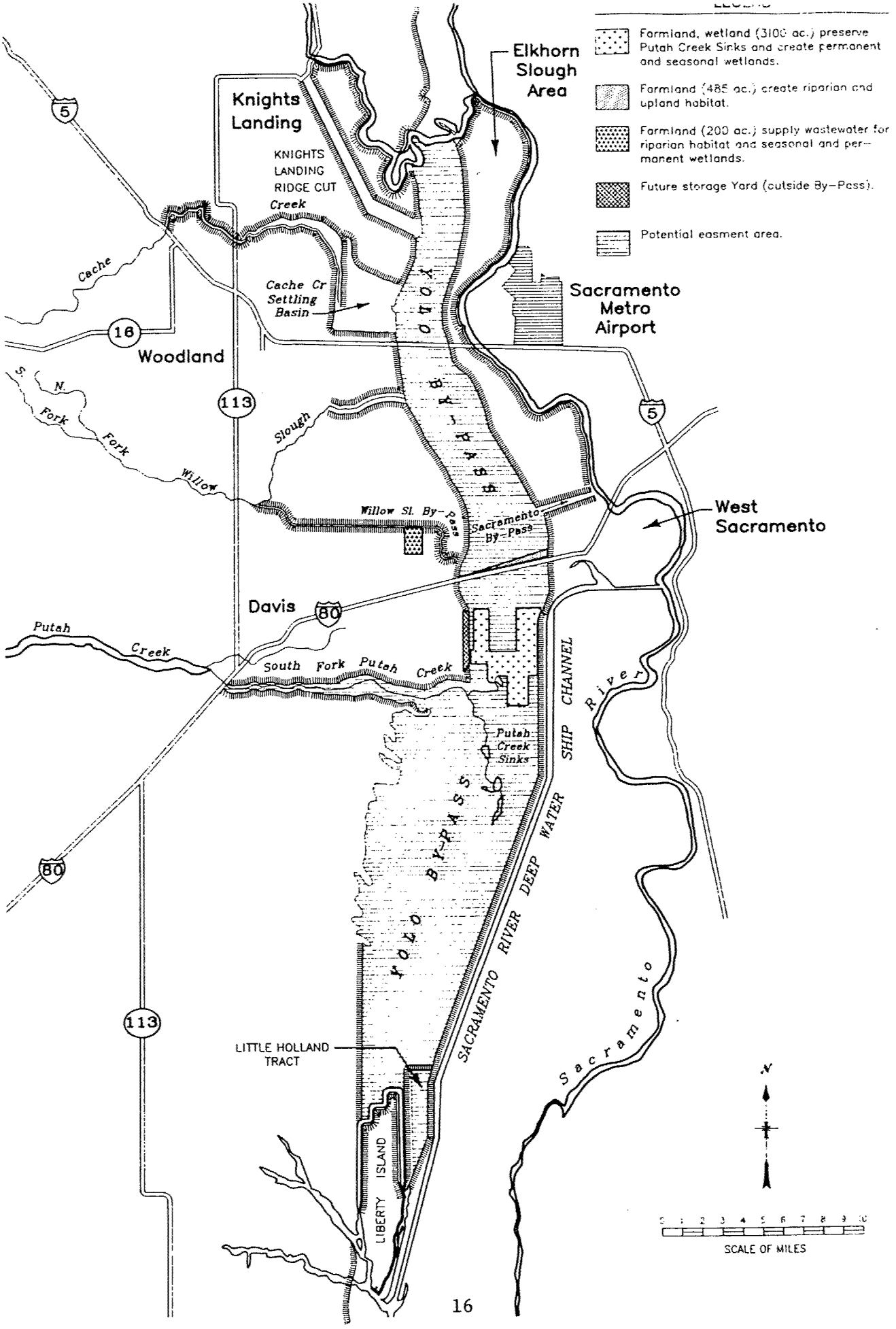


Figure 5 Yolo Basin

Private wetlands

Flooded agricultural lands or uplands

Natural marsh



NORTHERN CALIFORNIA STREAMS,
YOLO BY-PASS

Endangered Species

Two federally-listed threatened species occur in the study area, the valley elderberry longhorn beetle (Desmocerus californicus dimorphus) and winter-run chinook salmon (Oncorhynchus tshawytscha). Valley elderberry longhorn beetles may be found where the elderberry host plant is found. Winter-run chinook salmon utilize the Sacramento River and Yolo Bypass (when flooded) for migration to and from spawning grounds located in the Sacramento River upstream from Red Bluff to Redding, California.

The Service has been petitioned to list the delta smelt and giant garter snake. The giant garter snake has been documented as occurring in the Yolo Bypass. Although the delta smelt is not within the Yolo Bypass, it could be affected by floodwaters in the Bypass if these floodwaters pick-up pesticides and other contaminants.

Attachment 3 provides a summary of a Federal agency's responsibilities under Section 7(a) and (c) of the Endangered Species Act. If the Corps determines endangered or threatened species or critical habitat are present and may be affected by the project, formal consultation with the Fish and Wildlife Service's endangered species staff must be initiated to determine if the contemplated actions would jeopardize the continued existence of these species, or adversely modify critical habitat of such species. If proposed species are present and may be affected by the project, then conferencing with the Service is recommended. The Service also recommends conservation of candidate species and their habitats.

The Service has responsibility for the threatened valley elderberry longhorn beetle potentially affected by the proposed project, pursuant to the Endangered Species Act, as amended. The National Marine Fisheries Service has this responsibility for the threatened winter-run chinook salmon (Oncorhynchus tshawytscha).

There are nine candidate species which may be found in the area. These include:

Fish
- Sacramento splittail, Pogonichthys macrolepidotus (2)

Amphibians
- California tiger salamander, Ambystoma tigrinum californiense (2)
- Weastern spadefoot toad, Ambystoma hammondi hammondi (2R)

Reptiles
- giant garter snake, Thamnophis gigas (1R)

Birds
- tricolored blackbird, Agelaius tricolor (2)

Mammals
- Pacific western big-eared bat, Plecotus townsendii townsendii (2)

Plants
- Suisun aster, Aster chilensis var. lentus (2)
- California hibiscus, Hibiscus californicus (2)
- Mason's lilaeopsis, lilaeopsis masonii (2)

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(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(1R)-Recommended for Category 1 status.
(2R)-Recommended for Category 2 status.

IMPACTS OF ALTERNATIVES

The following section is a general discussion of the significant impacts anticipated from the alternatives currently being considered by the Corps.

Alternative A - No Action.

No significant impacts to fish and wildlife resources are expected to occur without the project.

Alternative B - Raise levees.

The proposed raising of the levees would adversely affect grasses and other herbaceous vegetation growing on the existing levee slope and beyond the toe of the berm (currently an undefined distance). Depending on the location of the work (waterside,landside, or straddle), the impacts would differ greatly.

Waterside Construction

Waterside construction would adversely affect Shaded Riverine Aquatic Cover, riparian vegetation, and grasses along the levee slope where it occurs. Any adverse effect on Shaded Riverine Aquatic Cover and riparian habitat would adversely impact fish and wildlife, including anadromous (adults and smolts) and resident fish species, and the threatened valley longhorn elderberry beetle if elderberries, its host plant, are removed. Loss of these habitat types would also reduce cover and food for fish, and nutrient input to the aquatic system; water temperatures could also be increased due to a reduction of shading of water. Any adverse effect on anadromous fish would be significant because Sacramento River system populations are already severely depressed.

Any loss of riparian vegetation along the watercourses within the study area would adversely affect many wildlife species. The riparian forest, with its multi-layered vegetation and high plant species density, supports the largest populations and most diverse wildlife along the Sacramento River. The high diversity of tree species with varying growth rates, cover conditions and layers, and close proximity to water provides a wide variety of ecological niches. Any loss of plant area or diversity would adversely affect those species inhabiting the area.

Losses of Shaded Riverine Aquatic Cover and riparian habitats could have a significant adverse impact on many species of fish and wildlife including resident and anadromous fish, water-related birds, and small mammal species that use these areas to meet part or all of their life needs. Cover and food sources for anadromous and resident fish would be lost, nesting habitat for raptors would be eliminated or greatly reduced. Cover and nesting habitat for songbirds would be lost, and cover, food and a portion of the migration corridor for small mammals would be eliminated.

Any disturbance and loss of riparian vegetation, and construction activity would adversely affect nesting raptors, including the Swainson's hawk. Loss or disturbance of nesting habitat could severely impact these species.

The impact on grassland habitat on the levee slopes would be minimal and temporary. Disturbance or loss of this habitat would adversely impact some mammals, raptors, and other species. However, reseeded grasses should recover quickly after project construction allowing the area to be relatively quickly repopulated by similar wildlife species.

Landside Construction

Landside construction would impact grasses on the levee slopes, trees and shrubs growing along the levee, and wetland habitats along existing toe drains for an undetermined distance. In areas where agricultural lands with value to wildlife are adjacent to construction sites, impacts may be sustained in these agricultural lands by losses of food and cover. Also, construction activity during raptor nesting periods could lead to nesting failure.

The impacts on fish, wildlife and vegetation would be significantly reduced with landside construction. It would primarily eliminate or reduce any adverse project effects on riparian vegetation and Shaded Riverine Aquatic Cover.

Straddle Construction

Straddle construction would impact the grassy levee slopes, some riparian vegetation and trees and shrubs found immediately adjacent to the levee toe for an undetermined distance. Also, depending on the locations of the toe drains, impacts to wetland habitats could be reduced or eliminated. The impacts to Shaded Riverine Aquatic Cover could occur; however, they would probably be significantly less than with a waterside construction alternative.

If a landside berm is constructed with straddle construction, the impacts would be similar to landside construction.

A significant amount of borrow material would be required to raise and reinforce the levees. The impacts on vegetation and wildlife could be adverse. However, the magnitude of the impacts would vary with site location and amount of borrow material required.

Alternative C - Channel work. Channelization of the watercourses in the study area would adversely affect vegetation growing within the channel (all area between the levees). The effect of these losses on fish and wildlife would be similiar to that described in Alternative B. Losses of Shaded Aquatic Cover would also be likely to occur, resulting in adverse impacts to fish and other species that utilize these areas to meet part or all of their life requisites.

Clearing and snagging activity greatly reduces or eliminates habitat value for fish by removing cover, reducing substrate material for aquatic invertebrates, and reducing flow and current diversity. Terrestrial wildlife are also adversely affected when streamside vegetation is lost through removal of perching and nesting sites for birds, and cover and food sources for small mammals. Fish would lose instream and overhead cover, aquatic insects and insect drop from overhanging vegetation for food, and may experience increased summer water temperatures from loss of shading.

Alternative D - Excavation within channel bypasses. Excavation of the channel would also adversely affect vegetation growing within these areas. The effect of these losses has been generally described. This alternative would potentially impact all habitats discussed in Alternative B.

Alternative E - Nonstructural measures. The construction actions should have only minimal adverse effects on vegetation and wildlife in the project. Few, if any, impacts are expected to fish resources. Construction activities could adversely affect raptor nesting success if it is conducted during the nesting periods.

Location of construction staging areas could have an adverse impact on vegetation and wildlife if they were located in sensitive areas.

Use of wetland buffer zones to reduce flood damages would result in a beneficial impact to wetland vegetation and wildlife through creation of additional protected habitat. Habitat values for wildlife could be increased through active restoration of wetlands in the buffer zones.

Alternative F - Breach or remove levees.
Complete removal of levees would adversely affect vegetation growing on the levee. Breaching would adversely affect vegetation in the area where breaching occurs. Impacts from breaching at intervals would be less than with complete removal of the levee.

DISCUSSION

The Fish and Wildlife Service mitigation recommendations are based on the value of the habitat in the study area to fish and wildlife species. During the impact assessment, specific habitat types that may be impacted by the project are identified. Evaluation species which utilize each habitat are selected for impact analysis. Selection of evaluation species can be based on several rationales including (1) species known to be sensitive to specific land and water use actions, (2) species that play a key role in nutrient cycling, or energy flow, (3) species that utilize a common environmental resource, or (4) species that are associated with Important Resource Problems as designated by the Director of the Fish and Wildlife Service, such as anadromous fish and migratory birds.

Habitat value determinations are based on the importance of the habitat types found in the study area to the selected evaluation species and relative scarcity of the habitat types. Habitat values range from those considered to be unique and irreplaceable to those believed to be of relatively low value to fish and wildlife and generally common. In the study area, seven distinct habitat types are found: (1) freshwater marsh, (2) woody riparian forest, (3) riparian scrub/shrub, (4) oak woodland, (5) grassland (upland), (6) Shaded Riverine Aquatic Cover and (7) agricultural lands.

Of all the habitat types available to wildlife, riparian habitat supports the greatest diversity and abundance of wildlife species. Unfortunately, much of the riparian habitat necessary to maintain fish and wildlife resources has been eliminated in the study area. Instream aquatic habitat in the project

area is also becoming scarce. The loss of these habitat types can be attributed to numerous flood control, water storage, and navigation projects, and to water diversions, agricultural expansion, urbanization, and pollution. The combined effects of habitat destruction (through damming, channelization and other stream alterations), habitat degradation by excessive human disturbance, and the introduction of exotic species have resulted in tremendous losses of native habitats, and subsequently, native fish and wildlife species.

The evaluation species selected to determine the value of riparian vegetation including riparian forest and scrub/shrub in the study area include water-associated birds, passerine birds, and small and large mammals which inhabit the project area. Riparian vegetation in the study area provides important nesting, resting and/or feeding habitats for raptors, passerine and water-associated birds. The riparian corridor provides a high-value feeding habitat and migration corridor to mammal species which occur in the study area. The riparian corridor is also of high value to chinook salmon and other anadromous fish of the Sacramento River because of the importance of vegetation in providing cover, water, temperature control, a food source, and nutrient input into the ecosystem. Because of the high value of riparian habitats in the study area to fish and wildlife species, and due to the relative scarcity of this habitat type, our goal is no net loss of in-kind habitat value. Under this mitigation goal, we will seek in-kind replacement of lost habitat values.

The evaluation species selected to determine the value of Shaded Riverine Aquatic Cover in the study area include chinook salmon (excluding winter-run), steelhead trout, and other resident and anadromous species. The Sacramento River system, including distributaries, sloughs, and bypasses (when flooded) within the study area, provides principal migratory routes for anadromous fish of the Sacramento River. Therefore, the protection of instream aquatic habitat is important in maintaining, and possibly enhancing, the anadromous fish resources. Inventories conducted by the Service along the lower Sacramento River and its four major distributaries found only 20 percent of the riverbanks had any Shaded Riverine Aquatic Cover remaining, which totalled about 28 acres (from an original estimate of over 400 acres), and this acreage was clumped rather than uniformly distributed.

Because of the high value of Shaded Riverine Aquatic Cover in the study area to fish and wildlife evaluation species, and because of the relative scarcity of this habitat type, our mitigation goal is no net loss of in-kind habitat value. Under this mitigation goal, we will seek in-kind replacement of lost habitat values.

The evaluation species selected to determine the value of freshwater marsh (permanent and seasonal wetlands, toe drains, and associated canals) in the study area include migratory waterfowl and other water-associated birds reptiles and amphibians that frequent these areas. These seasonal wetlands provide important wintering habitat for waterfowl. As the number of permanent wetlands in the Central Valley diminishes, seasonal wetlands assume an added importance for these species. Seasonal wetlands are also becoming scare as agricultural expansion and urban growth continues.

Because of 1) the importance of permanent and seasonal wetland areas to migratory waterfowl and other water-associated birds, protected under the Migratory Bird Treaty Act, and 2) the relative scarcity of this habitat in the region, our mitigation goal is no net loss of in-kind habitat value. Under this mitigation goal, we will seek in-kind replacement of lost habitat values.

The evaluation species selected to determine the value of oak woodlands, grasslands, and agricultural lands include raptors, songbirds and small mammals that inhabit the areas. Because these habitat types are still fairly common throughout the region and in the State, and because of the relatively high value to fish and wildlife, our mitigation goal for these habitats is no net loss of habitat value, while minimizing the loss of in-kind habitat value. This means that we will seek replacement of habitat value, but not necessarily in-kind value.

To minimize the impacts of the project to fish and wildlife resources, we recommend that Alternative E be selected for further investigation or implementation to provide flood protection for the study area. This alternative would generally be the least damaging scenario (outside of no action) of the alternatives presently identified. Disruption to vegetation and wildlife would be minimal around structures. The addition of wetland buffer zones to reduce flood damages would benefit wildlife and would enhance local efforts to establish a wildlife management area in the Yolo Bypass.

The remaining three alternatives have potential to adversely impact fish and wildlife. Alternatives C and D, although less desirable than Alternative E, are similar and would have less adverse impact on biological resources than Alternative B, primarily because of the limited extent of the work. Although disturbance of vegetation would occur in and along the banks of the watercourses, grass or upland areas are expected to recover quickly if revegetation efforts are included. Spoil disposal would likely have to be sited on upland areas.

The impacts of Alternative B would be the least desirable from an environmental viewpoint. Straddle or landside construction would be significantly less damaging than waterside construction. Alternative B with waterside construction would be the least desirable of all the conceptual alternatives presently identified.

To avoid any adverse impact on valuable riparian vegetation, instream aquatic habitat, and wetlands in the study area, we recommend that alternatives that impact these habitat types not be implemented. If, however, impacts to these habitats are unavoidable, impact determinations and mitigation requirements should be accounted for with the Service's Habitat Evaluation Procedures (HEP).

To mitigate adverse impacts to freshwater marsh, woody riparian forest, and scrub/shrub habitats, an area (or areas) without these attributes and of sufficient size (as determined by the HEP), should be provided for management. Plantings of indigenous species (trees and shrubs) would likely be required in the area(s) to provide habitat compensation values. Estimated cost to create these habitat types is currently averaging about $25,000 per acre, excluding land acquisition and maintenance costs. Irrigation would be required for a

minimum of several years, depending on conditions, or until the plantings were well established and self-sustaining. Any dead or decadent trees and shrubs would need to be replaced and maintained until self-sufficient. A detailed long-term mitigation monitoring study would be required. This plan would have to be developed jointly by the Corps, Fish and Wildlife Service, and California Department of Fish and Game when specific impacts and mitigation sites are identified. At a minimum the plan should identify specific attributes of the site that will be monitored, sampling procedures, and reporting requirements.

To offset the loss of instream aquatic habitat values, a planting program, coordinated with riparian plantings, would be required. Dense plantings of select indigenous trees and shrubs would be required along the shoreline to provide the attributes associated with overhanging and in-water cover. In addition, the placement of tree trunks and tree root balls anchored to the river bank, could be necessary for providing full habitat value replacement.

The loss of wetland vegetation along the toe drains and seeps could be offset through the construction of new toe drains and ponding areas. To further minimize any losses, toe drain construction could be initiated, water provided, and vegetation planted (transplanted from the old drain), at least 6 months prior to covering old toe drains and seeps. This would essentially eliminate any adverse impacts on such habitat types.

Scattered trees and shrubs lost on levee slopes or the landside toes of levees could require replacement at a ratio as high as 5:1. Due to lower soil moisture conditions, such plantings could require watering and maintenance for up to 6 years.

Any loss of grassland habitat values due to project construction could be offset relatively quickly and easily by reseeding the disturbed areas with native grasses and forbs. Seedings would need to be done just prior to the rainy season, to provide adequate germination and establishment of these species.

RECOMMENDATIONS

We recommend that:

1. Funding be provided so that the Fish and Wildlife Service can prepare a Section 2(b) Fish and Wildlife Coordination Act Report for your next phase of planning for this project.

2. The project be coordinated closely with the planning efforts of the Central Valley Joint Habitat Venture to establish a wetland complex to be known as the Yolo Basin Wildlife Refuge.

3. Based on its lowest overall impacts to fish and wildlife habitat values, Alternative E be selected for further investigation or implementation to provide flood protection to the Yolo Bypass portion of the study area. From an environmental viewpoint, we believe Alternative E would have the least adverse effect on fish and wildlife followed by Alternatives D, C and B. With

regard to waterside, landside and straddle construction, we believe waterside construction would be the most detrimental of the three, followed by landside and straddle construction. Waterside construction should be avoided if at all feasible.

In the Knights Landing area either cut-off wall alternative would have less impact to fish and wildlife than raising the levee around the entire island. Perimeter levee raising would have the least impact on fish and wildlife if construction takes place on the landside of the levee.

In the Elkhorn Slough area the cut-off wall construction proposed near Interstate 5 with perimeter levee raising on the southern half of the island would have the lesser impact. Again landside levee construction to raise the levee would have the least impact on fish and wildlife.

4. To mitigate any adverse impacts of the proposed alternative on riparian vegetation, instream aquatic habitat, wetland vegetation grassland, and landside trees and shrubs, measures as indicated in the Discussion Section should be planned early on in the process. A determination of impacts and mitigation requirements should be accomplished through the use of the Service's Habitat Evaluation Procedures. The Service's estimated cost to conduct these procedures based on preliminary information is contained in Attachment 4.

5. To avoid construction activity impacts to Swainson's hawk and other raptors, construction not be conducted during the late March to early August period.

6. To minimize the loss of wetland vegetation (toe drains, seeps) with project construction, open toe drains be included in lieu of culverts. The toe drains should be designed to allow growth of wetland and other vegetation in and adjacent to the drain. Also, as a possible wetland restoration measure, depressions be excavated in adjacent farmlands and drain water be directed to these areas. Such depressions could be a source of borrow material for levee construction. This would promote the growth of wetland and other vegetation.

7. After completion of repair work, the non-woody vegetated levees and surrounding areas should be revegetated with grasses and forbs to restore wildlife habitat and overall environmental quality. Impacts to woody vegetated areas will be mitigated on other lands.

Additional Studies

8. If waterside construction is proposed for the middle Sacramento River and associated tributaries, the following procedures be implemented and the following studies be conducted:

a. Consultation with the National Marine Fisheries Service under Section 7 of the Endangered Species Act should be initiated for any activities which may adversely affect the winter-run chinook salmon.

b. Surveys of existing winter-, spring-, fall- or late fall-run salmon as well as other anadromous fishes in the Sacramento River as well as Cache Creek, South Fork Putah Creek, Knights Landing Ridge Cut, and Willow Slough Bypass and other watercourses in the Yolo Bypass.

c. Population surveys of species of special concern, such as the Swainson's hawk and bank swallow. The surveys would include evaluating nesting sites and territories.

9. Because little information exists for the fish resources of Knights Landing Ridge Cut, Cache Creek, Willow Slough, Willow Slough Bypass, and South Fork Putah Creek and ditches adjacent the levee at Liberty Island and Little Holland Tract, a limited effort to inventory the fish resources of these waterways be conducted, especially if channel work (channelization or excavation) is proposed.

10. A mapping inventory of Shaded Riverine Aquatic Cover be completed for the as yet unmapped areas of the study area waterways. The areas needing mapping include the Sacramento River from the Natomas Drain to Knights Landing and all study-area-associated tributaries (Cache Creek, South Fork Putah Creek, Knights Landing Ridge Cut, and Willow Slough Bypass).

11. Prior to any attempt at impact analyses the Service be provided with good quality aerial photographs of the proposed work sites, with photographic scale of about 1:4,800 or less. Specific zones of construction would have to be clearly delineated to assess impacts (i.e., easement areas or widths, area of new levees, etc.).

12. A land-use analysis be completed prior to the Service conducting any detailed evaluation. The land-use analysis should present future with- and without-the-project scenarios regarding land use (urban, agricultural, etc.) over the project life.

13. Borrow sources be identified if levee construction is selected for further evaluation. The Corps would need to see that these sources are analysed for potential contaminant and toxics problems early in the planning process.

14. The Corps identify jurisdictional wetlands within the study area and provide this information to the Service prior to initiation of any Habitat Evaluation Procedures (HEP's).

We appreciate the opportunity to provide input to your planning process. For further assistance regarding this letter, please contact Doug Weinrich of my staff at (916) 978-4613.

Sincerely,

Wayne S. White
Field Supervisor

cc: ARD (FWE), Portland, OR
NMFS, Tiburon, CA.
Director, CDFG, Sacramento,
Reg. Mgr., CDFG, Region II, Rancho Cordova

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ATTACHMENT 1

Habitat Types in Project Area

Freshwater Marsh

This habitat (Figure 1) occurs in association with the ponds, sloughs, canals and waterways of the Natomas area where water depths do not exceed 5 feet for prolonged periods. The marshes of the study area typically consist of narrow bands along the sloughs, channels and drainage ditches that run throughout the area. Tules and cattails typify freshwater marsh habitats, but other water margin associates include smartweed, rushes, sedges, water plantain, and vervain on the upper margins.

FIGURE 1

Riparian Forest

Riparian forest habitats (Figure 2) in the project area include sites that either have never been cleared (remnant stands), or altered sites where human disturbance has not prevented (either purposely or incidentally) the maturation of woody vegetation. Several "phases" of riparian forest habitat may be recognized, including young-growth willow-cottonwood forest, mixed riparian forest, and valley oak riparian forest. However, these three riparian forest "phases" appear to be successional stages in the natural maturation and progression of the riparian forest toward the oldest community phase of valley oak woodland and/or savanna habitat. Virtually all stands of the riparian forest in the project area occur along the levees, channels, and canals of the area and along the banks of the Sacramento River. Consequently, the stands are generally linear bands of forest varying from a few yards wide to several hundred feet.

FIGURE 2

Riparian Scrub-Shrub

This woody shrub-dominated habitat (Figure 3) is frequently associated with marsh and other perennial wetland habitats along the bypasses, canals, channels, and streams in the project area.

Most of the canals, sloughs, ponds and channels of the area support small, mostly linear patches of riparian scrub-shrub vegetation. It is characterized by various woody shrubs including shrub willows, berry vines, poison oak, wild rose, elderberry, buttonwillow, and some seedling and sapling trees such as oak, walnut, cottonwood, willows, and box elder. Herbaceous associates include many aggressive forbs and grasses including brome, oat, and barley grasses, barnyard grass, ryegrass, wild mustard, horseweed, ambrosia, thistle, sweet fennel, dock, knot weed, and lippea.

Scrub-shrub habitat is largely transitional and, if given sufficient time (approximately 5 or more years), would eventually develop into a forest or woodland habitat type. However, periodic disturbances associated with levee, canal, and channel maintenance (mowing, discing, burning, and spraying) prevent the vegetation from developing past the scrub-shrub stage. This habitat also is often similar to and associated with ruderal upland habitats because of comparable disturbance and species composition.

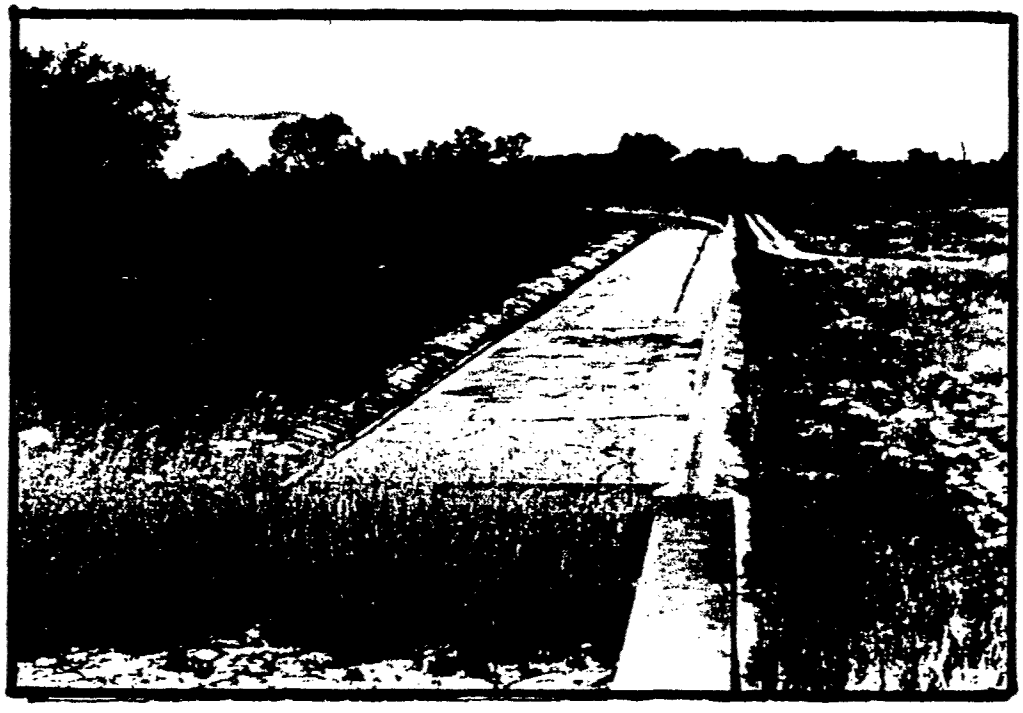
FIGURE 3

Oak Woodland

In several scattered locations throughout the study area, mainly adjacent to the Sacramento River levee and on the landward side, the forest vegetation has matured past the riparian forest condition and now exists as woodland (Figure 4). This cover type consists of a largely two-layered community dominated by valley oak with an open tree overstory, but canopy cover typically greater than 30 percent. Associated native trees include an occasional cottonwood, infrequent tree willows, and rarely one or two sycamores. The ground cover is dominated by herbaceous, largely ruderal grasses and forbs. A shrub layer is virtually nonexistent except for an occasional elderberry, wild rose, poison oak shrub, coyote bush, or berry vine.

Abandoned landscape plantings such as hawthorne, locust, or other ornamental shrubs frequently occur at former home sites.

FIGURE 4



Grassland (Upland)

In areas where tree cover drops below 30 percent and ground cover consists mainly of grasses and forbs, the community is considered a savanna-grassland (Figure 5). Grassland species, which now consist mainly of naturalized European annuals, occur throughout the project area. Although grassland is considered a distinct cover type, it exists as the most common ground vegetation within virtually all of the other terrestrial cover types. Only in well-drained areas of low tree and shrub cover does grassland become the apparent dominant. The most common grass species include wild oats, slender wild oats, softchess, rip-gut brome, Bermuda grass, annual and perennial ryegrass, dog tail grass, dallis grass, and hairgrass. Common forbs include clover spp., vetch, star thistle, plantain, dove weed, bur clover, storks bill, horseweed, wild lettuce, telegraph weed, and many other less common herbaceous species, Grassland is the common vegetation of the levees throughout the area. It also occurs along road shoulders, levees and powerline rights-of-way.

FIGURE 5

Shaded Riverine Aquatic

Shaded riverine aquatic habitat (Figure 6) is a unique aquatic zone which occurs where riparian vegetation overhangs and protrudes into a stream or river channel. Shaded riverine aquatic habitat is characterized mainly by the shade it receives from the overhanging vegetation, but other unique attributes, one or more of which are usually present, are: (1) living roots, branches, and tree trunks exposed within the water; (2) fallen plant material, including logs, branches, and leaves within the water; (3) relatively irregular and uneven natural banks, often with many depressions, cavities, and crevices; (4) comparatively shallow, low-velocity areas near the shoreline; (5) more detritus and greater primary food-chain production than nearby unshaded areas; and (6) lower water temperatures than comparable unshaded nearshore areas.

FIGURE 6

Agriculture

Intensive agriculture (Figure 7) is practiced on most of the lands in the project area. Therefore, the type of vegetation present on a given parcel varies greatly throughout the crop year. In some areas, two row crops may be harvested per year. Information on current cropping patterns is normally available from the California Department of Water Resources.

FIGURE 7

ATTACHMENT 2

Fish and Wildlife Species in the Project Area

BIRD SPECIES SEEN ALONG THE SACRAMENTO RIVER[1]

The following list of bird species represents a cumulation of observations over many years. Some species may be more commonly sighted than others, depending on time of year and populations of the species.

COMMON NAME	SCIENTIFIC NAME
Common Loon	*Gavia immer*
Arctic Loon	*Gavia arctica*
Red-throated loon	*Gavia stellata*
Red-necked grebe	*Podiceps grisegena*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps nigricollis*
Western grebe	*Aechomophorus occidentalis*
Pied-billed grebe	*Popilymbus podiceps*
White pelican	*Pelecanus erythrorhynchos*
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea herodius*
Great egret	*Casmerodius albus*
Snowy egret	*Egretta thula*
Black-crowned night heron	*Nycticorax nycticorax*
Least bittern	*Ixobrychus exilis*
American bittern	*Botaurus lentiginosus*
White-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Ross goose	*Chen rossi*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
Green-winged teal	*Anas crecca*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
American widgeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Wood duck	*Aix sponsa*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*
Ruddy duck	*Oxyura jamaicensis*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Turkey vulture	*Cathartes aura*

[1] From USFWS, 1976

White-tailed kite	Elanus leucurus
Goshawk	Accipiter gentilis
Sharp-shinned hawk	Accipter striatus
Cooper's hawk	Accipiter cooperii
Red-tailed hawk	Butoe jamaicensis
Red-shouldered hawk	Buteo lineatus
Swainson's hawk	Buteo swainsoni
Rough-legged hawk	Buteo lagopus
Ferruginous hawk	Buteo regalis
Golden eagle	Aquila chrysaetos
Bald eagle	Haliaeetus leucocephalus
Northern harrier	Circus cyaneus
Osprey	Pandion haliaetus
Prarie falcon	Falco mexicanus
Peregrine falcon	Falco peregrinus
Merlin	Falco columbarius
American kestrel	Falso sparuerius
California quail	Lophortyx californicus
Ring-necked pheasant	Phasianus colichicus
Sandhill crane	Grus canadensis
Virginia rail	Rallus limicola
Sora	Poranza carolina
Common gallinule	Callinula chloropus
American coot	Fulica americana
Semipalmated plover	Charadrius alexandrius
Killdeer	Charadrius vociferus
Mountain plover	Charadrius montanus
American golden plover	Pluvialis dominica
Black-bellied plover	Pluvialis squatorola
Common snipe	Capella gallinago
Long-billed curlew	Numenius americanus
Whimbrel	Numenius phaeopus
Spotted sandpiper	Actitis macularis
Solitary sandpiper	Tringa solitaria
Willet	Catoptrophorus semipalmatus
Greater yellowlegs	Tringa melanoleuca
Lesser yellowlegs	Tringa flavipes
Baird's sandpiper	Calidris bairdii
Least sandpiper	Calidris minutilla
Dunlin	Calidris alpina
Long-billed dowitcher	Limnodromous scolopaceus
Western sandpiper	Calidris mauri
Marbled godwit	Limosa fedoa
American avocet	Recurvirostra americana
Black-necked stilt	Himantopus mexicanus
Herring gull	Larus argentatus
California gull	Larus californicus
Mew gull	Larus canus
Bonaparte's gull	Larus philadelphia
Forster's tern	Sterna forsteri
Caspian tern	Hydroprogne caspia
Black tern	Childonias niger
Band-tailed pigeon	Columba fasciata

Rock dove	*Columba livia*
Mourning dove	*Zenaidura macroura*
Barn owl	*Tyto alba*
Screech owl	*Otus asio*
Great horned owl	*Bubo virginianus*
Burrowing owl	*Speotyto cunicularia*
Long-eared owl	*Asio otus*
Short-eared owl	*Asio flammeus*
Saw-whet owl	*Aegolius acadicus*
Poorwill	*Phalaenoptilus nuttallii*
Lesser nighthawk	*Chordeiles acutipennis*
Vaux's swift	*Chaetura vauxi*
White-throated swift	*Aeronautes saxatalis*
Black-chinned hummingbird	*Archilochus alexandri*
Anna's hummingbird	*Calypte anna*
Rufous hummingbird	*Selasphorus rufus*
Allen's hummingbird	*Selasphorus sasin*
Calliope hummingbird	*Stellula calliope*
Belted kingfisher	*Megaceryle alcyon*
Common flicker	*Colaptes auratus*
Acorn woodpecker	*Melanerpes formicivorus*
Lewis woodpecker	*Asyndemus lewis*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Hairy woodpecker	*Dendrocopos villosus*
Downy woodpecker	*Dendrocopus pubescens*
Nuttall's woodpecker	*Dendrocopus nuttalli*
Western kingbird	*Tyrannus verticalis*
Ash-throated flycatcher	*Myiarchus cinerascens*
Black phoebe	*Sayornis nigricans*
Say's phoebe	*Sayornis saya*
Willow flycatcher	*Empidonax traillii*
Western flycatcher	*Empidonax difficilis*
Western wood pewee	*Contopus sordidulus*
Olive-sided flycatcher	*Nuttallornis borealis*
Vermilion flycatcher	*Pyrocephalus rubinus*
Horned lark	*Eremophila alpestris*
Violet-green swallow	*Tachycineta thalassina*
Tree swallow	*Iridoprocne bicolor*
Bank swallow	*Riparia riparia*
Rough-winged swallow	*Stelgidopteryx ruficollis*
Barn swallow	*Hirundo rustica*
Cliff swallow	*Petrochelidon pyrrhonota*
Purple martin	*Progne subis*
Steller's jay	*Cyanocitta stelleri*
Scrub jay	*Aphelocoma coerulescens*
Yellow-billed magpie	*Pica nuttalli*
Common raven	*Corvus corax*
Common crow	*Corvus brachyrhynchos*
Black-capped chickadee	*Parus atricapillus*
Mountain chickadee	*Parus gambeli*
Plain titmouse	*Parus inornatus*
Bushtit	*Psaltriparus minimus*
Water pipit	*Anthus spinoletta*

Cedar waxwing	Bombycilla cedrorum
Phainopepla	Phainopeple nitens
Loggerhead shrike	Lanius ludovicianus
Starling	Sturnus vulgaris
Hutton's vireo	Vireo huttoni
Solitary vireo	Vireo solitarius
Orange-crowned warbler	Vermivora celata
Nashville warbler	Vermivora ruficapilla
Yellow warbler	Dendroica petechia
Yellow-rumped warbler	Dendroica coronata
Black-throated gray warbler	Dendroica nigriscens
Townsend's warbler	Dendroica townsendi
Black-throated blue warbler	Dendroica caerulescens
Black-throated green warbler	Denroica virens
Hermit warbler	Dendroica occidentalis
MacGillivray's warbler	Oporonis tolmiei
Common yellowthroat	Geothlypis trichas
Yellow-breasted chat	Icteria virens
Wilson's warbler	Wilsonia pusilla
House sparrow	Passer domesticus
Western meadowlark	Sturnella neglecta
Yellow-headed blackbird	X. xanthocephalus
Red-winged blackbird	Agelaius phoeniceus
Tri-colored blackbird	Agelaius tricolor
Hooded oriole	Icterus cucullatus
Brewer's blackbird	Euphagus cyanocephalus
Brown-headed cowbird	Molothrus ater
Western tanager	Piranga lucoviciana
Black-headed grosbeak	Pheucticus melanocephalus
Blue grosbeak	Guiraca caerulea
Lazuli bunting	Passerina amoena
Purple finch	Carpodacus purpureus
House finch	Carpodacus mexicanus
Pine siskin	Spinus pinus
American goldfinch	Spinus tristis
Lesser goldfinch	Spinus psaltria
Lawrence's goldfinch	Spinus lawrencei
Rufous-sided towhee	Pipilo erythrophthalmus
Brown towhee	Pipilo fuscus
Savannah sparrow	Passerculus sandwichensis
Vesper sparrow	Pooecetes gramineus
Lark sparrow	Chondestes grammacus
Rufous-crowned sparrow	Aimophila ruficeps
Sage sparrow	Amphispiza belli
Dark-eyed junco	Junco hyemalis
Chipping sparrow	Spizella passerina
White-crowned sparrow	Zonotrichia leucophrys
Golden-crowned sparrow	Zonotrichia atricapilla
White-throated sparrow	Zonotrichia albicollis
Fox sparrow	Passerella iliaca
Lincoln's sparrow	Melospiza lincolnii
Song sparrow	Melospiza melodia

FISHES OF THE SACRAMENTO RIVER SYSTEM[2]

Anadromous Fishes

Pacific Lamprey	*Lampetra tridentata*
River Lamprey	*Lampetra ayresi*
White Sturgeon	*Acipenser transmontanus*
Green Sturgeon	*Acipenser medirostris*
American Shad	*Alosa sapidissima*
Pink Salmon	*Oncorhynchus gorbuscha*
Chum Salmon	*Oncorhynchus keta*
Silver Salmon	*Oncorhynchus kisutch*
King Salmon	*Oncorhynchus tschawytscha*
Sockeye Salmon	*Oncorhynchus nerka*
Steelhead Trout	*Oncorhynchus mykiss*
Striped Bass	*Morone saxatilis*

Resident Fishes

Brook Lamprey	*Lampetra pacifica*
Threadfin Shad	*Dorosoma petenense*
Kokanee	*Oncorhynchus nerka*
Brook Trout	*Salvelinus fontinalis*
Dolly Varden Trout	*Salvelinus* sp.
Brown Trout	*Salmo trutta*
Redband Trout	*Salmo* sp.
Golden Trout	*Salmo aquabonita*
Rainbow Trout	*Oncorhynchus mykiss*
Arctic Grayling	*Thymallus arcticus*
Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Golden Shiner	*Notemigonus crysoleucas*
Sacramento Blackfish	*Orthodon microlepidotus*
Hardhead	*Mylopharodon conocephalus*
Hitch	*Lavinia exicauda*
Sacramento Squawfish	*Ptychocheilus grandis*
Tui Chub	*Gila bicolor*
Thicktail Chub	*Gila crassicauda*
Sacramento Splittail	*Pogonichthys macrolepidotus*
California Roach	*Hesperoleucus symmetricus*
Speckled Dace	*Rhinichthys osculus*
Lahontan Redside	*Richardsonius egregius*
Fathead Minnow	*Pimephales promelas*
Mountain Sucker	*Catostomus platyrhynchus*
Sacramento Sucker	*Catostomus occidentalis*
Channel Catfish	*Ictalurus punctatus*
White Catfish	*Ictalurus catus*
Yellow Bullhead	*Ictalurus natalis*
Brown Bullhead	*Ictalurus nebulosus*
Black Bullhead	*Ictalurus melas*
Mosquitofish	*Gambusia affinis*
Threespine Stickleback	*Gasterosteus aculeatus*
Sacramento Perch	*Archoplites interruptus*
Black Crappie	*Pomoxis nigromaculatus*
White Crappie	*Pomoxis annularis*

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[2] From Moyle, 1976

Warmouth	*Lepomis gulosus*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Pumpkinseed	*Lepomis gibbosus*
Redear Sunfish	*Lepomis microlophus*
Largemouth Bass	*Micropterus salmoides*
Spotted Bass	*Micropterus punctatus*
Smallmouth Bass	*Micropterus dolomieui*
Redeye Bass	*Micropterus coosae*
Yellow Perch	*Perca flavescens*
Bigscale Logperch	*Percina macrolepida*
Rough Sculpin	*Cottus asperrimus*
Coastrange Sculpin	*Cottus aleuticus*
Prickly Sculpin	*Cottus asper*
Pit Sculpin	*Cottus pitensis*
Marbled Sculpin	*Cottus klamathensis*
Riffle Sculpin	*Cottus gulosus*

ATTACHMENT 3

Endangered Species Consultation Summary Information

ATTACHMENT 3

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species; 2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and 3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment--Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat are present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirements; interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; an analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of indirect effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, any problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

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[1] A construction project (or other undertaking having similar physical impacts) which is a major Federal action significantly affecting the quality of the human environment as referred to in NEPA (42 U.S.C. 4332(2)C).

[2] "Effects of the action" refers to the direct and indirect effects on an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

ATTACHMENT 4

Estimated Cost For Habitat Evaluation Procedures

ESTIMATED COSTS FOR HABITAT EVALUATION PROCEDURES
NORTHERN CALIFORNIA STREAMS - YOLO BYPASS

	Task	BD's
1.	Review project proposal	2
2.	Cover type mapping	10
3.	Develop assumptions and procedures package[1]	5
3.	Field sampling[2]	20
4.	Data analysis	10
5.	Report	5
	TOTAL	52[3]

52 BD's @ $550/day = $ 28,600

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1 Assumes models and general procedures used on Sacramento River Flood Control Systems Evaluation, Phase II can be modified for application on this project.

2 Assumes two Service biologists do field work.

3 Based on current project description. This will increase if additional work is added to project.

APPENDIX 5

Cultural Resources Overview

RECONNAISSANCE STUDY FOR FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS, YOLO BYPASS, CALIFORNIA
CULTURAL RESOURCES OVERVIEW

by

Sannie Kenton Osborn
Archeologist

July 2, 1991

Planning Division
U.S. Army Corps of Engineers
Sacramento District
650 Capitol Mall
Sacramento, California 95814

RECONNAISSANCE STUDY FOR FLOOD CONTROL
NORTHERN CALIFORNIA STREAMS, YOLO BYPASS, CALIFORNIA
CULTURAL RESOURCES OVERVIEW

Introduction

The purpose of the reconnaissance study being undertaken by the Sacramento District Corps of Engineers is to determine the potential for Federal participation in the development and construction for higher levels of flood control protection primarily along the west side of the Yolo Bypass in Yolo and Solano Counties. Cache Creek, Willow Slough, Willow Slough Bypass, Knights Landing Ridge Cut, Putah Creek, South Fork Putah Creek, and other westside tributaries to the Bypass will be investigated.

The study area is located within the limits of the Sacramento River Flood Control Project in Yolo and Solano Counties and covers lands on the west side of the Yolo Bypass from Knights Landing to South Fork Putah Creek and includes nearby Liberty Island and Little Holland Tract. In the east-west direction, the study area covers from the Yolo Bypass on the east, to lands west of the cities of Davis and Woodland. The Elkhorn Slough area is also in the study area. This area lies within the boundaries of the Sacramento Bypass, Yolo Bypass and the Sacramento River (Map 1).

The area is predominantly agricultural, however, existing development that may be subject to flood damage includes outlying areas of the cities of Davis and Woodland, a wastewater treatment plant that serves the cities, and the Yolo County landfill. During the winter storms in 1983-84 and February 1986, sustained high river flows saturated the Yolo Bypass levees south of Interstate 5, southwest of Elkhorn Park and at the confluence of the bypass and Willow Slough. There is concern that the levees on the west side of the Yolo Bypass and its adjacent streams are inadequate.

Authority and Objectives

The reconnaissance study is being conducted under authorization contained in the Flood Control Act of 1962, the amended Flood Control Act of 1966 and the Water Resources Development Act of 1986 (P.L. 99-662). If alternatives are found that are economically justified and a non-Federal sponsor is identified, the study will proceed into the feasibility phase.

The National Historic Preservation Act of 1966, as amended (16 USC 470), implementing regulations 36 CFR 800, the Archeological and Historic Preservation Act of 1974 (16 USC 469), Corps of Engineers regulation ER-1105-2-100, and other authorities, require the identification and evaluation of cultural properties that may be affected by Federal, federally assisted, or federally authorized undertakings. The purpose of this report is to comply with 36 CFR 800.4 (a) "Assessing Information Needs". This requires

the Corps to (1) review existing information on historic properties potentially affected by the proposed undertaking, including data concerning the likelihood that unidentified cultural resources exist in the Area of Potential Effect (APE), (2) request the views of the State Historic Preservation Officer on further actions to identify historic properties that may be affected, and (3) seek information from other parties likely to have knowledge of, or concerns with, cultural resources in the area.

If the study proceeds into the feasibility stage, cultural resources investigations will continue in accordance with 36 CFR 800.4 (b) "Locating Historic Properties" 36 CFR 800.4 (c) "Evaluating Historical Significance", and 36 CFR 800.5 "Assessing Effects". This would include archival research and archeological field surveys plus evaluation of sites for National Register of Historic Places eligibility.

Methodology

Records Check

Archeological site records and reports for the study area are located at the Northwest Information Center of the California Archeological Inventory, Sonoma State University. A records check was conducted by the author at the Information Center on May 21, 1991. With the exception of the archeological survey for the City of Davis Wastewater Disposal Facility Expansion (True 1976) and one CALTRANS report, cultural resource investigations in the study area are dominated by reports prepared for past and current Corps of Engineers investigations.

Previous Surveys and Reports

An overview of historical resources in the Sacramento-San Joaquin Delta was prepared for the Corps in December 1990 (Owens 1990). Compilation of this report required an extensive review of both established listings of recorded historical sites, as well as a search of published historical sources and archival repositories. A total of 1596 historical resource site entries were tabulated in the database for the Delta and were marked on 7.5 minute USGS topographic maps. The Liberty Island/Holland Tract portion of the Yolo Bypass study is within the area included in Owens' overview.

Several archeological surveys have been completed in close proximity to the current study's APE. Thirty-one miles along the east bank of the Sacramento River and 515 acres of borrow or mitigation areas were surveyed as part of the Corps' Sacramento Urban Area Levee Reconstruction Project (Bouey & Herbert 1990). Twenty-two separate parcels, each 30 feet wide with a combined linear distance of 15 miles, were surveyed for the Corps' Sacramento Metropolitan Area Feasibility Report (Glover & Bouey 1990b). This survey is entirely within the Yolo Bypass study area

and includes part of the current Willow Slough Bypass APE. Several of the twenty-five levee parcels surveyed for the Corps' Mid-Valley investigation (Glover & Bouey 1990a) are also within the Yolo Bypass study area, as is a portion of the Sacramento Deep Water Ship Channel (Werner 1985).

National Register of Historic Places

The only site determined eligible for or listed in the National Register of Historic Places is the Sacramento Weir. The Weir was determined eligible for the Register in 1977. It is located just south of the project APE and will not be affected.

California Historical Landmarks

Two California Historical Landmarks (CHL) have been designated for Yolo County, the Woodland Opera House and the Gable Mansion, also in Woodland. Fourteen CHL are found in Solano County. Nine of these are in Benicia; two in Vallejo; and one each in Rockville, Vacaville and Winters (State of California 1990). No CHL will be affected by the Yolo Basin project.

Studies in Progress

The Sacramento District Corps of Engineers has two current studies within the Yolo Bypass APE for which detailed archival research and intensive field investigations are being undertaken. Both of these should be completed prior to the final Yolo Bypass Reconnaissance Report and any new information will be included at that time.

The Colusa Basin/Knights Landing Ridge Cut area is scheduled to be surveyed in the summer of 1991. A contract was awarded to PAR Environmental and commencement of work is pending acquisition of real estate rights-of-entry. The lower reach of this survey, the Knights Landing Ridge Cut, is within the Yolo Bypass APE.

The Yolo Basin Wetlands Investigation is also within the Yolo Bypass APE. Far Western Anthropological Research Group, Inc. (FWARG) completed an archeological survey of 3750 acres in May 1991. One site was identified. A report will be submitted to the Corps in June 1991.

Findings

Yolo Bypass

Much of the land within the confines of the lower Yolo Bypass was historically designated as "impassable tule swamp" or "swamp and overflow land" (GLO Records). Other than railroad, road,

Basin Wetlands study. One archeological site, a lithic scatter, was recorded (FWARG n.d.).

Knights Landing Ridge Cut

No archeological sites, surveys or reports for this area are on file at the Northwest Information Center. The Knights Landing Ridge Cut is an artificial canal, constructed between 1914 and 1916, to provide a gravity outlet for flood waters going into the Yolo Bypass. The seven mile long canal is 400 feet wide and 20 feet deep (Thompson & Dutra 1983, DWR 1990). An evaluation of the canal for the National Register of Historic Places will be required during any future feasibility studies for the Yolo Bypass or as part of the Corps' Sacramento River Flood Control Project Colusa Basin and Knights Landing Ridge Cut investigation. An archeological survey of a 100' corridor on both sides of the Ridge Cut will be completed in the summer of 1991 for the latter study.

Elkhorn Slough & West Side of Sacramento River upstream of the Sacramento Weir

At least thirteen prehistoric archeological sites have been recorded within this portion of the study area. The majority of these were first documented in the 1930s and the site locations cannot be considered reliable. Several of the sites have alternate locations and additional field investigations would be required to determine the actual number of sites, their present condition and a more precise location. Sections of the river have been surveyed more recently as part of Corps of Engineers bank protection construction activities and other planning studies such as the Sacramento River Flood Control Systems Evaluation: Mid-Valley Area (Glover & Bouey 1990). The Sacramento Weir has been determined eligible for the National Register of Historic Places; the Fremont Weir could be eligible and should be evaluated.

Liberty Island and Little Holland Tract

No archeological sites, surveys or reports for this area are on file at the Northwest Information Center. An historical overview completed for the Corps' Sacramento-San Joaquin Delta study (Owens 1990a, 1990b) shows two potential historical site locations near the current study alternative. The first is Camp 9 at Liberty Farms, dating to 1931 or earlier. The second site is a removable span bridge, also from the same time period, on Shag Slough just north of Liberty Farms. Neither of these sites has been verified in the field.

Recommendations

If the study proceeds into the feasibility phase, additional cultural resources studies will be required. The scope of these will be developed in consultation with the SHPO and may include but not be limited to the following:

- Further archival research using historic maps, GLO records, ethnographies, and other documents to more accurately ascertain the likelihood of locating additional archeological, historical and ethnographic sites.

- Information on sites of ceremonial or religious concern to Native Americans.

- Public involvement including Native Americans, historical societies and other interested persons or groups.

- Examine all areas not previously surveyed and areas surveyed prior to 1980 for cultural resources. Revisit previously recorded sites.

- National Register evaluation of cultural resources within the Area of Potential Effect.

- Determination of effect in consultation with the SHPO.

Mitigation

At this early phase of planning, it is premature to specify what mitigation, if any, would be required. Archeological, historical and Native American sites are nonrewable resources. Avoidance and preservation of these is always preferable to mitigation. When a decision is made that cultural resources will be affected in the public interest, mitigation measures are developed in consultation with the SHPO and the Advisory Council on Historic Preservation. This procedure is outlined in 36 CFR 800 and results in a signed Memorandum of Agreement or concurrence with a no adverse effect determination.

Mitigation of archeological sites often includes data recovery through scientific excavation, analysis of data, reporting and curation. Historic structures may be recorded according to federal standards such as those of the Historic American Buildings Survey (HABS) or the Historic American Engineering Record (HAER). Relocation of structures is also possible under certain circumstances, although this often compromises the historical integrity of the resource.

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1985 Sacramento Deep Water Ship Channel Cultural Resources Survey and Literature Review. Report on file Sacramento District Corps of Engineers.

APPENDIX 6

Letters of Comment on the Reconnaissance Study

National Park Service
State Historic Preservation Officer
University of California, Davis
Yolo Basin Foundation
The Planning Center
Henry Bennett

United States Department of the Interior
NATIONAL PARK SERVICE
WESTERN REGION
600 HARRISON STREET, SUITE 600
SAN FRANCISCO, CALIFORNIA 94107

IN REPLY REFER TO:

L7621(WR-RRA)

July 17, 1991

Mr. Walter Yep
Chief, Planning Division
Attn: Environmental Resources Branch
U.S. Army, Corps of Engineers
Sacramento District
650 Capitol Mall
Sacramento, California 95814-4794

Subject: Cultural Resources Review of "Reconnaissance Study for Flood Control, Northern California Streams, Yolo Bypass, California, Cultural Resources Overview"

Dear Mr. Yep:

We have reviewed the referenced study provided with your letter of July 3. The research documented by the study is commensurate with the stated purpose of assessing information needs. The recommendations for additional work (research, survey, and evaluation) pending project authorization are appropriate. Please call Mark Rudo at FTS 484-3916 if you have any questions.

Sincerely,

Ronald C. Corbyn

Ronald C. Corbyn
Acting Chief, Interagency Archeological Services Branch

STATE OF CALIFORNIA — THE RESOURCES AGENCY PETE WILSON, *Governor*

OFFICE OF HISTORIC PRESERVATION
DEPARTMENT OF PARKS AND RECREATION
P. O. BOX 942896
SACRAMENTO 94296-0001
(916) 445-8006
FAX: (916) 322-6377

29 August 1991

Reply to: CoE 910709A

Col. Lawrence Sadoff, USA
District Engineer
US Army Corps of Engineers
ATTN: Sannie Osborn, Planning Division
1325 J Street
SACRAMENTO, CA 95814

Subject: YOLO BYPASS RECONNAISSANCE STUDY

Dear Col. Sadoff:

Thank you for sending me a copy of the cultural resources overview study for the proposed Flood Control, Northern California Streams/Yolo Bypass undertaking.

The cultural resources study will be a valuable addition to the more specific studies that will be conducted if it proves to be feasible to continue with the undertaking.

Thank you for considering historic properties during project planning. If you have any questions, please call staff archaeologist Nicholas Del Cioppo at (916) 322-4419.

Sincerely,

Kathryn Gualtieri
State Historic Preservation Officer

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

DAVID PIERPONT GARDNER
President of the University

THEODORE L. HULLAR
Chancellor at Davis

OFFICE OF THE CHANCELLOR
DAVIS, CALIFORNIA 95616-8558

15 January 1991

Walter Yep, Chief Planning Division
US Army Corps of Engineers
Sacramento District
650 Capitol Mall
Sacramento, CA 95814

Dear Mr. Yep:

This letter is in response to your request for comments on the Northern California Streams-Yolo Bypass Reconnaissance Study. The primary interests of University of California, Davis are related to the levees along Putah Creek, and we would like the opportunity to participate in any future workshops and public meetings.

Please notify the University of these workshops and meetings by writing to:

Sid England, Environmental Planner
Office of Planning and Budget
University of California
Davis, California 95616

We would appreciate the Corps including the Putah Creek Reserve in the Environmental Inventory. This reserve is administered by the UC Davis campus as an area for teaching, research, and recreation. Attached for your information is a map depicting the Reserve and its relationship to the Putah Creek.

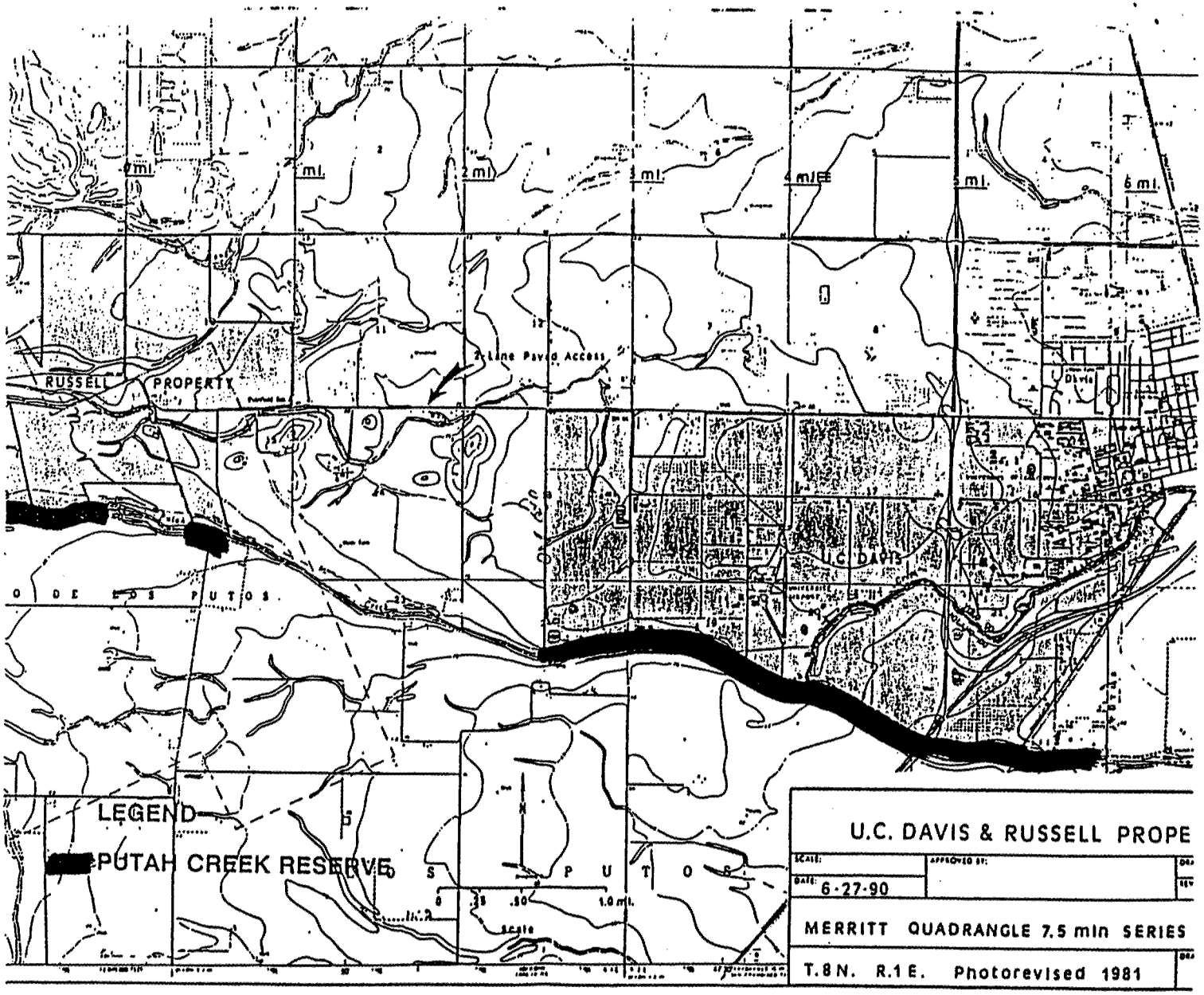
Another important issue from our perspective is the effects of land subsidence on flood protection. We recently became aware that Jim Blodgett, with the U.S. Geological Survey in Sacramento, has documented this phenomenon in the lower Sacramento River Valley. Also, the Department of Energy and the University are working on remediating soil and groundwater contamination on a south campus site that is adjacent to the north levee on Putah Creek. You may wish to have discussions with Environmental Planner England or Environmental Health and Safety Representative, Carolyn Owen about this matter and how future remediation activities might relate to the Putah Creek levees. Mr. England may be reached at 752-2432 and Ms. Owen at 752-3572.

Sincerely,

Larry N. Vanderhoef
Executive Vice Chancellor

/lb

cc: Environmental Planner England
EH&S Representative Owen


RUSSELL PROPERTY
2 Line Paved Access
U.C. DAVIS
O D E L O S P U T O S
LEGEND
PUTAH CREEK RESERVE
P U T O S
1 mi.
2 mi.
3 mi.
4 mi.
5 mi.
6 mi.
U.C. DAVIS & RUSSELL PROPE
SCALE:
APPROVED BY:
DATE: 6-27-90
MERRITT QUADRANGLE 7.5 min SERIES
T.8N. R.1E. Photorevised 1981

YOLO BASIN FOUNDATION
P.O. BOX 943
DAVIS, CA 95617
(916)756-7248

April 22, 1991

Congressman Vic Fazio
4th District
House of Representatives
Washington D.C. 20515

Dear Congressman Fazio:

I am writing to you on behalf of the Board of Directors of the Yolo Basin Foundation to urge your support for the inclusion of a recreational element in the Yolo Bypass Reconnaissance Study currently being prepared by the U.S. Army Corps of Engineers (Corps). This represents a great opportunity to provide badly needed funding for recreation for the citizens of Yolo and Sacramento Counties.

It is our understanding that a local sponsor must provide the land on which the recreation development is to occur. The local sponsor provides 50 percent of the construction costs with the federal government providing the remaining 50 percent. The Corps can be involved in development of the following facilities: trails (bike, walking,equestrian), visitors centers, overlooks, parking areas, restrooms, interpretive signs, plantings, ramps, and public access. The Foundation has already met with representatives of the Corps and Yolo County, Davis, Woodland, and West Sacramento. This group plans to meet periodically to pursue a recreational element in the Bypass Study.

The Yolo Basin Foundation is a non-profit, public benefit corporation organized to provide for public access to the Yolo Basin Wildlife Area through the planning and funding of interpretive programs and a visitors center. We plan to participate in the development of a recreation element with the Corps and a local sponsor. Our goal is to assist local agencies and the Corps in the development of recreational opportunities related to the Yolo Basin Wildlife Area.

Sincerely,

Kenneth B. Noack, Jr.
Chair, Yolo Basin Foundation

cc: Col Laurence R. Sadoff, District Engineer
Betsy Marchand, Yolo County Board of Supervisors
Lois Wolk, Davis City Council
Helen Thomson, Yolo County Board of Supervisors
Earl Balch, Yolo County
Lester Neblett, City of Woodland
Larry von Krenel, City of West Sacramento
Jeannie Hippler, City of Davis
Fred Kindel, U.S. Army Corps of Engineers

THE
PLANNING
CENTER

MEMORANDUM

Date: 9/16/91

To: Tanis Toland, U.S. Army Corps of Engineers

From: Paul Junker, Community Planner

Subject: Yolo Gateway Center/I-5 Metro Center

2277 FAIR OAKS BLVD.
SUITE 450
SACRAMENTO, CA 95825
(916) 646-0325

As we discussed on September 13, The Planning Center is involved with the Yolo Gateway Center project (formerly known as the I-5 Metro Center). Among the uses we are proposing for the site is a network of trails within the project that connect to potential regional trail alignments.

Among the planned trail connections is along the eastern levee of Tule Canal, which we understand is also the eastern levee of the Yolo Bypass. Our intent is to provide access to the top of the levee, see enclosed diagram, and provide a trail along levee the length project site.

In addition to providing access to the levee top, we are interested in managing the levee bank in a more attractive fashion. This would take the form of hydroseeding the bank with native grasses or wildflowers. We feel this might also offer erosion reducing benefits that would help to protect the levee bank.

We would appreciate your review of these proposals and your assistance with identifying the appropriate persons within the State Reclamation Board to review these proposals. Thank you for your assistance with the review of this project.

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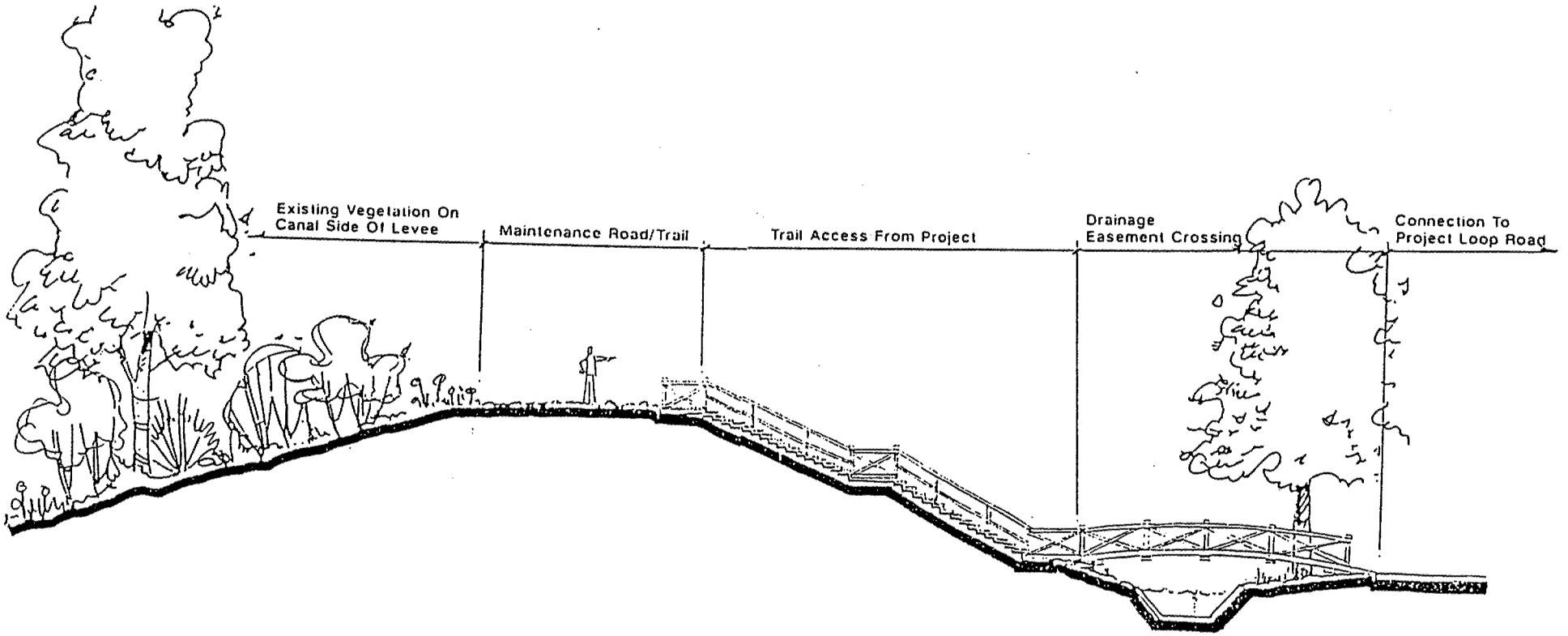

LEVEE ACCESS

THE PLANNING CENTER

12 SEPTEMBER 1991

WE WOULD APPRECIATE YOUR COMMENTS ON THE YOLO BYPASS CALIFORNIA, INVESTIGATION

CORPS OF ENGINEERS

SACRAMENTO

916-551-1864

WRITE OR CALL

To: Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814

Henry E. Bennett
710 Oak Avenue
Davis, CA 95616

(916) 758-2350
(916) 758-3325

Dear Sirs:

I hope that non-structural measures are given a thorough review. Items such as economic disincentives for up stream practices which increase run off should be used in full force.

An up-stream pavement and roof tax, taxes on wood land or perennial grass land destruction, taxes for annual croping, tax on indiscriminate weed control. Economic incentives for hedge rows, perennial grasses at road sides, (rather than grading and weed killing.) Economic incentives to not clear cut, over graze, abuse water sheds with off road vehicles, and limit creation of new roads. Let's look to what inhances the inability of this basin to absorbe heavy precipitation and then release water in a timely manner rather than as a flood.

Sincerely,

Henry E. Bennett