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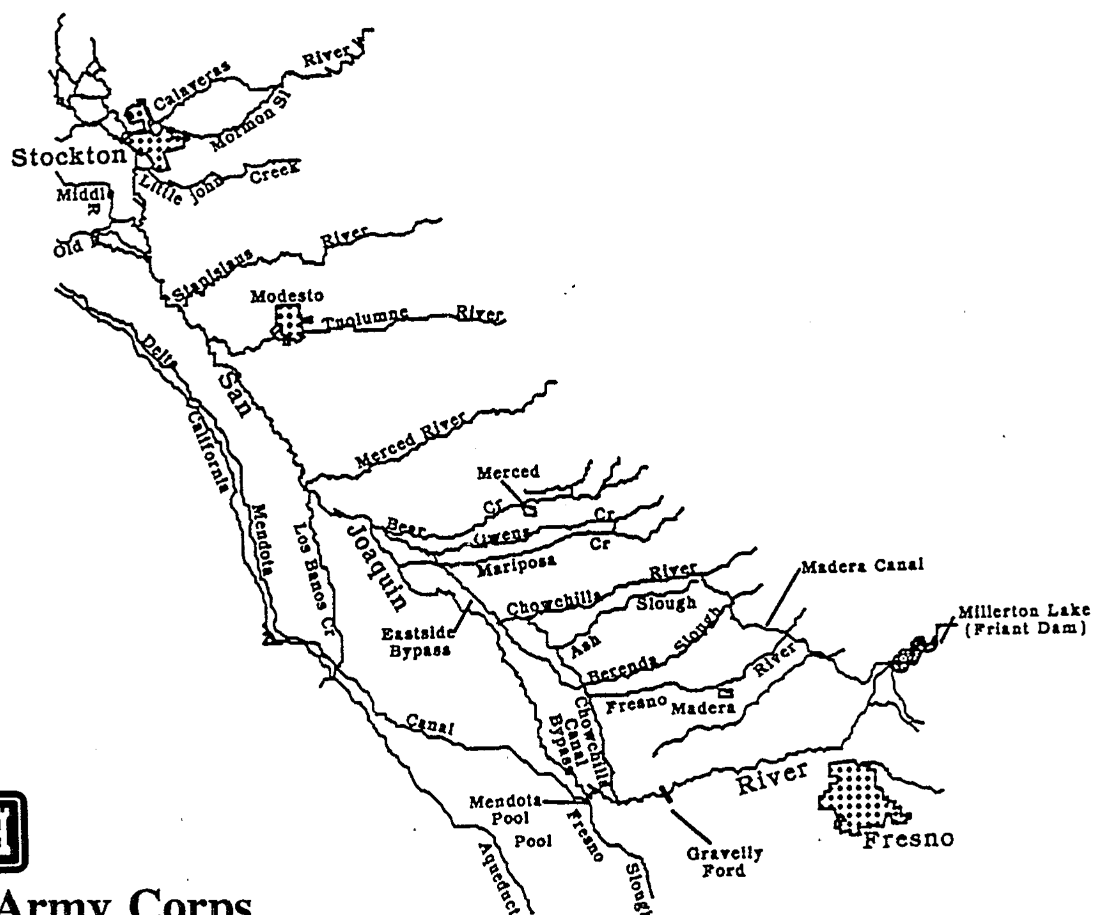
Reconnaissance Report

JANUARY 1993

SAN JOAQUIN RIVER MAINSTEM, CALIFORNIA



US Army Corps of Engineers
Sacramento District
South Pacific Division

CESPK-PD-J (1105) 14 January 1993

MEMORANDUM FOR, Commander, South Pacific Division

SUBJECT: San Joaquin River Mainstem and Tributaries, California Reconnaissance Report

1. Enclosed are 25 copies of the subject report for your review and approval.

2. The report presents studies of flood control improvements and environmental restoration opportunities along the San Joaquin River Mainstem. Several alternatives were evaluated, including channel and levee modification, full diversion, partial diversion, and environmental restoration with flood control. Study results indicate that the environmental restoration with flood control alternative is economically feasible.

3. A draft Feasibility Cost Sharing Agreement (FCSA) and preliminary Initial Project Management Plan (IPMP) for the feasibility phase study are enclosed.

4. The State of California Department of Water Resources (DWR) has indicated their support for the study, and we await their formal reply to act as the non-Federal sponsor for the feasibility phase of the study. We will continue to work with DWR in negotiating the FCSA and finalizing the IPMP, and once completed, we will submit these documents to your office for review and approval.

Encls
as

LAURENCE R. SADOFF
COL, EN
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cc:
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RECONNAISSANCE REPORT

SAN JOAQUIN RIVER MAINSTEM AND TRIBUTARIES

January 1993

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

SUMMARY

The area for this study is the San Joaquin River and tributaries from Friant Dam downstream to the vicinity of Stockton, including the Stanislaus, Tuolumne, Fresno, Calaveras, Chowchilla, and Merced Rivers up to the first major dam. The area also includes the North Fork Kings River from the southern boundary of the James Reclamation District Number 1606 to Mendota Dam.

Historically, the basin has been subject to floods originating in the Sierra Nevada. These floods result from general rainstorms that occur during late fall and winter months, and from unseasonable and rapid melting of the winter snowpack during the spring and early summer months. Fed by hundreds of streams, the main channel of the San Joaquin River and its tributaries have historically overtopped their banks.

The flood control system of the San Joaquin River and its tributaries is a complex system of dams, levees and channel improvements, bypasses and canals. The effectiveness of this comprehensive system continues to be affected by reductions in floodway channel capacity caused by sediment deposition, bank erosion, vegetation encroachment, reduced mean flows within the channel, and environmental constraints.

This reconnaissance report focuses on problems along the mainstem of the San Joaquin River related to flood protection and environmental restoration. Some topics addressed include the effects of the reduction in channel capacity, conditions of the project levees, constraints to carrying out the current operation and maintenance responsibilities, loss of riparian and wetland habitats, losses of associated wildlife populations, and needs of existing or proposed wildlife refuge areas. Measures and opportunities to reduce the effects of the identified problems are discussed, and alternative plans are developed which combine the measures into plans of flood protection and environmental restoration. Measures considered include upstream storage reservoirs, channel modifications and levee improvements, diversion of floodwaters, and nonstructural measures. Alternative plans focus on diversion of floodwaters, channel and levee improvements, and restoration of riparian and wetland habitats. These plans also include restoration of biological resources along the mainstem of the San Joaquin River.

The results of this reconnaissance study indicate that there is a Federal interest in at least one potential flood control/environmental restoration alternative in the San Joaquin River Mainstem study area. The cost of the feasibility study is estimated at $3.1 million. Reconnaissance estimates of the project cost is $44 million. The State of California, Department of Water Resources is a likely local sponsor.

RECONNAISSANCE REPORT

SAN JOAQUIN RIVER MAINSTEM AND TRIBUTARIES

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CHAPTER I
INTRODUCTION

STUDY AUTHORITY

The general authority for this reconnaissance study comes from the 1964 Congressional Resolution of the House Committee on Public Works. The resolution states:

"Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports on Sacramento-San Joaquin Basin Streams, California, published as House Document No. 367, 81st Congress, 1st Session, and other reports, with a view to determining whether any modification of the recommendations contained therein are advisable at this time, with particular reference to further coordinated development of the water resources in the San Joaquin River Basin, California."

The authority to study environmental restoration comes from Section 1135(a) of the Water Resources Development Act (WRDA) of 1986 as amended by Section 41 of the WRDA of 1988 and Section 304 of the WRDA of 1990. Additional guidance is contained in Policy Guidance Letter No. 24, "Restoration of Fish and Wildlife Resources," March 7, 1991.

Funding for the study was provided in the Energy and Water Development Act of 1991.

PURPOSE AND SCOPE

This study evaluates the flood control and other natural resource problems of the San Joaquin River. Plate 1 shows the general vicinity. The study has been carried out to identify problems, formulate and evaluate solutions, determine Federal interest in participating in solution implementation, and recommend appropriate future action. This report is a partial response to the authorization contained in the 1964 Resolution.

The study has been conducted in coordination with the San Joaquin River Management Program (SJRMP). This is a 5-year comprehensive, multi-agency program designed to identify the many natural resource problems and issues of the San Joaquin River. One component of the SJRMP is an evaluation of flood control problems. The Corps of Engineers' (Corps) study coincides with the purpose and scope of the SJRMP's flood control mission. This flood control mission is to "increase public safety by restoring and enhancing flood protection on the San Joaquin River and tributaries, balancing regional needs with all legitimate instream beneficial uses of the water and other natural resources in the basin."

Work carried out in the Corps' study has been coordinated with the missions of the SJRMP to ensure that flood control protection measures and plans are formulated that balance regional flood control needs with instream beneficial uses of the water and other natural resources. However, any work proposed by the Corps is still subject to limitations imposed by Federal legislation and policies.

STUDY AREA

The study area includes the San Joaquin River from Friant Dam downstream to Stockton, a distance along the river of about 225 miles, and the major tributaries up to the first flood control dam (see Plate 2). The area also includes the north fork of the Kings River from the southern boundary of the James Reclamation District Number 1606 to Mendota Dam. The San Joaquin River flows through the counties of Fresno, Madera, Merced, Stanislaus, and San Joaquin. There are six primary tributaries to the San Joaquin. They include the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno Rivers and Kings River North. The principal river distributaries discharge into the southern portion of the Sacramento-San Joaquin Delta (Delta). Because of various constraints, the study has focused primarily on the mainstem of the San Joaquin River.

STUDY PARTICIPANTS AND COORDINATION

The Corps, Sacramento District, conducted the San Joaquin River Mainstem study. This included coordination of study efforts with the U.S. Fish and Wildlife Service (FWS), U.S. Bureau of Reclamation (Bureau), State of California (State) Department of Fish and Game (DFG), State Reclamation Board, reclamation districts, members of the SJRMP, and other local agencies, citizen's groups and individuals. The potential non-Federal sponsor for this study is the State Department of Water Resources, and other State and local agencies could participate in cost sharing the feasibility studies.

PRIOR STUDIES AND REPORTS

Some prior reports of primary importance to the San Joaquin River Mainstem study are summarized below. Each report provided background information on the water resources and opportunities in the study area, as well as engineering, economic and environmental data used in the technical analyses and environmental evaluation.

Corps of Engineers

"Lower San Joaquin River and Tributaries Project, California, San Joaquin River Levees, General Design, Design Memorandum No. 1," December 1955. This design memorandum defined flood related problems along the lower river and described the general design of the levee, channel and bank protection work that was authorized as part of this project.

"Report on Floods, Central Valley of California, 1968-1969 Flood Season," August 1970. This report documented the hydrologic, physical and economic damage data of the rain and snowmelt floods that occurred in the Central Valley during 1968-69.

"Sacramento-San Joaquin Delta Investigation, California, Documentation Report," October 1982. This report contained detailed studies that were done to provide data for the investigation of the Delta region. These studies included hydrology, island subsidence, existing levee system, levee erosion, levee design, levee failure, economics, and cultural resources.

"Preliminary Report for Flood Control, San Joaquin River and Kings River North," prepared by Stoddard & Associates, November 1983. This report identified the flood problems along the study reaches, developed and evaluated various alternative plans to reduce these problems, and identified a plan that appeared to be the most economically beneficial. The plan included rehabilitating and restoring the channel to a maintainable condition.

"Lower San Joaquin River and Tributaries Project, California, Eastside Bypass at San Joaquin River, Design Memorandum No. 5," September 1984. The purpose of this design memorandum was to describe a plan to reduce the threat of major flooding from the Eastside Bypass and San Joaquin River due to the high probability of levee failure. The report recommended that the plan be approved for construction prior to the 1984-85 flood season.

"Lower San Joaquin River and Tributaries, California, Channel Clearing, Draft Design Memorandum No. 6 and Draft Environmental Impact Statement," May 1985. This report defined flood-related problems along the San Joaquin River and described the type and scope of clearing and snagging measures needed to help resolve some of the problems.

"Lower San Joaquin River, California, Clearing and Snagging, Revised Draft General Design Memorandum No. 6 and Draft Environmental Impact Statement/Environmental Impact Report," April 1989. This report updated the May 1985 report. In addition, the report found that implementation of the proposed work and mitigation measures would cost more than the monies authorized.

"Calaveras River, California, Reconnaissance Report," October 1990. This report investigated flood control and other water related problems along the Calaveras River and determined the feasibility of solutions to solve these problems. The report concluded that no economically feasible plan could be identified and recommended no further studies at that time.

"Mokelumne River and Tributaries, California, Reconnaissance Report," June 1991. This report identified the level of flood protection provided by existing projects, evaluated the need for additional flood protection, and identified and evaluated potential plans to increase the level of flood protection. The report concluded that no economically feasible plan could be identified at that time.

Soil Conservation Service

"West Stanislaus Sediment Reduction Plan, Stanislaus County, California," February 1992. The purpose of this study was to prepare a plan to reduce the sediment load from west Stanislaus County into the San Joaquin River. Current farming and irrigation methods are primarily responsible for the sediment load. The study recommended that local growers integrate reduction methods into their operations and not wait for solutions to be dictated by a regulatory agency.

CURRENT STUDIES

Corps of Engineers

Revision to the Release Diagram, Friant Dam, California

The Corps has recently revised the Emergency Spillway Release Diagram for Friant Dam. The modification was needed to (1) ensure that the control room and access road are not inundated during extreme flood conditions and (2) try and reduce peak flood releases, thereby increasing flood protection downstream from the dam. The revised diagram is temporarily being used during emergency situations and will be permanently implemented after completion of the environmental evaluation.

Merced County Streams, California

The Merced County Streams project is located in eastern San Joaquin Valley, between the Merced and Chowchilla Rivers, in both Merced and Madera Counties. The area includes the watersheds of Canal, Fahrens, Black Rascal, Burns and Bear Creeks, which are naturally intermittent. The creek channels on the valley floor are used to convey water from the Merced River via the Main, Fairfield, and La Grande Canals for local irrigation. However, channel capacities are limited. During flood periods, the streams overflow their banks, and water from the streams commingle and pond against the Eastside Canal levees.

The project will create new water storage facilities on Canal and Black Rascal Creeks, enlarge Bear Dam on Bear Creek, and provide about 33 miles of levee and channel improvements along the Bear Creek stream group. The project will provide flood protection to residential, commercial, and agricultural lands within, and adjacent to, the city of Merced and Castle Air Force Base.

Bureau of Reclamation

San Joaquin River Basin Resource Management Initiative

In November 1989, the Secretary of the Interior announced the San Joaquin River Basin Resource Management Initiative (Initiative) and directed the Bureau to explore opportunities for environmental recovery in the San Joaquin basin. Authorized under the Reclamation Act of 1902 and Reclamation Project Act of 1939, the purpose of the Initiative is to identify and evaluate opportunities which would improve the water related environment in the study area.

The study area includes the eastern portion of the hydrologic basin of the San Joaquin River and its eastern tributaries from their headwaters in the Sierra Nevada to the southern boundary of the Delta. It also includes the area west of the San Joaquin River and east of the Delta-Mendota Canal. The Initiative is focussing its initial effort on that part of the study area from the Merced River to the southern edge of the Delta. The Initiative emphasizes the needs of anadromous and resident fish, water quality conditions, wetlands, wildlife, reservoir fishery and recreation.

As part of the Initiative program, the Bureau has been participating in the SJRMP, which has similar objectives. The Bureau is assisting in identifying the problems and using its staff to evaluate some of the potential solutions identified by the combined effort. The Bureau's current work efforts involve new offstream storage sites, replacing Mendota Dam, providing a real-time basin water quality monitoring system, securing aerial photographs, and providing funding to the FWS. The Initiative is scheduled to be completed in FY 95.

Montgomery Dam and Reservoir

The development and evaluation of the Montgomery Dam and Reservoir is part of the Initiative program. This potential offstream storage site is located on Dry Creek about 2 miles north of the Merced River near Snelling. The reservoir could potentially store up to 250,000 acre-feet of water in wet or flood years. This water could be used to improve the salmon fishery in the Merced River and also to improve downstream water quality conditions.

Madera Irrigation District

Fine Gold Water Conservation Project

The Fine Gold Water Conservation Project has been proposed by the Madera Irrigation District to increase the yield of the San Joaquin River by storing floodwater. Floodwater, which historically has passed through Millerton Lake and Friant Dam, would be pumped into a new off-stream reservoir. The reservoir would be located at the confluence of Fine Gold Creek with the San Joaquin River near the upper reaches of Millerton Lake. The terrain in this area would allow a reservoir with about 350,000 acre-feet of storage with a maximum water surface elevation of 1,000 feet msl. Part of the cost of the new facility would be offset by generating hydroelectric power.

LEGISLATION

Reclamation Projects Authorization and Adjustment Act of 1992

This comprehensive Act authorizes new studies, as well as numerous changes to existing Federal reclamation projects, in several western states. Title XXXIV of this Act is the Central Valley Project Improvement Act, which directly affects the operation of the Central Valley Project and could affect the study area. The main sections of the Act involve (1) limitation on contracting and contract reform, (2) water transfers, improved water management and conservation, (3) fish, wildlife, and habitat restoration, (4) restoration fund, (5) environmental review, (6) compliance with State water law, and (7) extension of the Tehama-Colusa Canal Service Area. The changes emphasize the restoration and protection of fish and wildlife and other environmental values in the Trinity River basin, Central Valley and Delta.

C-104284

CHAPTER II
RESOURCES AND ECONOMY OF THE STUDY AREA

EXISTING CONDITIONS

Water and Related Developments

Development of water resources in the basin began over 130 years ago and includes large multiple-purpose reservoirs, extensive levee and channel improvements, bypasses, and local diversion canals. Numerous agencies have been involved in water resources development. Some of these agencies include the Corps, Bureau, State, county irrigation districts, local reclamation districts, and local levee districts.

Dams and Reservoirs

Each of the main tributaries, as well as the San Joaquin River, has a large dam and reservoir that includes storage space for control of rain floods and/or snowmelt. The Corps prescribes the regulations for the use of the Federal flood control space. Each dam is operated to control floodflows on its downstream tributary river and has a secondary objective of reducing floodflows along the lower San Joaquin River. The successful operation of several dams also involves levee and channel improvements along downstream reaches of tributary rivers.

Pine Flat Dam and Lake. - Pine Flat Dam, which is located on the Kings River 25 miles east of Fresno, was completed by the Corps in 1954. The dam is a concrete structure 429 feet high and 1,820 feet long. The lake has a capacity of 1 million acre-feet, and 260,000 acre-feet of storage space is reserved for control of rain floods. One million acre-feet is available for snowmelt. The lake also provides an average of 165,000 acre-feet of regulated irrigation water annually, 8 developed recreation areas and a 165-megawatt powerplant. Downstream work along the Kings River, Clarks Fork, Crescent Bypass and Kings River North was completed in 1976. The work included 35 miles of levee construction or rehabilitation, 60 miles of intermittent channel clearing and modification of Army Weir.

Friant Dam (Millerton Lake). - Friant Dam, which is located on the San Joaquin River about 10 miles north of Fresno, was completed in 1949 by the Bureau. Millerton Lake has a capacity of 520,000 acre-feet, which is primarily used for conservation. Up to 170,000 acre-feet can be reserved for flood control during the flood season, and 390,000 acre-feet is available for snowmelt.

Mendota Dam. - Mendota Dam, located on the San Joaquin River at its confluence with Kings River North, is used for irrigation water supply diversion. It provides few, if any, direct flood damage reduction benefits downstream. Over the years, the pool area upstream from the structure has filled with sediments. The sediments have little to no adverse impact on water supply delivery. However, the sediments do significantly affect water surface elevations at high flows in the San Joaquin River and Kings River North systems.

Hidden Dam (Hensley Lake). - Hidden Dam, which is located on the Fresno River 15 miles northeast of Madera, was completed by the Corps in 1974. The dam is an earthfill structure 163 feet high and 5,730 feet long. Hensley Lake has a capacity of 90,000 acre-feet, of which 65,000 acre-feet are reserved for rain flood control. The lake also provides an average annual supply of about 24,000 acre-feet of water for irrigation, improves the water quality of the Fresno River, allows greater recharge of groundwater, offers recreational opportunities, and increases fish and wildlife benefits. Downstream work included 13 miles of channel improvements upstream from the river crossing of Chowchilla Canal.

Buchanan Dam (H.V. Eastman Lake). - Buchanan Dam, which is located on the Chowchilla River 16 miles northeast of the town of Chowchilla, was completed by the Corps in 1974. The dam is an earth and rockfill structure 205 feet high and 1,800 feet long. H.V. Eastman Lake has a capacity of 150,000 acre-feet, of which 45,000 acre-feet are reserved for rain flood control. The lake also provides irrigation water, improves the water quality of the Chowchilla River, allows greater recharge of groundwater, offers recreational opportunities, and increases fish and wildlife benefits. Downstream work included about 20 miles of channel improvements and levee construction on Ash and Berenda Sloughs, distributary channels of the river.

New Exchequer Dam (Lake McClure). - New Exchequer Dam, located on the Merced River about 25 miles northeast of Merced, was completed by the Merced Irrigation District in 1966. The dam is a concrete-faced rockfill structure 480 feet high and 1,200 feet long at the crest. The dam is operated under rules and regulations prescribed by the Corps. Lake McClure has a storage capacity of just over 1 million acre-feet, of which 350,000 acre-feet are reserved for rain flood control. About 400,000 acre-feet is available for snowmelt. The lake also provides 80 megawatts of hydroelectric power, irrigation water, and recreation facilities.

New Don Pedro Reservoir. - New Don Pedro Dam, located on the Tuolumne River about 35 miles east of Modesto, was completed in 1971 under a cooperative agreement between the Federal government, City and County of San Francisco, and the Turlock and Modesto Irrigation Districts. The New Don Pedro Reservoir has 340,000 acre-feet of storage space for rain flood control or snowmelt and provides flood protection to Modesto, several rural communities, and about 8,000 acres of agricultural land along the lower Tuolumne River. Operated by the Turlock and Modesto Irrigation Districts, the reservoir is also operated for irrigation and municipal water supply and power production.

New Melones Dam and Lake. - New Melones Dam, located on the Stanislaus River about 30 miles northeast of Modesto, was completed by the Corps in 1978. The dam is an earth-rockfill embankment type dam 625 feet high and 1,560 feet long. The operation of the dam was transferred to the Bureau in 1979, and the dam is operated under rules and regulations prescribed by the Corps. The lake has a storage capacity of 2.4 million acre-feet, of which 450,000 acre-feet is reserved for rain flood control or snowmelt. The lake also provides power generation, irrigation, water supply, water quality control, recreation and fisheries enhancement.

Levees and Channel Improvements

Lower San Joaquin River and Tributaries Project. - The 1944 Flood Control Act authorized the Lower San Joaquin River and Tributaries Project. The project allowed improvements authorized by the Federal government to the then existing channel and levee system. This system followed along the San Joaquin River from the Delta upstream to the mouth of Merced River and along several tributaries. The project also provided for flood protection along the San Joaquin River above the mouth of the Merced River by authority of the State. These project elements are an integral part of the overall plan for flood control and other purposes in the San Joaquin River basin. The project is designed to supplement upstream reservoirs by providing adequate channel capacity along the San Joaquin River system to safely pass regulated flows. Plate 3 shows the location of these project elements.

Federal construction of the Lower San Joaquin River and Tributaries Project was initiated in 1956 and completed in 1968 except for the left (west) bank levee along San Joaquin River from Tuolumne River to Merced River (completed in 1972). Additional modifications were made in the mid-1980's. The Federally constructed portion of the project consists of about 100 miles of intermittent levees along San Joaquin River, Paradise Cut, Old River, and the lower reaches of the Stanislaus and Tuolumne Rivers. The levees vary in height from about 15 feet at the downstream end to an average of 6 to 8 feet over much of the project. The project levees, along with upstream river regulation, were designed to contain floods varying from about once in 60 years at the lower end of the project to about once in 100 years at the upper limits. The State Reclamation Board provides assurances to the Federal government to operate and maintain the project. The State Reclamation Board has made agreements with local reclamation districts which actually perform the maintenance work with funds derived from taxes in the area of benefit.

Under the authorized plan of improvement for the portion of the project upstream from Merced River, the State was to provide flowage easements in areas subject to flooding. However, in lieu of flowage easements, the State chose to construct a bypass system consisting of levees and channel improvements. These improvements were coordinated with the Federal government to insure the effectiveness of the Federal portion of the project. The bypass system consists primarily of manmade channels (Eastside, Chowchilla, and Mariposa Bypasses), which divert and carry floodflows from the San Joaquin River at Gravelly Ford, along with inflows from other eastside tributaries, downstream to the mainstem just above Merced River. The system consists of about 193 miles of new levees, several control structures, and other appurtenant facilities, and about 80 miles of surfacing on existing levees. Construction of the original State system was initiated in 1959 and completed in 1966. Operation and maintenance (O&M) of the completed State upstream bypass features of the project are accomplished by the Lower San Joaquin Levee District (LSJLD). The State Reclamation Board provided assurances to the Federal government to operate and maintain the project in accordance with regulations prescribed by the Secretary of the Army.

Gravelly Ford. - In 1968, 1969, and 1970 the Corps conducted channel clearing near Gravelly Ford under authority of Section 208 of the 1954 Flood Control Act. The work was in response to requests from the Upper San Joaquin River Association and included clearing vegetation and snags from about 8.5 miles of channel at critical locations from near Highway 145 to Gravelly Ford. Required assurances, including maintenance responsibility for the cleared areas, were provided by the Upper San Joaquin River Flood Control Association.

Merced County Streams Group. - Original construction of this project was completed by the Corps in 1957. The project includes (1) flood retention dams on Burns, Bear, Owens, and Mariposa Creeks, (2) diversion canals on Black Rascal and Owens Creeks, and (3) channel improvements on various streams near Merced. The dams are low, earthfill structures and are located in the foothills about 15 miles east of Merced. The flood retention capacity of the project is 33,300 acre-feet. Local interests also improved the flood-carrying capacity of the streams through Merced. The system provides 100-year protection within the city and 50-year protection in urban areas.

Local. - In addition to the Lower San Joaquin River and Tributaries Project, there is an intricate series of minor levees and other channel improvements constructed, owned, operated, and maintained by local interests throughout the natural river system. These improvements significantly reduce the threat of flood-related damages to primarily agricultural land adjacent to the river.

Bypasses

Chowchilla Canal Bypass. - The Chowchilla Canal Bypass is a component of the Lower San Joaquin River and Tributaries Project and carries excess flow from the San Joaquin River to the southern end of the Eastside Bypass. The design capacity of the bypass is 5,500 cubic feet per second (cfs).

Eastside Bypass. - The Eastside Bypass is a component of the Lower San Joaquin River and Tributaries Project and carries excess river flow from the Chowchilla Canal Bypass to a point just upstream from the Merced River. The design flow of the bypass ranges from 10,000 to 18,500 cfs.

In the process of investigations for the Lower San Joaquin River, California, Clearing and Snagging project, completed in 1985, a serious flood problem was discovered in the Eastside Bypass at the confluence with San Joaquin River. The design capacity of the bypass at this location is 16,500 cfs. This capacity was found to have deteriorated to between 6,000 and 7,000 cfs. If the west bypass levee at this location fails due to flow capacity exceedence, nearly 100 square miles of primarily agricultural lands would be inundated. Two primary causes for the capacity reduction were identified. One was a buildup of sand beginning at the confluence and extending downstream in the bypass about 2 miles and amounting to about 1 million cubic yards (cy). The other cause was subsidence of the bypass west levee in about the same location as the deposited sand. An emergency plan was formulated to remove the sand and reduce the chances of levee failure. The plan also called for restoration of the west State project levee. Removal of about 1 million cy of sand by the Corps restored approximately 30 percent of the design capacity and reduced backwater effects, which lowers the water surface upstream along the San Joaquin River. The work was accomplished between November 1984 and February 1985. The LSJLD initiated construction to raise the west levee in February 1985 and completed the work in May 1985.

The State Reclamation Board was the local sponsor for this emergency work. In addition to operating and maintaining the completed work, the State Reclamation Board agreed to ensure restoration to grade and maintenance of the west project levee and removal of other flow obstructions in the bypass near the confluence location.

Mariposa Bypass. - The Mariposa Bypass is a component of the Lower San Joaquin River and Tributaries Project and carries excess flow from the Eastside Bypass near Owens Creek to the San Joaquin River. The design capacity of the bypass is 8,500 cfs.

James Bypass. - The James Bypass (also called Fresno Slough) is a 16-mile-long manmade channel located about 25 miles southeast of Fresno. The bypass was constructed between 1916 and 1920 by Reclamation District 1606 to carry excess runoff from the Kings River and convey irrigation water south. The bypass is now part of the Kings River designated floodway adopted by the State Reclamation Board in 1974. The bypass contains about 2,400 acres, most of which is native pasture and leased for cattle. Approximately 290 acres of the remaining acreage is used for cotton, wheat, and rice production. In the bypass, a low-flow channel runs parallel to, and about 20 feet from, the west levee. Due to concentrated flow velocities, erosion of the channel banks and the toe of the west levee has taken place. Reclamation District 1606 and the James Irrigation District are responsible for channel and levee maintenance.

Canals

San Luis Drain. - The San Luis Drain is located south and west of the San Joaquin River and extends about 85 miles from Five Points to the Kesterson Reservoir near Gustine. The drain is a concrete-lined canal that was designed and partially completed in 1972 by the Bureau as part of the Central Valley Project. The drain has a maximum capacity of 300 cfs and was designed to convey subsurface irrigation return flows from 8,000 acres of land to the Kesterson Reservoir, pending approval and construction of an outlet to the Delta. The complete drain would extend about 188 miles. The intent was to decrease the accumulation of salts in the agricultural soil.

In 1985, elevated concentrations of drainage water contaminants were discovered in water, sediments, food chain organisms, and major vertebrates in several valley areas outside of Kesterson Reservoir and the San Luis Drain. Drainage water deliveries to Kesterson Reservoir were ended by the summer of 1986, and ponds in the reservoir area were dried out, filled in, and leveled the following year.

Madera Canal. - The Madera Canal is located about 10 miles east of Madera in Madera County. The canal was constructed by the Bureau in 1945 and is a component of the Central Valley Project. The canal is 35.9 miles long and has an initial capacity of 1,200 cfs, decreasing to a capacity of 625 cfs at the Chowchilla River. The canal diverts water north from Friant Dam for use in Madera and Merced Counties. The major diverters from the canal are Madera Irrigation District, Chowchilla Water District, and La Branza Water District.

Local. - Numerous local irrigation distribution systems have been constructed throughout the valley floor area to convey irrigation water to the farms. Part of this water is diverted from the Delta-Mendota Canal and the California Aqueduct, which were constructed by the Bureau to transport water from the Delta to water deficient areas in the San Joaquin Valley, Tulare Lake basin, and southern California. These canals are located along the west side of the San Joaquin Valley.

Operation and Maintenance

Design Channel Capacities

The Corps has established objective flows for the San Joaquin River and its tributaries for use in flood control operation of the reservoirs on these streams. These flows are generally considered to be safe carrying capacities; however, some minor agricultural damage occurs when these flows occur. These flows were used to establish project levee elevations for the lower San Joaquin and Tributaries Project. The objective and/or design flows are shown in Table II-1.

Design capacity was authorized as the amount of water that can pass through a given reach with a levee freeboard of 3 feet within the historical San Joaquin River and 4 feet of freeboard along the bypasses, except along the left side of the Eastside Bypass, which has 3 feet of design freeboard. Project levees along the mainstem of the river were authorized with 3 feet of freeboard. Project design channel capacities were probably estimated to be very similar to flows which produced little or no significant damage during the planning, design, construction, and initial operation phases of water resource facilities in the San Joaquin River system. However, over time river stages in various reaches of the river have increased, and flood, seepage, and erosion damages have increased. Although some channel clearing work has been accomplished by the Corps, Bureau, and others, an adequate maintenance program has been difficult to maintain.

Lower San Joaquin River and Tributaries Project

When the San Joaquin River and Tributaries Project was formulated, designed, and finally constructed, the State Reclamation Board provided assurances to the Federal government to operate and maintain the completed project in accordance with regulations prescribed by the Secretary of the Army. The State Reclamation Board has made agreements with local reclamation districts which actually perform the maintenance work with funds derived from taxes in the areas of benefit. A detailed discussion of the O&M of the authorized project is included in Appendix A, Operation and Maintenance Report.

Table II - 1
Design Channel Capacities

Reach Flow 1/	cfs
San Joaquin River Friant Dam to Chowchilla Bypass Structure	8,000
Chowchilla Bypass	5,500
Mariposa Bypass	8,500
Eastside Bypass	10,000- 18,500
Kings River North	4,750
San Joaquin River San Joaquin River Structure to Mendota 2/	2,500
Mendota Dam to Sand Slough	4,500
Sand Slough to Mariposa Bypass	1,500
Mariposa Bypass to Merced River	10,000- 26,000
Merced River to Tuolumne River	45,000
Tuolumne River to Stanislaus River	46,000
Stanislaus River to Paradise Dam (at head of Paradise Cut)	52,000
Paradise Dam to Old River	37,000 3/
Old River to Stockton Deep Water Ship Channel	22,000

1/ Source: Report on Flood Control Operation and Maintenance, San Joaquin River, Friant Dam to Stockton, California.
2/ Chowchilla Bypass structure and San Joaquin River structure are adjacent facilities comprising the bifurcation works at the head of Chowchilla Bypass.
3/ Diversion capacity of Paradise Cut is 15,000 cfs.

The O&M includes activities on parts of the project completed by both the Federal government and the State. The area with Federally constructed levees has been subdivided into 13 geographical units. These units generally conform to the 23 local reclamation districts which are responsible for O&M within their boundaries. The State part of the project is maintained by the LSJLD.

There are O&M requirements for levees, channels and floodways. Levees must be maintained to ensure protection during flooding. Activities include promoting the growth of grasses on bare soil, mowing excess grasses and weeds, and removing wild growth and drift deposits. Bank erosion and wave wash are retarded by planting small willow trees, brush, and other vegetation on waterward slopes. To maintain channel and floodway capacities, excess debris, weeds and wild growth must be cleared, and the formation of shoals must be prevented. Channel and floodway clearing must be completed prior to the flood season.

The State Department of Water Resources, Division of Flood Management, prepares annual inspection reports on the condition of the flood control levees, structures, and channels operated under the cooperative agreement between the State and Federal governments for this project. A review of these reports indicates that the overall maintenance of the project is good. However, analyses and site visits during this reconnaissance study have revealed several site-specific deficiencies in the maintenance of levees and channels capacities. These deficiencies include areas of extensive sediment deposition, encroachment of vegetation, bank erosion, seepage and boils, cracks caused by settlement, loss of grade, slope erosion, and deterioration of the levee crown by recreational vehicles.

Institutional and statutory constraints have limited the ability of the State and local levee districts to carry out O&M procedures, including clearing and sediment removal programs. Requirements of the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), Clean Water Act, Migratory Bird Treaty Acts, and other Federal and State laws have made it nearly impossible to maintain the levee, channel, and bypass features of the existing flood control system as originally envisioned.

In June 1990, for example, the LSJLD requested a 404 permit from the Corps for a clearing program for various sections of the San Joaquin River. Due to the constraints in Federal, State, and local policy, this permit was not granted, and the proposed work was not accomplished. Subsequent coordination among the LSJLD, Corps, and resources agencies has resulted in a plan to remove vegetation by hand from the channel and levees. This work will be done in coordination with the resources agencies on a site-by-site basis and does not require a 404 permit. No sediment will be removed. Lack of sediment removal and only partial removal of vegetation will result in reduced channel capacities.

Environmental Setting and Natural Resources

This section includes an overview of existing environmental resources in the study area. Additional details can be found in Appendix B, Environmental Evaluation.

Basin Description

The San Joaquin River basin covers a 14,000-square mile area in Central California. The San Joaquin River, traversing the eastern side of the basin, extends from glacial lakes in the Sierra Nevada to its mouth in the Delta. The principal tributaries to the San Joaquin River are the Stanislaus, Tuolumne, Fresno, Calaveras, Chowchilla, and Merced Rivers.

Climate

The climate of the basin is characterized by wet, cool winters, dry, hot summers, and relatively wide variations in relative humidity. In the valley area relative humidity is very low in the summer and high in the winter. The characteristic wet winters and dry summers are due principally to a seasonal shift in the location of a high pressure air mass ("Pacific high") that usually exists a thousand or so miles west of the mainland. In the summer the high pressure deflects or blocks storms; in the winter it often moves southward and allows storms to reach the mainland.

Temperatures in the basin vary considerably because of seasonal changes and the large range of elevations. Temperatures in the lower elevations are normally above freezing but range from slightly below freezing at times during the winter to highs of over 100 degrees Fahrenheit at times during the summer. At intermediate and higher elevations, the temperature may remain below freezing for extended periods during the winter.

Topography

The San Joaquin River basin lies between the crests of the Sierra Nevada and Coast Range and extends from the northern boundary of the Tulare Lake basin, near Fresno, to the southern boundary of the Delta, near Stockton. The basin is drained by the San Joaquin River and its tributary system. The basin extends about 100 miles from the crest of the Sierra Nevada and about 120 miles from the northern to southern boundaries. The Sierra Nevada has an average crest elevation of about 10,000 feet with occasional peaks as high as 13,000 feet. The Coast Range crest elevations reach up to 5,000 feet. The valley area measures about 100 miles by 50 miles and slopes gently from both sides towards a shallow trough somewhat west of the center of the valley. Valley floor elevations range from about 250 feet near Mendota to sea level near Stockton. The trough forms the channel for the lower San Joaquin River and has an average slope of about 0.8 foot per mile between the Merced River and Paradise Cut and an average slope of about 1.6 feet per mile from Friant Dam to the Merced River.

Major tributary streams, from north to south, are the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, and the Merced Rivers. These streams, plus the San Joaquin River, contribute the majority of the surface inflow to the valley. Minor streams on the east side of the valley are the Fresno and Chowchilla Rivers and Burns, Bear, Owens, and Mariposa Creeks. Panoche, Little Panoche, Los Banos, San Luis, Orestimba, and Del Puerto Creeks comprise the minor streams on the west side. These west side streams contribute very little to the runoff of the San Joaquin River. Numerous other small foothill channels carry water only during intense storms. During high runoff periods, a distributary channel of the Kings River (called James Bypass) discharges water into the San Joaquin River near Mendota. In addition, flood water is diverted to the San Joaquin River from Big Dry Creek Reservoir near Fresno. Flows from rivers and creeks are significantly reduced by storage, diversions, and channel seepage losses as they cross the valley floor so that only a portion of the water at the foothill line reaches the San Joaquin River. Peak flows from these tributaries usually do not coincide and, consequently, the combined capacity of tributary channels is considerable greater than that of the lower San Joaquin River.

Geology and Soils

The basin lies within parts of the Sierra Nevada, California Coast Ranges, and the Great Central Valley geomorphic provinces. Its sedimentary, metamorphic, and igneous rocks range in age from pre-Cretaceous to recent nonwater-bearing crystalline rocks. In the California Coast Ranges, Jurassic and Cretaceous sandstones and shales dominate. In the valley, upper Tertiary and Quaternary sediments in places contain fresh water as deep as 2,000 feet. Also, in most of the area, impermeable Corcoran clays confine the lower water bearing zone.

Soils in the valley basin bottoms are poorly drained and fine textured. Some areas are affected by salts and alkali and require reclamation before they are suitable for crops. Bordering and just above the basin bottoms are soils of the fans and flood plains. They are generally level, very deep, well drained, non-saline and non-alkaline, and well suited to a wide variety of crops. The soils of the terraces bordering the outer edges of the valleys generally are of poorer quality and have dense clay subsoils or hardpans at shallow depths. These soils are generally used for pasture and rangeland.

Soils in the foothills and mountains of the Sierra Nevada are generally shallow or moderately deep to bedrock, acid in reaction, medium to course textured, and gravelly or rocky. Above timberline there are broad expanses of exposed rock on the ridges and peaks.

Soils in the Coast Range are generally moderately deep to shallow and fine to course textured. Rocky soils occur at higher elevations.

Seismicity and Faulting

According to the Corps' ER 1110-2-1806, "Earthquake Design and Analysis for Corps of Engineers Projects," dated May 16, 1983, the study area is located in seismic zones 3 and 4. These are the two highest ratings used by this system. The capability for damage in zone 4 is considered to be great.

The foothills are within the Western Metamorphic Belt, a 250-mile-long and 30- to 50-mile-wide bank of rocks that parallel the western side of the Sierra Nevada. Within this belt is a series of northwest trending faults and shears collectively called the Foothills fault system. Within this fault system are two principle northwest trending fault zones, the Bear Mountains and the Melones.

The San Andreas Fault is located about 40 to 50 miles southwest of the river between Mendota and Los Banos and is capable of a magnitude 8.25 earthquake. The Calaveras Fault is located about 35 miles southwest of the San Joaquin River between Patterson and Stockton and is capable of a magnitude 7.0 earthquake.

Air Quality

The study area is within the San Joaquin Valley Air Basin (SJVAB). Air quality is generally poor to marginal. The basin is designated as a nonattainment area for ozone and fine particulate matter and has not met Federal or State standards for over 15 years. In 1990, the valley exceeded the Federal ozone standard on 45 days and the State standard on 130 days. The Fresno, Modesto, and Stockton metropolitan areas are nonattainment areas for carbon monoxide (CO) and have been for over 10 years. In 1990, Fresno exceeded the State standard for CO on one day, Modesto on 3 days, and Stockton on 7 days.

Air quality problems result from the region's geographic location, topography, climate, population growth, and economic activities. The SJVAB is affected by air pollution from the Sacramento and San Francisco Bay metropolitan areas, as well as Stockton, Modesto, and Fresno. Pollutants from these areas consist mostly of ozone and CO, primarily from automobile exhausts. Valley agricultural operations such as plowing and burning introduce the bulk of the particulates into the air. Plans have been developed to address air quality problems and try to bring the SJVAB and metropolitan areas into compliance with Federal and State standards.

Water Quality

Water quality in the San Joaquin Valley varies and is greatly influenced by agricultural practices. Surface water on the valley floor is generally of poor quality. This is particularly true of the mainstem of the San Joaquin River, which functions as a drain for the valley's irrigation drainage and municipal and industrial (M&I) wastewater. During summer months and low flow periods, these return flows comprise most of the flow in portions of the lower river. The drainage and wastewater contain contaminants and suspended solids and cause poor water quality conditions, especially during critically dry water years.

Irrigation drainage in the valley has been shown to contain selenium, boron, various heavy metals, and pesticides. High levels of suspended solids (salts) and contaminants are present in many of the sloughs, creeks, groundwater aquifers, and some wetlands on the valley floor, in addition to the mainstem of the river. Salt and Mud Sloughs in the Grasslands area are particularly affected by contaminants and suspended solids. These sloughs carry drainage from agricultural lands with high levels of selenium and boron to the San Joaquin River. The reach of the river below the confluence of Salt and Mud Sloughs shows the highest levels of contaminants and salinity.

The M&I wastewater introduces nutrients, toxic compounds, heavy metals, and other contaminants into the mainstem and some tributaries. High nutrient levels lower dissolved oxygen levels in the water.

Directly below the major dams, the mainstem of the San Joaquin River and tributaries have relatively good water quality due to reservoir releases. Temperatures, turbidity, nutrients, and alkalinity are low, and dissolved oxygen is high. Substantial in-stream flows are present, and agricultural drainage and M&I wastewater are minimal. Water quality gradually degrades downstream, but the quality of most eastside tributaries is better than that of the mainstem and sloughs of the valley floor.

Vegetation

The types of vegetation in the San Joaquin River basin consist of cultivated crops, pasture grasses, forbs, hardwood forests, chaparral mountain brush, and coniferous forests. The distribution of these vegetation types is primarily a function of elevation with the cultivated crops located on the valley floor, the hardwood forests and chaparral brush located at mid-elevations, and the coniferous forests located at higher elevations.

The historic natural vegetation of the San Joaquin Valley consisted of an extensive belt of riparian forest and willow thickets along perennial streams, lakes, or sloughs; freshwater wetlands and tule marshes; oak savanna; California prairie grasslands in upland areas; and San Joaquin saltbush in xeric alkaline areas. Today, however, the San Joaquin Valley contains the largest contiguous block (roughly 4.7 million acres) of irrigated land in California. Almost 60 percent of the valley floor is in agricultural use. The natural habitats are only a fraction of their former extent. Plate 4 illustrates how the natural vegetation of the valley floor has changed over time. Table II-2 shows the historic and current status of selected wildlife habitat.

Riparian and wetland habitats are the most important habitat types found in the study area. The riparian habitat includes woody vegetation located adjacent to rivers and streams and depends on high soil moisture and/or periodic flooding. Most remaining riparian habitat is located along the San Joaquin River, and this habitat is very fragmented and has been disturbed or degraded. Characteristic overstory species include cottonwood, sycamore, willow, and valley oak. Intermediate and understory species include box elder, willow, elderberry, wild grape, poison oak, wild rose, and California blackberry.

The wetland habitat includes non-riparian areas that are permanently or seasonally inundated by shallow water. Permanent wetlands in the San Joaquin Valley include tule marshes and are typically covered with several inches of water for most of the year. Characteristic species include common tule, cattail, sedges, and rushes. Seasonal wetlands include vernal pools and wet meadows. Vernal pools form in shallow depressions and contain unique assemblages of species, often native annuals.

About 80,000 flooded acres exist in the San Joaquin Valley in an average year, most being managed permanent and seasonal wetlands (duck clubs or wildlife refuges). In addition, there are many vernal pools and some wet meadows. In recent years, seasonal wetlands have been forming in agricultural lands adjacent to mainstem levees during high river flows.

Wildlife

Despite the loss of significant habitat areas, the San Joaquin Valley supports many wildlife species and individuals that depend on the plant communities found along the San Joaquin River and its tributaries. Upland game species in the study area include California quail, ring-necked pheasant, mourning dove, band-tailed pigeon, Audubon cottontail, brush rabbit, black-tailed jackrabbit, and gray

Table II - 2

HISTORIC AND CURRENT STATUS OF SELECTED WILDLIFE HABITATS[a]

Habitat	State			Central Valley			San Joaquin Valley		
	Historic[b]	Current[b]	% Remaining	Historic[b]	Current[b]	% Remaining	Historic[b]	Current[b]	% Remaining
Wetlands	5,000,000[c]	459,000[d]	9%	1,500,000[e]-4,000,000[c]	281,000[f]	7-19%	1,093,000[g]	~85,274-~90,749[h]	8%
Riparian Forests[i]	---	---	---	1,600,000-2,000,000[e]	102,000[j]	5-6%	902,000[g]	~39,300[j,k]	4%
California Prairie	20,000,000[l]-22,000,000[m]	7,580[n]	<1%	---	---	---	4,444,000[g]	1,500[n]	<1%
San Joaquin Saltbush	1,172,000[g]	99,381[o]	8%	1,172,000[g]	99,381[o]	8%	1,172,000[g]	99,381[o]	8%

[a] Habitat figures are presented in acres. "---" indicates no data are available.
[b] Historic habitat figures represent habitat extent prior to European settlement (prior to the mid-1800's), unless otherwise noted. Current habitat acreages are for the mid-1970's to the present time, unless otherwise noted.
[c] USFWS, May 1978.
[d] Acreage presented is sum of coastal wetlands (USFWS, Feb 1979; USFWS, Nov 1989), and Central Valley wetlands (USFWS, Sep 1987). Total wetlands for the State probably exceed the acreage given because mountain and desert wetlands (acreage unknown) are not included.
[e] Warner and Hendrix, 1985.
[f] USFWS, Sep 1987.
[g] Acreages derived from figure 2-1, "Historic Hydrography and Natural Habitats of the San Joaquin Basin," and figure 2-2, "Historic Hydrography and Natural Habitats of the Tulare Basin," which were adapted from Hall (1886) and Kuchler (1977).
[h] Acreages from table 2-6, "Changes in Wetland Habitat Acreage: 1957-63 through 1986-89." Does not include wetlands in the south Delta and Farmington-Escalon duck club areas; therefore, wetlands acreage presented should be viewed as conservative.
[i] Includes riparian forest and valley oak savanna habitat types.
[j] Adapted from data generated through photo-interpretation of 1977 aerial photographs (Katibah et al., 1980). Data were not available for all areas on the San Joaquin Valley floor; therefore, acreage estimate presented may be low. Conversely, current acreage has probable been reduced by suburban and/or other developments since 1977.
[k] Acreage of riparian forest on the San Joaquin Valley floor in 1977 was approximately 35,360 acres; acreage of valley oak savanna on the San Joaquin Valley floor in 1977 was approximately 3,933 acres (adapted from Katibah et al., 1980).
[l] Burcham, 1982.
[m] Dasmann, 1965.
[n] Current acreage represents remnants of native California prairie dominated by perennial bunchgrasses as of 1972 (Barry, 1972).
[o] Werschkull et al., 1984. Actual acreage may be higher because estimate based on San Joaquin saltbush habitat remaining in Tulare Basin only.

squirrel. Furbearers are represented by coyote, red and gray foxes, bobcat, raccoon, opossum, spotted and striped skunk, badger, muskrat, weasel, and beaver.

Birds are probably the most common wildlife type in the study area. About 200 species of birds are known to visit or inhabit the riparian habitat, which provides breeding, nesting and feeding areas. Raptors include the golden eagle, northern harrier, red-tailed hawk, short-eared and barn owls, and turkey vulture. Passerine species include the Brewer's blackbird, scrub jay, red-shafted flicker, common crow, yellow-billed magpie, and swallow.

The San Joaquin River system is part of the Pacific Flyway and provides important resting and feeding areas for migratory waterfowl, shorebirds, and other water associated birds. The use of the basin by waterfowl is extensive on State and Federal wetlands in the study area, and on waterfowl hunting clubs. The agricultural lands also provide food and resting areas. Waterfowl include the mallard, pintail, cinnamon teal, and American widgeon. Shorebirds and wading birds include the great blue heron, great and snowy egrets, sandhill craine, American avocet, and black-necked stilt.

Reptiles and amphibians include the aquatic garter snake, common garter and gopher snakes, western fence and California legless lizards, bullfrogs, and Pacific pond turtle.

Fisheries

Prior to major water developments, the San Joaquin River system supported a productive fishery of resident and anadromous fishes, including Sacramento and tule perch, Sacramento sucker, thick-tailed chub, Sacramento squawfish, hardhead, Sacramento blackfish, hitch, Sacramento splittail, rainbow trout, white sturgeon, steelhead, and fall- and spring-run chinook salmon. These native species are still present but in fewer numbers. Introduced warmwater species are now the most abundant fish. Common species include green sunfish, bluegill, redear sunfish, largemouth bass, black crappie, threadfin shad, common carp, Sacramento blackfish, white catfish, black bullhead, brown bullhead, and mosquito fish.

Spring-run chinook salmon in the San Joaquin River were essentially eliminated as a result of construction and operation of Friant Dam. Spring-run chinook on the other tributaries had been eliminated by dam construction around 1900. As a result, chinook salmon production in the San Joaquin Valley has declined by over 85 percent since the

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1940's. Due to artificial propagation, fall-run chinook continue to exist in five major eastside tributaries, including the Merced, Tuolumne, Stanislaus, Mokelumne, and Cosumnes Rivers.

There is presently no minimum instream flow requirement for the mainstem of the San Joaquin River below Friant Dam. The Bureau does release water to meet the demands of water rights holders downstream to Gravelly Ford, but the river is essentially dry from that point downstream (except for agricultural return flow) until it receives tributary inflow from the Merced River about 90 miles downstream from Friant Dam. As a result, the mainstem above the mouth of the Merced River no longer supports a fishery. The mainstem below the Merced River, however, remains an essential migratory corridor for salmon and steelhead adults moving into the tributaries to spawn in the fall and for juveniles moving out in the spring.

In summary, the San Joaquin River above the confluence of the Merced River has no significant fishery, and the San Joaquin River below the Merced River is dominated by introduced warmwater fish species. Remnant populations of native fish species continue to survive here as well, including anadromous species in the tributaries.

Rare, Threatened and Endangered Species

According to a list supplied by the FWS on May 15, 1992, there are 10 Federally-listed threatened and endangered species that may occur in the study area. Two additional species, the giant garter snake and the western snowy plover (coastal population) have been proposed for listing. There are 48 candidate species that may occur in the study area, and 29 of them are plants.

The listed species include three birds, two mammals, one reptile, one insect, and three plants. The birds are the bald eagle, American peregrine falcon, and Aleutian canada goose, all of which winter in the San Joaquin Valley. The Los Banos-Grasslands area typically contains a large number of wintering geese. The mammals include the Fresno kangaroo rat and the San Joaquin kit fox. The kangaroo rat occupies at least a 400-acre parcel within 857 acres of Federally-designated critical habitat west of the town of Kerman in Fresno County. The kit fox is known to occur in 11 counties, including parts of Fresno, Merced and San Joaquin. The reptile is the blunt-nosed leopard lizard. The lizard occurs in scattered patches of undeveloped land in Merced, Madera, Fresno, and Kings Counties.

In addition to the Federally-listed species, there are several State-listed species that occur in the study area. State threatened species include the Swainson's hawk, San Joaquin antelope squirrel, giant garter snake, and bank swallow. State endangered species are the western yellow-billed cuckoo, Delta button celery, Ferris' birds beak, and Colusa grass. Most of these species are associated with riparian areas and wetlands.

During feasibility studies, the Corps would request a current list of threatened and endangered species from the FWS and obtain a list of State-protected species from the State. Biological surveys and data reports would be completed, and the Corps would prepare a biological assessment of the listed species and describe any potential adverse impacts on them. If necessary, formal consultation with the FWS would be conducted as required under Section 7 of the Endangered Species Act.

Hydrology

Precipitation

Precipitation is unevenly distributed throughout the basin. About 90 percent of the precipitation falls during the months of November through April, and precipitation is negligible during the summer months, particularly on the valley floor. Normal annual precipitation varies from 6 inches near Mendota to about 70 inches at the headwaters of the San Joaquin River. In the higher elevations of the Sierra Nevada, precipitation occurs principally in the form of snow and in the rest of the basin in the form of rain, with mean values of approximately 20 inches. Basins on the east side of the Coast Ranges lie in a rain shadow and receive considerably less precipitation than do basins of similar altitude on the west side of the Sierra Nevada.

Snowfall

Winter precipitation usually falls as snow above the 5,000-foot elevation and as rain and/or snow at lower elevations. Snow cover below 5,000 feet is generally transient, and may accumulate and melt several times during the winter season. Normally the snow accumulates at higher elevations until about the first of April when the melt rates exceed snowfall. Surveys of the snowpack are conducted by the State starting in January of each year.

Storm Characteristics

Winter storms affecting the area are cyclonic wave disturbances along the polar front and usually originate in the vicinity of the Aleutian Islands. The normal trajectory of the waves is toward the southeast; however, the storms producing the greatest amount of precipitation have maintained a more easterly trajectory across the Pacific Ocean. The Coast Range Mountains form a barrier that reduces the moisture in the air mass moving inward. Most of the water carried past this barrier is precipitated by orographic effect on the western slope of the Sierra Nevada.

Major storms over the area normally last from 2 to 4 days and consist of two or more waves of relatively intense precipitation with lesser rates between the waves. Storms that produce major floods from the Sierra Nevada combine intense precipitation with high freezing levels and are called warm type storms. Rainfall during some of the major storms have occurred up to about the 11,000-foot level. Warm type storms generally occur early in the rainflood season. Storms that produce major runoff from the foothill, valley, and east facing slopes of the Coast Range streams are called cold type storms. Rainfall during cold type storms generally falls as snow above the 4,000-foot elevation and is more intense on the foothills and Coast Range areas than in the high mountain reaches.

Streamflow

The major tributaries to the San Joaquin River have a drainage area (excluding the Kings River) of about 15,000 square miles. The vast majority of basin runoff occurs from the eastside tributary rivers and streams. The westside streams contribute very little to the total runoff of the basin. Several small tributaries enter the San Joaquin River between Friant Dam and Gravelly Ford, the largest of which is Little Dry Creek. This stream, in addition to carrying floodflows from its own drainage basin, is used to convey excess floodwater to the San Joaquin River from Big Dry Creek Flood Control Project located northeast of Fresno. Between Gravelly Ford and the Merced River, floodflows into the San Joaquin River system occur primarily from Fresno and Chowchilla Rivers, Fresno and Berenda Sloughs, Bear Creek, and several other small streams via the Eastside and Chowchilla Bypasses. During high runoff periods, a distributary channel of the Kings River (Fresno Slough and James Bypass) discharges water into the San Joaquin River near Mendota. The Tuolumne and Stanislaus Rivers are the primary tributaries between Merced River and Stockton Deep Water Ship Channel, and Littlejohn, Duck, Hospital, Del Porto, and Orestimba Creeks also contribute floodflows.

Streamflow and reservoir records have been maintained for varying periods of time at many locations throughout the basin. The average annual floodflow from the river tributaries is about 7 million acre-feet from both rainfall and snowmelt. During the 1983 water year, flows were on the order of 19 million acre-feet. Flows from the rivers and creeks are significantly reduced by diversions and channel seepage losses as the creeks flow across the valley floor, and only a portion of the flows occurring at the foothill line reach the San Joaquin River. Because of this and other water uses in the basin, the average flow at Vernalis on the Lower San Joaquin is about 3 million acre-feet. Flows as high as 80,000 cfs have been recorded at the Vernalis streamflow gage where the mean annual floodflow is about 25,000 cfs. Controlled flows from Friant Dam measured at Gravelly Ford are 8,000 cfs. A flow of about 10,000 cfs was recorded at the Gravelly Ford gage in 1983. Average annual flows at this location are well below 1,000 cfs.

Groundwater

In the northern part of the San Joaquin Valley, groundwater levels are above the elevation of adjacent, incised stream channels. This situation results in groundwater seepage into these channels. Groundwater constitutes a majority of the summer flow in the lower reaches of the San Joaquin, Merced, Tuolumne, and Stanislaus Rivers, as well as in Dry Creek (tributary to the Tuolumne River).

Water Supply

Agricultural development in the San Joaquin Valley has been intensive. In the eastern part of the valley, from Kings River to the north, surface streams from the Sierra Nevada supply most of the water for irrigation, but the surface streams are supplemented by groundwater, especially after midsummer when streamflow is deficient. South of Kings River, local surface water supplies have been small to negligible. Prior to the construction of major canals or aqueducts, irrigation was mainly from thousands of large and deep irrigation wells, and conditions of groundwater overdraft prevailed.

Importation of surface water to areas of serious overdraft on the east side of the valley began in 1950 when water from the San Joaquin River was brought south through the Friant-Kern Canal. The average annual delivery from this canal is about 1 million acre-feet.

Surface water imports to the northwestern part of the area from the Delta via the Delta-Mendota Canal began in the early 1950's. About two-thirds of the water in the Delta-Mendota Canal that is transported south to the San Joaquin River at Mendota Pool is used by westside irrigation companies in exchange for water formerly taken from the San Joaquin River, thus releasing rights to water behind Friant Dam for eastside deliveries through the Friant-Kern Canal. The remaining one-third of the water from the Delta-Mendota Canal is delivered to irrigation contractors along the canal.

From 1968 to 1971, surface water from the California Aqueduct became available to deficient areas on the west side and to the south end of the valley.

Socioeconomic Conditions

The study area includes parts of five counties: Fresno, Madera, Merced, Stanislaus and San Joaquin. Population statistics for these five counties are included in Table II-3 and indicate that these counties have grown at a faster rate than the State average. The largest cities in the study area include Madera, Los Banos, and Merced, and statistics show that most of the cities in the area have grown at a rapid rate over the past 20 years (see Table II-4).

Table II - 3
County Population

COUNTY	*1970*	*1990*	*Percent Increase 1970-1990*	*Estimated 2035**	*Estimated Percent Increase 1990-2035*
FRESNO	413,053	667,490	38	1,129,300	41
MADERA	41,519	88,090	53	204,500	57
MERCED	104,629	178,403	41	424,000	58
SAN JOAQUIN	290,208	480,628	40	1,021,000	53
STANISLAUS	194,506	370,522	47	679,200	45
CALIFORNIA	20,039,000	29,976,000	33	44,542,500	32

* California Department of Finance, Population Research Unit

Source: California Cities, Towns, & Counties Basic Data Profiles for all Municipalities & Counties, 1992

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Table II - 4
Population of Cities

CITY	COUNTY	POPULATION		
		1970	1990	Percent Increase 1970-1990
FIREBAUGH	FRESNO	2,517	4,429	43
MENDOTA	FRESNO	2,705	6,821	60
MADERA	MADERA	16,044	29,281	45
DOS PALOS	MERCED	2,496	4,196	40
GUSTINE	MERCED	2,793	3,931	29
LOS BANOS	MERCED	9,188	14,519	37
MERCED	MERCED	22,760	56,216	60
LATHROP	SAN JOAQUIN	N/A	6,841	N/A
RIPON	SAN JOAQUIN	2,679	7,455	64
NEWMAN	STANISLAUS	2,505	4,151	40
PATTERSON	STANISLAUS	3,147	8,626	63
CALIFORNIA		20,039,000	29,976,000	33

Source: California Cities, Towns, & Counties Basic Data Profiles for all Municipalities & Counties, 1992

Many of the people who live in the cities commute to jobs in Sacramento, San Jose, and the Bay Area. The unemployment rates in the five counties are larger than the State average in 1990 of 5.6 percent (see Table II-5). The unemployment rate for the State was 9.1 percent in 1992.

Table II - 5
1990 Unemployment Rate

COUNTY	*UNEMPLOYMENT RATE*
FRESNO	10.2
MADERA	12.3
MERCED	11.6
SAN JOAQUIN	9.8
STANISLAUS	11.3
CALIFORNIA	5.6

Public services include police and fire protection. All the cities have individual school districts except Lathrop, which is under the Manteca Unified School District. Many of the elementary and high schools are overcrowded.

Transportation facilities in the basin are extensive. Federal, State, and county road systems provide access to all parts of the basin and to adjoining areas. In addition, the area is served by air and rail lines and by the Stockton Deep Water Channel.

Land use in the study area includes rural, agricultural and urbanized areas. Mining, lumbering, livestock production and recreation are significant in the mountainous areas. The valley area supports intensively irrigated agricultural development with related manufacturing and industrial activities. Most of the urbanized areas are found in the valley area along Highway 99.

Agriculture is the economic base of the area, and over 50 percent of the land in all five counties is currently used for agriculture (see Table II-6). A variety of crops are grown, including tree orchards, vineyards, row crops and grains. Typical agricultural products are almonds, walnuts, peaches, plums, grapes, tomatoes, corn, sugar beets, cotton, wheat, oats, and barley. Much of the agricultural land is held under Williamson Act contracts. The California Land Conservation Act of 1965 (commonly known as the Williamson

Act) established a voluntary tax incentive program for preserving agricultural and open space lands. A property owner enters into a 10-year contract with the County, which places restrictions on the land in exchange for tax savings. These contracts are renewed automatically each year unless they are canceled or a Notice of Nonrenewal is filed with the State.

Table II - 6
Agricultural Acreage and Production Value

COUNTY	*ACREAGE IN FARMS 1989*	*PERCENT OF LAND AREA*	*VALUE OF PRODUCTION 1989 ($ MILL.)*
FRESNO	1,975,373	51.7	2,603
MADERA	757,263	55.2	471
MERCED	1,049,302	82.7	1,050
SAN JOAQUIN	823,729	91.3	871
STANISLAUS	719,845	75.0	963
CALIFORNIA	30,598,178	30.5	20,671

Source: California Department of Finance, Economic Research October 1991

Urban development is increasing due to the low cost of land, housing, and the close proximity to the job markets in Sacramento, San, Jose and the Bay area. All five counties are trying to accommodate new urban development and planned industrial growth. Most of the growth is planned for areas in the incorporated cities located adjacent to Highway 99 and Interstate 5.

Cultural Resources

Available data indicate that Man has occupied portions of western North America for at least the past 10,000 years. Within the study area, however, such evidence is limited to the last 6,000 years. The area lies within the traditional territory occupied mainly by Northern Valley group of the Yokuts Indians. The Yokuts were a large, diverse group who spoke the Yokutsan language.

The San Joaquin Valley was first explored by Pedro Fages in 1772, and historians credit Fages with the discovery of the San Joaquin River. Lieutenant Gabriel Moraga explored the area for new mission sites in 1806 and 1808 and named the major tributaries. American control of California began in 1848 as part of the settlement of the Mexican War.

The Gold Rush brought thousands of men into California looking for gold. After initial failures at mining, many of them moved into the San Joaquin Valley and established farms. However, agriculture did not become widespread until levees and canals were constructed to provide flood control and water for irrigation.

The northern San Joaquin Valley has never been the subject of an exhaustive archeological study. A cultural resources overview and literature search for known cultural resource sites was conducted in the study area for this reconnaissance report. This search identified at least 85 archeological and 9 ethnographic sites, no archeological districts listed in the National Register of Historic Places, and 5 State historical landmarks within the study area.

Recreation

The San Joaquin River system provides a source of recreation for many people throughout the year. The San Joaquin, Merced, Tuolumne, and Stanislaus Rivers and adjacent areas offer a variety of water- and land-based leisure activities, including fishing, hunting, swimming, boating, golf, picnicking and sight-seeing. Table II-7 shows the public recreational facilities in the study area.

Hazardous, Toxic and Radioactive Waste Sites

Hazardous, toxic and radioactive waste (HTRW) sites located in the study area could require special design or construction considerations. To determine the extent of known HTRW sites located in the study area, Federal and State lists were identified and reviewed. The U.S. Environmental Protection Agency (EPA) maintains and updates the Federal "National Priorities List" for uncontrolled hazardous waste sites as required by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The latest updated list was published in the Federal Register, August 30, 1990, on pages 35502 through 35525. The State EPA maintains and updates the Hazardous Waste and/or Substance Sites List (AB 3750 list). The State Water Resources Control Board, Waste Management Board, and Department of Health Services contribute data to this list.

The literature review indicated that numerous HTRW sites exist in the study area. However, most of the listed sites involve minor tank leaks and are not located in any areas where flood control plans, environmental restoration, or environmental mitigation are being considered.

Table II - 7
Public Recreational Facilities in the Study Area

Name of Facility	Location	Operated by	Size	Facilities	Comments
Lost Lake Regional Park	2 miles below Friant Dam	County of Fresno	305 acres	campground, lake, picnic, fields, playground, nature trail	Good access to river, canoe put-in site
Woodward Park	South side of San Joaquin River near Hwy. 41	City of Fresno	265 acres	picnic, fields, Japanese gardens	Overlooks river from bluffs
Skaggs Bridge Regional Park	West of Hwy. 145	County of Fresno	17 acres	day use, picnic	Used for beach and fishing activities
National Wildlife Refuges - Kesterson - Merced - San Luis - Los Banos Wildlife Area	West of San Joaquin River and north of Los Banos	U.S. Fish and Wildlife Service		auto tour	Primarily used as a hunting area
Hagaman County Park	Merced River and Hwy. 165	County of Merced	15 acres	picnic, fields, playground	
George J. Hatfield State Recreation Area (SRA)	On Merced River in northwest Merced County	California Dept. of Parks and Recreation (DPR)	47 acres	campsites, picnic, and fishing areas	Over 9,000 paid visitors in 1991
Fremont Ford SRA	On San Joaquin River in northwest Merced County	DPR	114 acres	fishing access	Over 14,000 day use visitors in 1991
Las Palmas Fishing Access	San Joaquin River east of Patterson	Stanislaus County	5 acres	fishing access, boat ramp	1,400 feet of river frontage
Shiloh Fishing Access	Tuolumne River, west of Hwy. 99	Stanislaus County	1.25 acres	fishing access	
Riverdale Fishing Access	Tuolumne River, west of Hwy. 99	Stanislaus County	2.5 acres	fishing access	
Caswell Memorial State Park	North side of Stanislaus River, 6 miles SW of Ripon	DPR	258 acres	campsites, picnic, nature walk, exhibits	Over 50,000 visitors in 1991
Durham Ferry SRA	5 miles west of Caswell Memorial State Park	San Joaquin County	207 acres	campsites, day use, picnic	Owned by State of California

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A field reconnaissance and review of aerial photos of the study area would be conducted during feasibility studies to determine if there are any unlisted HTRW sites in the area. Results of this work and an updated literature survey would be coordinated formally with the non-Federal sponsor and appropriate Federal, State and local agencies. In addition, the Corps would develop a contingency plan identifying a responsible agency and outlining a course of action in the event that HTRW sites are uncovered during construction.

The Corps 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 for any HTRW sites located on a Civil Works project. However, if HTRW 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 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 or 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.

FUTURE CONDITIONS

The populations of the counties in the study area are expected to grow at a higher rate than the State during the next 40 years. This growth is due to the influx of people who work in Sacramento, San Jose and the Bay Area. Since the counties are attempting to preserve agricultural land, future development is planned adjacent to existing urban areas. County plans include additional housing, schools, water systems, and other public facilities. This future growth will occur with or without a flood control project in place.

CHAPTER III
PROBLEMS AND OPPORTUNITIES

SAN JOAQUIN RIVER MAINSTEM

Designated Floodway

The State's Designated Floodway Program is administered by The Reclamation Board. Technical studies and public coordination are carried out by the State Department of Water Resources. As defined by The Reclamation Board, a "designated floodway" is a waterway of certain defined limits that is needed to safely pass the design flood (now the 100-year flood). The floodway consists basically of a stream channel and part of the adjoining flood plain.

A designated floodway is a nonstructural means of keeping development from encroaching into floodprone areas. It reduces future potential flood damages by preserving the reasonable flood passage capacities of natural watercourses. To provide this control, The Reclamation Board develops plans, adopts floodway boundaries, investigates possible modifications of boundaries, and approves as acceptable the use and structures within floodways.

Currently, the State has designated floodways along the Kings River North and several reaches of the San Joaquin River. These reaches include Friant Dam to Gravelly Ford, Salt Slough to the Merced River, and the Merced River to Airport Way.

Flood Plain

Historically, the flood plain was fairly broad, and many small sloughs existed. Today it is now confined to within the levees except during major flood events when the levees are either overtopped or breached. Flood plains for economic evaluations were developed based on historic flooding and information gathered from FEMA 100-year flood plain studies. Historic mapping of inundation during 1955, 1958, 1965, 1967, and 1969 was available to develop the flood plain. Various FEMA flood plain studies were also used to determine the 100-year flood plain. These FEMA flood plain studies covered Fresno, Madera, Merced, San Joaquin, and Stanislaus Counties and were completed between 1982 and 1989.

The flood plain from Friant Dam downstream to Gravelly Ford, a distance of about 35 river miles, is fairly narrow and confined. The river is entrenched upstream from Highway 145. Riverbed slopes vary from about 3.5 feet per mile near Friant Dam to about 2 feet per mile at Gravelly Ford. Near Gravelly Ford, despite numerous sand and gravel mining operations along the river, deposits of sands and gravels are highly pronounced. However, the channel bottom appears to have degraded significantly at many locations along this reach of the river. The flooded areas adjacent to the river in this reach are primarily agricultural lands. Only minor structures are found in this reach. No specific flood plains were developed in this reach for this study.

Most of the river downstream from Gravelly Ford is bounded by levees. Flood plains for reaches below the Chowchilla Bypass are shown on Plates 5 through 18. The average channel slope in the reach of river from Mendota Pool downstream to Mariposa Bypass is about 1.2 feet per mile. Numerous sediment deposits are found throughout this reach of the river. The lower San Joaquin River downstream from Merced River is bounded by setback levees with the average channel slope being about 0.8 foot per mile. Flood plain areas adjacent to the river are also primarily agricultural lands. Areas from river mile 118 to 170 are primarily wildlife refuge lands. Several small communities are located along the river reach, including Mendota, Firebaugh, and Dos Palos. Most of these communities are outside the flood plain of the San Joaquin River. However, the community of Firebaugh is located on the edge of the identified flood plain.

Flood Characteristics

Floods on the streams in the basin are of two general types: those which occur during the late fall and winter, primarily as a result of intense rainfall, and those which occur during the late spring and summer, primarily as a result of snowmelt. Rain floods are characterized by high peak discharges at foothill elevations and lower peaks downstream. Damaging stages last only a few days along the tributary streams, but have a longer duration along the lower San Joaquin River. The snowmelt floods are characterized by moderate peak flows and damaging stages for several weeks. The flood hazard on the drainage basins below the 4,000-foot elevation is due to rainfloods. The effect of snow on the flood runoff from these streams is negligible.

Flood Problems

Historical Flooding

Historically, the basin has been subject to floods occurring during late fall and winter months, primarily as a result of prolonged general rainstorms, and to floods occurring during the spring and early summer months, primarily as a result of unseasonable and rapid melting of the winter snowpack in the Sierra Nevada. Fed by many hundreds of streams, the main channel of the San Joaquin River and its tributaries has historically overtopped their banks. One of the earliest recorded floods was the great winter flood of 1861-1862. During this flood, waters of the San Joaquin and Sacramento Rivers spilled over their banks, forming an inland sea covering an area 250 to 300 miles long and 20 to 60 miles wide. Other early floods occurred in 1850, 1862, 1868, 1886, 1907, and 1911. Long recognized as a flood threat, the flood problems of the San Joaquin River have been studied since the 1800's.

Thirteen flood events along the San Joaquin River occurred between 1950 and 1986. Tables III-1, III-2, and III-3 show historic flooding and the resulting economic damages from these floods. Widespread flooding resulted from levee failures and seepage. Photographs on the following pages show some historical flooding.

Existing Flood Problems

During floods that occurred during 1969, 1983, and 1986, it became apparent that the San Joaquin River in various reaches no longer has the capability to convey channel design flows. Two resource problems are perceived to cause increased flood stages resulting in capacity problems. These problems are encroachment of vegetation and sediment deposition in the river channel. Vegetation encroachment and sediment deposition are in part caused by geomorphic changes resulting from reduced mean flows in the channel. It is desirable to maintain the channel capacity in the lower reaches of the San Joaquin River to reduce the flood frequency and stage of water in the overbank floodways which contribute to seepage and erosion problems. In the reaches, overflows into wetlands are desirable to contribute to additional wetland water and to reduce peak flows. Other existing flooding problems include subsidence and levee stability deficiencies. Each of these problems is described in more detail below.

Sedimentation

Throughout the San Joaquin River system, aggradation, erosion, and agricultural practices have caused large amounts of sediment to accumulate in the San Joaquin River. This sediment has reduced the flow capacity of the channel and increased the frequency and duration of high water stages. These stages in the river channel have caused numerous levee failures and seepage problems at flows substantially below the design capacities in both San Joaquin and Stanislaus Counties. Bank erosion, low turbid flows during dry years, and agricultural runoff are the primary sources of this sediment buildup on the mainstem of the San Joaquin River. The overall effect of the ongoing sediment deposition is a reduction in the amount of flood protection for the San Joaquin basin.

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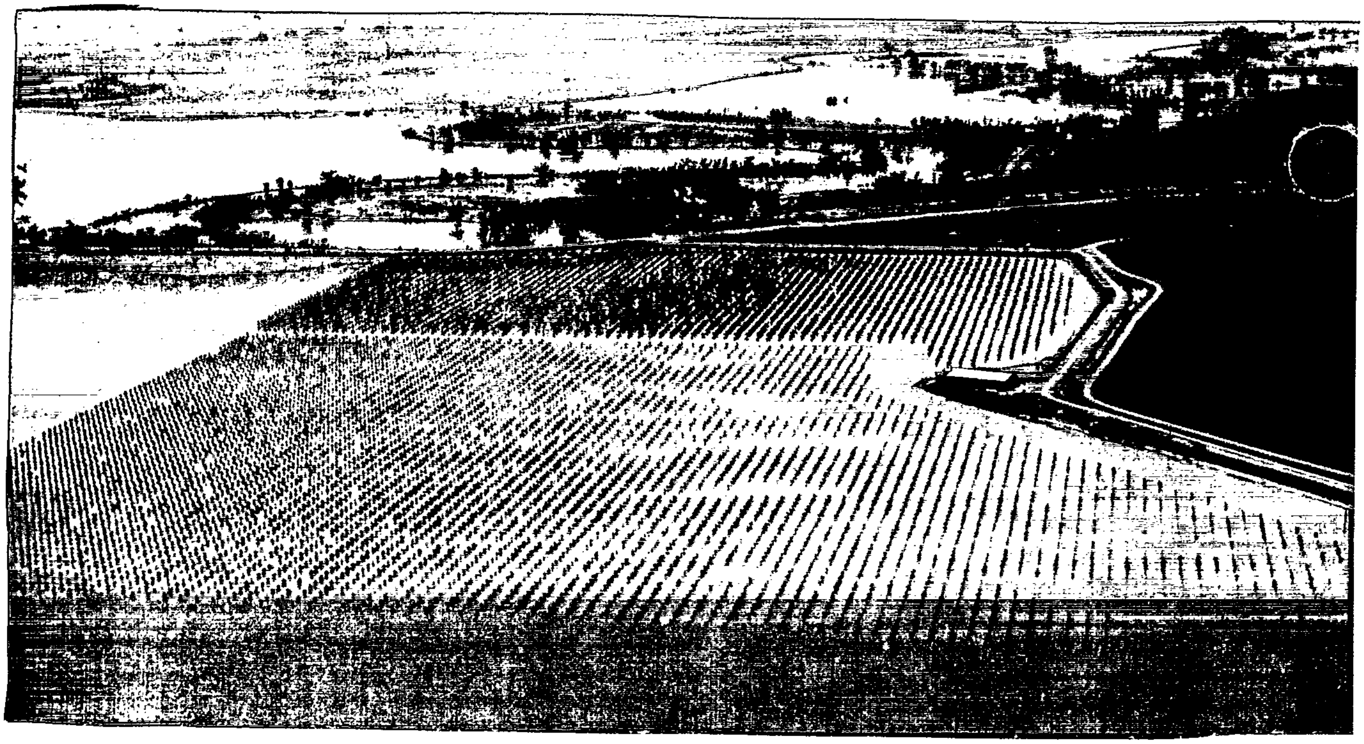

Flooded Orchard South of Highway 132 in May 1967.

Flooding on San Joaquin River near Perrin Way in March 1983.

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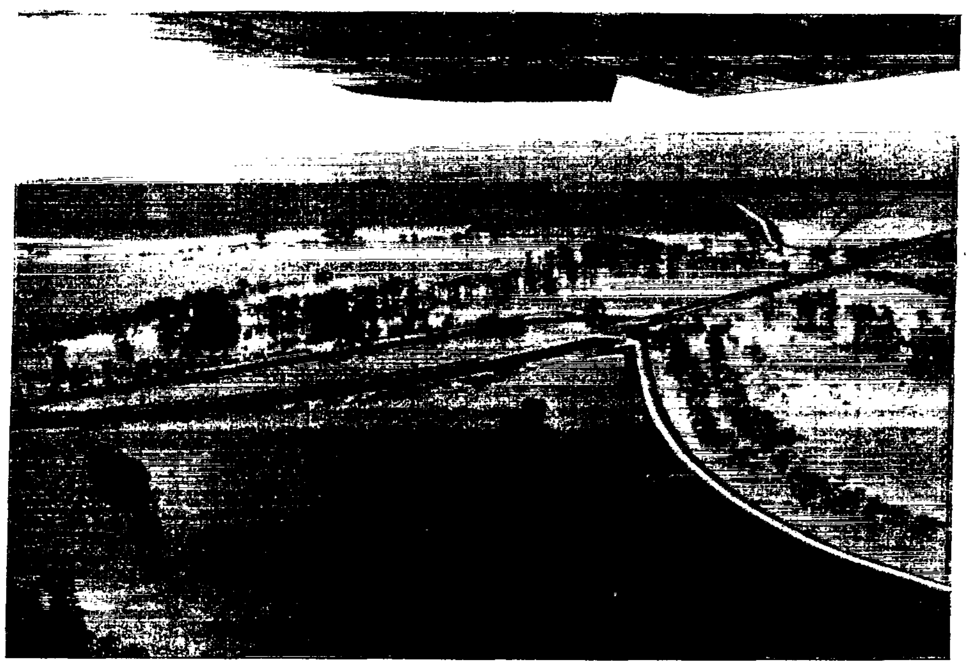
Flooding on San Joaquin River near Airport Way in March 1983.



Flooding on San Joaquin River near Highway 132 in March 1983.

Table III - 1
Historic Flooding from Rain Storms in San Joaquin River Basin

SAN JOAQUIN RIVER NR NEWMAN			SAN JOAQUIN RIVER NR VERNALIS		
DATE	PUBLISHED FLOW (cfs)	EXCEEDENCE INTERVAL (years)	DATE	PUBLISHED FLOW (cfs)	EXCEEDENCE INTERVAL (years)
11 Dec 1950	11,600	4	9 Dec 1950	79,000*	160
29 Dec 1955	16,800	8	25 Dec 1955	50,900	60
6 Apr 1958	21,600	13	5 Apr 1958	41,400	41
26 Feb 1969	34,700	50	27 Jan 1969	52,600	65
25 Feb 1980	23,500	18	27 Feb 1980	33,900	9
17 Apr 1982	20,300	12	18 Apr 1982	29,800	8
4 Mar 1983	30,300	40	7 Mar 1983	45,100	45
19 Mar 1986	36,900	60	18 Mar 1986	23,100	5

* Estimated peak including flow through levee breaks

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Table III - 2
Historic Snowmelt Flooding in San Joaquin River Basin

SAN JOAQUIN RIVER NR NEWMAN			SAN JOAQUIN RIVER NR VERNALIS		
DATE	PUBLISHED FLOW (cfs)	EXCEEDENCE INTERVAL (years)	DATE	PUBLISHED FLOW (cfs)	EXCEEDENCE INTERVAL (years)
30 May 1952	13,200*	8	1 Jun 1952	33,700	42
20 May 1958	11,600*	6	26 May 1958	29,100	18
27 Apr 1967	15,400*	9	30 Apr 1967	25,900	11
11 Jun 1968	19,300*	18	1 Jun 1968	35,000	50
29 Apr 1978	15,300	9	3 May 1978	26,200	17
4 May 1983	18,400	16	6 May 1983	37,300	60

* Does not include flows in Merced River Slough that bypass gage.

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Table III - 3
Historical Flood Damages[1]

Date	Basinwide[3]		San Joaquin Mainstem[2]	
	Acres Flooded	Flood Damages	Acres Flooded	Flood Damages
Nov. - Dec. 1950	164,500	$6,008,000 (1950 dollars)	68,900	$1,948,000 (1950 dollars)
Dec. 1955 - Jan. 1956	149,100	$12,144,000 (1955 dollars)	27,800	$2,025,000 (1955 dollars)
Feb. - June 1958	275,400	$10,816,000 (1958 dollars)	91,400	$2,606,000 (1958 dollars)
Jan. - Feb. 1963	17,940	$370,000 (1963 dollars)	0	
Dec. 1964 - Jan. 1965	27,900	$2,234,000 (1965 dollars)	1,000	$274,000 (1965 dollars)
Dec. 1966 - Mar. 1967	15,480	$414,000 (1967 dollars)	400	$2,000 (1967 dollars)
Jan. 1968 - Feb. 1969	288,400	$21,030,000	129,470[4]	$7,462,000 (1969 dollars)
1983			8,000	$8,000,000
1986				

1 Based on data from Corps past flood reports and design memoranda.
2 Does not include damages above Friant Dam.
3 Does not include the Cosumnes, Mokelumne and Kings River, Upper Delta area, and areas above the dams.
4 Includes 41,087 acres of duck ponds and wasteways from Chowchilla Canal to Merced River.

Many areas with high berms in the floodway have been eroded and transformed into downstream lower elevation deposits. These low level deposits are inundated more often and for longer periods than the higher berms lost by erosion. Seasonal vegetation can be found where these mineral-enriched sediments have formed into sandbars and mid-channel islands.

Eroded soil from furrow-irrigated cropland accounts for a large quantity of the sediment that enters the San Joaquin River. As croplands are irrigated, water is built up in furrows or tailwater ditches in order to allow sufficient time for the water to infiltrate into the soil. This practice generally creates excessive runoff, causing soil erosion and sediment transport.

As these runoff flows reach the rivers, streams and sloughs, the suspended solids settle out, creating sandbars that can restrict flows and reduce the overall channel capacity.

The "West Stanislaus Sediment Reduction Plan," completed by the Soil Conservation Service (SCS) in 1992, identifies problems and recommends measures that could reduce many of the nonpoint source pollution problems in the West Stanislaus Resource Conservation District. Increasing agricultural return flows from this side of the valley contribute heavily to the sediment load of the river. These sediment loads are primarily a result of current farming and irrigation practices. The SCS proposes a variety of irrigation management measures that could be implemented to reduce sediment rates by 50 to 100 percent.

Increased sedimentation also causes other problems. For example, suspended sediments increase turbidity and may have adverse effects on fisheries and other aquatic life. Also, agricultural pesticides and chemical pollutants attach themselves to soil particles and may deposit in the bottom of the river channel.

Other surveys by various agencies since the 1930's attest to the substantial aggradation of the channel caused by increasing levels of sediment deposits. Currently, there is no successful program of aggradation control in the San Joaquin River basin.

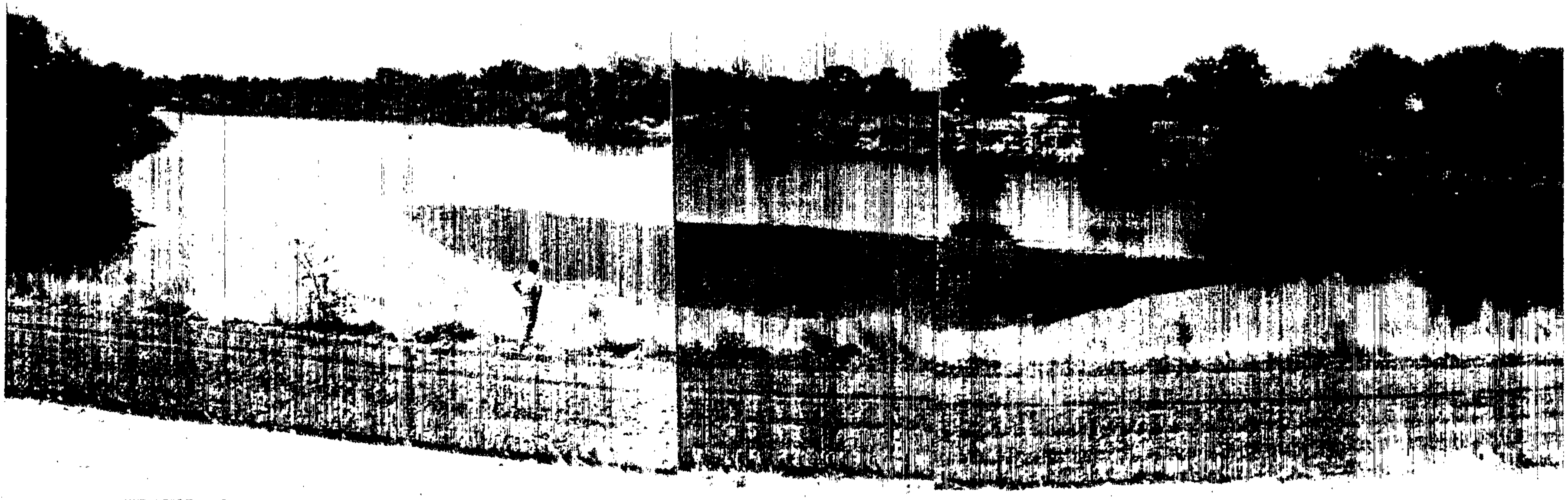
Encroachment of Vegetation

Excess vegetation exists along some reaches of the San Joaquin River. This vegetation consists mainly of grasses and scrub that has colonized the areas. Willows and alders are interspersed with some elderberry and cottonwood trees. This excess vegetation results from lack of adequate channel maintenance and the prolonged drought. Vegetation is now growing in areas that would normally be flooded during normal flow years.

This vegetation causes problems, including capturing flood debris, restricting passage of floodflows, and increasing water surface elevations in the channels. During high flows, the elevated water surface elevations have resulted in crop damage due to seepage and loss of irrigation facilities due to flooding. Photographs on the following page show sediment deposition and vegetation encroachment.

Erosion

Active river bank erosion occurs throughout the entire San Joaquin basin. Most of the erosion occurs due to the meandering nature of the river system. Tight river bends, high vertical banks, and seasonal fluctuations in channel flows contribute to the erosion process. Most of the worst erosion occurs on the



Sedimentation at river mile 60.6.

O[illegible]growth vegetation on top and riverside [illegible] Overgrowth vegetation on riverside s[illegible] of outside of bends with less serious erosion taking place on straight sections and on the inside banks of the meanders.

Some of the erosion areas pose an immediate threat to the existing flood control system. Numerous levees, access roads, and flood control structures are within 50 feet of these eroding banks. Along the mainstem of the San Joaquin River, 1.8 of the 28.9 miles of actively eroding banks have been identified as critical according to aerial surveys and field visits. Photographs on the following page show some of these erosion sites. If these critical areas are not repaired, erosion will continue to damage the banks and could lead to serious levee failures and related damages during a flood event. The areas found to be less critical do not pose an immediate threat but could eventually threaten the flood control system.

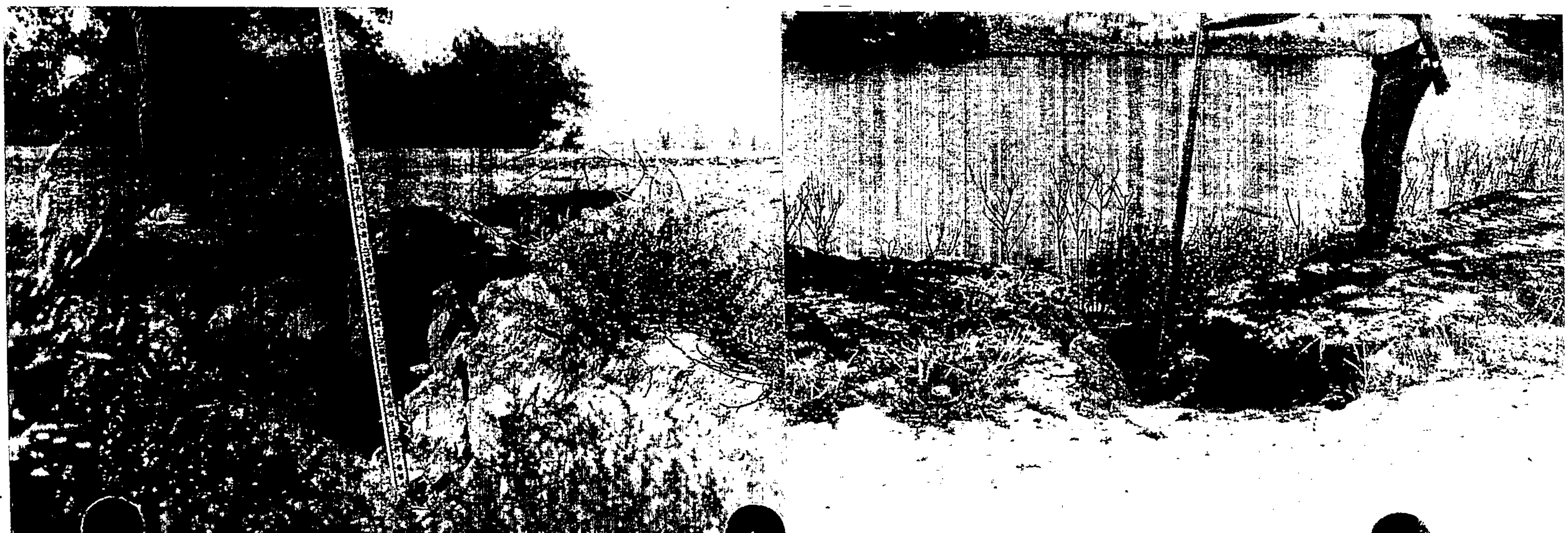
Seepage

Seepage is the condition where water in the leveed river channel saturates the levees and leaks or seeps through the levee structure onto the adjoining landside areas. Seepage damages occur primarily during snowmelt floods when there are high stages in the rivers for prolonged periods.

In general, the areas of seepage damage include all lands whose elevations are below the levels of the water in the river and where permeable subsurface soil strata conduct large quantities of lateral flow by the hydraulic pressure of the higher water. In some places the seepage flow saturates these lands in a day or two, and in some places, particularly where the soil strata surfaces some distance from the river, it may take 2 or 3 weeks.

This seepage causes primarily agricultural damages. Seepage quickly drowns most planted crops. Losses also occur on lands that are not planted at the time of seepage. Most such lands either have had, or need, expensive preparatory work for the next crop. Delays caused by seepage typically prevent timely planting of a crop or necessitate planting fast-growing, lower yielding crop varieties. Lands often cannot be economically farmed to any crop in the year that seepage occurs. Furthermore, in most situations, the upward flow of seepage waters brings previously leached residual salts up into the root zone. These salts stunt and reduce the yield of the next crop. According to local interests, seepage and soil salinity problems start at a water elevation of about 21 feet at Vernalis and increase rapidly as the river rises.

Levee erosion on landside slope at river mile 60.7.



[illegible]osion on landside slope at river mile 60

Land Subsidence

Two main types of land subsidence are found in the study area: (1) generalized subsidence due to overpumping of groundwater aquifers and (2) localized subsidence due to wetting of moisture-deficient ground by irrigation. The second type, which is known as hydrocompaction, occurs along irrigation canals but does not usually affect the streambeds of natural streams and rivers.

Land subsidence due to groundwater pumping began in the San Joaquin Valley in the mid-1920's. The affected areas were mainly in the western and southern parts of the valley where runoff from surface streams is minimal. In western Fresno County, the maximum exceeded 25 feet by 1970 and reached 29.7 feet by 1981. More than 5,200 square miles of irrigable land, one half of the entire valley, has subsided at least one foot.

This subsidence caused several serious and costly problems for the farmers. These problems included (1) uneven land levels, (2) ruptured casings of deep water wells, and (3) unexpected flooding due to changes in the gradient and course of valley streams. In addition, highways and water-transport structures were more difficult to construct and maintain.

However, due to the importation of surface water through major canals and the California Aqueduct in the 1950's and 1960's, pumping of groundwater was greatly reduced. By 1983, groundwater levels in most actively subsiding areas of the San Joaquin Valley basin had returned to their 1940-50 levels, and subsidence had slowed or stopped.

Levee Stability

Structural stability problems in the levees result from erosion, seepage, boils, and sloughing.

Prolonged high water in the river channel in San Joaquin and Stanislaus Counties has caused levee failures at river flows substantially below design flow capacities.

Future Flood Threat

The flood control system of the San Joaquin River and its tributaries is a complex system of dams, levees, channel improvements, and bypass canals. The effectiveness of this system continues to be affected by reduced floodway capacity due to reduced mean flows within the channels, sediment deposition, and environmental constraints. As socioeconomic conditions and the uses of natural resources change, the system needs to be evaluated, improved, and maintained to address changing flood control problems and needs.

Opportunities

Reservoir Reoperation

Potential solutions to the water-related problems in the study area could include the improved coordinated management of the San Joaquin River system reservoirs to meet flood control and environmental needs. Some solutions could consist of modifying the operations of the reservoirs so that releases are made on an integrated basis. Currently, operations for each reservoir are based on the water rights and needs of the individual owners and districts for their service. However, the owners do informally coordinate their operations during the flood season, and the Corps continually attempts to improve the coordinated operation of all flood control projects in the basin.

The Corps has recently evaluated the potential of modifying the Emergency Spillway Release Diagram for Friant Dam and has determined that changes could improve the operation of the flood control system. Procedures to implement these changes to the flood control diagram are proceeding. This type of change could be considered for other projects within the San Joaquin River basin. However, only two other projects with emergency release diagrams exist within the San Joaquin system: Pine Flat Lake and New Exchequer Dam. The Pine Flat Lake diagram has already been optimized in a similar manner to Friant Dam, and no appreciable benefit would result from a change to the New Exchequer diagram.

The Corps presently has a computer model of the San Joaquin River basin which can be used to determine the impacts of refinements to the flood control operation of all the projects in the system. This model can be used as a planning tool or during real time operation. The Corps is continuing to improve this model. If planning studies indicate a need for a water control benefit for a specific area which is not presently considered in the flood control operation, the model can be used to estimate the impact on the entire system and to help determine if a change is desirable.

While current operating procedures involve coordination among the agencies responsible for flood control, an overall flood control systems operation could be developed to optimize the use of water resources and provide optimal levels of flood protection.

Environmental Restoration

Local, State, and Federal flood control and water development projects account for the major losses of wetlands and riparian habitat in the Central Valley. Direct and indirect impacts from these projects have contributed to a serious decline in the biological resources of the San Joaquin Valley. Since the

Corps' projects have been a major influence in the development of the San Joaquin basin, there is a significant opportunity for the restoration of fish and wildlife resources now in a degraded condition.

Flood control along the mainstem has caused direct impacts on riparian and wetland wildlife habitat areas through construction of levees and bypasses and sediment and vegetation removal. These activities have destroyed streamside vegetation, denied floodwaters to wetlands and riparian areas, and filled in many acres of wetlands. Fish and wildlife are adversely affected as these habitat areas diminish or are adversely affected.

Indirect impacts on riparian and wetland wildlife habitat areas have resulted from the numerous upstream multipurpose water storage projects in the basin, which have changed the river's hydrology and flood plain. Reduced peak flows have lowered the water table and narrowed the 100-year flood plain. This has allowed and/or encouraged the development (primarily agricultural) of these historic riparian and wetland areas, which has largely eliminated their previously abundant fish and wildlife habitat values. Thus, fish and wildlife resources have significantly diminished.

Native fish, especially anadromous species, have also been directly affected by water development projects. Upstream impoundments have altered the hydrology of the river system and eliminated spawning areas, while channel clearing and levee construction have reduced fish habitat in the mainstem, especially important shaded riverine habitat. Dams on the mainstem and tributaries have blocked access to approximately 40 percent of upstream spawning and rearing areas. Dams have also caused a loss of gravel recruitment and gravel cleansing flows to downstream reaches.

Recreation

The main problem affecting recreation on the mainstem and tributaries of the San Joaquin River is the lack of water in many reaches. As the water supply and water quality of the rivers decrease, so do the supply and quality of opportunities for fishing, swimming, and boating. Other problems include limited managed access to the rivers and few fishing sites.

There is a need for additional outdoor recreation areas in the study area. The five counties had a total 1990 population of 1.78 million people, and this number is expected to double in about 40 years. To meet the current unmet and future needs of the San Joaquin River area, efforts need to be made to create a variety of new recreational and leisure opportunities.

Currently, the greatest opportunity to promote recreational activities beyond traditional hunting and fishing is the San Joaquin River Parkway Plan. The plan, adopted the spring of 1992 by the San Joaquin River Parkway Task Force, is a proposal for conservation, education, and recreational uses on 33 miles of San Joaquin River bottomlands from Friant Dam to State Highway 145.

TRIBUTARIES

Kings River North

The Kings River watershed is located in the southeast portion of the San Joaquin River basin. The Kings River originates in the Sierra Nevada and flows into the valley, where it divides into two branches. The Kings River North branch (also called Fresno Slough) flows north into the San Joaquin River, and the second branch flows south to Tulare Lake.

Flows on the Kings River are regulated by the Pine Flat Dam, which was first operated for flood control in 1952. The operation of Pine Flat in conjunction with Army Weir, which controls the flow to the north and south branches, has been to send floodwaters north up to channel capacity and the remainder south up to channel capacity. During periods of high flow, flow at Mendota Dam has been kept well below the flow that would have occurred naturally. However, project flows have been allowed to exceed computed natural flows during low flow periods in order to avoid spilling the reservoir.

Early studies indicated that the capacity of Kings River North channel was 4,750 cfs; however, the channel has passed flows exceeding 4,750 cfs. In 1969, the channel passed over 6,000 cfs and in 1982 over 5,000 cfs. However, these flows were sent north only when it was apparent that if they were not, Pine Flat Lake would spill, and much larger flow would result later.

High flows in the Kings River North cause seepage along that channel and on the San Joaquin River. High flows also flood land that is in the channel on both the San Joaquin River and Kings River North. (Much of the land within the levee systems is farmed or used for other purposes, such as recreation, based on the assumption that it will not flood very often.) High flows also increase channel maintenance costs.

Fresno River

The Fresno River is located in Madera County and enters the valley east of Madera below Hidden Dam. The drainage area of the Fresno River at Hidden Dam is 240 square miles. The 1912-1988 average flow at the dam was 81,700 acre-feet. Hidden Dam is operated to mitigate floodflows and to conserve water for Madera

Irrigation District, which diverts water at the Madera Canal in Madera.

Chowchilla River

The Chowchilla River is located in Madera County and has a drainage area of 240 square miles above Buchanan Reservoir. Buchanan Dam, the only major structure on the Chowchilla River, was completed in 1977 by the Corps. Soon after entering the valley floor below the dam, the Chowchilla River splits into three channels: the lower Chowchilla River, Berenda Slough, and Ash Slough. Most river flows pass into Berenda and Ash Sloughs, and much of this water is diverted at Chowchilla Water District's Berenda Diversion Dam. The average flow of the Chowchilla River at Buchanan Dam was 71,900 acre-feet. Of this total, the portions diverted by Chowchilla Water District and others, as well as the seepage losses from the various channels of the river, provide a source of water supply to the valley.

Merced River

The Merced River is located in Merced County and has a drainage area of 1,037 square miles above Exchequer Dam, which is the largest dam on the Merced River and is operated by the Merced Irrigation District to regulate runoff and generate hydroelectric power. The average flow of the Merced River at Merced Falls Dam, just downstream of Exchequer Dam, was 1,024,000 acre-feet. Irrigation water supplies are diverted by the Merced Irrigation District through its Main and Northside Canals, which divert from the river near Merced Falls. Downstream from these diversions, several riparian diversions of Merced River water are made near Snelling by various companies. Further downstream, additional riparian diversions are made by pumping from the river.

Tuolumne River

The Tuolumne River is located in Stanislaus County and has a drainage area of 1,540 square miles above Don Pedro Dam. Don Pedro Reservoir is the primary irrigation storage facility on the Tuolumne River and is jointly operated by Modesto and Turlock Irrigation Districts. The 1922-1978 average flow of the Tuolumne River below La Grange Dam, a smaller downstream diversion dam, was 449,900 acre-feet per year. Water is diverted at La Grange Dam by Modesto and Turlock Irrigation Districts through their separate main canals. Upstream diversions of Tuolumne River water by the City and County of San Francisco limit the amount of water available to the valley. In the past, these diversions have averaged 220,000 acre-feet per year.

Stanislaus River

The Stanislaus River is located in Stanislaus County and has a drainage area of 900 square miles above New Melones Dam. This dam and the downstream Tulloch Dam regulate the Stanislaus River for conservation. At Knights Ferry, where the Stanislaus River enters the valley, the 1922-1978 average flow was 542,700 acre-feet per year. Stanislaus River water is diverted by South San Joaquin Irrigation District and Oakdale Irrigation District from Goodwain Dam near Knights Ferry. Additional riparian diversions are made downstream of Knights Ferry by various growers.

LOCAL CONCERNS

Most organizations and individuals concerned with flood and seepage problems along the San Joaquin River believe that aggradation and encroachment of vegetation have occurred at many locations, causing higher stages in the river. Local interests have frequently requested that restrictions and blockages in the river channel be removed in order to reduce flood stages.

CHAPTER IV
PLAN FORMULATION

GENERAL

Plan formulation is the process of developing and evaluating alternative plans to meet the needs and desires of society as expressed in specific planning objectives. The procedure followed in this reconnaissance study was:

- Establish specific planning objectives.
- Define constraints and assumptions for formulating alternative plans.
- Identify measures to address the planning objectives.
- Develop alternatives from the measures to meet the planning objectives.
- Compare and evaluate the alternative plans.

PLANNING OBJECTIVES

On the basis of the flooding problems and other water resource needs and opportunities, the following planning objectives were developed and used in the formulation and evaluation of alternative plans. Review of historical flood damages within the basin indicated that significant damages have occurred on the tributaries. It became apparent that evaluation of all the tributaries was beyond the capabilities of this reconnaissance study. Consequently, planning objectives focused on addressing problems related to the mainstem of the San Joaquin River. Separate studies of alternative plans for the tributaries are needed to provide basin wide water resources development.

Flood Control

The overall flood control objective is to provide greater levels of flood protection to the San Joaquin Valley area from overflows from the San Joaquin River Mainstem and tributaries. More specific flood control objectives include the following:

- Identify problems in carrying out existing O&M requirements.
- Eliminate problems related to O&M requirements of maintaining channel capacity.
- Reduce peak flows in the San Joaquin River Mainstem.

- Maintain existing levels of flood protection or increase levels of flood protection consistent with environmental values.

Environmental Restoration

- Enhance and/or restore biological resources in the San Joaquin River basin and evaluate such opportunities elsewhere in the watershed incidental to the flood control objective.

PLANNING CONSTRAINTS

Plan formulation constraints for this study include congressional direction; current applicable laws, regulations, and policies; and existing water resource projects affecting the study area. Also, due to the complexity of the flood control and environmental issues in the study area, the focus of the development of alternative plans was on the mainstem of the San Joaquin River.

Specific constraints include the following:

- Implementation of existing O&M requirements is constrained by institutional requirements to prepare environmental documentation (leading to significant mitigation requirements and costs) related to the regulatory Clean Water Act Section 404 permitting process.

- Implementation of standard sediment and vegetation removal procedures for maintenance requirements are constrained by compliance requirements established under NEPA, CEQA, Migratory Bird Treaty Act, and other Federal and State statutes.

- Environmental restoration alternatives must address environmental impacts caused by past flood control projects.

- Environmental restoration alternatives must meet constraints established under Section 11356 (a) of the WRDA 1986 and Policy Guidance Letter No. 24.

PLANNING ASSUMPTIONS

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

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 Condition

Under the without-project condition, no action would be taken by the Federal government to improve flood control or environmental values of the system. Institutional constraints related to carrying out the O&M of the existing project will continue to hamper maintaining channel capacity. The following assumptions are made related to future O&M and the channel capacity:

- The O&M requirements as currently established will require further NEPA and CEQA documentation to address potential impacts related to vegetation and sediment removal required for maintenance of channel capacity.

- It is likely that any NEPA and CEQA documentation will establish that significant, costly mitigation will be required to offset the impacts relating from vegetation removal. In particular, losses related to riparian and shaded riverine aquatic habitat will likely result in significant mitigation requirements.

- Sediment removal within the mainstem of the San Joaquin River will not be accomplished.

- Vegetation removal will be limited to 50 percent of the total amount that needs to be removed.

- Restricted sediment removal and vegetation removal within the mainstem of the San Joaquin River will lead to a slow deterioration of the existing flood control project.

The amount of vegetation and sediment removal that is expected to be carried out under the without-project condition is shown in Table IV-1. Flood events in the lower San Joaquin River would continue to erode certain riparian areas, resulting in a loss of mature woodlands and willow thickets. This would be somewhat offset by the creation of riparian habitat at sediment deposition areas, although at younger successional stages. Limited vegetation clearing could prevent significant increases in riparian vegetation within the channel.

TABLE IV - 1 CHANNEL AND LEVEE MODIFICATION ALTERNATIVE - INITIAL VEGETATION AND SEDIMENT REMOVAL

RIVER MILE	EXISTING VEGETATION				NO ACTION ALTERNATIVE VEGETATION REMOVAL			CHANNEL & LEVEE ALTERNATIVE VEGETATION REMOVED			CHANNEL & LEVEE ALTERNATIVE SEDIMENT REMOVED	
	TOTAL ACREAGE (ACRES)	MATURE GROWTH (ACRES)	BRUSH (ACRES)	UPLAND (ACRES)	MATURE GROWTH (ACRES)	BRUSH (ACRES)	UPLAND (ACRES)	MATURE GROWTH (ACRES)	BRUSH (ACRES)	UPLAND (ACRES)	VOLUME (CY)	AREA (ACRES)
132-133	6.82	0.51	4.56	1.75	0.00	2.28	0.88	0.51	2.28	0.88	107.00	6.50
133-135	23.57	6.75	10.02	6.80	0.00	5.01	3.40	6.75	5.01	3.40	467.00	8.75
135-137	15.06	1.73	5.47	7.86	0.00	2.74	3.93	1.73	2.74	3.93	278.00	8.95
137-139	18.39	3.29	6.99	8.11	0.00	3.50	4.06	3.29	3.50	4.06	247.00	6.09
139-141	13.14	2.61	4.20	6.33	0.00	2.10	3.17	2.61	2.10	3.17	207.00	7.36
141-142	12.25	1.81	5.05	5.39	0.00	2.53	2.70	1.81	2.53	2.70	230.00	11.38
142-144	52.36	6.91	14.05	31.40	0.00	7.03	15.70	6.91	7.03	15.70	388.00	15.07
144-147	40.30	7.90	16.66	15.74	0.00	8.33	7.87	7.90	8.33	7.87	255.00	11.60
147-148	9.47	1.79	3.09	4.59	0.00	1.55	2.30	1.79	1.55	2.30	92.00	0.75
168-169	9.40	0.00	4.11	5.29	0.00	2.06	2.65	0.00	2.06	2.65	465.00	7.48
169-171	11.98	0.00	1.38	10.60	0.00	0.69	5.30	0.00	0.69	5.30	237.00	2.70
171-173	9.22	0.00	0.72	8.50	0.00	0.36	4.25	0.00	0.36	4.25	201.00	4.02
173-175	0.49	0.00	0.49	0.00	0.00	0.25	0.00	0.00	0.25	0.00	226.00	7.96
175-176	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.00	2.70
176-178	10.81	0.00	1.81	9.00	0.00	0.91	4.50	0.00	0.91	4.50	169.00	33.33
178-179	6.60	0.00	0.85	5.75	0.00	0.43	2.88	0.00	0.43	2.88	169.00	10.61
179-181	5.97	0.00	0.97	5.00	0.00	0.49	2.50	0.00	0.49	2.50	249.00	9.40
181-183	34.49	3.85	10.53	20.11	0.00	5.27	10.06	3.85	5.27	10.06	1576.00	9.00
183-185	18.98	5.13	9.95	3.90	0.00	4.98	1.95	3.34	4.98	1.95	2522.00	14.02
185-186	16.60	3.50	10.02	3.08	0.00	5.01	1.54	3.50	5.01	1.54	468.00	9.55
186-187	19.61	4.33	9.95	5.33	0.00	4.98	2.67	4.33	4.98	2.67	789.00	11.81
187-190	16.29	7.57	8.37	0.35	0.00	4.19	0.18	7.57	4.19	0.18	460.00	16.28
190-192	26.15	6.16	12.24	7.75	0.00	6.12	3.88	6.16	6.12	3.88	516.00	8.00
192-194	19.24	4.45	9.01	5.78	0.00	4.51	2.89	4.45	4.51	2.89	700.00	10.50
194-196	23.91	6.21	9.70	8.00	0.00	4.85	4.00	6.21	4.85	4.00	15601.00	3.96
196-198	37.74	7.94	16.55	13.25	0.00	8.28	6.63	7.94	8.28	6.63	1197.00	7.00
198-200	29.78	5.74	10.63	13.41	0.00	5.32	6.71	5.74	5.32	6.71	699.00	9.50
200-201	39.66	16.55	11.11	12.00	0.00	5.56	6.00	16.55	5.56	6.00	449.00	6.00
201-205	30.01	11.85	10.16	8.00	0.00	5.08	4.00	11.85	5.08	4.00	453.00	5.00
TOTAL	558.29	116.58	208.64	233.07	0.00	104.32	116.54	114.79	104.32	116.54	29454.00	265.27

As sediment deposition continues and channel capacity is restricted in various locations, there will likely be increased erosion and other structural stability problems along the levee. This could lead to increased emergency work to repair erosion and other threatened areas and further degradation of the riparian habitat. Eventually, however, restrictions to channel capacity will most likely cause additional flooding to agricultural lands adjacent to the river, and to the community of Firebaugh located near the river.

Land uses within the study area are not expected to change significantly in the near future. The relative percentages of lands in various cover types and uses should remain fairly constant. Some agricultural and natural lands will be converted to residential and commercial uses to accommodate the expected population increases, but this will not change the predominantly agricultural landscape of the valley. Most of the expected growth is already planned for marginal agricultural lands adjacent to the existing urban areas.

In the long term, land use patterns could change radically if salinity or agricultural drainage problems are not solved, if the drought continues, or if potential water reallocations for fish and wildlife are mandated based upon Federal legislation. In any of these cases, agricultural lands could be forced out of production and would likely revert back to native grasslands and/or scrub/shrub habitats.

With-Project Condition

The with-project condition involved the implementation of one or more flood control/environmental restoration alternative plans. Each alternative plan would provide an increase in the level of flood projection and restore historic environmental resources.

POTENTIAL MEASURES

Possible flood control/environmental restoration measures were identified by the Corps and local interests at the onset, and during, the study. These measures included storage, levee and channel work, diversion, nonstructural, and enhancement or restoration of environmental resources. Sites where specific measures could be used were identified in the study area. Finally, these measures were evaluated with respect to technical, economic, environmental and local acceptance criteria.

Flood Control

Develop Upstream Storage

The purpose of this measure is to provide high levels of flood protection to downstream areas. The work involves constructing new upstream dams and reservoirs and operating them to control streamflows. However, each of the main tributaries, as well as the San Joaquin River, already has a large dam and reservoir that includes storage space for flood control. In addition, the Bureau and the Madera Irrigation District are currently studying the feasibility of constructing dams on Dry Creek (Montgomery Dam and Reservoir) and Fine Gold Creek, respectively. These agencies may ask the Corps to participate in their projects in the future.

Modify Existing Levees

The purpose of this measure is to restore the structural integrity of the existing levee system along the mainstem of the San Joaquin River. The work involves ensuring structural stability of levees and raising levees to provide freeboard where needed. This measure would reduce flooding and seepage on lands adjacent to the floodway, and it was considered further.

Increase Channel Capacity

The purpose of this measure is to increase the flow capacity of the river channel. The work involves (1) removing excess sediment and vegetation from the river floodway, (2) removing sediment from Mendota Pool, (3) constructing sediment basins on tributaries to collect sediments prior to entering the mainstem, (4) constructing on-farm sediment retention basins to collect sediments prior to entering either the tributaries or mainstem, or (5) constructing sediment basins within the mainstem to control sediments which enter the river system.

Removing excess sediment and vegetation from the river floodway improves channel capacity conditions by removing site-specific constrictions. While requiring intensive management along the full length of the river system, this measure has proven to be effective in other river systems and was considered further.

Sediment removal from Mendota Pool would have a direct flood protection benefit by providing an easily accessible sink to trap sediments that would otherwise continue downstream, reducing the downstream channel capacity. This would significantly reduce the downstream maintenance work required by the State Reclamation Board. The proposed work would limit the reduction of channel capacity downstream due to sediment build up and would also reduce water surface elevations in the San Joaquin River and

Kings River North upstream of the pool. However, this sediment removal work falls under the jurisdiction of the Bureau since the Mendota Pool is a component of the CVP. Also, the Bureau is considering construction of a new Mendota Dam downstream of the existing structure. Because of the work being done by the Bureau, this measure was not considered further.

Sediment traps constructed on the tributaries just upstream of their junction with the mainstem of the San Joaquin River would reduce the deposition of material into the mainstem and contribute to maintaining the flood carrying capacity of the mainstem. The sources and quantity of the sediment would be determined to size the basins, and a maintenance program for removal of the sediment would be developed. However, a study of the sources and quantity of sediment for the San Joaquin basin was estimated to be a 2-year study and was beyond the scope of this reconnaissance study. Possible watersheds include the Toulumne, Stanislaus, Merced, and Chowchilla Rivers and Bear Creek.

On-farm sediment detention basins capture sediments before they enter the river system. The SCS has examined this measure and found it to be feasible in areas along the Stanislaus River. Since programs administered by SCS reduce agricultural erosion, this measure was not considered in detail.

Constructing sediment detention basins within the mainstem control sediments without having to implement an intensive program along the entire length of the river system. Similar in-stream basins have been effective in other river basins, and this measure was carried forward.

Divert Floodwaters

The purpose of this measure is to provide temporary storage for floodwaters on lands adjacent to the San Joaquin River and existing bypass facilities and thereby create immediate reductions in peak flows downstream from the diversion areas. Other potential benefits include recharge of depleted groundwater supplies, leaching of accumulated salts and other dissolved minerals on adjacent lands, availability of diverted floodwaters for Federal and State wildlife refuges, and use of flood flows for environmental restoration. Water would be diverted by constructing gated culverts. Existing channels, levees, and irrigation canals would be used to distribute the diverted floodflows to various sites. This measure appeared to be feasible and was evaluated further.

Nonstructural Measures

The purpose of nonstructural measures is to reduce flood damages rather than controlling floodwaters. Nonstructural measures may include such physical activities as relocating, elevating, flood proofing, or constructing floodwalls or levees to protect individual or small groups of structures. They can also include regulations or policies such as flood plain zoning and flood warning and preparedness planning.

In addition, a basin-wide nonstructural measure would involve optimizing the operation of existing reservoirs in the basin to improve flood protection to downstream areas consistent with other authorized purposes. Part of this measure could include an overall flood release schedule to coordinate releases among tributaries.

Environmental Restoration

This section presents measures for environmental restoration along the San Joaquin River. These measures focus on the significant resources in the study area as determined by the SJRMP, State and Federal fish and wildlife agencies, and the North American Waterfowl Management Plan. Riparian habitat, wetlands, and waterfowl are the most significant resources. These measures are consistent with the objectives of SJRMP and the Central Valley Habitat Joint Venture.

The Corps' criteria to qualify for historical restoration are:

- a previously constructed Corps civil works project contribution to the problem must be shown;
- significant resources must be addressed;
- an incremental analysis must show benefits;
- restoration should involve engineering measures and construction expertise while land acquisition should play a minor role or be unnecessary; and
- restoration must be justified by showing that monetary and non-monetary benefits outweigh monetary and non-monetary costs.

Corps involvement in environmental restoration appears to be justified by the environmental degradation associated with the numerous dam and reservoir projects the Corps has built or participated in within the San Joaquin basin. In addition, the Corps has completed flood control work along the mainstem of the San Joaquin River. To determine whether Corps' projects caused part or all of the environmental degradation for each restoration measure, a further examination is needed of the individual circumstances.

Restore Historic Wetlands

The purpose of this measure is to restore wetlands habitat in the valley consistent with the California Central Valley Habitat Joint Venture plan. This plan establishes a goal of restoring 20,000 acres in the San Joaquin Valley.

Restore Historic Riparian Habitat

The purpose of this measure is to restore riparian habitat along the mainstem of the San Joaquin River.

Restore Historic Shaded Riverine Aquatic Habitat

The purpose of this measure is to restore shaded riverine aquatic habitat along the mainstem of the San Joaquin River.

Restore Historic Fisheries

The purpose of this measure is to restore fisheries in the mainstem of the San Joaquin River.

TECHNICAL STUDIES

Hydrology

Hydrology of the San Joaquin River basin has been severely altered by the construction of several dams and reservoirs. Under the O&M program, the hydrology of the river basin has been updated, and this updated work has been used in this reconnaissance investigation. The work included the evaluation of precipitation, storm characteristics, stream flow, flood characteristics and flow frequency data, and the development of a hydrologic model to simulate past, present, and future conditions.

Precipitation

Annual precipitation in the basin ranges from 6 inches on the valley floor near Mendota to about 70 inches at the head waters of the San Joaquin River. Precipitation in the valley occurs primarily during the period beginning in November and ending in April. During the summer, little precipitation falls in the valley. The basins on the east side of the Coast ranges lie in a rain shadow and receive less precipitation than basins of the same altitude on the west side of the Sierra Nevada. The dividing line between precipitation in the form of rain or snow occurs at about 5,000 feet. Occasionally, snow reaches lower levels, but it does not remain long. By early April, the snow at higher levels begins to melt. When the melt rates exceed the snowfall, the State surveys the snowpack.

Storm Characteristics

Storms usually originate near the Aleutian Islands and are cyclonic wave disturbances occurring along the polar front. These waves normally head in a southeast trajectory. However, storm trajectories moving easterly across the Pacific Ocean produce the greatest amount of precipitation. Moisture in the inward moving air mass is reduced by the Coast Range Mountains, which act as a barrier. Most of the water that makes it past this barrier is precipitated by the orographic effect on the western slope of the Sierra Nevada.

The duration of major storms is usually 2 to 4 days. These storms normally consist of at least two waves of relatively intense precipitation rates and lesser rates between waves. Warm storms that produce major floods from the Sierra Nevada are those that combine intense precipitation with high freezing levels. These storms generally occur early in the rainflood season. Cold storms produce major runoff from the foothill, valley, and east-facing slopes of the Coast Range streams. The rainfall produced during cold storms usually falls as snow above the 4,000-foot elevation and is more intense on the foothills and Coast Range areas than in the high mountain reaches.

Streamflows

At many locations throughout the basin and for varying periods of time, streamflow and reservoir records have been maintained. The stations of interest along the mainstem and their associated peak flows are shown on Table IV-2.

Flood Characteristics

There are two general types of floods on the steams in the basin: those due primarily to intense rainfall during the late fall and winter, and those that result from snowmelt during spring and summer. Floods with high peak discharges at the foothill line and lower discharges downstream are characterized as rain floods. The duration of the damaging stages that result from these floods is longer along the lower San Joaquin River than along the tributary streams. Unlike rain floods, snowmelt floods have moderate peak flows and damaging stages which last for several weeks. The rainfloods are the source of the flood hazard on the drainage basins which are located entirely below the 4,000-foot elevation. The snowmelt has a negligible effect on the flood hazard.

In 1850, 1862, 1868, 1886, 1907, and 1911, major floods occurred in the lower San Joaquin River basin. Unfortunately, flow records are not available. However, flows have been recorded at Newman since 1914 and Vernalis since 1922.

Table IV - 2
Stream Gaging Stations
San Joaquin River

Station	Operating Agency	D.A. (sq mi)	Period of Record	Peak Flow of Record (cfs)	Date
SAN JOAQUIN					
Millerton Lake	USBR	1,638	1941-date	97,000	23 Dec 55
Below Friant	USGS	1,676	1907-date	77,200	11 Dec 37
Near Mendota	USBR	4,310	1939-date	11,760	20 Jun 41
Near Dos Palos	USBR	5,630	1940-date	8,920	24 Jun 41
at Fremont Ford Br	DWR	7,615	1937-date	9,180	26 Feb 69
Near Newman	USGS	9,520	1912-date	34,000	26 Feb 69
Near Crows Landing	DWR	-------	1965-1972	30,800	26 Jan 69
at Patterson Br	DWR	9,760	1938-1966 1969-date	9,600	16 Feb 73
at Maze Rd Br	DWR	12,400	1943-date	45,600	28 Feb 59
Near Vernalis	USGS	13,536	1922-date	79,000	9 Dec 50
EASTSIDE	BYPASS				
Near El Nido	DWR	-------	1964-date	21,700	25 Feb 69

Hydrologic Model

A hydrologic model was developed for O&M purposes and calibrated through the use of control points at all major gaged tributaries along the San Joaquin River. Calibration of the model was achieved by routing reservoir outflow and local flow hydrographs to gaging stations along the San Joaquin River where data was recorded. The calibration period used was from 1980 through 1983 because both high and low flow conditions were experienced during that time. To calibrate the model for floods which exceeded design channel capacities, the December 1950 and 1955 floods were routed. The flood peak progression down the San Joaquin River depends mainly on tributary inflow. In the development of the model, the routing parameters, diversions, and loss rates were adjusted until the routed hydrographs closely matched the observed hydrographs. The Muskingum routing procedure was used to route the flood hydrographs. The same loss rates, routing times, Muskingum coefficients, and irrigation demands were used to route historical floods.

Routed hydrographs at several gaging stations and the observed hydrographs for the water years 1980 through 1983 were used in calibrating the hydrologic model. The variability of loss rates, local flow relationships, and irrigation demands are some reasons for the differences between the computed and the observed hydrographs. Comparisons of December 1950 and 1955 flood hydrographs were also used to determine that flows in excess of channel capacities require about twice the travel time as the flow which remains in the channel. In addition, it was determined that for overbank flows a zero Muskingum X value was the most suitable. The inability to define local flow relationships and channel loss rates result in the difference between the observed and computed hydrographs.

Flow-Frequency Analyses

Flow-frequency analyses were performed on regulated and unregulated flows for rainflood and snowmelt flows. The unregulated flow analysis used 1991 channel conditions without upstream storage and diversion. The regulated flow analysis used current 1991 channel conditions with project upstream storage and diversions.

Unregulated rainflood frequency curves for the Newman and Vernalis gaging stations were developed by routing daily changes in storage at upstream reservoirs and adding them to the gaged daily flows. To account for channel losses, the routed flows were adjusted. Prior to 1930, records for several gaging stations upstream were incomplete. Therefore, statistical frequency curves were computed for the period 1930 to 1990 for the 1-, 3-, 7-, 15- and 30-day flow volumes. The final curve statistics were smoothed to permit an orderly transition between the curves of the different durations, standard deviations, and skews for the final curve statistics.

The same method used to develop unregulated rainflood frequency curves was also used to develop unregulated snowmelt flood frequency curves. Irrigation imports, diversions, and return flows were also incorporated into the method. However, only the 90-day-duration unregulated snowmelt curve was developed because short-term irrigation diversions, corrections for upstream regulations, channel losses, irrigation return flows, and routing times from historical records were difficult to determine.

Regulated rainflood and snowmelt flood curves were developed for eight locations in the basin. The rainflood curves for the Newman and Vernalis gages are shown on Plates 19 and 20. The development of the regulated frequency curves required that the historical operation of upstream reservoirs be investigated, irrigation demands be determined, and historical and hypothetical floods be routed. The statistical frequency curves were computed for the peak, 1-, 3-, 7-, 15- and 30-day flow volumes for the eight locations. In some cases not all curves were plotted to minimize confusion. When the peak flow was not shown, this indicated that the peak flow was not significantly greater than the mean daily flow.

The same method used to develop regulated rainflood frequency curves was also used to develop regulated snowmelt flood frequency curves. The frequency curves were computed at each of the eight locations for the 1-, 15-, 30-, 60-, 90- and 120-day flow volumes. These curves are shown on Plates 21 and 22.

Hydraulics

The purpose of the hydraulic analysis was to evaluate the adequacy of the channel capacity to pass design flows. The analysis included: (1) compiling existing channel capacity data, (2) identifying developed HEC-2 computer models of the basin, (3) performing field work, including cross-sectional surveys, (4) making HEC-2 computer runs using new cross-sectional data, and (5) comparing current capacity versus design capacity data.

Existing data in the basin was limited. In 1985, an HEC-2 model was developed for the reach from Highway I-5 to the mouth of the Merced River (RM 58-118), and an HEC-2 model was also available for the reach from Mendota Pool to Highway 99 (RM 267). To supplement these models, limited cross-sectional surveys at 10 locations in the middle reaches and 7 locations along the bypasses were conducted. In addition, surveys along the lower river were taken to compare current cross sections with data in the 1985 model.

The cross-sectional data was used in normal depth computations and HEC-2 water surface computations to estimate current channel capacity. These estimates indicate reduced channel capacities throughout the river system. Present capacities range from 65 to 100 percent of design flows. Table IV-3 shows some of the project design capacities and the estimates from the limited cross-sectional data. Plate 23 shows the location of river miles within the study area.

Table IV - 3
Channel Capacities

River Miles	Project Design Capacity (Including Bypass)	1992 Estimated Channel Capacity
229-267	8,000	8,000
205-229	8,000[1]	11,000[2]
118.5-205	18,000[3]	12,300[4]
84-118.5	45,000	45,000
75-84	52,000	46,000
58-75	37,000	56,000

[1] 2,500 San Joaquin + 8,500 Chowchilla Bypass
[2] 2,500 San Joaquin + 8,500 Chowchilla Bypass
[3] 1,500 San Joaquin + 16,500 Eastside Bypass
[4] 4,500 San Joaquin + 7,800 Eastside Bypass

The estimated channel capacity is used to determine the non-damaging flood capacity of the system. For this study, the non-damaging capacity was determined by comparing historical flood events with the estimates of current capacity. The historical events were assigned a frequency of occurrence within each reach based on the regulated flow-frequency curves for the San Joaquin River. The non-damaging flow was estimated to be the 10-year flood event for all reaches of the river.

The flood plains used in the economic analysis of damages were developed using historical flood reports. These reports were available for the 1955, 1958, 1964-65, 1966-67, and 1969 events. Plates 5 through 14 show some of the flooding that has occurred along the river. Several reservoirs have been constructed within San Joaquin River basin since these flood events, but the frequencies attached to them were determined using the 1991 (draft) regulated flow-frequency curves.

Operation Studies

A hydrologic model (described in the "Hydrology" section) was used to demonstrate the impact of diversion of floodflows at key locations along the San Joaquin River. Plate 24 graphically depicts the routing model. The hydrologic model divides the basin into many reaches based on gaging data or other key geographic points such as confluence locations of the tributaries with the mainstem. Fourteen diversion areas were identified along the river. These 14 areas were incorporated into the model based on the reach in which they were located. Table IV-4 correlates the 14 diversion areas with the hydrologic model reaches. Various assumptions related to flows within the mainstem where diversions begin, maximum diversion rates, and maximum percolation rates were used in modeling the effectiveness of these diversion areas.

Flow conditions were approximated for 10-year and 50-year floods (simulated on an hourly basis). In addition, simulations of flow throughout the San Joaquin River system for the last 17 years (simulated on a daily basis) were completed for conditions with and without the diversions. During all simulations, operation parameters such as irrigation demand and time to evacuate flood space represented current operation objectives for power, irrigation, water quality, and flood control.

Rough assumptions were made to try and represent some losses within the diversion areas and return flow to the river. Percolation and other losses were assumed to be 1 inch per day, and half of the losses were returned to the river. The model was calibrated to reflect historic losses along the river.

The completed modeling represents just one of many possible combinations of diversion areas and assumptions. The modeling serves as a reasonable starting point to evaluate the best use of diversion areas so that flood control and other beneficial uses can be provided.

Geotechnical

The purposes of the geotechnical study were to identify past problems and to assess the current conditions of the levees along the mainstem of the San Joaquin River. The study included a written survey of levee district personnel, a review of past records, and a field inspection. The actual length of levees in the project totals 262 miles.

Table IV - 4
Correlation of Hydrologic Model Reaches and Diversion Areas

Hydrologic Model Reach	Diversion Area
Reach A	Grasslands
Reach B	North of Wolfson Road Lone Willow Slough Area
Reach C	Area North of Mariposa Bypass
Reach D	Area Northwest of Merced National Wildlife Area
Reach E	East Gallo West Gallo Freitas Ranch West of Freitas Ranch Northwest of West Gallo
Reach F	Arena Plains I Arena Plains II
Reach G	Eastside Canal West
Reach H	China Island

In April 1992, a written survey was mailed to the 19 local levee districts. The districts were asked to provide information on the flood control problems in their area. Six districts responded to the survey. Several problems were identified: uncontrolled seepage, sand boils, slope sloughing, instability, bank erosion, and low spots on levee crests.

The review of past records indicated that only limited repairs to project levees along the mainstem have been completed. This implies that the overall performance of these levees has been good.

The field inspection included the 262 miles of project levees and 16 miles of private levees. The LSJLD and 18 reclamation districts are responsible for maintaining these levees. Only minor problems were noted in the field: erosion, rodent activity, sloughing, poor road surfaces, off-road vehicle damage, and vegetation overgrowth. However, these minor problems appear to result from inadequate maintenance by the reclamation districts. A complete description of the findings of the field inspection are found in Appendix C.

Seepage during high flows was reported as a problem along 39 miles of levees. The causes for this seepage on about 25.5 miles were identified as pervious soil conditions, improperly designed and constructed levees, and agricultural practices. Design and construction problems result from inadequate levee cross sections, construction with native sand material, and foundations not properly keeled. In some areas, land leveling by agricultural interests has created berms with the landsides lower than the watersides. In addition, field tile drain pumping is pulling fine material from the levee foundations. The cause of seepage on the remaining 13.5 miles either involved similar agricultural practices or no cause was determined. However, field inspections were completed during the summer months when water levels were relatively low, and information on problems was not provided by all reclamation districts. As a result, seepage conditions could not be fully evaluated. The levees should be inspected during flood conditions, and explorations should be conducted.

Based on the field inspections, geotechnical evaluations concluded that overall the project levees are considered to be adequate. The primary problem seems to be lack of adequate maintenance. Additional bank protection is needed in some areas, and setback levees may be needed in some locations in the future.

Economics

The economic analysis was based on a 50-year project life, October 1992 price levels, 8-1/2 percent interest rate, and existing levels of development. Average annual equivalent without-project damages, with-project damages, and benefits were analyzed.

The economic evaluation began with an inventory of the 100-year flood plain. The area within the flood plain is predominantly agriculture. Agricultural commodities grown in the floodplain include alfalfa, almonds, apples, barley, beans, broccoli, cauliflower, corn, cotton, oats, peaches, plums, sugar beets, tomatoes, vineyards, and wheat. Residential, commercial, public, and industrial buildings are subject to flooding from the San Joaquin River. Other notable structures include a dairy farm, a tomato processing plant, the San Joaquin River Club (hunting club), and a prison (Deuel Vocational Institution).

The structure inventory was separated by land use categories and consists of the following: (1) single family residential; (2) multiple family residential; (3) mobile homes; (4) form buildings; (5) public; (6) commercial; and (7) industrial. The value of damageable property is found in Appendix D. The property values were obtained by using the Marshall and Swift Appraisal Handbook and interviews.

The types of damages include structural, contents, agricultural, emergency costs, roads and automobiles. Historical agricultural damages were used to calculate the damages associated with inundation to crops, orchards, and vineyards and the clean-up costs associated with flooding. Historical flood events from 1955, 1958, 1964-65, 1966-67, and 1968-69 floods were used. The historical damages were updated to current October 1992 prices. Several sources were contacted to obtain a better dollar damage figure for agriculture since the latest dollar historical record used was 1968-69. Agencies contacted were the California Department of Water Resources, Agriculture Cooperative Extensions, SCS, LSSLD, and the Central Irrigation District.

Depth-damage relationships describe the probable damages that would occur under different depths of flooding condition, either as a percentage of the total value of damageable property or in the probable loss expected. The relationships used in this analysis were based on 1988 Federal Insurance Administration depth-damage curves as well as curves from other government agencies.

Damage-flow relationships describe the probable damages of several hypothetical floods of given streamflows. Intermediate damage points are interpolated from these estimates on the basis of proportionate changes in the magnitude of 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 category.

Probable average annual damages without the proposed project were estimated for the present year, the base year, and annually throughout the study period based upon existing conditions. The average annual with-project damages were also calculated to determine the residual damages which a specific proposed project does not eliminate.

For this investigation, inundation reduction benefits were analyzed. These flood damage reduction benefits are the difference between equivalent average annual losses with the proposed projects.

DESCRIPTION OF PRELIMINARY ALTERNATIVE PLANS

Nine preliminary alternatives were developed from the measures evaluated. Seven of these alternatives are flood control alternatives, and two address environmental restoration opportunities. Table IV-5 shows the components of the various preliminary alternatives.

Table IV - 5
San Joaquin Mainstem Preliminary Alternatives

ALTERNATIVE	DIVERT FLOOD WATERS	INCREASE CHANNEL CAPACITY			MODIFY EXISTING LEVEES	
	FULL	CLEAR VEGETATION	CONTROL SEDIMENT	REMOVE SEDIMENT	REPAIR	STABILIZE
1 Channel and Levee Modification		XX		XX	XX	XX
2 Full Diversion Areas	XX					
3 Partial Diversion Areas	XX					
4 Full Diversion - Control Sediment	XX		XX			
5 Full Diversion - Remove Sediment	XX			XX		
6 Full Diversion - Clear Vegetation, Remove and Control Sediment	XX	XX	XX	XX		
7 Partial Diversion - Clear Vegetation, Remove and Control Sediment	XX	XX	XX	XX		
8 Environmental Restoration with Flood Control	XX					
9 Environmental Restoration without Flood Control						

No Action

Under the no action plan, there would be no Federal participation in flood control and/or environmental restoration alternatives for increased levels of flood protection or restoration of historic natural resources. Levels of flood protection provided by the existing system would deteriorate, and potential damages due to flooding would increase from current levels. Despite increasing sediment deposition problems, it is assumed that no sediment removal would occur within the mainstem of the San Joaquin River. However, significant sediment removal would probably continue in the Chowchilla and Eastside Bypasses. Limited vegetation removal within the river is likely to occur using only hand labor. An estimated 220 acres of brush and upland habitat would be removed under the no action alternative, but no removal of mature growth is anticipated. Other normal O&M activities are expected to continue, including repair of erosion areas and related structural problems. Given current restrictions to vegetation and sediment removal, it is likely that erosion and other structural stability problems along the levees would increase over time. These problems could lead to an increase in emergency repair work. The no action alternative was assumed to be analogous to the without-project condition.

Flood Control

Channel and Levee Modification

This alternative includes activities that are not completed under the without-project condition. The alternative would be completed in two phases: (1) a 3-year comprehensive sediment and vegetation removal program to reestablish the flood control system to its original design and (2) a long-term maintenance program to ensure the integrity of the work completed during the 3-year program.

The first phase consists of removing a total of about 30,000 cy of sediment along 70 miles of the San Joaquin River and a total of 336 acres of vegetation. The vegetation to be removed includes about 104 acres of brush, 117 acres of upland habitat, and 115 acres of mature growth vegetation. The work would be performed at numerous small sites along the river. Table IV-1 lists the details of the proposed work, including existing vegetation, vegetation removed under the no action plan, and vegetation removed under the Channel and Levee Modification alternative. Under no action, 50 percent of the existing brush and upland habitat vegetation is removed. Under the Channel and Levee Modification alternative, the remaining 50 percent of the brush and upland habitat vegetation and 100 percent of the mature growth is removed. Sediment removal occurs on about 270 acres of the same area.

Due to current environmental constraints, all vegetation removal would be accomplished using hand labor. Removed vegetation would be chipped or used for firewood.

The second phase consists of implementing a long-term maintenance program. The program includes removing 10 percent of the original 30,000 cy of sediment (3,000 cy) and 5 percent of the 336 acres of vegetation (17 acres) every 5 years over the life of the project.

In addition to removing sediment and vegetation, several activities involving structural repair, stabilization and removal of levees would be completed. Table IV-6 shows that a total of about 12 miles of toe drain and berms need to be modified to correct seepage problems. Seepage in these areas is caused by poor levee foundation soils or improperly designed and constructed levees. The levee repair at RM 67 is required to correct seepage, boils, and sloughing. The levee foundation has developed cracking and open fissures, and levee material would be removed and replaced. Plates 25 through 28 show typical sections for seepage and erosion repairs and sediment and vegetation removal activities.

This alternative, in conjunction with the O&M activities that would carried out under the without-project condition, would provide continuous maintenance of channel capacities over the life of the project. These capacities would provide flood protection levels consistent with original design flows.

Full Diversion Areas

This alternative includes a series of temporary storage areas for floodwaters on lands adjacent to the San Joaquin River. Diversion of water to these areas reduces downstream peak flows. Adjacent areas are operated and managed in coordination with one another, creating a single system with numerous cells working together to divert, distribute, and direct the floodflows. These areas include Federal and State wildlife refuges, agricultural lands, and other privately owned properties. Floodwater is diverted by gated culverts. Historic sloughs, existing channels, levees, and irrigation canals are used to distribute and control the diverted floodflows to the proposed sites. In addition, at various locations, some low-lying berms are required to retain floodwater in storage areas. When full, these areas are designed to be drained over a 30-day period once water stages in the San Joaquin River recede to levels allowing gravity drainage. These areas would be used to control floods with frequencies between the 10- and 60-year event. Floods larger than the 60-year event exceed the capacity of the system, and flooding would follow natural historic patterns.

Each of the diversion areas is described below and shown on Plate 29. Table IV-7 summarizes the capacities, areas, depths of flooding, and existing ownership of the areas. These areas cover a total of about 109,000 acres with a storage volume of about 200,600 acre-feet.

Arena Plains I (Sunrise Ranch). - This area is bounded on the north by Highway 140 and on the southwest by the Eastside Canal. Water is diverted out of the Eastside Canal near Bear Creek. Berms are constructed to pond the water in the specified area. Structural improvements include:

- A 500-cfs gated culvert located within the west embankment of the Eastside Canal near the south border of this area would be used to divert floodwater into the area.

- A 54-inch CMP drain through the west embankment of the Eastside Canal at the northwest edge of the area would allow drainage of the Arena Plains I and Arena Plains II areas to the west of the Eastside Canal area.

- Approximately 11,000 feet of earthen dikes would be constructed to control ponding of diverted flows.

Arena Plains II (Area West of Sunrise Ranch). - The Arena Plains II area is located south of Highway 140 and west of the Sunrise Ranch. Floodwater would be ponded up to elevation 90. Structural improvements include:

- A 200-cfs gated box culvert on the Eastside Canal would provide gravity inflow to the area.

- A 54-inch CMP drain pipe would drain the area to the west of the Eastside Canal area.

Freitas Ranch. - The Freitas Ranch area is bounded on the north by the San Joaquin River (RM 125 - 130), on the east by the San Luis Drain, and on the west by the east branch of Salt Slough. Highway 165 bisects the southern end of the site. Diverted floodwater inundates the entire area from elevation 65 to 75. Floodwater would be diverted from the San Joaquin River into Salt Slough. Improvements of existing channels and construction of low-flow diversion structures are needed to direct flows throughout the property. Facilities include:

- A 500-cfs box culvert constructed at RM 141 would allow water to flow from the river through the various branches of Salt Slough. This structure would also be used to drain the floodwaters from the area through the Salt Slough system.

- A 54-inch CMP drain pipe would allow water to be conveyed under Highway 165.

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Table IV - 6
Channel and Levee Modifications
San Joaquin River Mainstem - Levee Work

WORK	LOCATION	DESCRIPTION	ALTERNATIVE SOLUTION
Structural Repair	Bear Creek - Junction Bear Creek, Eastside Canal, and Bear Creek project levee.	Bear Creek inlet structure improperly designed (flows cannot enter project levees due to structure being constructed too high).	Solution Being Developed under the Corps Ongoing Merced Stream Group Investigation.
Seepage/ Structural Stabilization	North Levee - River Mile 216.0 to 226.8. Six miles of levee.	Seepage due to improperly designed and constructed levees - cross section insufficient and constructed with native material/sand; foundations not properly keeled.	6 miles Toe drain and berm.
Seepage/ Structural Stabilization	River Mile 216 to 225. South levee San Joaquin River. About 6 miles of levee impacted.	Seepage due to improperly designed and constructed levees - cross section insufficient and constructed with native material/sand; foundations not properly keeled.	6 miles Toe drain and berm.
Levee Stabilization	River Mile 67.2 to 67.3.	Levee foundation cracking and open fissures on riverside slope. Significant levee settlement and near failure in 1983.	Complete additional studies to determine cause of problem and, if appropriate, carry out stabilization.
Levee Removal	Approximately River Mile 130.	Existing levee on refuge property no longer serves purpose.	Breach levee to allow spreading of floodwater onto refuge lands.

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Table IV - 7
Full Diversion Alternative

No.	Diversion Area	Area (acres)	Volume (acre-feet)	Maximum Depth (feet)	Ownership/ Easement Right
1	Grasslands Water District	50,000	50,000	2	Private
2	Lone Willow Slough Area	3,000	7,500	5	Private
3	Area North of Wolfson Road	3,640	9,100	5	Private
4	Area Northwest of Merced National Wildlife Refuge (Elevation 100)	3,270	14,180	5	USFWS
5	Area North of Mariposa Bypass (Elevation 90)	5,250	20,430	5	USFWS
6	Arena Plains I (Sunrise Ranch)	3,070	4,980	4	USFWS
7	Arena Plains II	1,930	7,045	5	USFWS
8	Area West of Eastside Canal	7,260	620	2	USFWS
9	East Gallo	8,130	36,030	5	Private
10	West Gallo	3,340	11,120	5	Private
11	Area Northwest of West Gallo	2,320	6,980	5	Private
12	Freitas Ranch	6,780	12,720	5	USFWS
13	Area West of Freitas Ranch	6,200	12,400	2	USFWS
14	China Island	4,730	7,470	5	DFG
	TOTAL	108,920	200,575	----	----

Area North of Mariposa Bypass (Elevation 90). - This area is bounded on the north by the Eastside Bypass, on the west by the Gallo property, and on the south by the Mariposa Bypass. Floodwaters are diverted out of the Eastside Bypass. Water flows from east to west across this site, ponding between elevations 85 and 90. Existing sloughs direct the water back to the river after the downstream stage has decreased. Structural improvements include:

- A 750-cfs gated culvert structure through the west embankment of the Eastside Bypass just downstream of the juncture of the Eastside Bypass and the Mariposa Bypass.

- Five low-flow gated diversion culverts would manage flows.

- Drainage out of the area is provided through gravity flow into the East Gallo area. A 54-inch gated CMP drain through low-lying dikes at the southwest corner of the site would drain diverted floodwaters.

- Five-foot-high earthen dikes extend along the boundary of this area with the East Gallo area. About 8,000 feet of these low-lying dikes are required.

China Island. - This area is bounded on the northwest by Hills Ferry Road, on the northeast by the San Joaquin River, and on the south by Highway 140 (Fremont Ford). Structural improvements include:

- Inflow into this area would be provided from ponded waters contained in the Grasslands area just to the south through a 200-cfs gated overflow culvert within Mud Slough. This culvert would be located just downstream of Fremont Ford at the southern end of this area.

- Diversion into the area would also be accomplished through two existing sloughs connected to the San Joaquin River. Gated culvert structures would be incorporated into these sloughs to control the diversion of floodwater.

- Drainage of the area is provided through a 42-inch CMP drain pipe control structure at the confluence of Mud Slough and San Joaquin River near the northern end of the area.

- Low-lying berms along Highway 140 and the Newman Wasteway are included to manage ponding of floodwater.

Grasslands Water District. - This existing private wildlife refuge area near Los Banos would receive floodwater using existing facilities. One thousand-cfs diversions into the Main Canal at Mendota Pool allow the diversion of floodwater.

Existing distribution facilities in the wildlife refuge would then be used to distribute the floodwater over the area. Facilities include:

- A 200-cfs gated culvert structure on Mud Slough upstream from Highway 140 would manage flows into the China Island area.

Area West of Eastside Canal. - This area is located west of the Eastside Canal and is located adjacent to, and managed in conjunction with, the East Gallo area and the Elevation 90 area. Water is diverted out of the Eastside Canal, Eastside Bypass, and/or Bear Creek. Structural improvements include:

- A 200-cfs gated culvert would divert floodwater from the Eastside Canal near Owens Creek into the area.

- A drain pipe connecting the Elevation 100 area to this area at its southeast end would also provide inflow to the area.

- Drainage of this area is accomplished by gravity flow into the Eastside Bypass near the Bear Creek crossing. A 18-inch CMP pipe allows drainage of floodwaters by gravity onto the East Gallo property.

- About 13,600 feet of low-lying berms, averaging about 3 feet in height, would be placed at the northeastern end of the site.

Area Northwest of West Gallo Property (Elevation 75). - This area is integrated with the West Gallo and Freitas Ranch sites. Outflow structures in these two other areas provide an inflow of 200 cfs to this Elevation 75 area. Structures include:

- A 42-inch CMP gated drain pipe would provide drainage of the area to the San Joaquin River.

Area West of Freitas Ranch. - This area lies along Mud Slough with Highway 140 on the north, Freitas Ranch on the east, and Grasslands on the west. Conveyance of floodwater to this area is coordinated with diversions to these other areas. Facilities required for this area include:

- Inflow to this area would be provided by a 500-cfs combined inflow from adjacent diversion areas.

- Outflow is provided by a 54-inch CMP culvert pipe draining the floodwater to the Freitas Ranch area.

- Low-lying berms would be required along adjacent duck pond areas.

Area Northwest of Merced Wildlife Refuge (Elevation 100). - This area lies south of Owens Creek and north of the Eastside Bypass. Duck Slough and Deadmans Creek flow through this area. These natural channels are used to distribute the floodwaters throughout the system. Water would be pooled to elevation 100. Structural improvements include:

- A 500-cfs gated culvert through the east embankment of the Eastside Bypass near Sandy Mush Road (near Merced Wildlife Refuge) to divert floodwater into the area.

- A 54-inch CMP pipe for drainage of the area into the Eastside Canal near Duck Slough.

- Three thousand feet of 3-foot-high berms along Sandy Mush Road to keep water in the designated flood area.

Area North of Wolfson Ranch. - This area lies south of Highway 152, southwest of the Eastside Bypass, and northeast of the San Joaquin River. Floodwater would pond in this area up to elevation 125. The Fresno River and Ash Slough are used to direct floodwaters in and out of the system. Structural improvements include:

- A 200-cfs gated culvert would be constructed to divert floodwater out of the San Joaquin River.

- A 48-inch CMP pipe would provide drainage back into the San Joaquin River at the Santa Rita Bridge.

Lone Willow Slough Area. - This area is bounded by the San Joaquin River on the west, Chowchilla Bypass on the east, and Berenda Slough on the north. Lone Willow Slough, Berenda Slough, Chowchilla Bypass, and the Fresno River are used to manage floodwaters. Low-lying berms would be constructed to prevent waters from inundating roads or other existing structures. Water could be pooled in some areas as high as elevation 150, depending on locations of berms. Required facilities include:

- A 200-cfs gated culvert on the San Joaquin River near Lone Willow Slough (north of Firebaugh at Avenue 9 1/2) to divert floodwater into the area.

- Construction of low-lying berms, an average of 3 feet high, along the Fresno River, Berenda Slough, and Avenue 7 1/2 to allow ponding of floodwaters.

- Construct a 42-inch CMP gated pipe at the northeast end of the area near the Fresno River for drainage.

West Gallo Property. - This area is located adjacent to the San Joaquin River between RM 134 and 141. It is bordered on the east by the east branch of Salt Slough and State Highway 165. Elevations vary from 75 to 80. Salt Slough is used to convey diverted floodwaters out of the system onto these lands. Structural improvements include:

- A 500-cfs gated box culvert at RM 141 on the San Joaquin River for inflow diversion.

- A 48-inch CMP gated pipe under Lander Avenue and an additional box culvert at the north end of the site, both for outflow of diverted floodwater to the river.

- 25,000 feet of low (3 feet) earthen berms to protect Lander Avenue.

East Gallo Property. - This area is bordered on the north by Bear Creek and Bravel Slough, on the west by the San Joaquin River (RM 136 - 144), and on the east by a levee. Floodwater is diverted out of the San Joaquin River at RM 143 and directed though several existing channels onto the property. Floodwater diversions would cause ponding to elevation 85. Floodwaters are returned to the river system at the junction of Bear Creek and the San Joaquin River. Structural improvements include:

- A 1,000-cfs gated box culvert out of the Eastside Bypass at the intersection with Deep Slough for diversion of floodwater into the area.

- Three 48-inch CMP gated pipes located at the northwestern end of the area, RM 134 and 136, for return of floodwater to the river system.

Partial Diversion Areas

This alternative is similar to the Full Diversion Areas alternative. However, this alternative includes those diversion areas that are currently owned or have easement rights retained by the Federal or State government or the privately-owned Grasslands area. The areas with a current government land interest include:

- Arena Plains I (Sunrise Ranch)
- Arena Plains II (Area West of Sunrise Ranch)
- Freitas Ranch
- Area North of Mariposa Bypass (Elevation 90)
- China Island
- Area West of Eastside Canal
- Area West of Freitas Ranch
- Area Northwest of Merced Wildlife Refuge (Elevation 100)

In 1986, the privately-owned Grasslands area applied to the State Water Resources Control Board for the right to divert floodwaters. Based on this action and their current interest in participating in a flood control/environmental restoration project, the Grasslands area was included in the partial diversion areas alternative.

These areas cover a total of 88,490 acres and have a combined volume of 129,845 acre-feet. The FWS is currently trying to purchase two additional areas, the East and West Gallo properties. Should these be acquired, they could be added to this alternative. The two Gallo areas would add 47,150 acre-feet of storage over a 11,470-acre area. Inflow and drainage facilities for these diversion areas would be the same as for the Full Diversion alternative.

Full Diversion - Control Sediment

This alternative includes all of the features of the Full Diversion alternative plus sediment control features. Sediment control differs from sediment removal in that site specific sediment retention basins would be constructed and maintained to trap and remove sediment. The locations of these removal areas would remain constant over the life of the project. Sediment removal is designed to eliminate site specific constrictions in the river system. Locations for removal of sediment may change over time as the geomorphology of the river changes.

Sediment control could be accomplished by either controlling the source of sediment or managing sediment after it enters the river channel. Sediment retention basins on lands adjacent to the river where sediment is entering the river system provide control before the sediments enter the system. Sediment retention basins placed within the channel trap sediments resulting from erosion of the surrounding watershed and the channel itself.

A series of three in-channel sediment retention basins would be constructed in the mainstem of the San Joaquin River. The locations and sizes of these basins are shown in Table IV-8. The basins would be dredged periodically to maintain their capacity to retain sediments. It is anticipated that sediments would be removed on a 5-year cycle.

Sediment retention basins on adjacent lands prevent eroding sediments from actually entering the river system. The SCS has identified agricultural return flows on the east side of the valley as a significant contributor of sediments to the river system, particularly in the Stanislaus River basin. In 1992, the SCS developed their west Stanislaus sediment reduction plan which proposes the establishment of on-farm sediment retention basins on lands adjacent to the Stanislaus River.

Table IV - 8
San Joaquin River Mainstem
In-Channel Sediment Retention Basins

Location	Sediment Surface Area (sq ft)	Volume (cy)
RM 67 - 68	151,000	28,000
RM 106 - 107	116,000	22,000
RM 211 - 218	3,012,000	560,000

In addition, better farming practices that reduce the amount of sediment erosion from the farmlands would also improve the sediment problems of the mainstem of the San Joaquin River. These on-farm basins, together with better farming practices to reduce the sediments at their source, could be used with the in-stream sediment detention basins to provide a comprehensive sediment control system.

However, controlling future levels of sediment in the mainstem of the San Joaquin river may not be effective. Based on the sediment deposition and erosion that have occurred during the past several years, it is apparent that the geomorphology of the river system has not stabilized. Permanent sediment retention basins may not be effective due to the changing nature of the river system. In addition, controlling sediment would not restore natural resources. As a result, this preliminary alternative was not evaluated further.

Full Diversion - Remove Sediment

This alternative is very similar to the Full Diversion - Control Sediment alternative except that sediment removal activities would not be concentrated at permanent sediment retention basins.

In this alternative, on a 5-year cycle, up to an estimated 3,000 cy of sediment would be removed from various locations in the river system. The locations would vary depending on the changes in river geomorphology over the life of the project. Sediment removal would involve identifying site specific sediment constrictions within the river. Sediment could be removed from one site within the channel to another location within the channel. For example, sediment deposition could be forming a point bar at a specific location along the river, causing constriction on an opposite bank. Typically, at such locations the opposite bank just downstream may be eroding. Under this alternative, the sediment deposition causing the channel constriction would be removed from that location and moved into the area just downstream where erosion is occurring. Where necessary, sediment would actually be removed from the river channel system. Typical sites where this sediment removal could occur are identified under the Channel and Levee Modification alternative.

However, removing sediment from the mainstem of the San Joaquin River would involve periodic loss of riparian vegetation. Since the FWS goal is no net loss of in-kind habitat value for riparian habitat, this habitat would need to be replaced in greater-than-equal amounts to account for average annual losses. Also, shaded riverine aquatic habitat would likely be lost. Since the FWS goal for this habitat type is likely to be no loss of existing habitat value, this loss cannot be mitigated over the 50-year life of the project. Due to the anticipated high cost of mitigation and potential loss of riparian and shaded riverine aquatic habitat, this preliminary alternative was not evaluated further.

Full Diversion - Clear Vegetation, Remove and Control Sediment

This alternative is a combination of features used in other alternatives. This alternative includes:

- All diversion areas and associated features of the Full Diversion alternative. These temporary storage areas cover 108,920 acres and provide 200,575 acre-feet of storage.

- Vegetation clearing as identified under the Channel and Levee Modification alternative. This involves a total of about 30 acres of vegetation removed on a 5-year cycle.

- Sediment removal includes the removal of about 3,000 cy of sediment on a 5-year cycle from various locations along the river system. Locations of this sediment removal vary depending on where constrictions are located within the river channel.

- Sediment control includes the construction of the three in-channel sediment detention basins identified in the Full Diversion - Control Sediment alternative. Sediment would be removed on a 5-year cycle.

Vegetation would be removed using hand labor to minimize environmental impacts. Organizations such as the California Conservation Corps could be used to accomplish this work. Debris would be hand carried out of the floodway to areas adjacent to the levee or channel system for disposal.

Sediment removal would probably be done with scrapers or a suction dredge. Sediment would be removed to areas immediately adjacent to the existing levees. It is anticipated that this sediment removal would be accomplished through commercial operators. Local commercial sand and gravel operators have historically removed sediments from the Eastside Bypass and used it for commercial purposes. Sediments removed from the mainstem of the San Joaquin River are also suitable for commercial uses. Operators have indicated a continued need for fill material.

However, clearing vegetation, removing sediment, and controlling sediment from the mainstem of the San Joaquin River would involve loss of riparian vegetation every year. Since the FWS goal is no net loss of in-kind habitat value for riparian habitat, this habitat would need to be replaced in greater-than-equal amounts to account for annual losses. Also, shaded riverine aquatic habitat would likely be lost. Since the FWS goal for this habitat type is likely to be no loss of existing habitat value, this loss cannot be mitigated over the 50-year life of the project. Due to the anticipated high cost of mitigation and potential loss of riparian and shaded riverine aquatic habitat, this preliminary alternative was not evaluated further.

Partial Diversion - Clear Vegetation, Remove and Control Sediment

This alternative is very similar to the Full Diversion - Clear Vegetation, Remove and Control Sediment alternative. Under this alternative, however, only those areas currently retaining either Federal or State easement or ownership rights and the Grasslands area are used for diversion of floodwater. This alternative includes:

- Diversion areas and associated features of the Partial Diversion alternative. These temporary storage areas cover 88,490 acres and provide 129,845 acre-feet of storage.

- Vegetation clearing as identified under the channel and levee modification alternative. This involves a total of about 30 acres of vegetation removed on a 5-year cycle.

- Sediment removal includes the removal of about 3,000 cy of sediment on a 5-year cycle from various locations along the river system. Locations of this sediment removal vary depending on where constrictions are located within the river channel.

- Sediment control includes the construction of the three in-channel sediment detention basins identified in the Full Diversion - Control Sediment alternative. Sediment would be removed on a 5-year cycle.

Vegetation would be removed using hand labor to minimize environmental impacts. Organizations such as the California Conservation Corps could be used to accomplish this work. Debris would be hand carried out of the floodway to areas adjacent to the levee or channel system for disposal.

Sediment removal would probably be done with scrapers or a suction dredge. Sediment would be removed to areas immediately adjacent to the existing levees. It is anticipated that this sediment removal would be accomplished through commercial operators. Local commercial sand and gravel operators have historically removed sediments from the Eastside Bypass and used it for commercial purposes. Sediments removed from the mainstem of the San Joaquin River are also suitable for commercial uses. Operators have indicated a continued need for fill material.

This alternative would involve the types of adverse impacts to riparian and shaded riverine aquatic habitat as the previous alternative. Consequently, this preliminary alternative was not evaluated further.

Environmental Restoration

Environmental Restoration with Flood Control

This alternative combines environmental restoration projects with the diversion of floodwaters, enabling the restoration areas to benefit from receiving intermittent floodwater while realizing incidental flood control benefits. The following diversion areas from Plate 29 would be used: Grasslands Water District, Arena Plains I, Arena Plains II, Area West of the Eastside Canal, and China Island. The environmental restoration projects allow the restoration of wetland and riparian habitats within these areas under dry, normal, and wet water years. The addition of the flood control diversions allows the use of floodwater as a water supply during wet years. The following environmental restoration projects could be done separately or in combination. All but one of these potential projects is in the Grasslands/Los Banos area. These proposed projects meet the objectives of the Central Valley Habitat Joint Venture, San Joaquin River Management Program, San Joaquin Basin Action Plan, Fish and Wildlife Service, United States Bureau of Reclamation, California Department of Fish and Game, Wildlife Conservation Board, and the Grasslands Water District.

China Island. - This component involves restoring historic wetlands and riparian habitat on the China Island unit of the North Grasslands Wildlife Area. This unit is owned by DFG and includes about 3,300 acres of land southwest of the San Joaquin River above its confluence with the Merced River. This land is within the historic San Joaquin River flood plain and flooded annually prior to the completion of upstream dams. Now it only floods in very wet years, such as 1983, except for 1,400 acres which is protected by a local levee. For the most part, the land no longer displays wetlands characteristics (hydrophytic vegetation) and resembles valley grasslands. Mud Slough North and two river overflow channels cross this property. Riparian vegetation is non-existent or severely degraded along these watercourses. Few acres of wetland habitat remain.

The present land surface consists of 1,100 acres of leveled formerly-irrigated agricultural fields between the local levee and the Newman Wasteway; 300 acres of former duck club property southwest of the agricultural fields; and 1,900 acres of degraded flood plain, dry channels, and degraded riparian corridors along Mud Slough North, San Joaquin River, and Merced River.

Appendix B shows the conceptual habitat development and management plan for the China Island unit. Wetlands and riparian vegetation would be restored by diverting surface waters and pumping groundwater onto this land. The plan includes the creation of 600 acres of seasonal and semi-permanent wetlands on the agricultural land, with the remaining 500 acres used to grow waterfowl food crops and provide nesting cover. The 300-acre duck club would be restored to seasonal and permanent wetlands, and the 1,900 acres of flood plain would become seasonally flooded and semi-permanent wetlands with continually flooded riparian corridors.

The plan would require constructing many features to move and manage water. Features to convert the former agricultural lands into wildlife habitat include 66,000 feet of low earthen levees (3 feet high with a 12-foot crown) to separate the land into management cells and water control structures (gated culverts) within the levees to manage water movement. The local levee which separates the agricultural lands from the flood plain would need to be breached in two or three places and flood gates installed. This would permit the former agricultural lands to flood during high flow events. In addition, an existing 6,120-foot-long earthen water supply canal would be rebuilt with concrete or replaced with a pipeline to ensure adequate water delivery to this area.

In order to divert and hold water in existing depressions in the flood plain, culverts with risers and canal or flood gates would be installed on Mud Slough North, the river overflow channels, and within some depressions. Including the water control structures within the agricultural lands, approximately 30 culverts and 217 canal/flood gates would be installed. Other work on the flood plain acreage would consist of almost 600 acres of riparian revegetation along the San Joaquin River, Mud Slough, and the river overflow channels. This includes planting native riparian species such as cottonwood, willow, wildrose, and buttonbrush, and constructing irrigation facilities such as ditches and pipes.

Grasslands Water District. - The Grasslands Water District provides water to about 50,000 acres of land, most of it wetlands owned by duck clubs. About 30,000 acres of this land is under FWS conservation easements. This component involves restoring historic wetlands and riparian habitat in four areas in the district. These areas are: (1) the Menezes Property, approximately 1,520 acres by the San Luis Spillway Ditch and Los Banos Creek; (2) the Ornallas-Carlucci-Silva Properties, approximately 930 acres west of the Los Banos Wildlife Management Area; (3) the Amabile-Sansoni Property, approximately 640 acres east of the Santa Fe Canal and north of Highway 152; and (4) the Thiercoff Ranch, approximately 800 acres west of the Santa Fe Canal south of Highway 152. Appendix B shows the locations of these areas and some of the proposed features.

The work would consist of excavating deep and shallow basins and other topographic modifications to restore about 3,020 acres of semi-permanent and seasonal wetlands and enhance an additional 780 acres; revegetating 90 acres of riparian habitat; constructing 119,000 feet of low earthen levees or dikes around individual parcels; designing and constructing 50 to 55 water control/diversion structures (screw gates, flash board risers and culverts); and designing and constructing over 25,000 feet of earthen canals. Constructed features would deliver water to newly created wetlands and allow for water management in individual areas. This work would also enhance the management and productivity of existing wetlands. An additional 84,000 feet of new canal would be needed to allow water delivery from existing supply canals to the new features, thus ensuring an adequate supply.

Arena Plains National Wildlife Refuge/FWS Easement Lands. - The FWS has recently purchased 2,700 acres of land (Sunrise Ranch) south of Highway 140 and north of the Eastside Canal and created the Arena Plains National Wildlife Refuge (NWR). The FWS also has over 8,800 acres of land under conservation easement in this general area east of the San Joaquin River. These lands are shown as 6, 7, and 8 on Plate 29. This component would restore wetlands and riparian habitat on former agricultural land and along degraded channels.

Work would include rehabilitating water delivery systems, rehabilitating levees, installing water control/diversion structures, and creating shallow basins. About 400 to 600 acres of irrigated pasture would be excavated to create additional wetlands, and these excavated areas would be revegetated with bulrush, smartweeds, and perennial grasses.

Specific features would include: one 1,320-foot-long connecting canal between Bear Creek and the Atwater Drain to divert high water flows into the Atwater Drain (250-cfs capacity); two inline water diversion structures on Bear Creek; four inline water control/diversion structures on the Atwater Drain in the Arena Plains NWR; two water control/diversion structures on an old extension of the Atwater Drain; two water control/diversion structures in the Eastside Canal west of the Arena Plains NWR; and one water control structure on the eastern boundary of the Arena Plains NWR by the Wilkinson Duck Club. These structures would supply water to, and control water levels within, the Arena Plains NWR and the easement properties. Approximately 15 culverts with risers would be placed at various locations to enable further management of water levels in various areas.

San Joaquin River (RM 63 to RM 70). - This component involves restoring riparian habitat, including shaded riverine aquatic (SRA), at selected sites along the mainstem. Table 9 lists the locations and acreage of the areas to be restored. All potential restoration areas are below the mouth of the Stanislaus River and are within the San Joaquin River floodway. The riparian vegetation at these areas is either absent or in a severely degraded condition. The proposed restoration areas formerly supported healthy riparian communities.

Work would consist of planting native riparian trees and shrubs and installing irrigation facilities on about 170 acres. Fencing could also be constructed to assist in managing these areas for habitat preservation. The local cost-sharing sponsor(s) would be required to secure these areas in fee or easement to ensure long-term protection. Erosion control work could also be needed to protect some of the new riparian areas. This would involve the construction of berms or other bank protection. This alternative would provide incidental flood protection to agricultural lands in the area that are experiencing seepage problems and help protect levees in this area that are being threatened by erosion.

Flood Control - The flood control component of this alternative involves diverting floodwaters to the areas on which environmental restoration features are being constructed. Floodwaters would be diverted onto a 59,730 acre area with the capability of storing 69,495 acre-feet. Flood control purposes would be optimized with environmental restoration features.

Environmental Restoration without Flood Control

This alternative would focus on fish and wildlife resources, especially waterfowl. Waterfowl, wetlands, and riparian areas are the most significant environmental resources in the study area.

Table IV - 9
Areas to be Restored along the San Joaquin River (RM 63-70)

Location	Approximate Acres
Three fields at RM 63, east bank	37
Area south of Banta-Corbona Canal, RM 64 to 64.5, west bank	24
Field at bend, RM 65, east bank	17
Bare areas, RM 66.5, east bank south of oxbow, and east bank of oxbow	38
Thin field, RM 67, east bank	10
Small area north of pond, RM 68, east bank	6
RM 69-70, west bank	40
Total	**172**

EVALUATION OF FINAL ALTERNATIVE PLANS

Flood control alternatives were evaluated based on four categories: (1) hydraulic and hydrologic impacts, (2) environmental impacts, (3) costs, and (4) monetary benefits. The combined restoration and flood control alternative was evaluated based on tangible and intangible environmental benefits. No benefit-to-cost ratio was made for the environmental restoration with flood control alternative.

No Action

Under the no action alternative, no further work is done by the Federal government to improve flood control or environmental values in the system.

Hydraulic and Hydrologic Impacts

No sediment is removed under this alternative. This could eventually decrease channel capacity by allowing increased constrictions within the existing channel. These constrictions would cause structural stability problems and erosion problems along the levees. This could lead to increased emergency work to repair erosion and other threatened areas. Reduced channel capacity could also eventually cause levee failures and increased flooding to lands adjacent to the river. The community of Firebaugh is likely to be subjected to increased threats of flooding.

Hydraulic modeling based on the most recent cross-sectional data available (1984) indicates that in the lower reaches of the mainstem (RM 56.3 to 118.2) there is sufficient capacity within the levees to generally convey design flows. At three locations in this reach, however, hydraulic modeling indicates that the channel or floodway cannot carry the design capacities. It appears that at these three locations there is insufficient freeboard to convey design flows. It is assumed, however, that these low spots within the levee would be corrected under O&M activities of the local reclamation districts. General subsidence data indicate that this reach of the mainstem has been subjected to lower levels of subsidence than reaches farther upstream. This apparent flattening of the river gradient leads to the conclusion that increased sediment deposition may occur in this reach over the period of analysis. Increased sediment deposition in this reach may be tempered, however, because this reach, being at the low end of the system, conveys the highest flows of the system. These higher flows may be able to flush these higher volumes of sediment.

Hydraulic modeling of the river system between RM 118 and 192 indicates a strong possibility of inadequate design flow channel capacity in specific reaches. Estimated channel capacities were developed with a limited number of channel segments without considering downstream backwater effects. A contiguous hydraulic model was not developed for this reach of the river. However, some evidence indicates that higher levels of deep subsidence exist in this reach of the river. These factors are also supported by local reclamation districts that have identified the extensive need for sediment and vegetation removal in this reach of the mainstem. Degradation of the flood control system in this reach is likely to be more pronounced in the immediate future.

In the river reaches between RM 193 and 197 and RM 216 and 267, hydraulic modeling indicates that design flows can be conveyed within the system.

Environmental Impacts

Some vegetation removal is expected to continue under the no action alternative under normal O&M. Existing mature growth would likely remain. Brush and upland habitat would likely be removed under normal O&M activities. This limited vegetation clearing could prevent significant increases in riparian vegetation in the system. Normal O&M would not likely impact mature growth. However, increased losses of mature growth could occur from natural flood events. It is expected that as flood events occur, continuation of erosion would lead to increased losses of riparian habitat. This would result in the loss of mature woodlands and willow thickets. Some natural replacement would occur.

In the long term, land use patterns could change radically if salinity or agricultural drainage problems are not solved, the drought continues, or potential reallocations of water for fish and wildlife are mandated by Federal legislation. In these cases, agricultural lands could be forced out of production and revert to native grasslands and/or scrub/shrub habitats. This reversion to native habitat could be restricted by salinity problems, however. In some areas, seepage has caused salts to rise into the root zones of agricultural crops, reducing the yields of the farmlands. This salinity problem could also affect the types of habitat that reestablish themselves.

Costs

Costs associated with the no action plan relate to existing O&M costs. These costs are likely to increase as the expected degradation of the flood control system continues and more emergency repairs are required during flood events.

Benefits

No specific benefits were identified for this alternative since it provides a baseline for evaluation.

Flood Control

Channel and Levee Modification

Hydraulic and Hydrologic Impacts. - The hydraulic impacts of sediment and vegetation removal programs are difficult to quantify without very detailed hydraulic analysis unavailable in this reconnaissance investigation. Previous investigations (Corps of Engineers, Clearing and Snagging, 1985) have attempted to quantify the lowering of water surface profile benefits of sediment and vegetation removal programs. These investigations evaluated sediment and vegetation removal programs very similar to the channel and levee modification alternative identified in this reconnaissance investigation. These hydraulic investigations compared water surface elevation effects between project conditions and existing conditions. In the lower reaches of the mainstem San Joaquin River from Old river to the Merced River, at flows of 8,100 to 13,000 cubic feet per second, sediment removal would yield about a 0.1 to 0.3 foot reduction in the water surface stage from existing conditions. At larger flows estimated reductions in stage were estimated at 0.5 feet. In the upper reaches of the river, sediment and vegetation removal was estimated to result in decreases of 0.2 to 0.5 feet at various flows. It is likely that hydraulic analysis of the reach of river between the Merced River and Mendota Dam would yield similar results in the effects of lowering river stages. These levels in reduction of river stage are all within the margin of error for the hydraulic models.

The low levels of impact to water surface elevations from the sediment and vegetation removal identified above are misleading. If sediment and vegetation buildup were to occur as in the no action alternative significant increases to water surface elevations could occur over time. The hydraulic modeling as evaluated demonstrates only water stage decreases associated with that incremental portion of hydraulic benefits associated with the periodic removal of sediment and vegetation. If sediments and vegetation increase to significantly high levels due to geomorphological conditions under the no action alternative, there would likely be significant hydraulic benefits associated with sediment and vegetation removal.

Environmental Impacts. - This alternative will result in the clearing of over 1,000 acres of vegetation within the San Joaquin River floodway, mostly riparian willow scrub and upland vegetation types (see Table 8). Initial vegetation and sediment removal will eliminate 336 acres. The periodic vegetation and sediment removal program that will follow will destroy an additional 450 acres. Levee and erosion repair work will remove vegetation from 157 acres, almost all uplands or agricultural land. Impacted areas should naturally revegetate during the life of the project and return to their former condition, except for the 121 acres of mature riparian vegetation which will in effect be permanently lost. Table IV-10 breaks down vegetation impacts by activity.

Riparian. An estimated 611 acres of riparian habitat will be temporarily lost under this alternative, mostly immature willow thickets. Willow vegetation should replace itself over the life of the project. Approximately 121 acres of mature riparian vegetation (i.e., cottonwoods and oaks) will be destroyed. This vegetation type will not replace itself over the life of the project resulting in more permanent losses. Furthermore, some of the riparian habitat for aquatic species, especially anadromous fish. Temporary losses of SRA habitat will be a significant impact.

Initial sediment and vegetation removal will eliminate 219 acres and maintenance removal 390 more acres (see Table IV-10). Levee repairs would probably eliminate only 2 acres. Almost all repair work is planned for the landside of the levees which will not cause the riparian and SRA impacts that waterside repair work would. The majority of the acreage lost to sediment and vegetation removal will be temporary losses, returning to their former condition over time. Levee repairs will likely eliminate seepage areas and the riparian vegetation that has developed there. It is not known how many acres will be affected. Wet areas on the landside of the levees that are filled will likely become upland habitat. However, new riparian areas will be crated around the toe drains which should at least partially offset these losses.

TABLE IV - 10.
Vegetation Impacts from Channel and Levee Modification, by Activity

Activity	Upland/ Ag. Land Losses	Riparian Losses (Mature Growth)	TOTAL
Initial Removal[1]	117	219 (115)	336
Maintenance Removal[2]	60	390 (6)	450
Construction of Staging and Dewatering Areas[3]	105	0[4]	105
Seepage Repair	154	0[4]	154
Erosion Repair	1	2	3
TOTAL	437	611 (121)	1048

Notes:

All numbers are based on information from Table 1.

All vegetation losses will be temporary except for mature growth.

[1] This assumes sediment removal areas are within vegetation removal areas.

[2] Estimated at 5 percent of initial acreage for vegetation removal and 10 percent for sediment removal, every 5 years. This assumes that vegetation and sediment removal areas no longer coincide.

[3] Staging assumes thirty 1.5-acre sites, dewatering assumes thirty 2-acre sites, all located on uplands or agricultural lands.

[4] This assumes that no riparian vegetation exists at the landside levee repair work areas.

<u>Wetlands.</u> Out-of-channel wetlands should not be much affected by this alternative as activities are mostly restricted to the San Joaquin River floodway. The exception is wetlands on the landside of the levees which have resulted from levee seepage. These wetlands will likely be eliminated by the levee repair work. It is not known how much of this type of wetland acreage exists. Creation of toe drains at the repair sites will crate new linear wetlands, thus partially offsetting any loss in wetlands.

Costs. - Table IV-11 shows the estimated costs of this alternative. The first costs of the two phases are $54,255,000 and $2,296,000, respectively. The average annual cost of this work is $5,079,000.

Benefits. - Benefits associated with this alternative relate to restoration of existing levels of flood protection to design levels. Average annual benefits associated with this alternative are estimated to be $2 million. However, if environmental constraints limit full implementation of this alternative, benefits would be significantly less.

Full Diversion Areas

Hydraulic and Hydrologic Impacts. - Under the 50-year frequency event, peak flows are reduced by 5,000 cfs at Vernalis and Newman. Under a 10-year frequency event, peak flows are reduced by about 3,000 cfs. When evaluated over the 16- year period from 1976 through 1992, diversion areas would have had beneficial impacts in 9 of those years.

Environmental Impacts. - This alternative would have minimal impacts on vegetation. Diverted floodwater from the San Joaquin River or the bypasses would be temporarily stored up to 30 days on an infrequent basis. Therefore, the vegetative compositions should not change significantly. Diversions may even encourage some areas to revert to historic flood plain vegetation types. Existing vegetation at the sites of the water control/diversion structures would be eliminated, but this is not expected to be significant. Construction of low earthen berms would impact mainly grassland, but new berms would revegetate with grasses. Some trees and woody vegetation would also likely be destroyed during construction.

There would be varying impacts to wildlife. There would be a minor loss of habitat due to construction of the water control/diversion structures and berms, but this should not be significant since mainly abundant grasslands would be affected. Certain species of wildlife, particularly upland species, may be adversely affected in the diversion areas. Temporary losses of feeding and nesting areas would occur. If diversions take place during nesting periods, a significant loss of that year's reproduction could occur. If the vegetative composition of the storage area changes, upland species may be permanently displaced. However, wildlife species that favor wetlands and riparian habitats would benefit greatly from periodic flooding, increased flows in historic overflow channels, temporary wetlands, and increased moisture levels in the diversion areas. A significant amount of wintering habitat would be created during diversion events.

Table IV - 11 Channel and Levee Modification Alternative First Costs

Feature	Cost
Phase 1 **Initial 3 - Year Rehabilitation Program**	
Vegetation Removal	$1,176,000
Sediment Removal	$15,000
Seepage/Structrual Repairs	$14,385,000
Levee Repair	$117,000
Mitigation*	$14,250,000
Real Estate	$6,992,000
Subtotal	$36,935,000
Contingency**	$11,780,000
EDSA**	$5,540,000
TOTAL - PHASE I	$54,255,000
Phase II **Periodic (5 - Year Cycle) Maintenance Program**	
Vegetation Removal	$59,500
Sediment Removal	$1,500
Mitigation*	$860,000
Real Estate	$620,000
Subtotal	$1,541,000
Contingency**	$524,000
EDSA**	$231,000
TOTAL - PHASE II	$2,296,000

* Does not include mitigation for loss of shaded riverine aquatic habitat. Such impacts are likely to be considered unmitigatible.

** Rounded to the nearest thousand dollars.

There should only be minor impacts to fishery resources from this alternative. Water control/diversion structures should not interfere with migrations of anadromous fish. In fact, storing and slowly releasing floodwater may aid the spring migration of juvenile salmonids downstream to the Delta. Floods causing higher flows in April or May would benefit juvenile salmonids. Some warm water fish species are likely to be diverted with the floodwater, but any potential adverse impacts should not be significant.

Impacts to water quality from this alternative are varied. Diversion and temporary storage of floodwater on these areas would likely leach salts, trace elements, and other contaminants from the soils and convey them to the mainstem when the floodwater is released. Soil contaminant levels and the timing of releases of mainstem flow would largely determine if adverse impacts occur. It is likely that instream flows would be sufficiently high to dilute any contaminants. In this case, the flushing action of the floodwater would benefit the lands. Releasing the floodwater could also benefit overall basin water quality if the release can be timed to coincide with the release of poor quality drainage water. Dilution of the contaminants would be a positive benefit.

About 99 cultural resources sites are found in the 14 floodwater storage areas. Impacts could result to these sites from inundation and construction activities.

Costs. - Table IV-12 summarizes the first costs of this alternative. Estimated first costs are $92,313,000, and average annual costs are $7,982,000.

Benefits. - Average annual flood control benefits associated with this alternative are $2,067,000. These average annual benefits represent the difference between equivalent average annual flood losses without the project and the residual annual losses with the project.

Partial Diversion Areas

Hydraulic and Hydrologic Impacts. - Under this partial diversion alternative, the total available storage for diverted floodwater would be about 30 percent less than the available storage under the full diversion alternative. Also, peak flows during the 10- and 50-year events are reduced by 2,000 cfs and 4,000 cfs, respectively, at Vernalis and Newman. This reduction in peak flows is an average 25 percent less than the reduction under the full diversion alternative.

Table IV - 12 Full Diversion Alternative - First Costs

Area	Inlet Structures	Outlet Structures	Berms	Land	Contingency*	EDSA**	Total
Grasslands	$130,500	$47,200		$12,500,000	$5,053,000	$1,902,000	$19,633,000
Lone Willow Slough	$37,500	$7,800	$100,200	$3,000,000	$1,244,000	$472,000	$4,862,000
Area North of Wolfson Road	$37,500	$10,600		$3,600,000	$1,454,000	$547,000	$5,649,000
Area Northwest of Merced National Wildlife Refuge	$86,000	$11,800	$10,020	$2,400,000	$992,000	$376,000	$3,876,000
Area North of Mariposa Bypass	$95,500	$13,100	$71,200	$5,200,000	$2,134,000	$807,000	$8,321,000
Arena Plains I	$86,000	$5,350	$231,400	$3,000,000	$1,297,000	$498,000	$5,118,000
Arena Plains II	$37,500	$7,800		$1,900,000	$774,000	$292,000	$3,011,000
Area West of Eastside Canal	$37,500	$3,750	$121,040	$4,300,000	$1,769,000	$669,000	$6,900,000
East Gallo	$130,500	$27,500	$275,900	$4,800,000	$2,050,000	$785,000	$8,069,000
West Gallo	$86,000	$10,600	$222,500	$2,000,000	$896,000	$348,000	$3,563,000
Area Northwest of West Gallo	$37,500	$7,800		$1,700,000	$694,000	$262,000	$2,701,000
Freitas Ranch	$86,000	$11,800	$222,500	$4,000,000	$1,696,000	$648,000	$6,664,000
Area West of Freitas Ranch	$86,000	$11,800		$3,700,000	$1,509,000	$570,000	$5,877,000
China Island	$37,500	$7,800	$26,700	$2,800,000	$1,142,000	$431,000	$4,445,000
TOTAL	$1,011,500	$184,700	$1,281,460	$54,900,000	$22,704,000	$8,607,000	$88,689,000 ***

* Land = 40%; all other = 30%, Rounded to the nearest thousand dollars.

** 15% of subtotal, Rounded to the nearest thousand dollars.

*** Does not include mitigation costs. Mitigation costs are estimated at $3.624 million. (including contingency and EDSA on mitigation costs).
Total estimated costs including mitigated are $92,313,000. Rounded to the nearest thousand dollars.

Environmental Impacts. - The types of potential environmental impacts are very similar to those of the full diversion alternative. There would be less impact since 63,743 acres of private land are not included in the partial diversion alternative. Since most of the private land is currently used for agriculture, the impacts would be mainly to natural vegetation and wildlife. Also, less area would receive the intangible environmental benefits from the diversion of floodwaters.

Costs. - Table IV-13 summarizes the costs of the partial diversion alternative. The first cost of this alternative is estimated to be $68,358,000, and the average annual cost is $5,911,000.

Benefits. - Average annual flood control benefits associated with this alternative are $1,073,000.

Environmental Restoration

Environmental Restoration with Flood Control

Hydraulic and Hydrologic Impacts. - Under this alternative, floodwater is diverted into the areas in which environmental restoration is being carried out. These areas include China Island, Arena Plains (I and II), and the Grasslands area. The storage volume of floodwater in these areas is about 69,495 acre-feet or only about 35 percent of the storage available in the full diversion alternative. The peak reductions in flows in the San Joaquin River Mainstem would be about 1,000 cfs for a 10-year flood event and about 3,000 cfs for a 50-year event. These reductions in peak flow would provide incidental flood control benefits.

Environmental Impacts. - There would be many environmental benefits associated with this alternative. In general, upland areas would be replaced with more valuable wetland and riparian habitats. An anticipated increase of up to 5,580 acres of wetland acres and 860 riparian acres would be expected. These habitat increases would lead to large increases in associated wildlife. Waterfowl, waders, and passerine birds would especially benefit. However, upland species could suffer from the loss of upland habitats. Revegetation work along the river would benefit the fishery by providing cover, and threatened and endangered riparian species would greatly benefit. There would also be water quality benefits associated with filtration by the wetlands, and the diversion of floodwater onto the lands would provide some flushing action on the soils.

Table IV - 13 Partial Diversion Alternative - First Costs

Area	Inlet Structures	Outlet Structures	Berms	Land	Contingency*	EDSA**	Total***
Grasslands	$130,500	$47,200		$12,500,000	$5,053,000	$1,902,000	$19,633,000
Area Northwest of Merced National Wildlife Refuge	$86,000	$11,800	$10,020	$2,400,000	$992,000	$376,000	$3,876,000
Area North of Mariposa B'/pass	$95,500	$13,100	$71,200	$5,200,000	$2,134,000	$807,000	$8,321,000
Arena Plains I	$86,000	$5,350	$231,400	$3,000,000	$1,297,000	$498,000	$5,118,000
Arena Plains II	$37,500	$7,800		$1,900,000	$774,000	$292,000	$3,011,000
Area West of Eastside Canal	$37,500	$3,750	$121,040	$4,300,000	$1,769,000	$669,000	$6,900,000
Area Northwest of West Gallo	$37,500	$7,800		$1,700,000	$694,000	$262,000	$2,701,000
Freitas Ranch	$86,000	$11,800	$222,500	$4,000,000	$1,696,000	$648,000	$6,664,000
Area West of Freitas Ranch	$86,000	$11,800		$3,700,000	$1,509,000	$570,000	$5,877,000
China Island	$37,500	$7,800	$26,700	$2,800,000	$1,142,000	$431,000	$4,445,000
TOTAL	**$720,000**	**$128,200**	**$682,860**	**$41,500,000**	**$17,060,000**	**$6,455,000**	**$66,546,000**

* Land = 40%; all other = 30%, Rounded to the nearest thousand dollars.

** 15% of subtotal, Rounded to the nearest thousand dollars.

*** Does not include mitigation costs. Mitigation costs are estimated at $1.812 million (including contingency are EDSA on mitigation costs).

Total estimated costs including mitigated are $68,358,000. Rounded to the nearest thousand dollars.

Adverse environmental impacts associated with flood control facilities would be minimal. Grassland and upland habitat would be affected. Less than 10 acres of habitat would be affected by the diversion structures. Approximately 30 acres would be affected by low berms required to control ponding of floodwater. These adverse impacts would be offset by environmental restoration benefits.

Costs. - The costs associated with this alternative are summarized in Table IV - 14. The first costs of the environmental restoration features are $43,425,000, and the first costs of the flood control features are $896,000. The average annual cost for environmental restoration features is $3,755,000 and for flood control features is $77,500 .

Benefits. - To develop benefits for this alternative, relationships between diversion storage volume and benefits were developed using data developed for the full and partial diversion alternatives. The average annual flood control benefits associated with the flood control portion of this alternative are estimated to be $103,400. The benefit-to-cost ratio of the separable flood control element is 1.3:1.

Table IV-15 summarizes the estimated fish and wildlife benefits of the restoration component of the alternative. These benefits are conservative estimates based on observations and data recorded at existing local wildlife refuges. The table shows tremendous increases in wetlands, riparian habitat, waterfowl use, wader and shorebird use, raptors, passerine birds, and aquatic mammals. Critical increases in fish habitat include the eventual creation of 19,000 linear feet of new shaded riverine aquatic habitat from overhanging vegetation. This habitat is of critical importance throughout the State, particularly along the San Joaquin River.

SUMMARY

The environmental restoration with flood control alternative has been determined to be the only feasible alternative examined. The elimination of the remaining alternatives was based primarily on cost considerations and adverse environmental impacts. Table IV-16 summarizes the environmental impacts of all the final alternatives. The primary reason that the infeasibility of the flood control alternatives were not feasible was the high cost of real estate.

The environmental restoration benefits associated with the feasible alternative are tremendous. The incidental flood control opportunities of diverting floodwater to these restoration areas provide a unique opportunity to combine restoration and flood control purposes. Floodwaters provide many intangible benefits to the proposed refuge areas, much as

Table IV - 14 Environmental Restoration With Flood Control Alternative - First Cost

Features	China Island Unit	Grasslands	Arena Plains	Total***
Environmental Restoration				
Diversion and Water Control Structures	$187,800	$205,027	$431,681	$825,000
Berms	$704,000	$875,459	$2,820,721	$4,400,000
Access Roads	$100,000			$100,000
Water Supply Pipeline	$30,000	$10,600		$41,000
Canal	$1,000,000	$599,658		$1,600,000
Channel			$14,520	$15,000
Spillover Weir		$23,150		$23,000
Shallow Ponds		$1,256,178		$1,256,000
Land	$2,830,000	$12,530,000	$4,930,000	$20,290,000
Contingency*	$1,738,540	$5,903,022	$2,952,077	$10,594,000
EDSA**	$727,770	$2,325,011	$1,229,538	$4,282,000
Subtotal	$7,318,110	$23,728,104	$12,378,537	$43,425,000
Flood Control				
Inlet Structures	$37,500	$130,500	$123,500	$292,000
Outlet Structures	$7,800	$47,200	$13,150	$68,000
Berms	$26,700		$231,400	$258,000
Contingency*	$21,600	$53,310	$110,415	$185,000
EDSA**	$10,800	$26,655	$55,208	$93,000
Subtotal	$104,400	$257,665	$533,673	$896,000
TOTAL	**$7,422,510**	**$23,985,769**	**$12,912,209**	**$44,321,000**

* Land = 40%; all other = 30%

** 15% of subtotal

*** Rounded to the nearest thousand dollars.

floodwaters historically allowed the establishment of seasonal and intermittent wetlands. The temporary storage of floodwaters on these areas provides potential benefits that need to be evaluated further during feasibility studies. Temporary storage of floodwaters on these areas in wet years may allow water exchanges between the Bureau and refuge area operators, which could benefit water supplies to agricultural areas. It may also be feasible to time the releases of these floodwaters to coincide with pulse flow requirements for fishery migrations.

The feasible alternative proposes environmental restoration on four areas: China Island, Arena Plains, RM 63-70, and Grasslands Water District. The potential exists that the State Department of Fish and Game or the U.S. Fish and Wildlife Service may acquire additional lands in the Grasslands area for environmental purposes. Floodwaters could be applied to these additional lands for environmental restoration purposes. The incidental flood control proposed under this alternative could then provide additional benefits.

The feasible alternative also provides some relief to existing O&M related to environmental constraints on vegetation and sediment removal. While this alternative would not replace the O&M requirements, it would allow reduction of peak flows, which could under specific storm conditions make the difference between levee failures and significant damages or no damages. The alternative also provides a common ground at which environmental interest groups can meet with flood control interests to develop a comprehensive management program for the San Joaquin River.

TABLE IV - 15
Estimated Fish and Wildlife Benefits from Environmental Restoration Projects.[1]

ITEM	CHINA ISLAND	ARENA PLAINS	GRASS-LANDS	RM 63-70	TOTAL
New wetlands (acres)	1,180	600	3,800	0	5,580
New riparian habitat (acres)	580	0	90	170[2]	840
Waterfowl (days of use/year)	3,495,000	200,000	1,115,000	minimal increase	4,810,000+
Waterfowl (add. nesting pairs)	670	120	9,000	minimal increase	9,790
Waders and shorebirds (days of use/yr.)	1,262,000	300,000	405,000	unknown increase	1,967,000+
Raptors (days of use/yr.)	46,000	1,200	7,500	unknown increase	54,700+
Passerine birds (days of use/yr.)	10 million	150,000	1,310,000	unknown increase	11,460,000
Aquatic Mammals (days of use/yr.)	82,000	unknown increase	unknown increase	unknown increase	82,000+
Fish (new habitat in acres)	110	0	0	large increase	110+
Other wildlife (days of use/yr.)	730,000	unknown increase	unknown increase	unknown increase	730,000+

[1] Numbers are based on observations and data recorded at local wildlife refuges and were provided by local biologists.

[2] Includes 19,000 linear feet of new shaded riverine aquatic habitat. This is expected to become established by the end of project life (50 yrs.).

C-104381

TABLE IV - 16.
Summary of Environmental Impacts of Alternative Plans

ALTERNATIVE	VEGETATION	WILDLIFE	FISHERIES	T & E SPECIES	WATER QUALITY
No Action (local O&M)	Losses: 154 riparian acres and 176 upland/agricultural acres. All losses temporary.	Likely adverse impacts on many species, especially riparian species.	Likely losses of riparian and SRA habitat below the Merced River would affect fish.	Listed species that favor riparian areas could be adversely affected.	Minor, temporary increased turbidity in the mainstem adjacent to the work areas would result.
Channel and Levee Modification	Losses: 611 riparian acres and 437 upland/ag. acres. Most losses temporary except for 121 acres of mature growth.	Habitat losses would likely cause declines for certain species, especially riparian.	Probable significant SRA habitat losses would likely cause declines in fish, especially anadromous species.	Listed riparian species such as VELB and Swainson's hawk are likely to be adversely affected.	Minor, temporary increased turbidity in the mainstem adjacent to the work areas would result, but on a larger scale.
Full Diversion Areas	Losses: 37 riparian acres and 190 upland/ag. acres. Only the riparian is permanently lost.	Possible impacts on upland and nesting species. Likely benefits to wetlands species such as waterfowl and wading birds.	Adverse impacts are unlikely. Possible benefits if April or May mainstem flows rise.	Listed upland species such as the San Joaquin kit fox and the leopard lizard potentially affected.	Possible adverse impacts from flushing of salts and other pollutants. Possible benefits with proper timing of releases.

C-104380

Partial Diversion Areas	Losses: 20 riparian acres and 90 upland/ag acres. Only the riparian is permanently lost.	Similar to Full Diversion but with fewer possible impacts/bene fits.	Similar to Full Diversion but with less potential impacts or benefits.	Similar to Full Diversion but with fewer potential effects.	Similar to Full Diversion but with fewer potential impacts and benefits.
Environmental Restoration with Flood Control	Losses: 600-6,420 upland/ag. acres. Gains: 600-5,580 wetland acres; 0-840 riparian acres.	Habitat increases would lead to big wildlife increases. Nesting and wintering birds should especially benefit. Upland species may suffer.	No adverse impacts are likely from most proposed work. Revegetation work along the mainstem would have great benefits.	Certain (riparian) species would benefit greatly. Others could be adversely affected.	Adverse impacts unlikely. Possible benefits from filtration by wetlands.

NOTES FOR TABLE IV - 16

1. The No-Action alternative assumes local levee districts will be allowed to remove some vegetation, but no sediment or mature growth, from within the floodway. Numbers are based on numbers from Table 1 and include 5 percent maintenance removal of vegetation. Brush and mature growth are assumed to be riparian vegetation.

2. The Channel and Levee Modification alternative assumes the following: initial vegetation and sediment removal areas will coincide; subsequent vegetation and sediment removal areas will not coincide; after initial removal, 5 percent of the initial vegetation removal acreage will be cleared every 5 years and 10 percent of the initial sediment removal acreage will have sediment removed every 5 years; 30 one and one half-acre staging areas and 30 two-acre dewatering areas will be required for the removal work; all staging and dewatering areas will be located on upland vegetation or agricultural land on the landside of project levees; all seepage repairs will take place on upland vegetation on the landside of levees. Again, numbers are based on Table 1.

3. Diversion alternatives assume that flooded acreage will be agricultural lands, native uplands, and wetlands and that agricultural lands will continue to be farmed or grazed. It is assumed that wetlands will not be affected and that the existing vegetation of the flooded acreage will not be changed due to the diversions.

4. Vegetation numbers in the Environmental Restoration with Flood Control alternative represent a range from completing only the smallest proposed project to all proposed projects.

CHAPTER V
LOCAL SUPPORT

NON-FEDERAL SPONSOR

Current Federal cost-sharing laws require that a non-Federal sponsor share 50 percent of the feasibility phase study costs. Representatives from the State Department of Water Resources have indicated preliminary support for studies of the alternative plans identified in this reconnaissance study.

PUBLIC INVOLVEMENT

The SJRMP was created by State Assembly Bill No. 3603 in September 1990. The objectives of the SJRMP are to develop compatible solutions to water supply, water quality, flood protection, fisheries, wildlife habitat, and recreational needs in the San Joaquin River system. Numerous agencies are members of the SJRMP. The program is managed by an Advisory Council, and designated subcommittees develop and coordinate the needs and opportunities in the system. The Corps is a member of the Advisory Council and also participates in the Flood Control and the Recreation Subcommittees.

The monthly SJRMP Advisory Council meetings are conducted in an open public forum and involve a wide spectrum of public interest that covers all of the basin counties, cities, water districts, Federal and State agencies, and many environmental groups. These groups include the Natural Resources Defense Council, Environmental Defense Fund, Sierra Club, Friends of the River, San Joaquin Parkway and Conservation Trust, and San Joaquin Raptor Society. These council meetings provide a forum for discussing proposed and ongoing activities. The meetings are publicized in advance to encourage public participation in the discussions.

In September 1991, the Corps distributed a notice of initiation outlining the study was sent to public agencies, organizations and individuals in the study area. The purpose of the notice was to identify information on flood control problems and significant natural resources in the areas. Responses to the notice were considered in preparation of the Reconnaissance Report and Environmental Evaluation.

In April 1992, the Corps conducted a survey of flood control needs and problems in the study area. A request for information was mailed to all reclamation and levee districts. Responses included location and extent of erosion, levee stability problems, seepage, sedimentation, encroachment of vegetation, and environmental needs.

During feasibility studies, a public involvement program would include information summaries, meetings with special interest groups, and a formal public meeting to be held near the conclusion of the study.

CHAPTER VI
FEASIBILITY PHASE STUDIES

REQUIRED STUDIES

A large number of studies will be required during the feasibility phase of the investigation. A scope of work, cost estimate, and schedule for the feasibility study have been prepared and are referenced by the Feasibility Cost-Sharing Agreement (FCSA). The FSCA is between the Department of the Army (represented by the Sacramento District Engineer) and the non-Federal sponsor (State Department of Water Resources) and identifies the equal sharing of costs for the feasibility study. A draft FCSA and Initial Project Management Plan (IPMP) are included in Appendices F and G, respectively. Accompanying submission of the final FCSA and IPMP for approval will be a letter of intent from the non-Federal sponsor stating that the FCSA is acceptable and that the sponsor will sign the agreement upon certification of the reconnaissance report.

STUDY MANAGEMENT

The non-Federal sponsor will be involved in study management. In order to manage a cost-shared study, an Executive Committee and a Study Management Team will be formed. This management structure will be formalized in the FCSA.

The Study Management Team will include the Corps and the non-Federal sponsor. This team will develop the studies, guide in their accomplishment, and participate in selection of potential solutions. The team will be directly involved in establishing mutual roles and in focusing on the critical issues. Corps representatives will include the study manager and the Chief of the San Joaquin River Basin Branch. The team will recommend to the Executive Committee the tasks to be conducted and extent of planning and evaluation to be carried out in the feasibility phase. It will also report the results of studies to the Committee and recommend alternative courses of action for project implementation.

The Executive Committee will include the District Engineer, his chief planner or designee, and the Deputy District Engineer for Project Management. The sponsor, along with primary technical advisors, will be equal partners with the Corps representatives on the Committee. The District Engineer and his counterpart with (State Department of Water Resources) will co-chair the Committee.

The Executive Committee will participate in Issue Resolution Conferences (IRC) and ratify decisions made by the Study Management Team. The Committee is also responsible for resolving any disputes that may arise during the study. The Committee will agree on the solutions and study direction, which may include termination. At least one IRC will be held prior to the public distribution of the draft feasibility report to ensure that all issues are resolved prior to submitting the final report to higher authority. Additional IRC's will be held, as required, throughout the study to resolve any problems that may arise.

A Life Cycle Project Manager (LCPM) will be assigned to this study prior to signing the FCSA. The LCPM's role is to manage the overall project from the development of the FCSA through construction and allocate funds for accomplishment of tasks. The LCPM will be the primary point of contact for the non-Federal sponsor for items regarding the FCSA, policy issues, budgetary requests, schedule and overall project development.

The Corps study manager will be required to perform both the general supervision of personnel involved in the study and the management of the study itself. He will ensure that funds are allocated to the proper organizational elements and that appropriate analyses are conducted to develop the information needed to evaluate the resource problems in the study area. He will also direct the flow of technical information between the Corps and the local sponsor in order to accomplish the work in an efficient and timely manner.

FINANCIAL ANALYSIS

Feasibility Phase

The feasibility phase will be cost shared 50 percent Federal/50 percent non-Federal. Fifty percent of the non-Federal share or 25 percent of the total project cost can be in-kind services.

Construction Phase

The cost of constructing the project will be shared in accordance with WRDA of 1986. During construction of a project, the non-Federal sponsor must pay 5 percent of the costs assigned to flood control. In addition, the sponsor must provide all lands, easements, rights-of-way, relocations and disposal areas (LERRD). If the total of the two of these is less than 25 percent of the total project cost, the sponsor will pay the difference during construction. However, the total non-Federal cost will not exceed 50 percent of the total project cost. For environmental restoration, the cost sharing is 75 percent Federal and 25 percent non-Federal with credit given for LERRD.

CHAPTER VII
DISCUSSION AND CONCLUSIONS

DISCUSSION

The extent of flooding in the San Joaquin Basin is extensive over a large geographic area. The tributary river systems to the San Joaquin River have historically been subject to significant flooding. While most of the major tributaries have upstream reservoirs constructed to help control flooding, historical flood reports still document significant damages along many of the tributaries.

Beyond these problems on the tributaries, very little definitive investigation of flooding problems along the mainstem of the San Joaquin River has been done since construction of the existing levee system. Many attempts have been made to investigate various problems along the mainstem of the river, but the hydraulic complexities and changing geomorphological conditions still leave many flood control issues and problems not clearly defined and are under constant change.

In the current reconnaissance study, many problems have been identified along the mainstem. If not corrected, many of these problems could lead to significant damages due to flooding. Ultimately, significant land use changes could occur. Local levee districts are attempting to maintain the existing flood control system but are finding it increasingly difficult due to the dynamic geomorphology of the river system and the institutional framework under which natural resources management is carried out today.

The analysis in this reconnaissance study has identified only limited flood control benefits along the mainstem of the river. The dynamic geomorphology and institutional constraints in managing the existing resources may eventually lead to significantly higher flood damages. The complexities of the hydraulics of the river system make it very difficult to predict the potential for future flood damages over the next 50 years. Until hydraulic and geomorphological conditions within the mainstem are more clearly defined, flood control operations will continue to be reactionary to specific flooding events and emergency situations along the existing levee system. Such reactionary management will likely lead to addressing only the problems and not their causes. This could eventually lead to additional loss of flood control protection and environmental damage.

The environmental resources within the San Joaquin River basin have also declined over the last several decades. The construction of many upstream reservoir storage facilities has led to significant changes in the ecosystem of the basin. Wetland, riparian, and shaded riverine aquatic habitats have been lost. An increasing need to restore these habitats has been recognized. The environmental alternative in this reconnaissance study provides for restoration of these habitats consistent with improving flood control conditions within the basin. The restoration alternative has been designed so that components can be implemented either in whole or on an incremental basis as funds become available. While only providing incidental additional flood protection, flood control operations associated with these restoration features do provide a starting point for overcoming institutional constraints and balancing natural resource values in the system.

The lack of a comprehensive evaluation of environmental conditions within the basin is very apparent. However, the State has identified a critical need to inventory baseline resource conditions of all waterways in California, including the San Joaquin River. As a result, the State initiated the California Rivers Assessment in December 1992. The Assessment is a comprehensive, cooperative effort to (1) gather and analyze river-related data into a centralized location, (2) provide a standardized evaluation system and the ability to overlay resource information, and (3) provide information about the significance of river resources on a statewide basis. The goal of this program is to create an informational planning and decision-making tool. Initially, the Assessment will focus on riparian and aquatic resources, but other resources categories could be assessed in the future.

CONCLUSIONS

Based on the studies discussed in this report, it is concluded that:

- A continuing flood threat exists along the mainstem of the San Joaquin River, and environmental resources have seriously declined due to past water resources development in the study area.

- There is at least one feasible alternative that would increase the levels of flood protection and/or restore historic environmental resources in the San Joaquin Valley.

- A responsible non-Federal entity has indicated a willingness and capability to share the costs of feasibility studies.

- Additional investigations and coordination are required to fully address constraints on the existing O and M activity.

- A comprehensive management plan of the riparian corridor along the mainstem needs to be completed.

- An investigation of system-wide reservoir operations needs to be carried out to balance flood control, environmental, and other water resource purposes.

- Future feasibility studies should assist in the comprehensive California Rivers Assessment evaluation.

CHAPTER VIII
RECOMMENDATION

The results of this reconnaissance study indicate that there is a Federal interest in at least one potential flood control/environmental restoration alternative in the San Joaquin River Mainstem study area. This alternative has local support, appears economically feasible, and has a local sponsor that is willing and able to cost share the feasibility phase. Therefore, I recommend that feasibility studies for the San Joaquin River Mainstem study be initiated under Life Cycle Project Management.

Laurence R. Sadoff
Colonel, Corps of Engineers
District Engineer

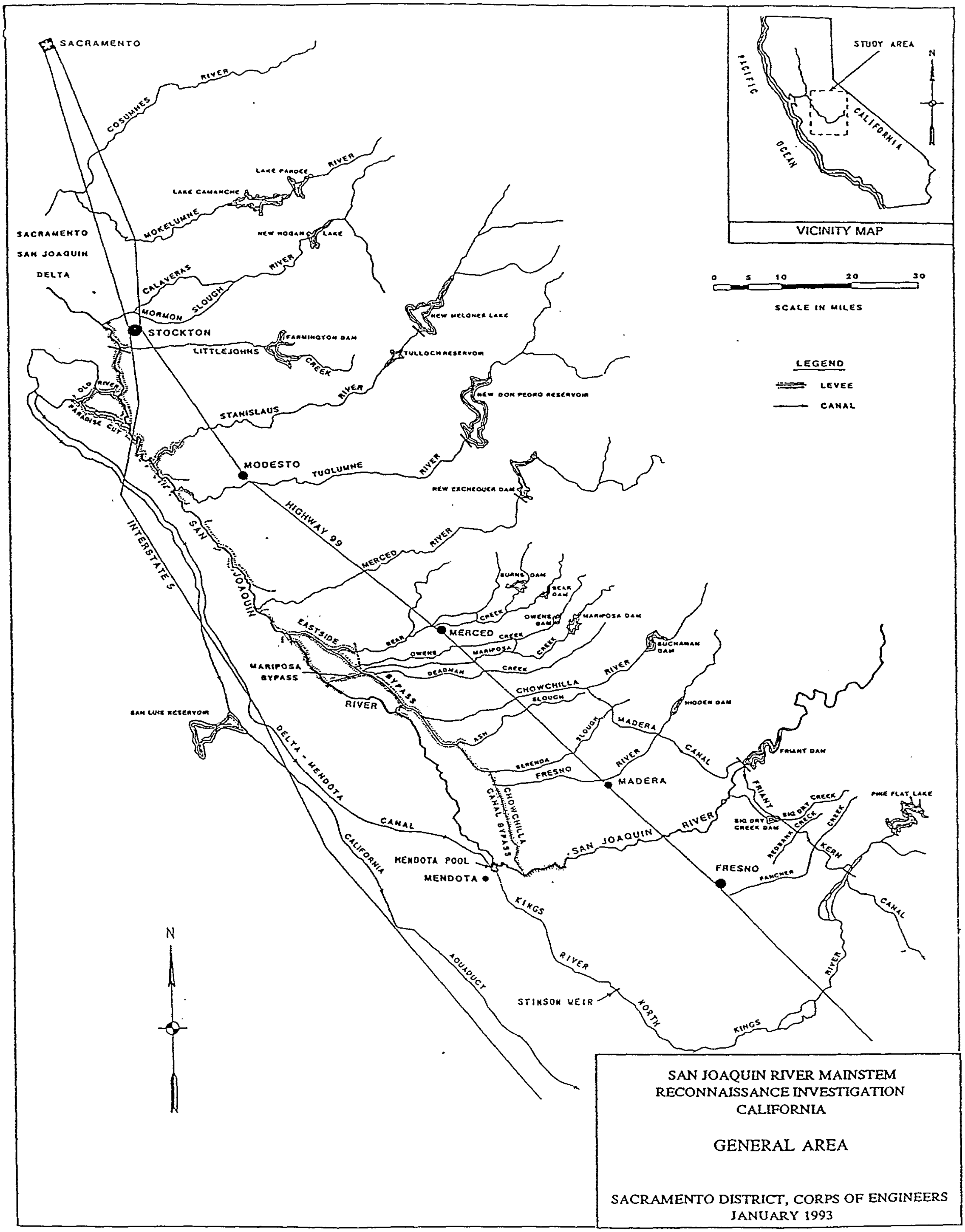
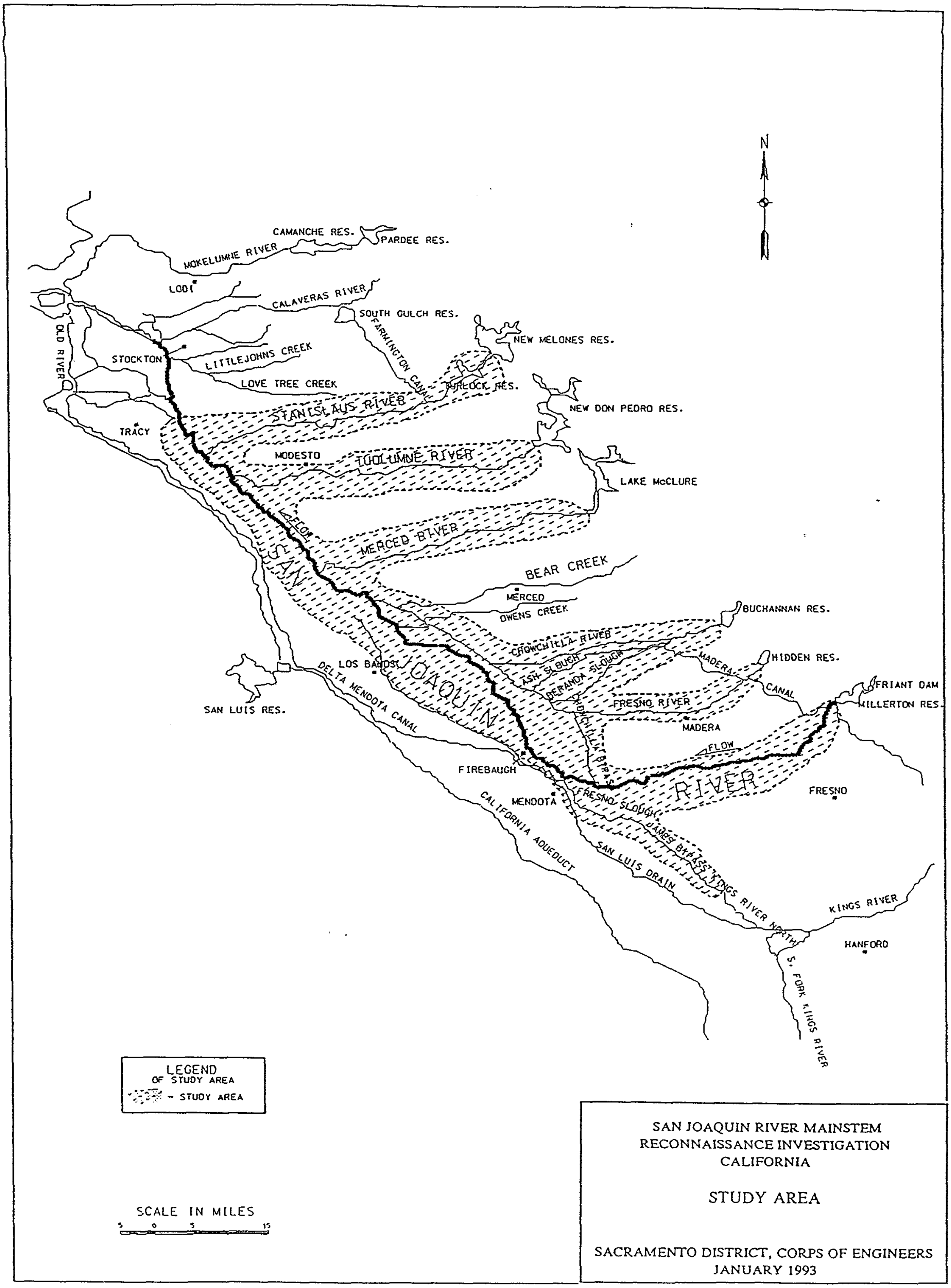


PLATE 1

C-104391



SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 2

C-104392

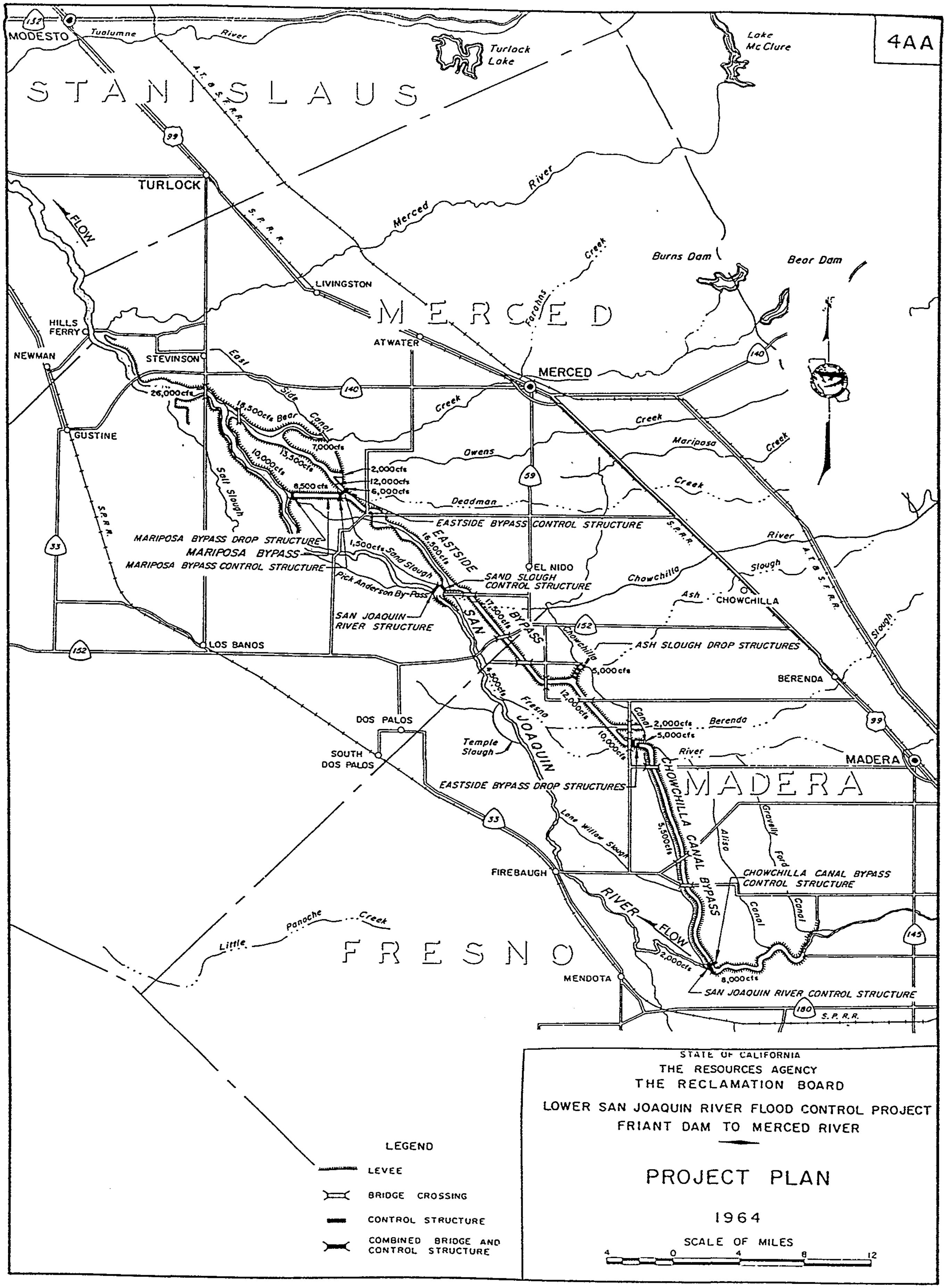
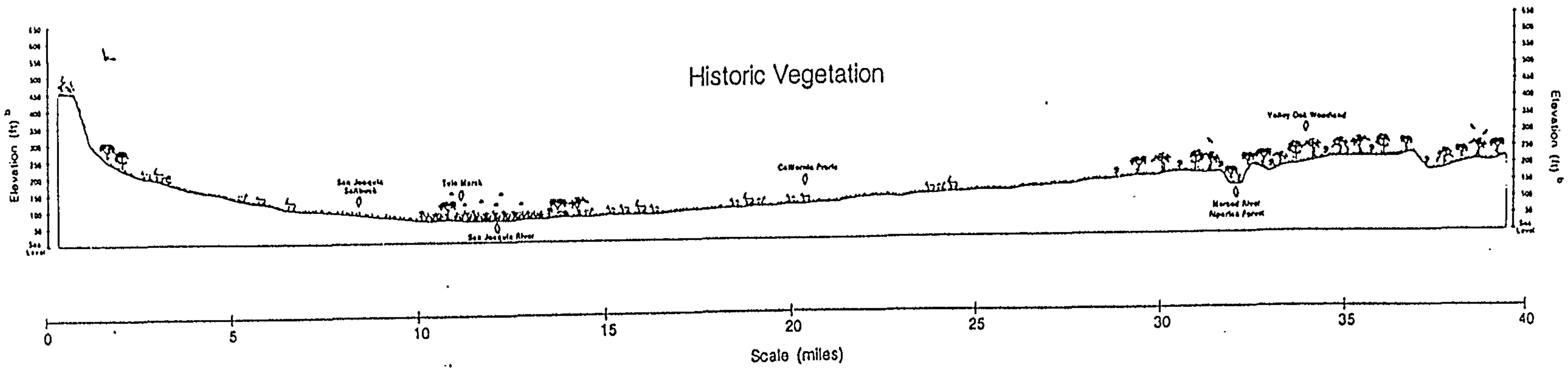
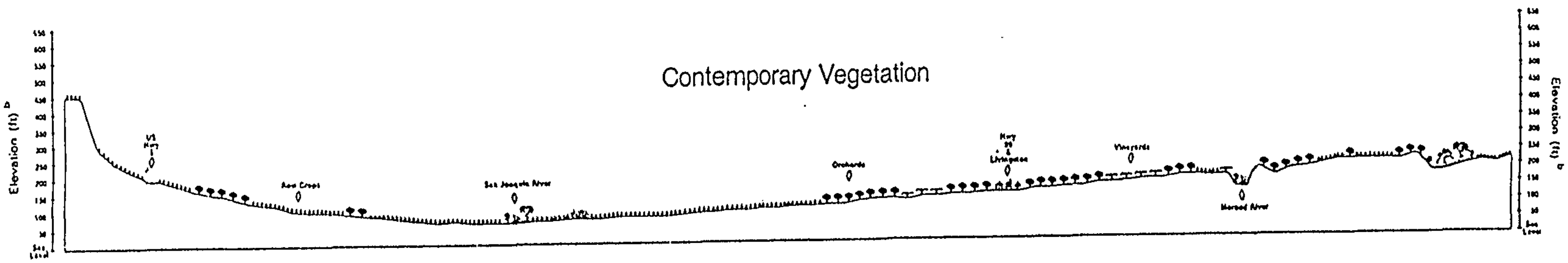


PLATE 3

C—104393

San Joaquin Basin Cross-section[ac]





[a] Historic vegetation compiled from: Kuchler, 1977; Piemsel and Lawson, 1937; Perkins in Smith, 1939; Preston, 1981. Historic hydrology compiled from: Hall, 1887; Goddard, 1857. Elevation and contemporary vegetation compiled from: USGS 7.5 minute series quadrangle maps: Kettleman City, 1981; Stratford SE, 1954; El Rico Ranch, 1954; Corcoran, 1954; Waukena, 1954; Paige, 1969; Tulare, 1969; Visalia, 1969; Exeter, 1969.

[b] Elevation is exagerated 50 times with respect to distance scale. Biota and structures represent distribution, but are not to scale.

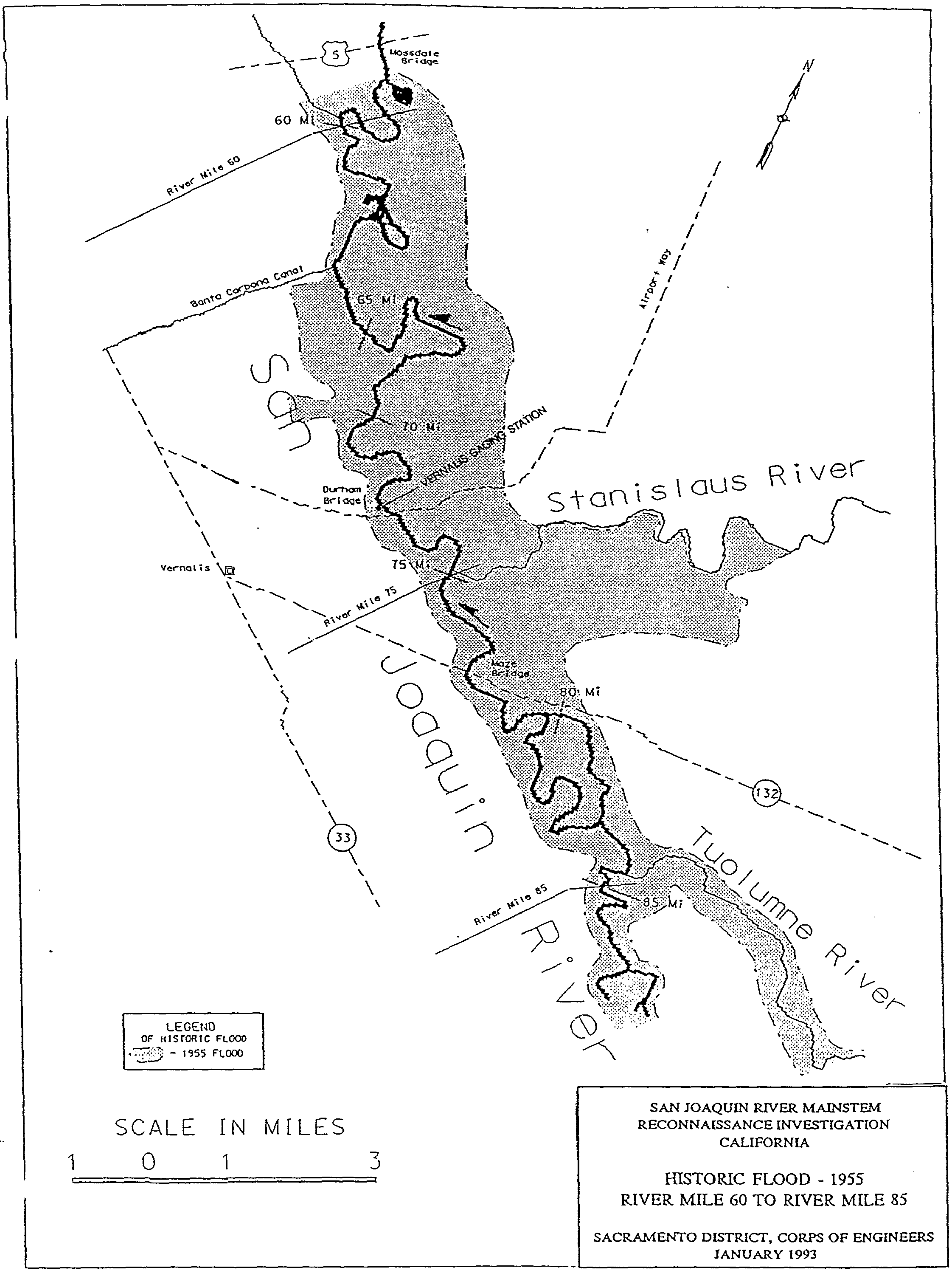
[c] From near Crevison Peak, Stanislaus Co. to near Snelling, Merced Co.

SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SAN JOAQUIN BASIN
CROSS-SECTION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 4

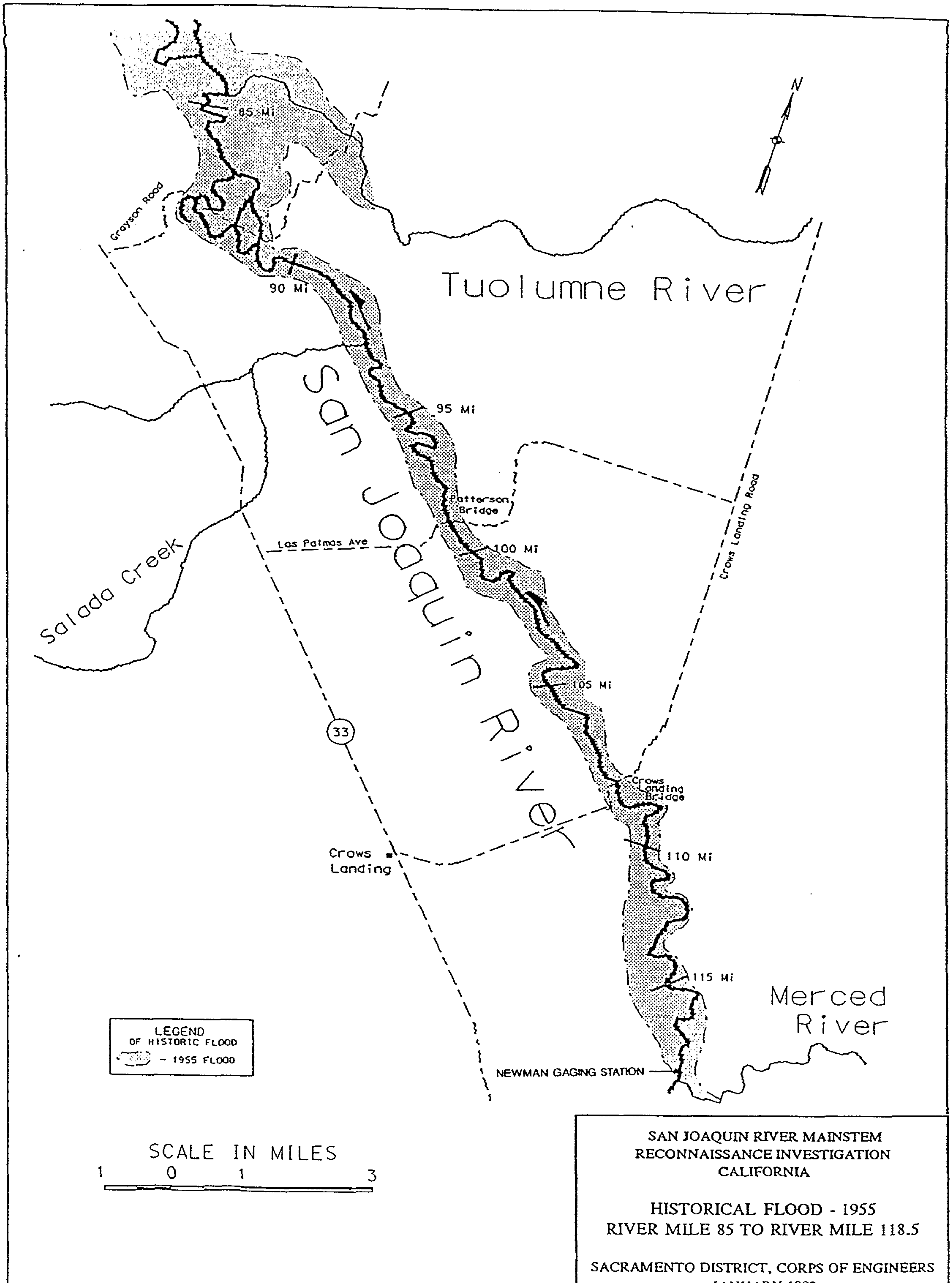


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORIC FLOOD - 1955
RIVER MILE 60 TO RIVER MILE 85

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 5

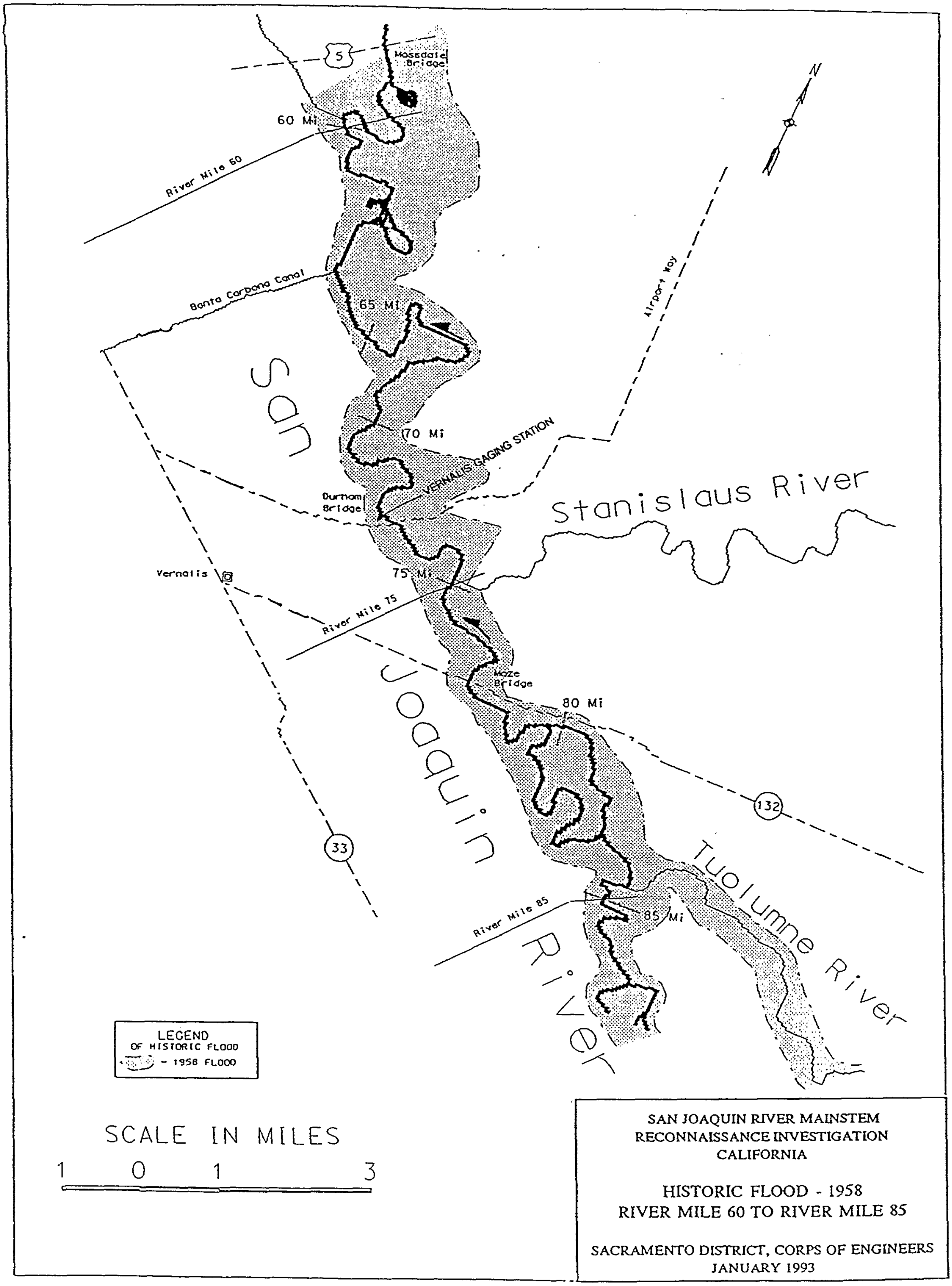


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1955
RIVER MILE 85 TO RIVER MILE 118.5

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 6



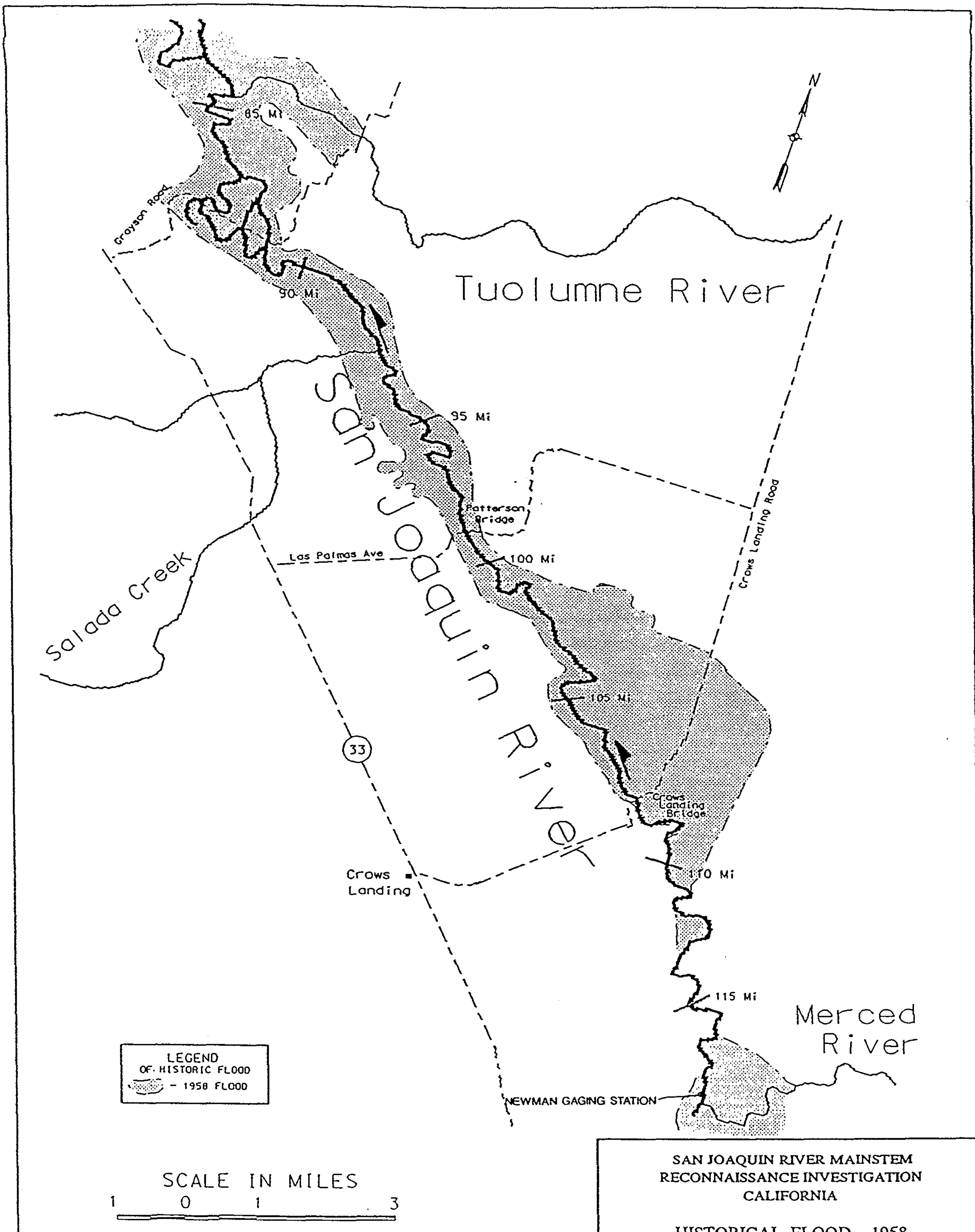
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORIC FLOOD - 1958
RIVER MILE 60 TO RIVER MILE 85

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 7

C-104397

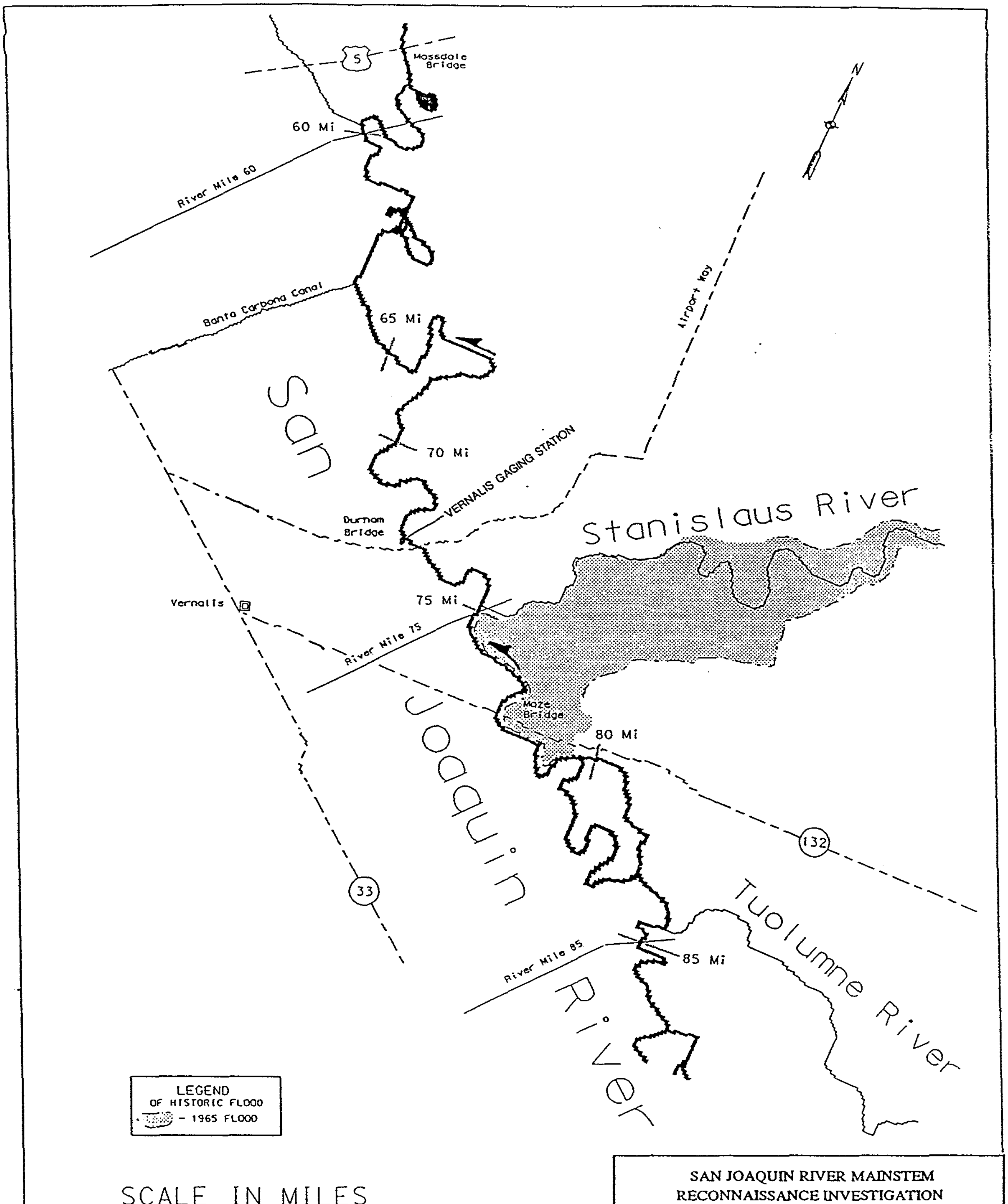


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1958
RIVER MILE 85 TO RIVER MILE 118.5

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 8

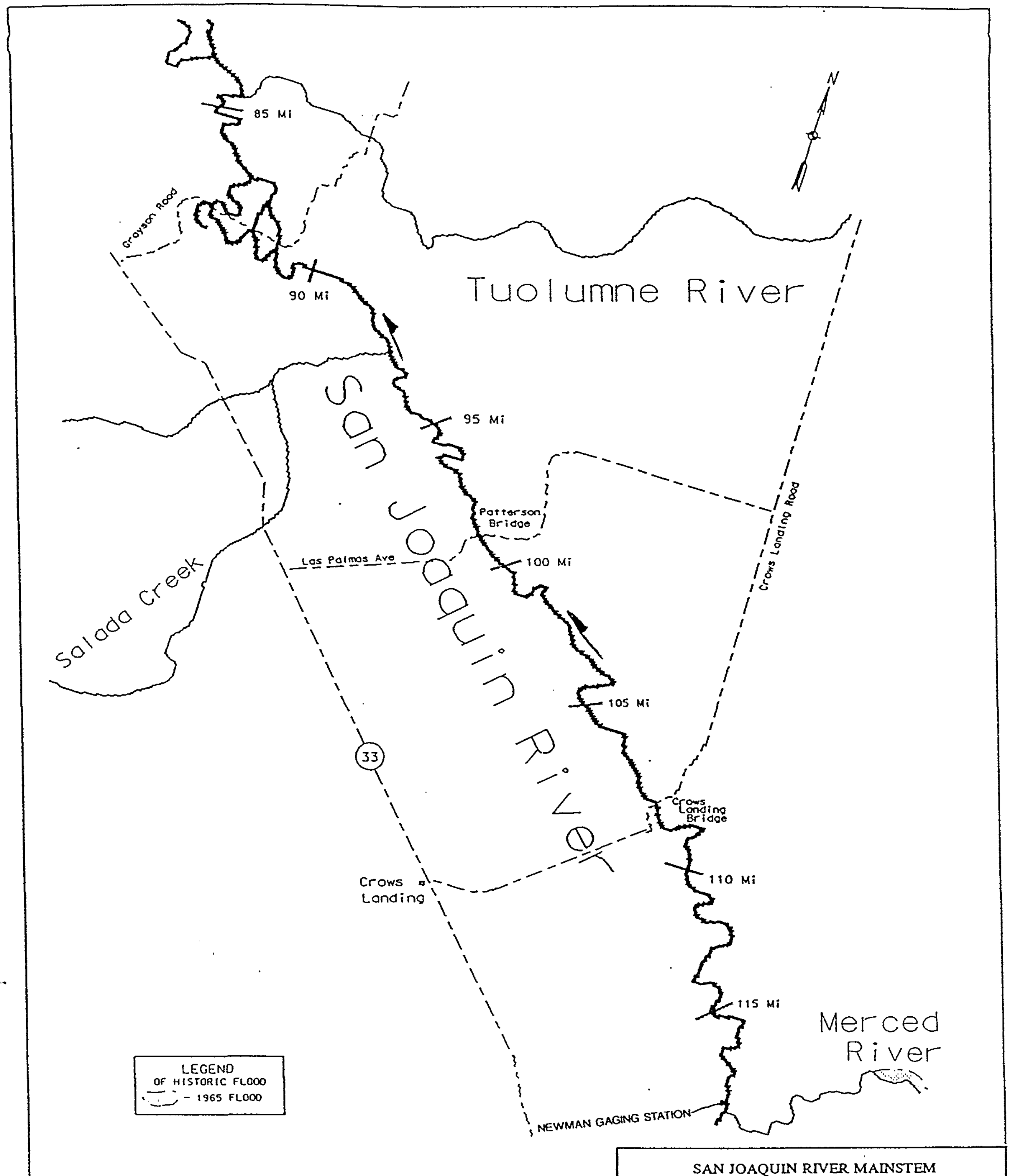


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORIC FLOOD - 1965
RIVER MILE 60 TO RIVER MILE 85

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 9

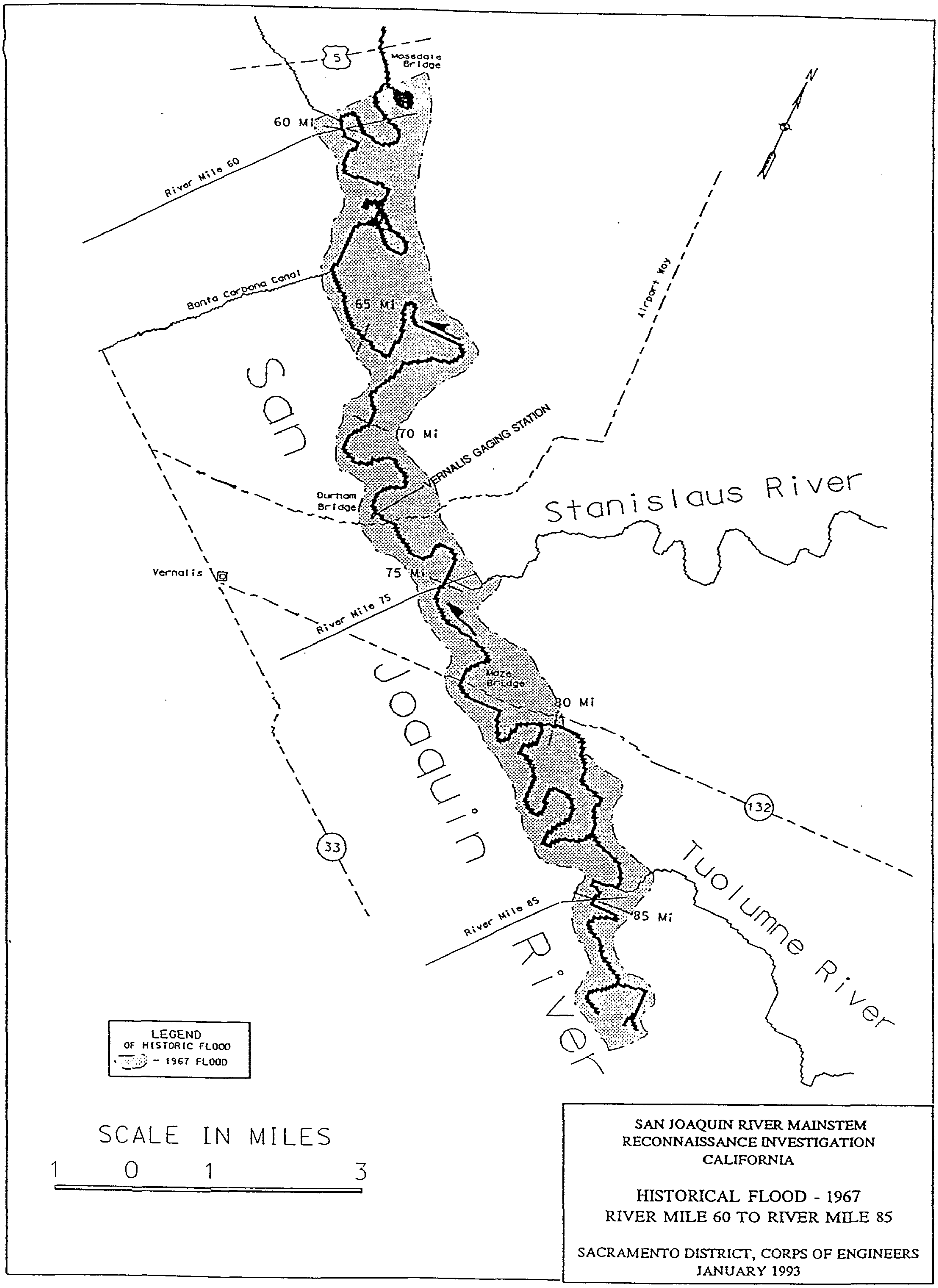


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1965
RIVER MILE 85 TO RIVER MILE 118.5

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 10



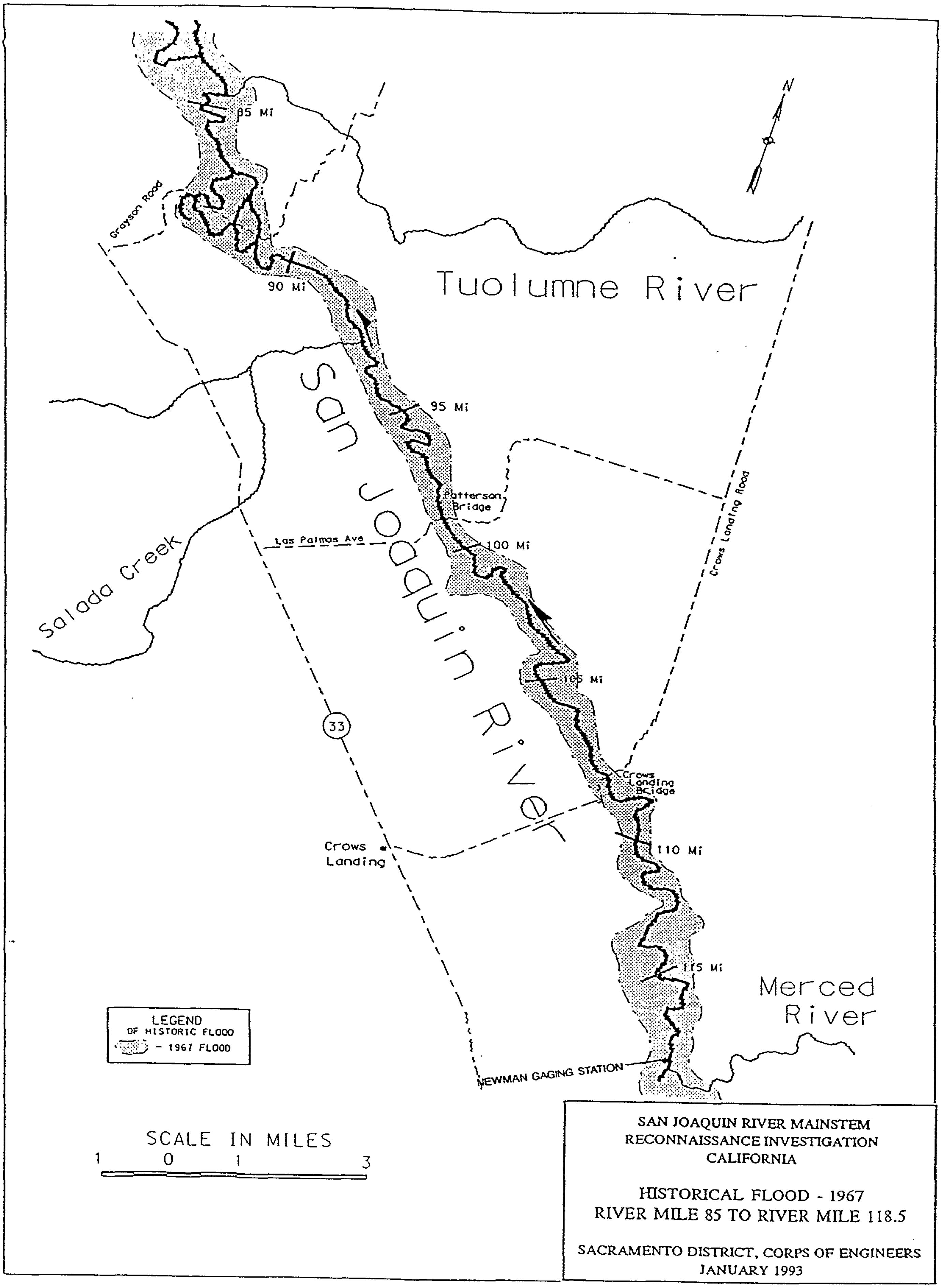
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1967
RIVER MILE 60 TO RIVER MILE 85

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 11

C-104401

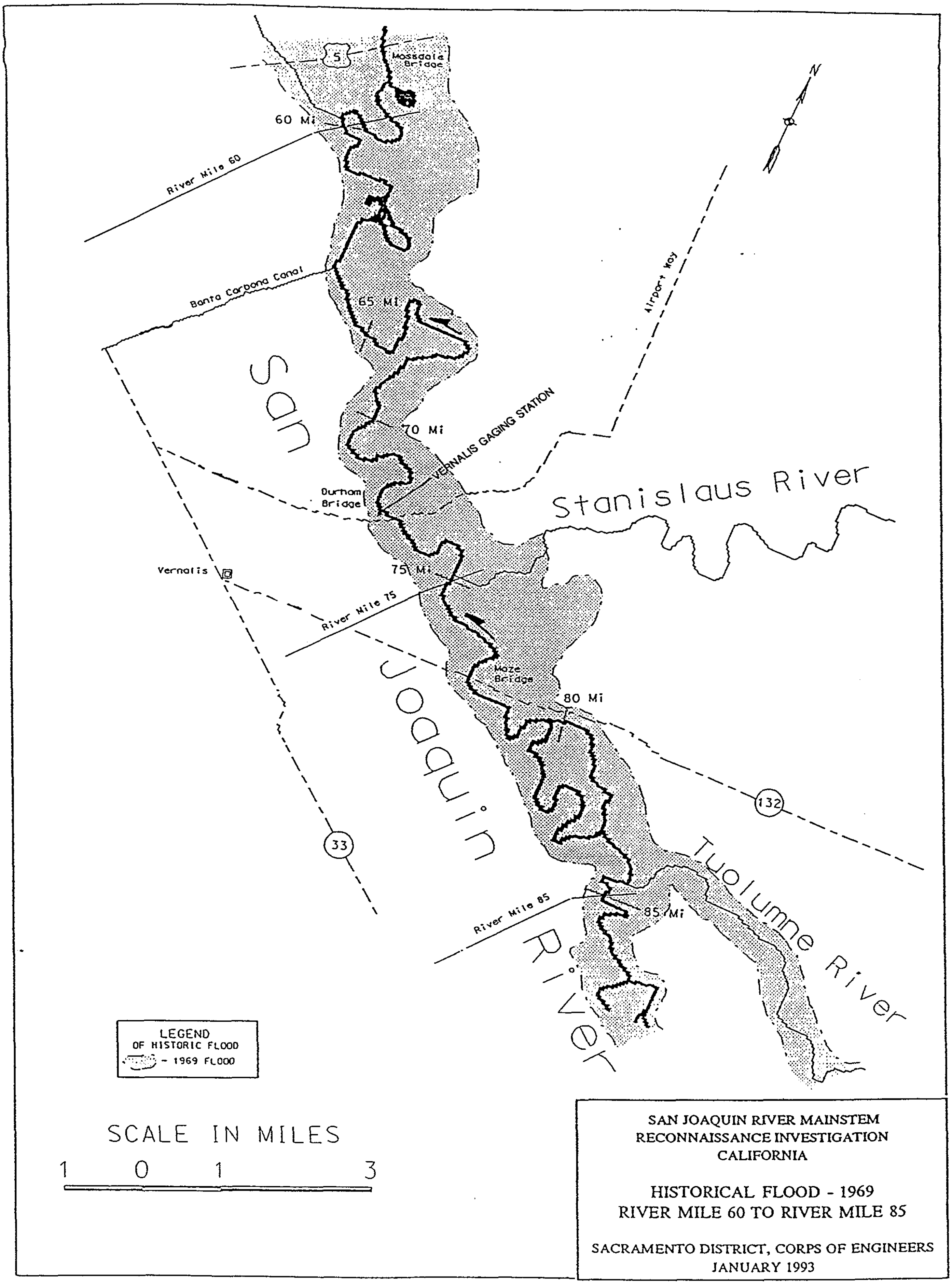


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1967
RIVER MILE 85 TO RIVER MILE 118.5

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 12

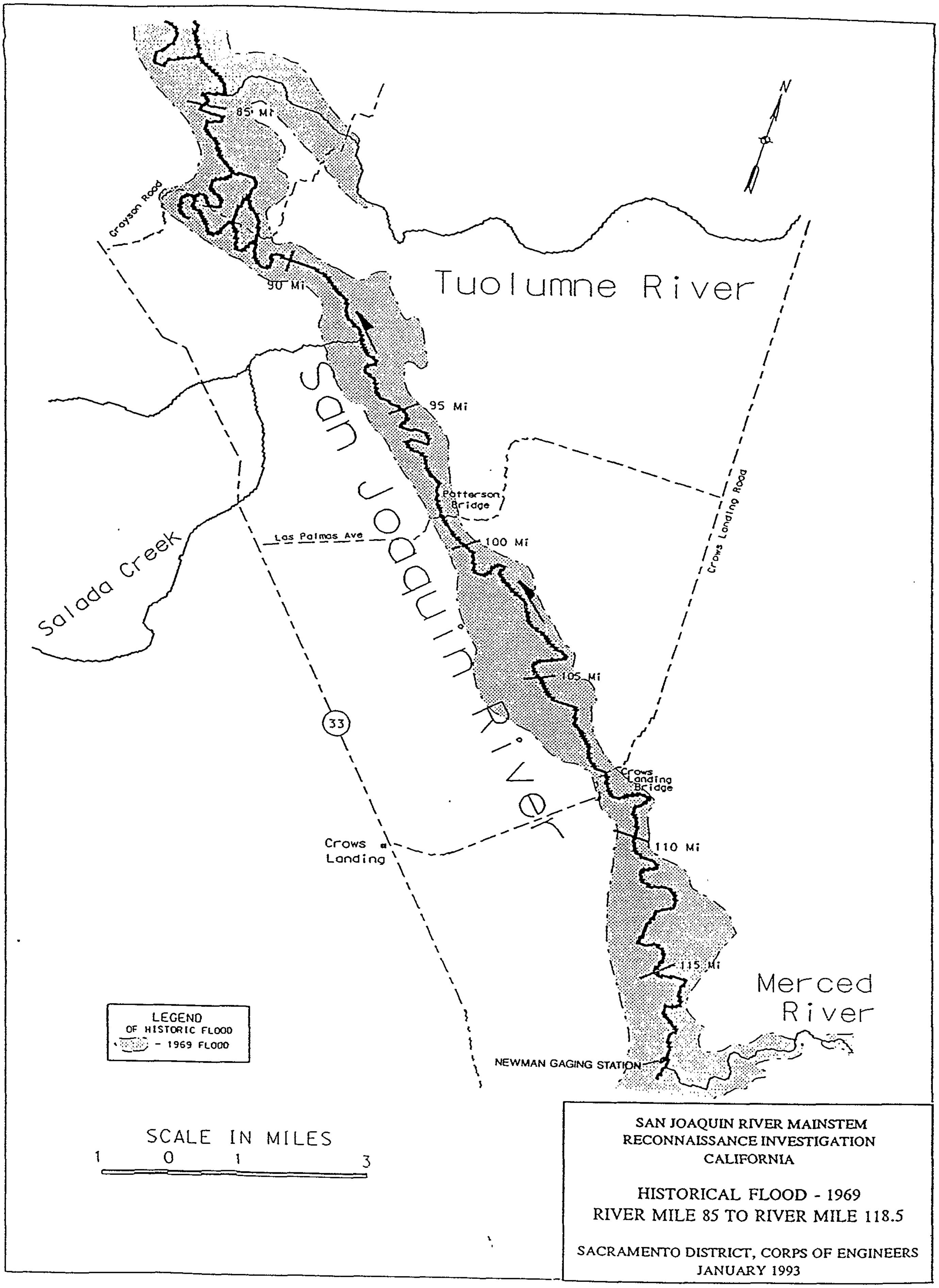


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1969
RIVER MILE 60 TO RIVER MILE 85

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 13

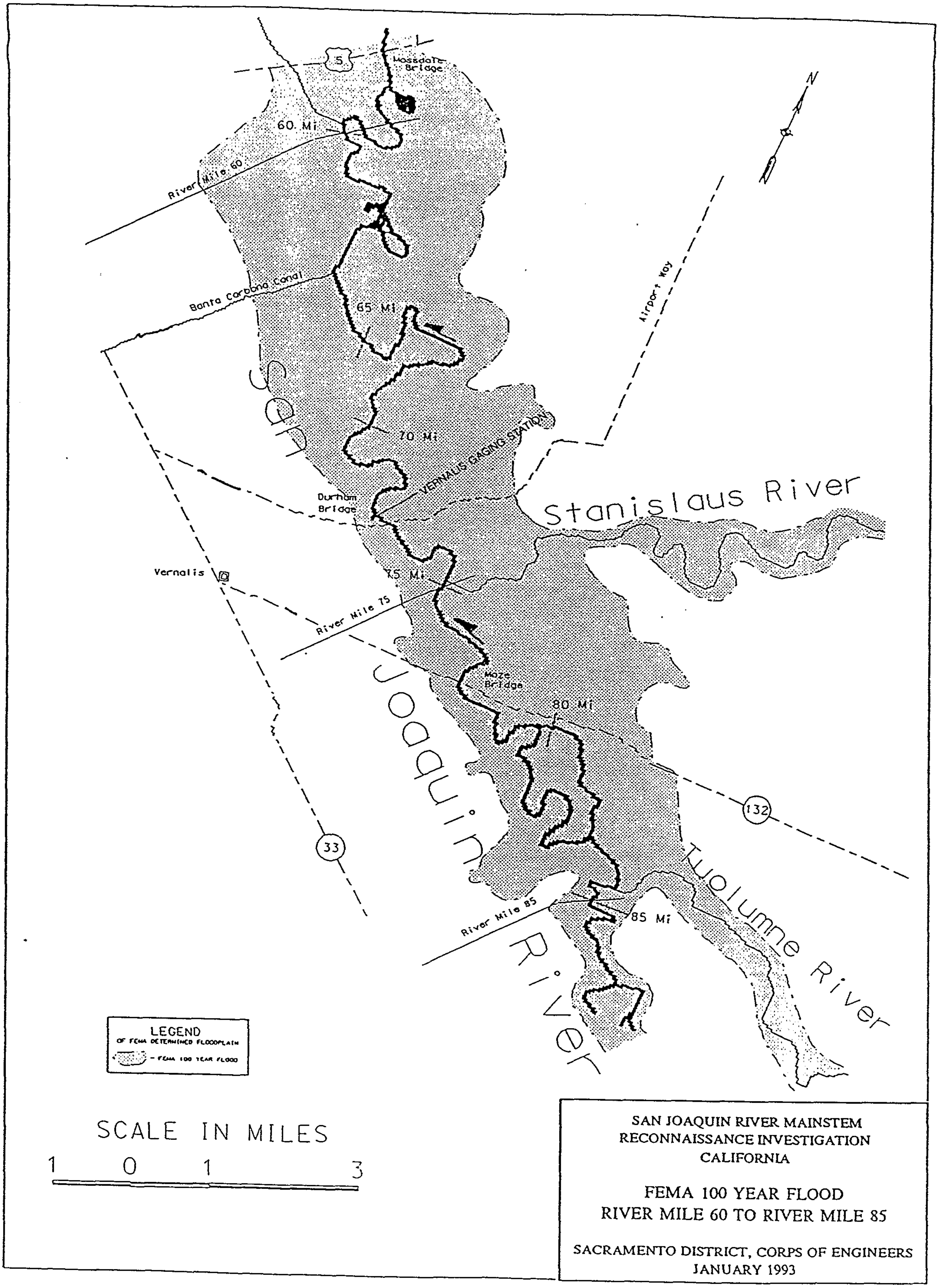


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

HISTORICAL FLOOD - 1969
RIVER MILE 85 TO RIVER MILE 118.5

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 14

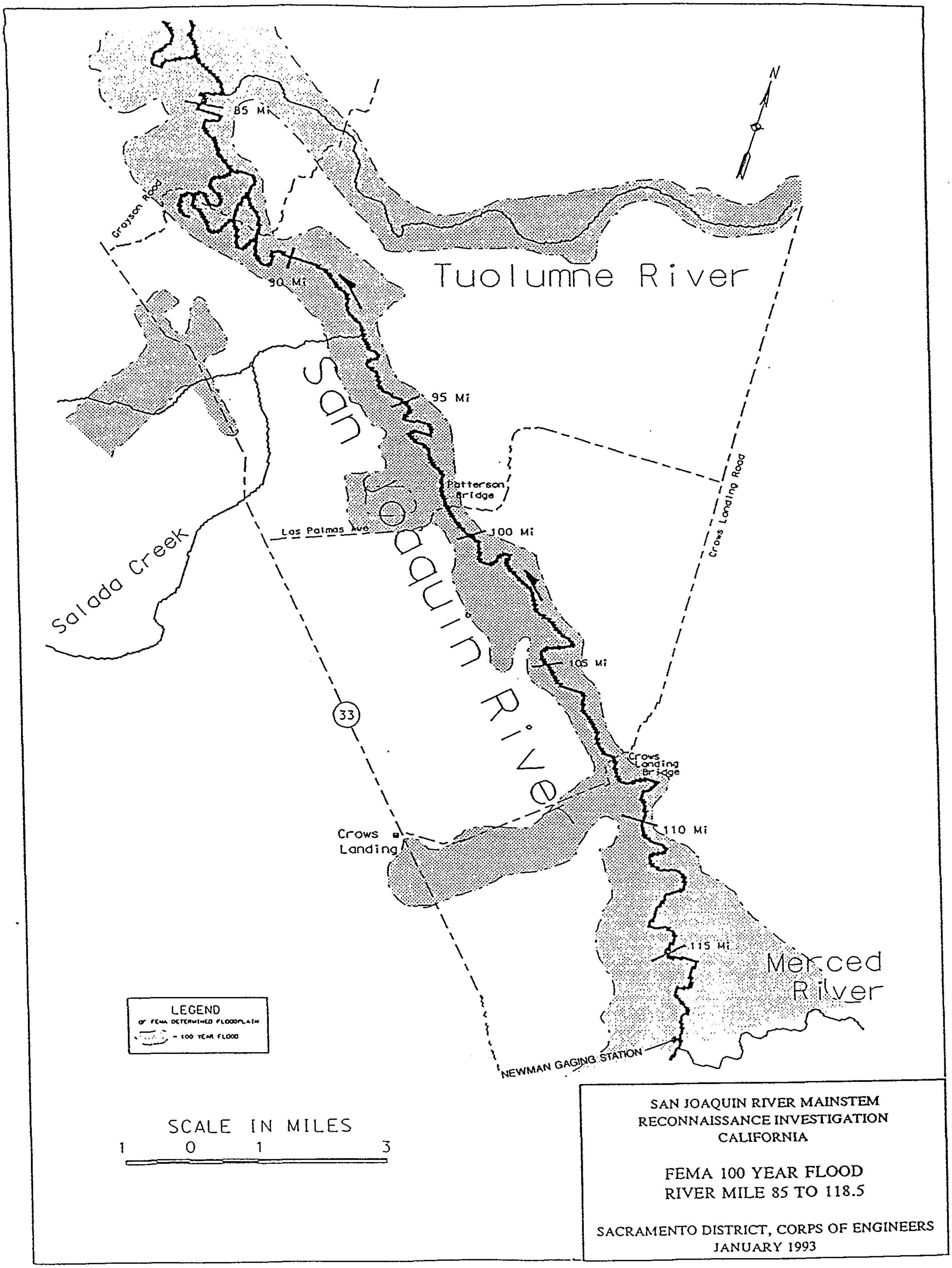


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

FEMA 100 YEAR FLOOD
RIVER MILE 60 TO RIVER MILE 85

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 15



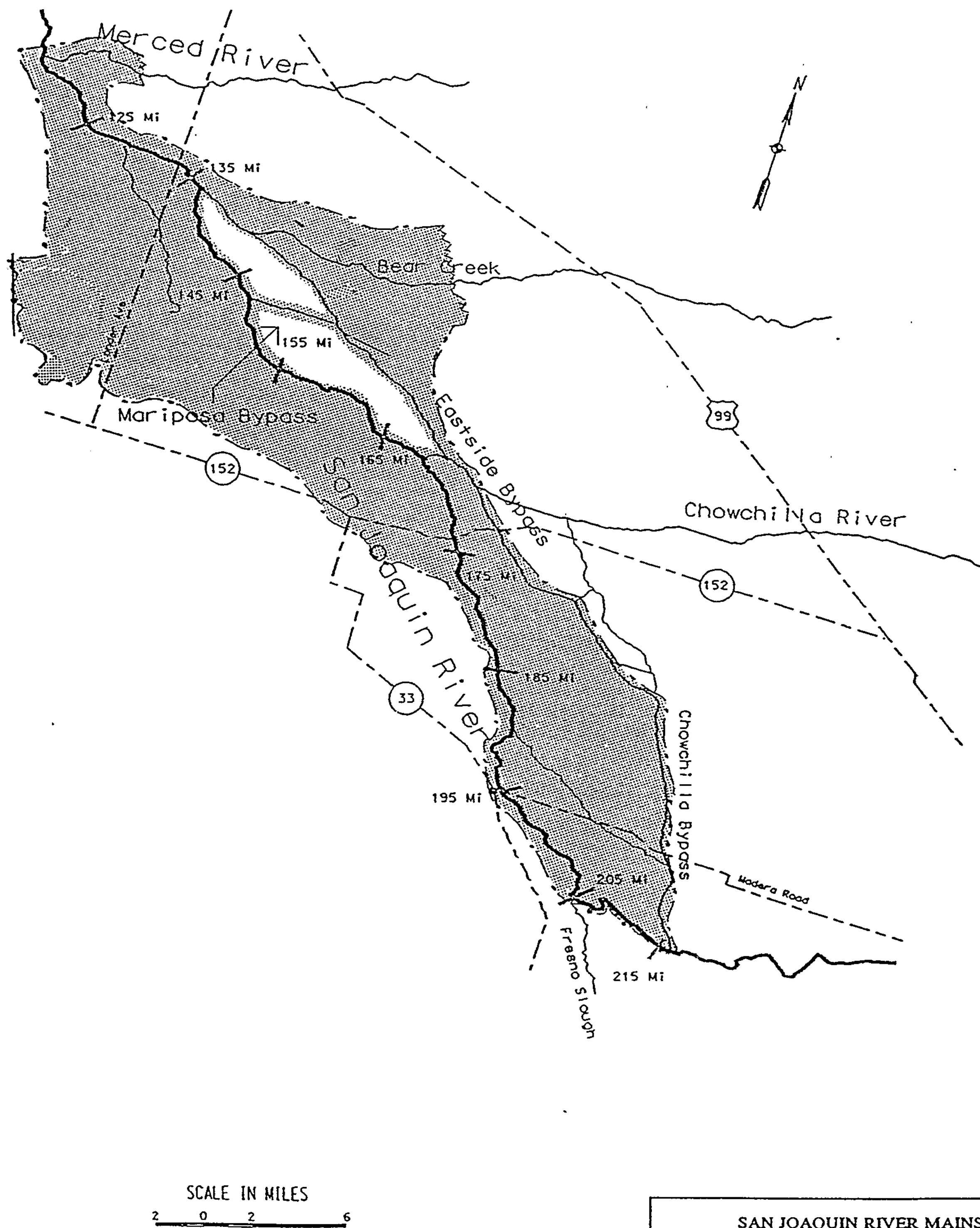
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

FEMA 100 YEAR FLOOD
RIVER MILE 85 TO 118.5

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 16

C-104406



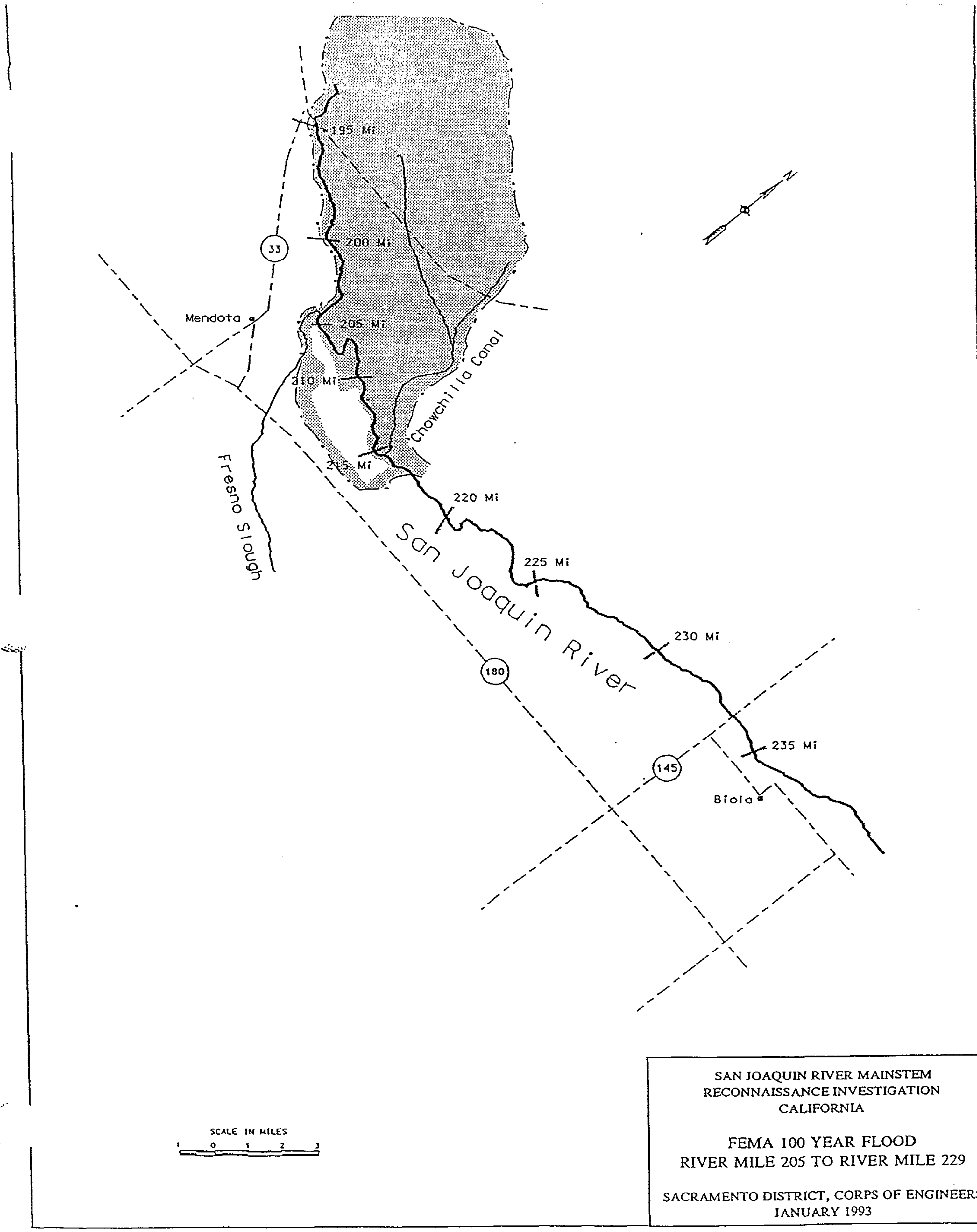
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

FEMA 100 YEAR FLOOD
RIVER MILE 118.5 TO RIVER MILE 205

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 17

C-104407



SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

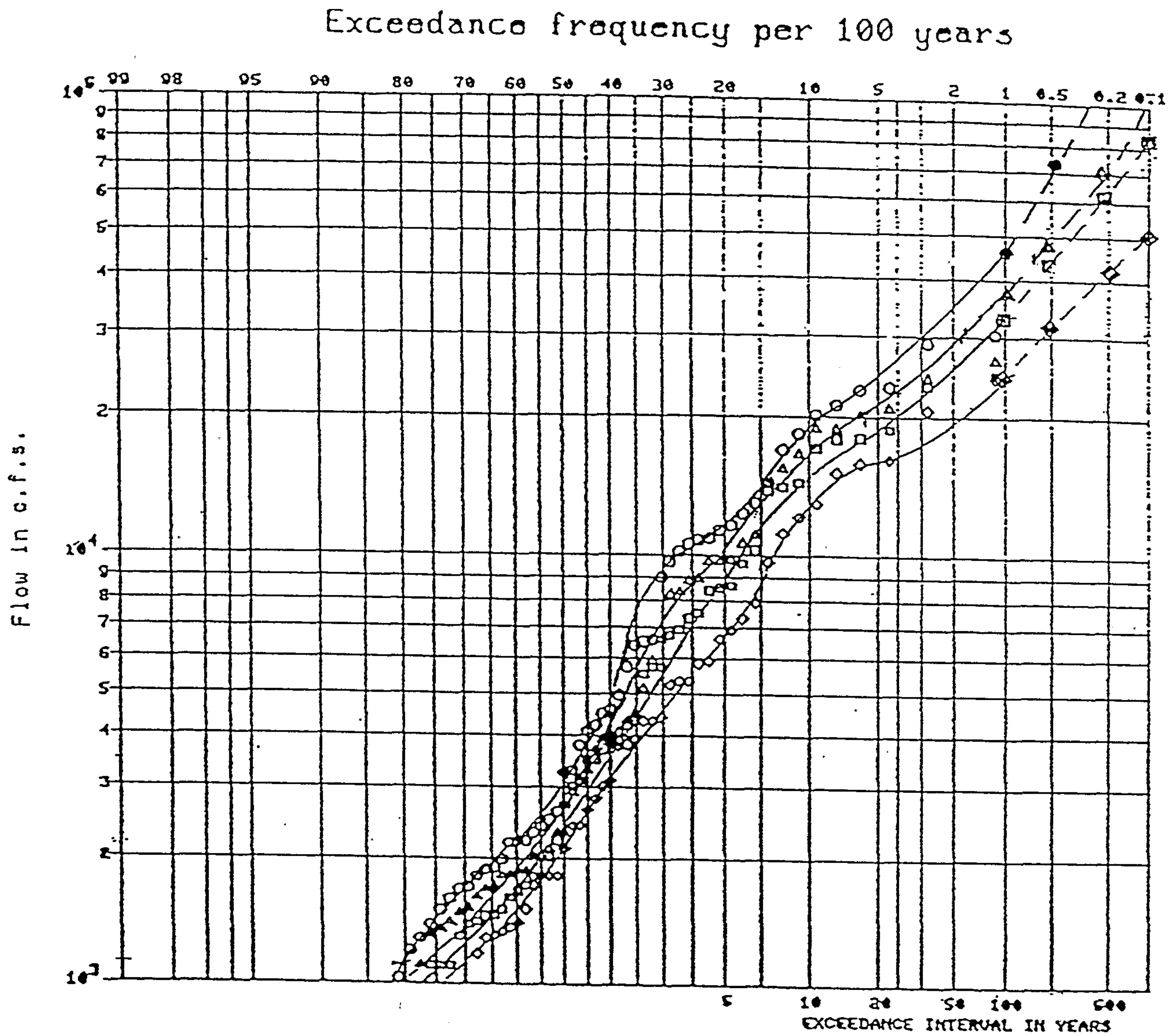
FEMA 100 YEAR FLOOD
RIVER MILE 205 TO RIVER MILE 229

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 18

C—104408

C-104409



Legend:
- ○ 1-Day
- △ 7-Day
- □ 15-Day
- ◇ 30-Day

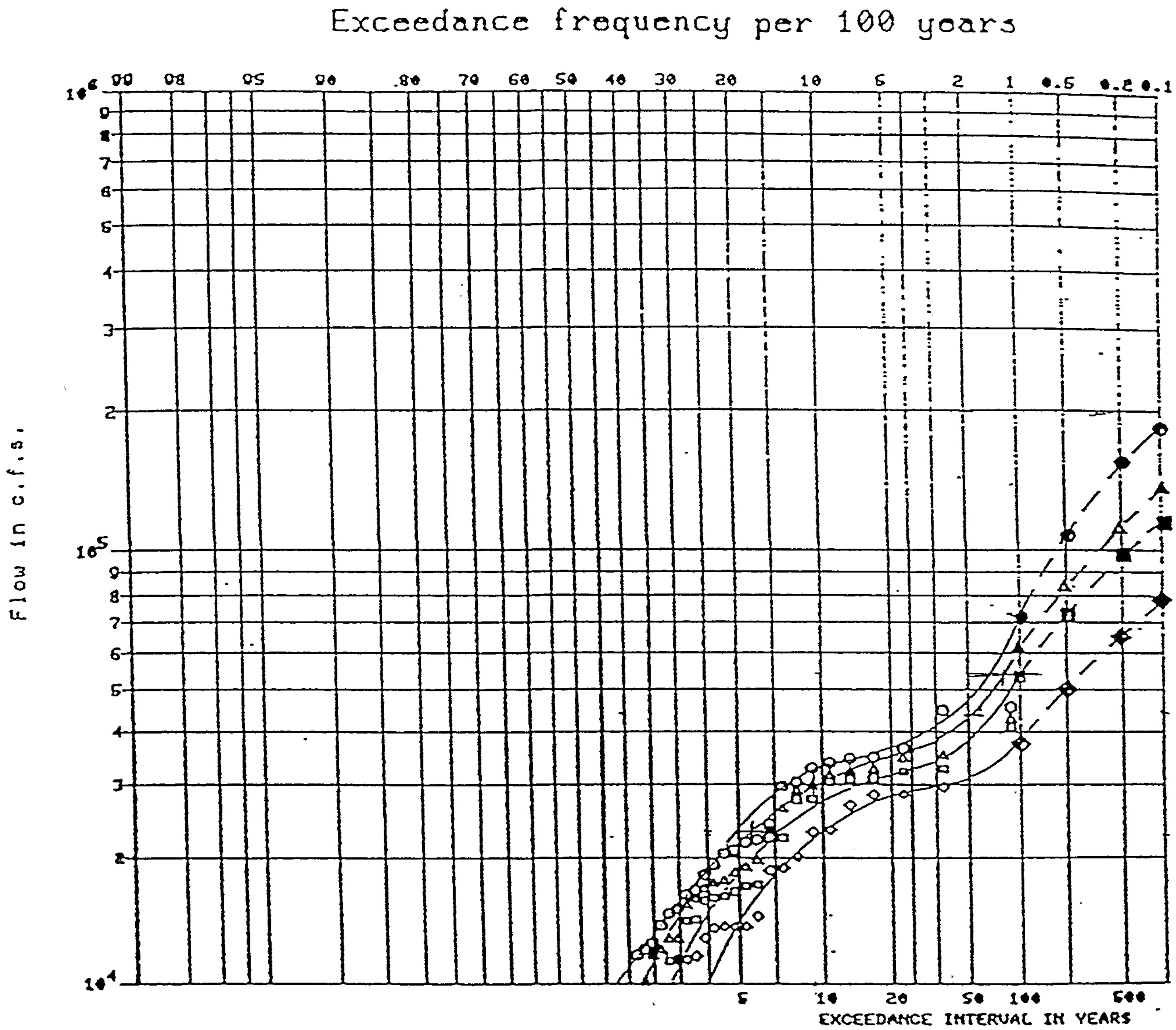
○ Historical Flow
● Hypothetical Flow

Notes:
1. Period of Record 1930-1990.
2. Drainage Area: 9,520 sq. mi.

SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

RAIN FLOW FREQUENCY CURVES
REGULATED CONDITIONS
SAN JOAQUIN RIVER NEAR NEWMAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993



Legend:

- ○ 1-Day
- △ 7-Day
- □ 15-Day
- ◇ 30-Day

○ Historical Flow
● Hypothetical Flow

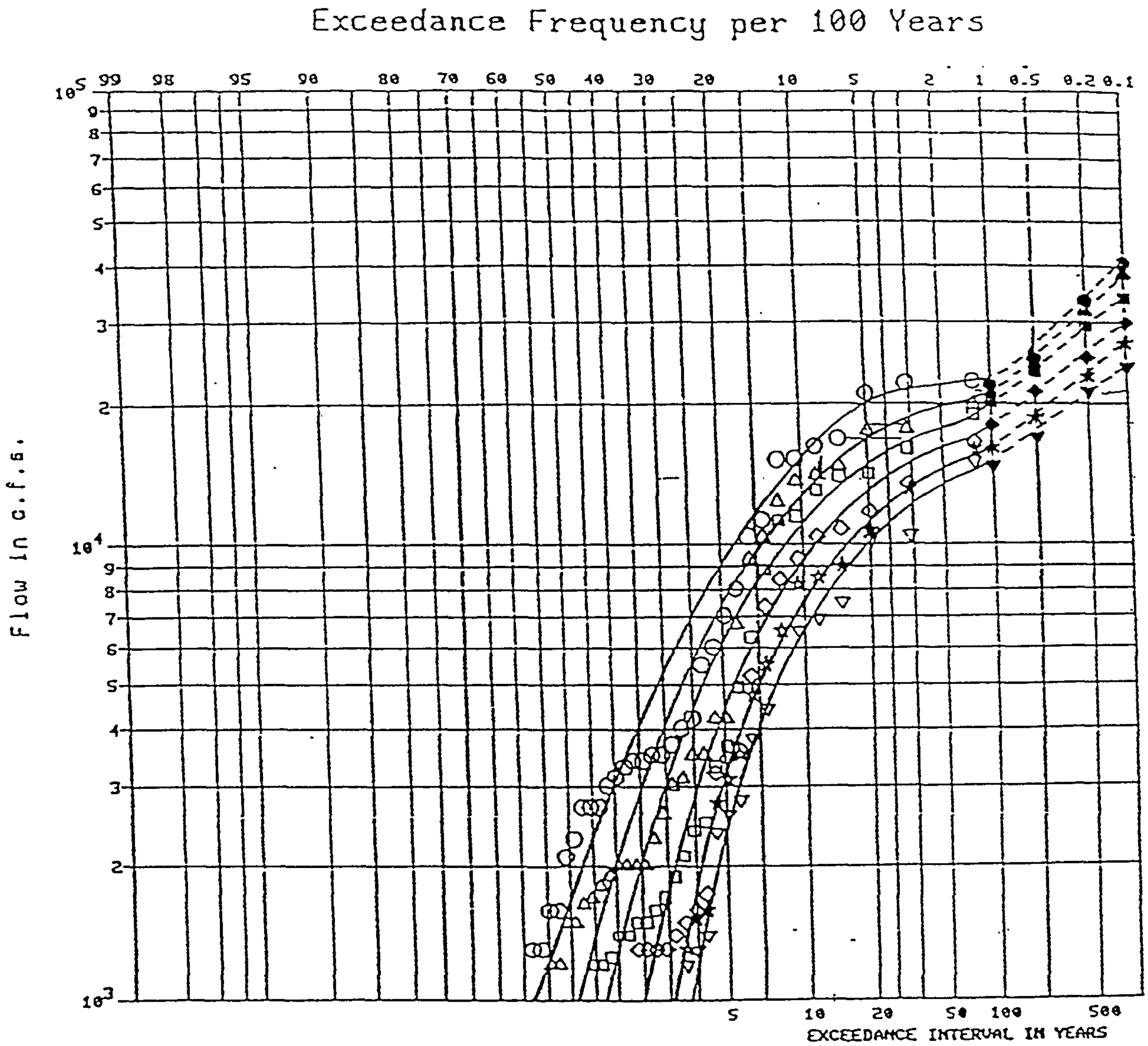
Notes:

1. Period of record 1930-1990.
2. Drainage Area: 13,536 sq. mi.

SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

RAIN FLOW FREQUENCY CURVES
REGULATED CONDITIONS
SAN JOAQUIN RIVER NEAR VERNALIS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993



Legend:

- ○ 1-Day
- △ 15-Day
- □ 30-Day
- ◇ 60-Day
- ★ 90-Day
- ▽ 120-Day

○ Historical Flow

● Hypothetical Flow

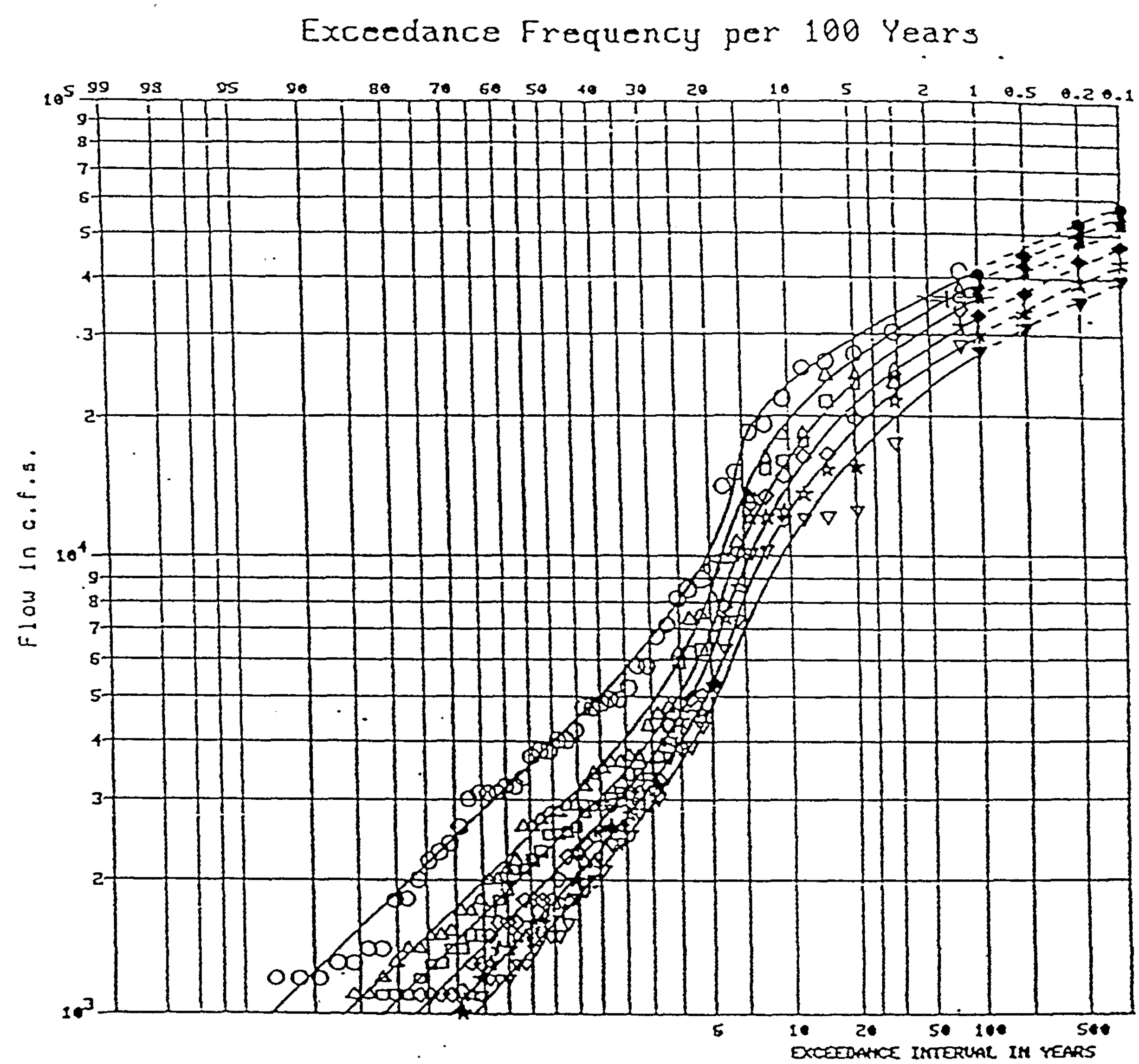
Notes:

1. Period of Record 1950-1990.
2. Drainage Area: 9,520 sq. mi.

SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SNOWMELT FLOW FREQUENCY CURVES
REGULATED CONDITIONS
SAN JOAQUIN RIVER NEAR NEWMAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993



Legend:

- O 1-Day
- Δ 15-Day
- □ 30-Day
- ◇ 60-Day
- ★ 90-Day
- ▽ 120-Day

O Historical Flow

● Hypothetical Flow

Notes:

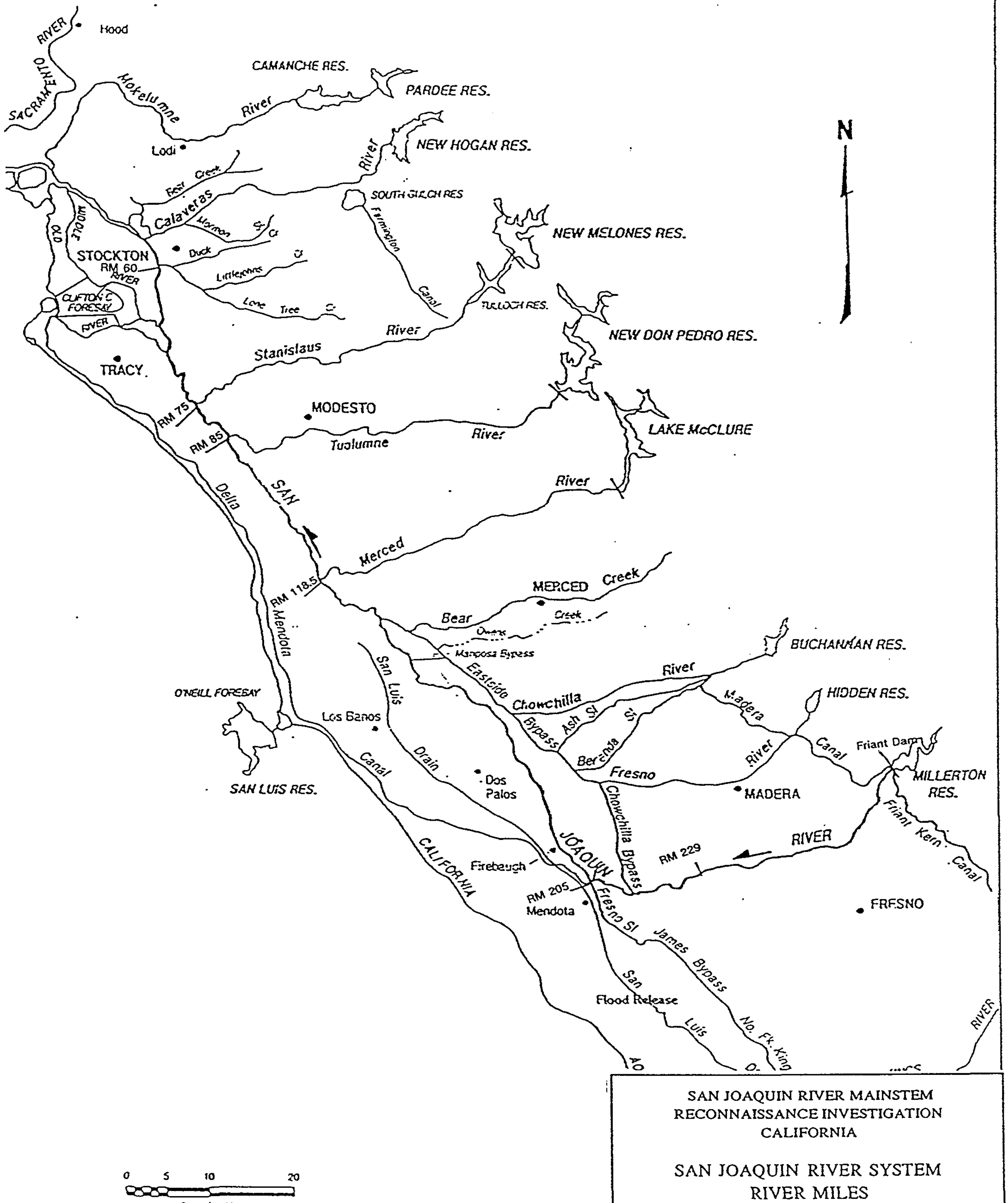
1. Period of record 1930-1990.
2. Drainage Area: 13,536 sq. mi.

SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SNOWMELT FLOW FREQUENCY CURVES
REGULATED CONDITIONS
SAN JOAQUIN RIVER NEAR VERNALIS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 22



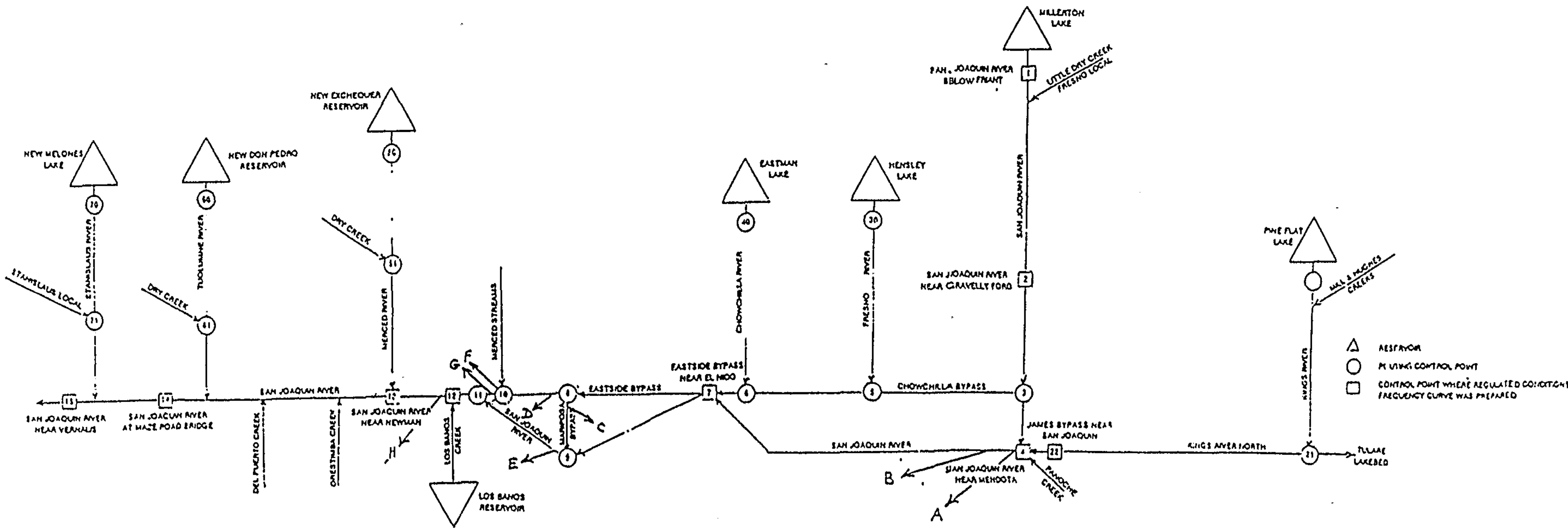
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SAN JOAQUIN RIVER SYSTEM
RIVER MILES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 23

C-104414



Legend

A Grasslands
B Notrh of Wolfson Road
  Lone Willow Slough Area
C Area North of Mariposa Bypass
D Area Northwest of Merced National Wildlife Area
E East Gallo
  West Gallo
  Freitas Ranch
  West of Freitas Ranch
  Northwest of West Gallo
F Arena I
  Arena II
G Eastside Canal West
H China Island

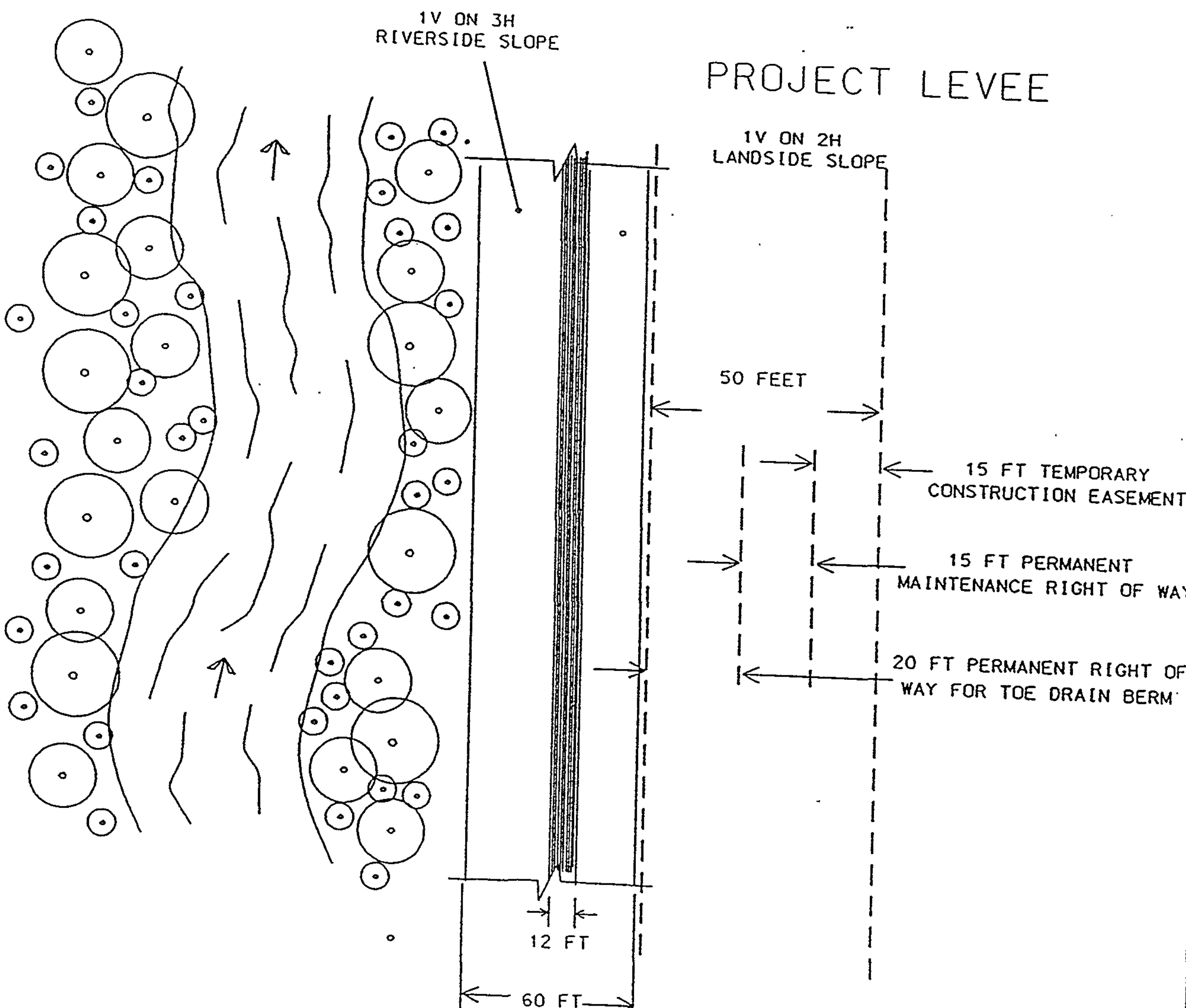
PLATE 24

SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

ROUTING DIAGRAM

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

TYPICAL RIVER SECTION
SEEPAGE REPAIR
SAN JOAQUIN RIVER



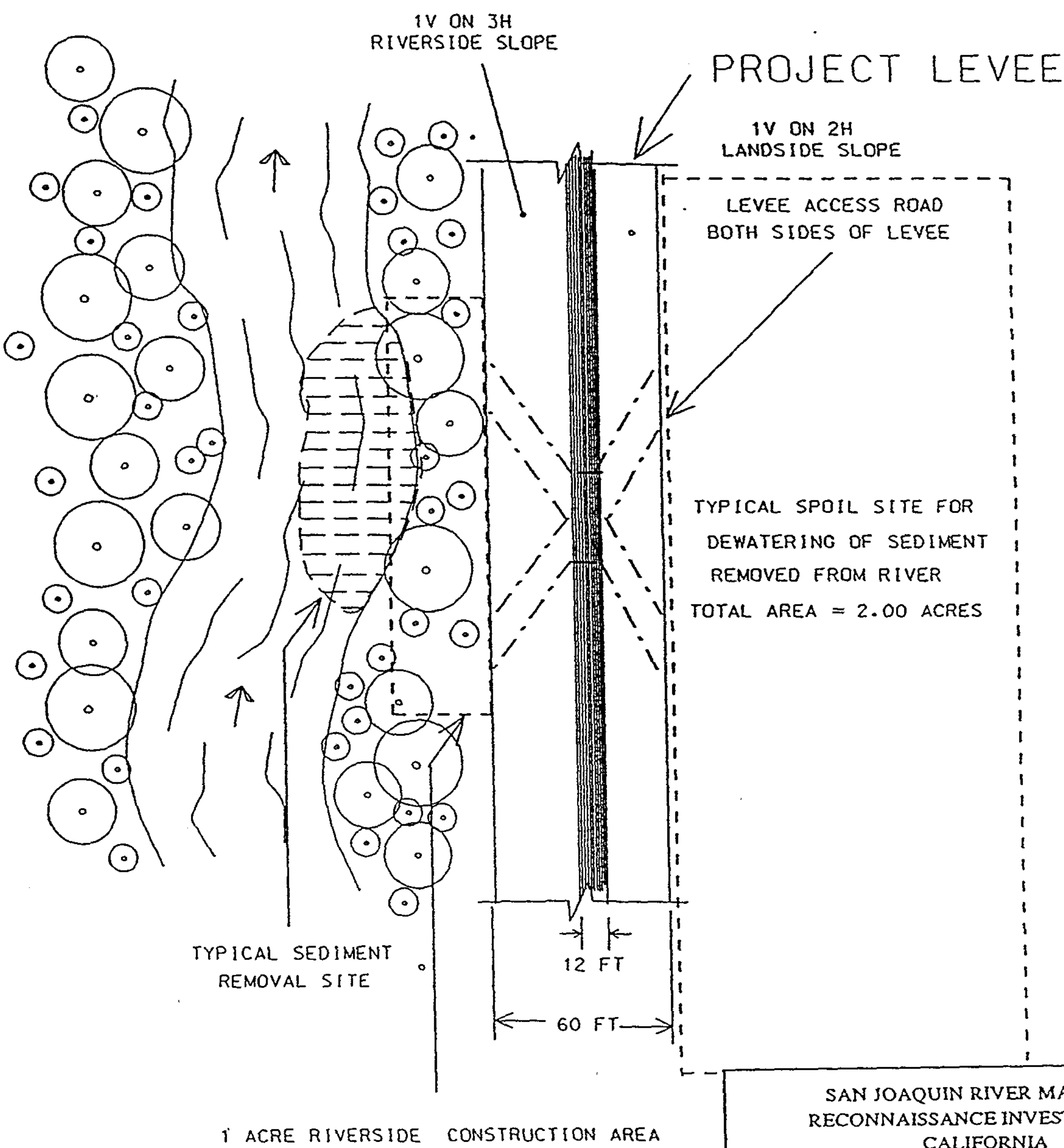
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SAN JOAQUIN RIVER
TYPICAL RIVER SECTION
SEEPAGE REPAIR

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 199[illegible]

PLATE 25

TYPICAL RIVER SECTION
SEDIMENT DEPOSITION
SAN JOAQUIN RIVER



SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

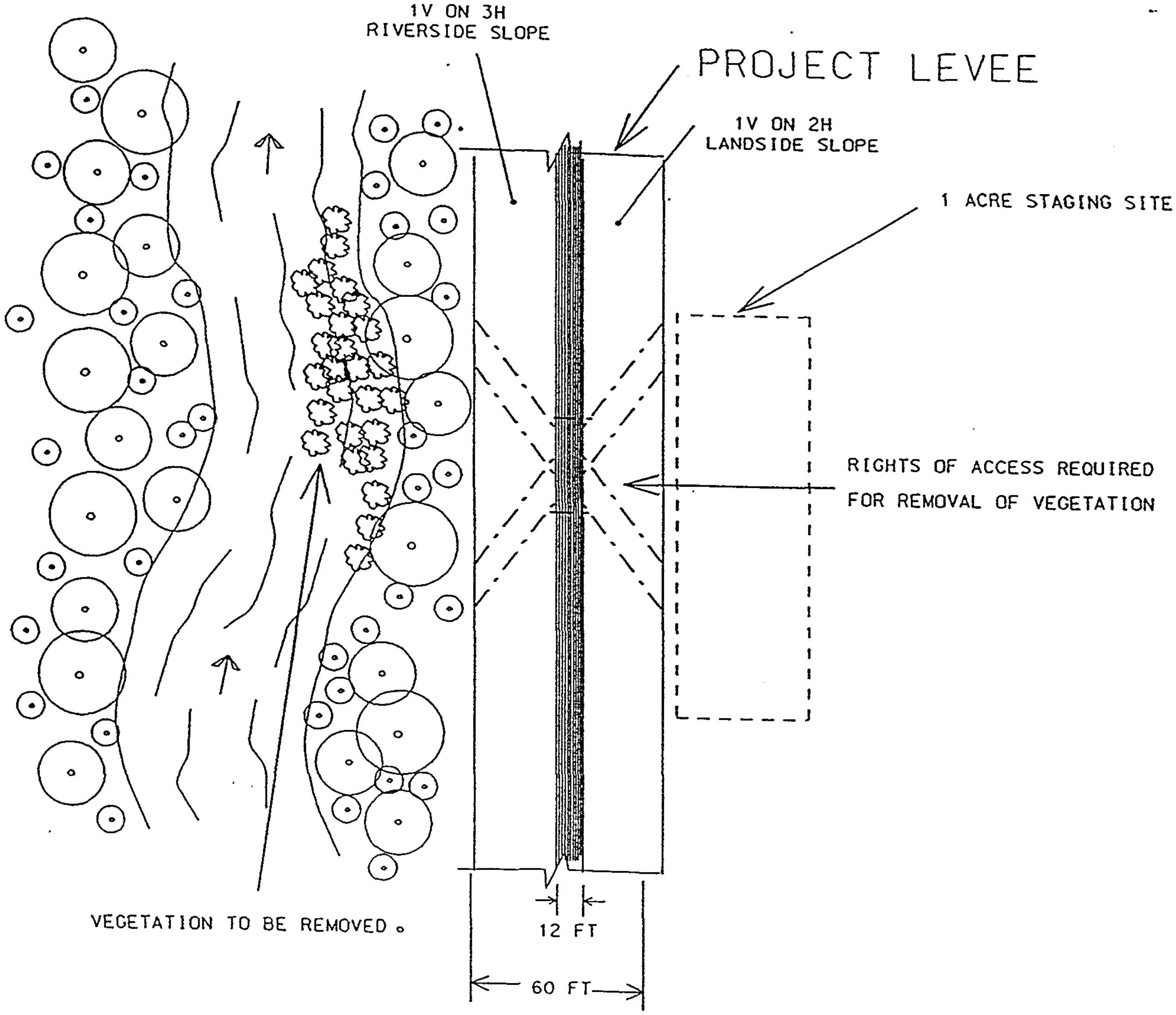
SAN JOAQUIN RIVER
TYPICAL RIVER SECTION
SEDIMENT DEPOSITION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 26

C-104416

TYPICAL RIVER SECTION
VEGETATION ENCROACHMENT
SAN JOAQUIN RIVER



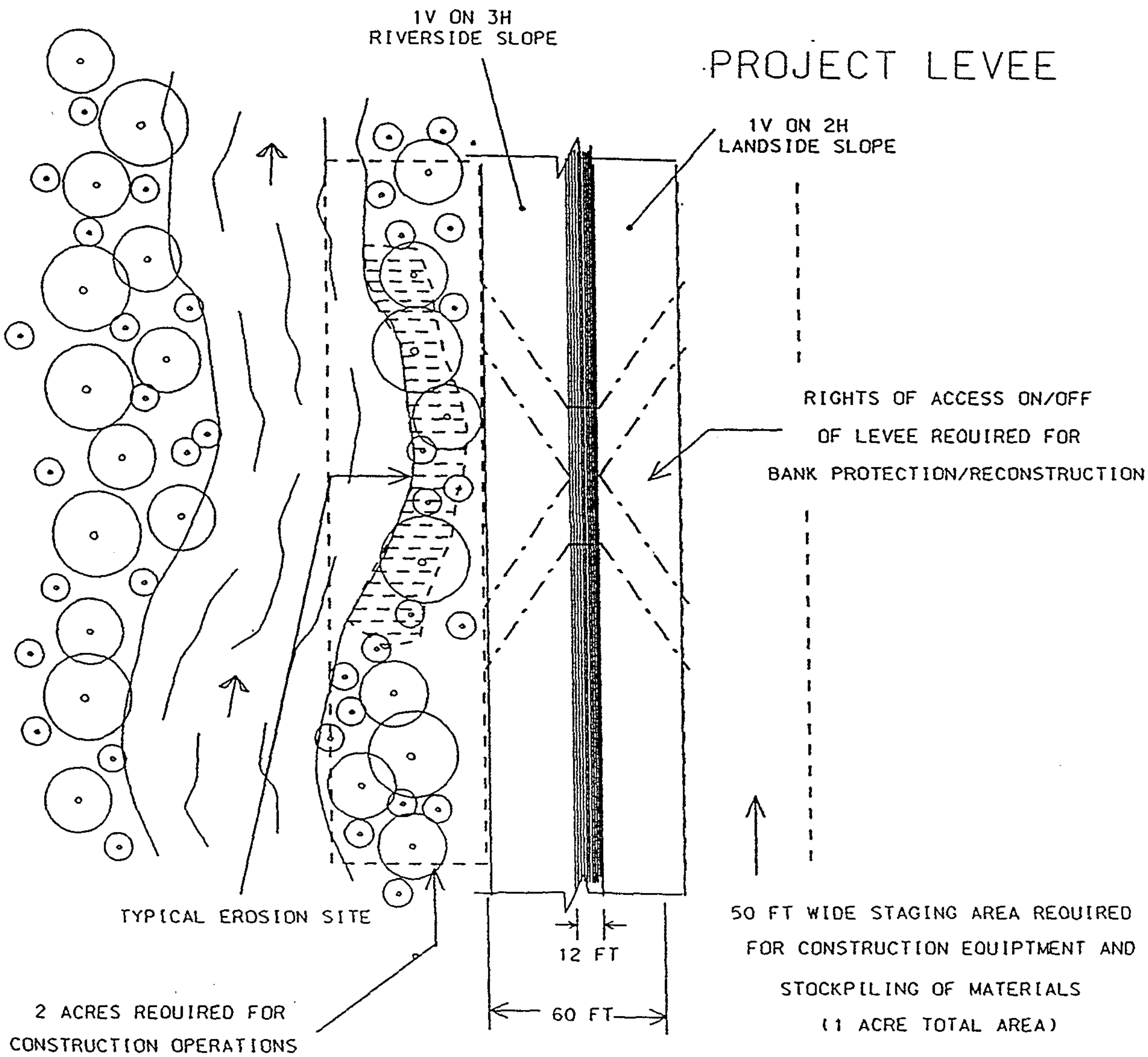
SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SAN JOAQUIN RIVER
TYPICAL RIVER SECTION
VEGETATION ENCROACHMENT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 27

TYPICAL RIVER SECTION
EROSION REPAIRS
SAN JOAQUIN RIVER

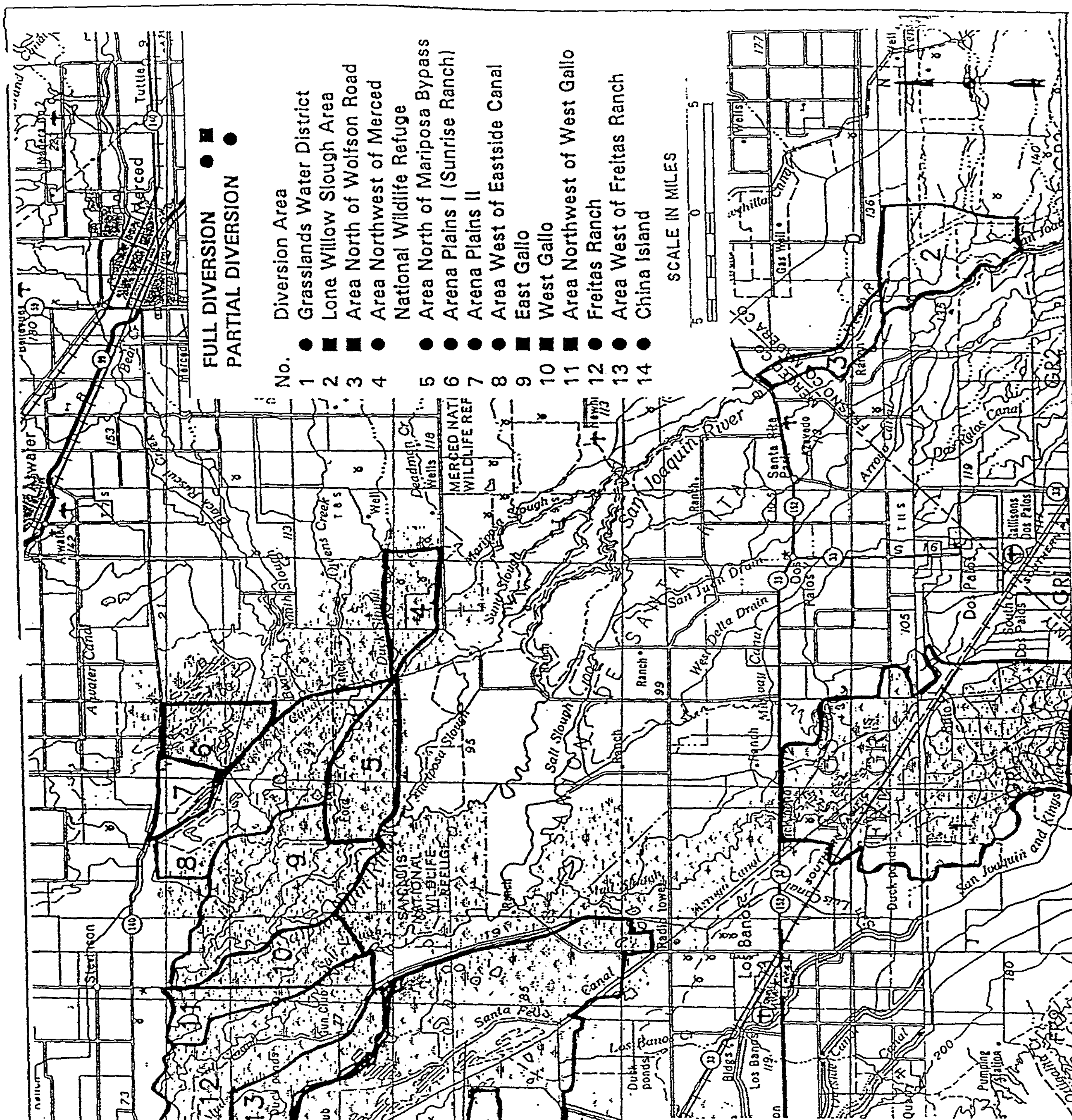


SAN JOAQUIN RIVER MAINSTEM
RECONNAISSANCE INVESTIGATION
CALIFORNIA

SAN JOAQUIN RIVER
TYPICAL RIVER SECTION
EROSION REPAIRS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 28



SAN JOAQUIN MAINSTEM RECONNAISSANCE INVESTIGATION, CA

DIVERSION AREAS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1993

PLATE 29

C-104419