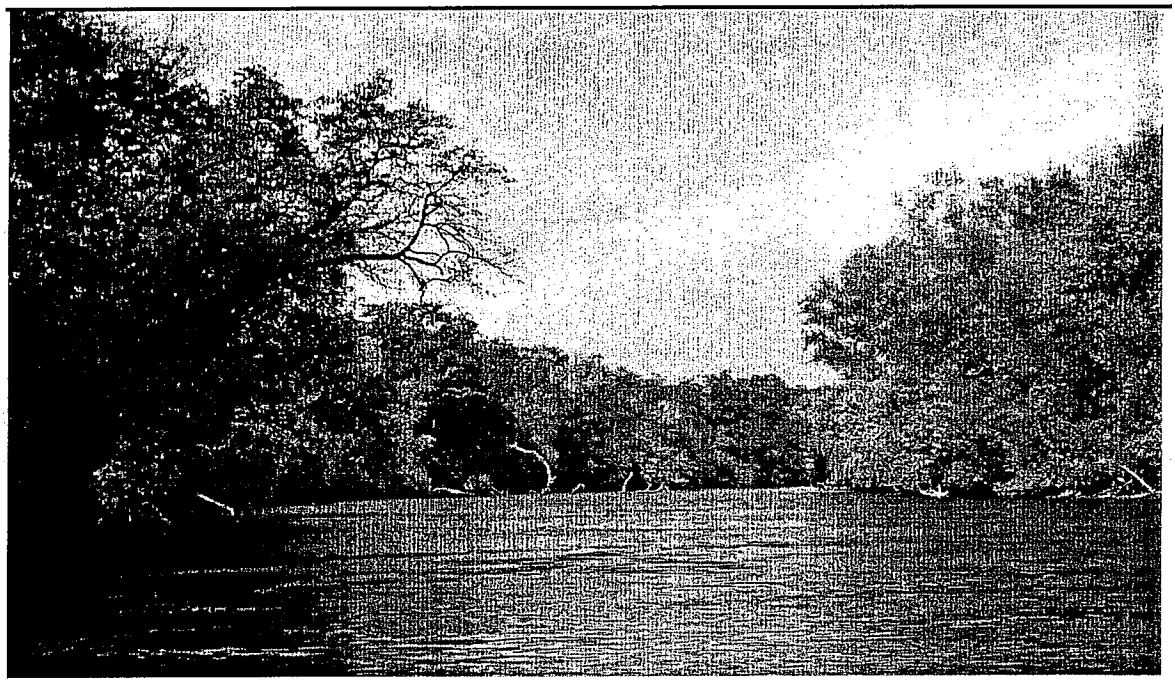
Draft Detailed Project Report and Environmental Assessment Section 1135 Ecosystem Restoration Project

Woodson Bridge, California



U.S. Army Corps of Engineers
Sacramento District
Tehama County
California State Reclamation Board

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CONTENTS

Alternative 2 –
Environmental Benefits and Costs

Alternative 3 –
Environmental Benefits and Costs
Comparison of Alternative Plans
Cost Effectiveness/Incremental Analysis
Fulfillment of Objectives
Identification of Net Ecosystem Restoration Benefits and Selected Plan

CHAPTER 5 – DETAILS OF SELECTED PLAN
Plan Components and accomplishments
Operation and Maintenance
Monitoring/Adaptive Management Plan
Detailed Cost Estimate
Real Estate Requirements
Environmental Effects

CHAPTER 6 – IMPLEMENTATION OF SELECTED PLAN AND SCHEDULE
Public Review of Draft Document
Report Approval and Future Activities
Federal and Non-Federal Responsibilities
Federal
Non-Federal
Schedule

CHAPTER 7 – CONCLUSIONS AND RECOMMENDATIONS
Conclusions
Recommendation

Tables

Plates

Appendixes

CHAPTER 1 - INTRODUCTION

BACKGROUND AND PROJECT AREA

The Sacramento River heads in the mountains west of Mount Shasta and flows to the south near Redding, where it enters the Shasta Reservoir. Below Shasta and its afterbay Keswick Reservoir, the river has cut a sinuous course through steep bluffs to the town of Red Bluff, where it enters the Sacramento Valley.

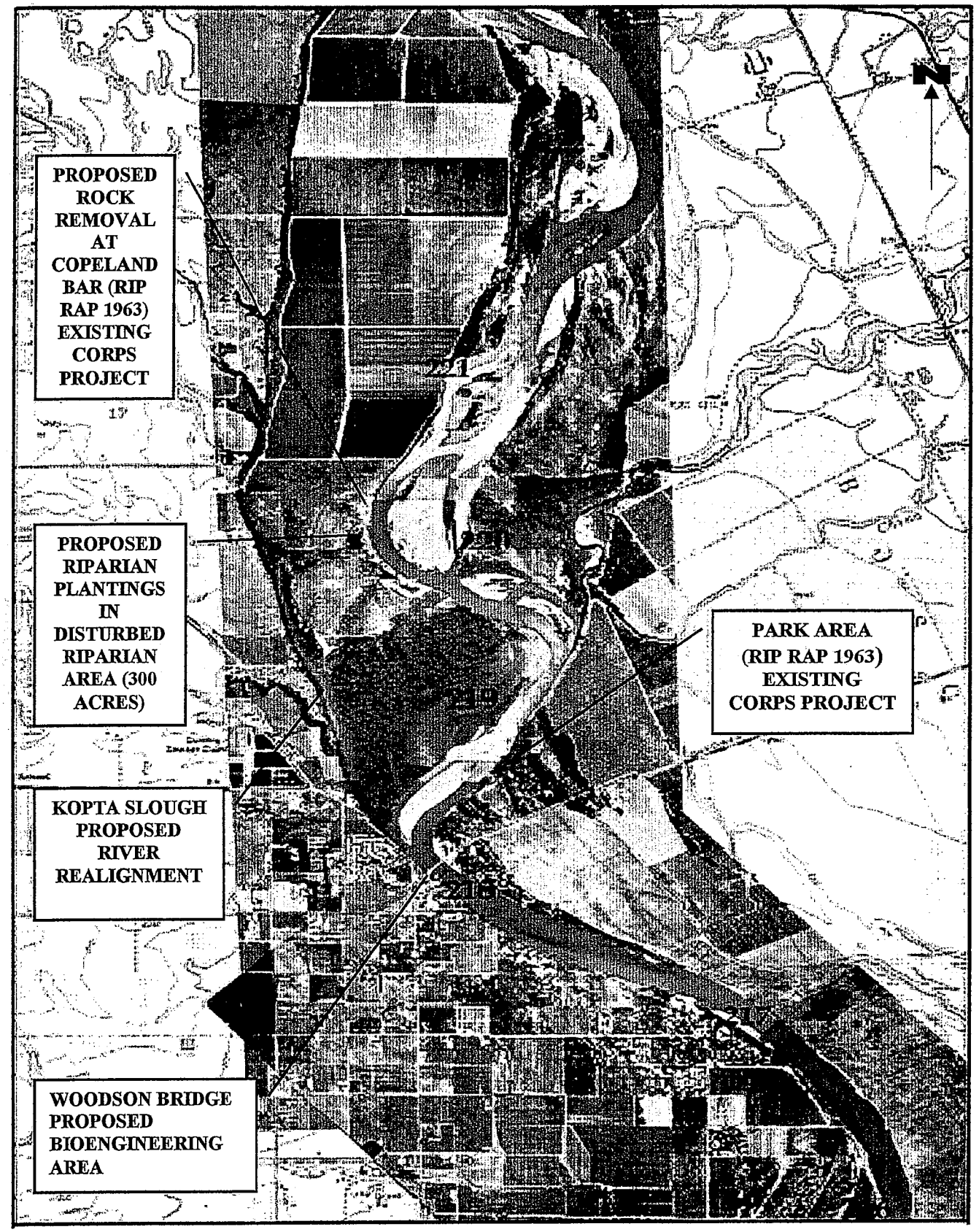
In the Sacramento Valley, the river meanders across its own fluvial deposits in a zone that varies between 500 and 7,500 feet wide. Geologic control, consisting of older river deposits that are more erosion resistant than the meander belt deposits, constrain the movement of the river is some areas.

Woodson Bridge State Recreation Area is east of Corning in the northern part of the Sacramento Valley and about 15 miles south of Red Bluff. The study area includes a 3-mile river reach and associated riparian corridor from River-Mile 218 near Vina Woodson Bridge State Recreation Area through River Mile 221 upstream of Vina Woodson Bridge. The area also includes Kopta Slough and the mouth of Deer Creek, both of which include high quality shaded riverine aquatic habitat. This river reach also includes 2.2 miles of rock revetment (previous Corp bank stabilization project), and 6.3 miles of shaded riverine aquatic habitat, and 0.4 miles of eroded banks. The location of the proposed restoration project is shown in Figure 1. The proposed project modifications are shown in Figure 2.

The community has requested assistance in restoring and preserving the Sacramento River stream corridor habitat and natural functions to sustain diverse and valuable wildlife, fish, amphibians, and plant species. In fiscal year 2003, the State Reclamation Board in coordination with Tehama County, agreed to become the local sponsor for the Corps of Engineers' study to restore riparian and aquatic habitat along the Sacramento River

PURPOSE AND SCOPE

This report addresses the results of a feasibility study to potentially modify a former Corps authorized 1958 flood control project. The 1958 project provided bank protection along 50 miles of the Sacramento River between Chico Landing and Red Bluff and for flood plain zoning along the river upstream to Keswick Dam. The land use in the area has changed since 1958 and the majority of the land in the study area is now used for open space and habitat at this time. The purpose of the Woodson Bridge/Kopta Slough ecosystem restoration study is to develop and evaluate alternative plans that would restore the degraded ecosystem structure, function, and dynamic processes to a more natural condition by establishing a self-sustaining aquatic and terrestrial ecosystem. Specifically, the study evaluates opportunities to increase the natural integrity, productivity, stability, and biological diversity of the Sacramento River and adjacent ecosystem. This report will address the results of restoring stability and river form and


PROPOSED ROCK REMOVAL AT COPELAND BAR (RIP RAP 1963) EXISTING CORPS PROJECT
PROPOSED RIPARIAN PLANTINGS IN DISTURBED RIPARIAN AREA (300 ACRES)
KOPTA SLOUGH PROPOSED RIVER REALIGNMENT
WOODSON BRIDGE PROPOSED BIOENGINEERING AREA
PARK AREA (RIP RAP 1963) EXISTING CORPS PROJECT
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pattern of hydrology, hydraulics, sediment transport, and morphologic functions near River Mile 220 by examining methods to reconnect the river to its active floodplain by modifying the existing bank protection project. This study will also address reducing bank erosion to help stabilize river banks and provide wildlife habitat near Vina Woodson Bridge. Reducing erosion will improve water quality by reducing non-point source sediment in the Sacramento River, which would benefit fish, wildlife, aquatic invertebrates, and their habitat; which would subsequently provide benefits to the aquatic system of the Sacramento River Finally this report will look at the possibility of restoring up to 300 acres of aquatic, riparian, and adjacent terrestrial habitats between Kopta Slough and the Sacramento River for use by migratory and neo-tropical birds that migrate along the Sacramento River corridor, listed species and other wildlife species. This detailed project report provides a complete presentation of study results and findings; indicates compliance with applicable statutes and policies; and provides a basis for the recommended plan. The enclosed Environmental Assessment/Initial Study addresses the potential effects of alternative plans, including the recommended action consistent with the NEPA, CEQA, and other pertinent laws, regulation and policy.

STUDY AUTHORIZATION

This project was authorized by Section 1135(b) of the Water Resources Development Act (WRDA) of 1986 (33 U.S.C. 2294), as amended. Under this authorization, ecosystems affected by Corps projects would be modified to restore the structure or function to a more natural, less degraded condition. Accordingly, the Corps has been requested by Tehama County to plan, design, and implement the restoration of a reach of the Sacramento River near Vina Woodson State Park Recreation Area and Kopta Slough near Red Bluff, California.

PRIOR AND PROPOSED STUDIES AND REPORTS

Department of Water Resources

"*Woodson Bridge State Recreation Area Long Term Solutions Study Working Draft*" November 1998. This study evaluated eight possible alternatives for the long-term solution to bank erosion at Woodson Bridge State Recreation Area outside the meander zone. California State Parks and Recreation supported the river restoration option which may require the decommissioning and removal of riprap on the right bank upstream of the confluence of Deer Creek, which will allow the river over time to form a chute cutoff and recapture Kopta Slough. The Nature Conservancy holds the land, where the new channel would be located, in trust for the State of California. It would be expected that over time this land would be eroded and the riparian vegetation rejuvenated. Land along Kopta Slough is protect by erosion resistant geologic units and is not expected to erode significantly.

University of California, Davis

"*Channel Migration of the Sacramento River near Woodson Bridge State Recreation Area: A Case Study of Alternative Channel Management Strategies*" published November 1998. Department of Geology, Department of Agronomy and Range Science, Eric W. Larsen, Steven E. Greco, and Christopher Barker.

The University of California, Davis was contracted by Department of Water Resources to create a computer model used to simulate migration of a segment of the Sacramento River (river miles 216 to 226) known as the Woodson Bridge State Recreation Area and this project's proposed study area. Channel migration is predicted over fifty years that would result from six different channel stabilization scenarios (including a case with no stabilization). Understanding the hydraulic controls on the evolution of the planform shape of meandering alluvial rivers allows for planning future locations of a river when alternative bank stabilization or channel realignment scenarios are proposed. The results of the UCD analyses and the DWR analyses are similar.

Deer Creek Watershed Conservancy

The Deer Creek Watershed Conservancy, an organization of watershed landowners, has proposed funding from CALFED to conduct a feasibility study for an ecosystem restoration and floodplain management project for lower Deer Creek , which is a tributary flowing into the Sacramento River near river mile 219.6. Deer Creek is one of only three streams in the Central Valley still supporting wild populations of the federally threatened steelhead trout and fall-run Chinook salmon. The levees in the area have failed repeatedly since their construction. CALFED has recommended that the Conservancy work in cooperation with the U.S. Army Corps of Engineers, the Reclamation Board, and Tehama County for consideration.

Division of Flood Management

The Palisades Demonstration Bank Protection Project – Monitoring and Evaluation Program – Background Conditions and Construction Impacts prepared 1986 by Division of Flood Management. The project was installed in the fall of 1986. The Palisades Project was an experimental "flow modification system" consisting of a collection of nets and poles designed to stop erosion by slowing flow velocities and causing the deposition of sediment along the bank. The Palisades installation did not result in bank restoration through sediment deposition, an had been experienced for installations by the vendor on siltier streams in the Midwest. The Palisades Project was removed in 1997 because of navigation hazards. Removal of the project has returned the site to its pre-project condition with renewed exposure to erosion of parkland and facilities.

Add Rio Vista restoration project here – final Feasibility Study due 10/30/03

STUDY PARTICIPANTS AND COORDINATION

The Corps of Engineers, as the lead Federal agency, has coordinated with the non-Federal sponsor, the California State Reclamation Board, to conduct the Woodson Bridge/Kopta

Slough feasibility study and prepare this Detailed Project Report/Environmental Assessment/ Initial Study. Coordination with U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS) California State Parks & Recreation, Department of Fish and Game, Bureau of Land Management, Cal Trans, Tehama County, special interest groups such as the Sacramento River Conservation Area, concerned agencies and members of the local community were accomplished throughout the study and report processing activities. Public Meetings were held to discuss the study and plan. The EA/IS was circulated from ____ to ____.

CHAPTER 2 - PROBLEMS AND OPPORTUNTIES

Ecosystem Problems

Human induced changes to the Sacramento River, including bank protection, gravel mining, riparian vegetation removal, flow regulation, and flood control, have resulted in a number of physical and ecological effects. According to DWR's report *Woodson Bridge State Recreation Area Long-Term Solutions Study Working Draft (1998)* since 1896, the Sacramento River has moved back and forth in a meander belt that is more than 4,300 feet wide. For 42 years the river occupied Kopta Slough along the west bank. Currently, a former bank protection project authorized in the 1960's near the upstream end of the slough is preventing the river, or portions of it, from reoccupying the slough. DWR has been monitoring changes in bank erosion, bank composition, river length, depth, width, sinuosity, and floodplain deposition as part of the *Sacramento River Bank Erosion Investigation (DWR 1994).* Bank Protection has reduced a source of salmon spawning gravel from freshly eroded banks and has over time, decreased the number of preferred spawning areas in multiple channel areas, chute cutoffs, point bar riffles and areas near islands. Because of flood protection provided by Shasta, Keswick, and Whiskeytown ``dams and extensive levee construction and bank protection along eroding banks, most of the rich high terrace soils and original riparian forest have been converted to agricultural and other uses. Wildlife populations have also declined due to loss of riparian habitat and suppression of the natural processes that maintain density and diversity of habitat within the riverine environment. Valuable cropland and orchards are lost due to erosion. Campgrounds, roads, levees, and bridges are also at risk as shown near local bridge in Figure 3.

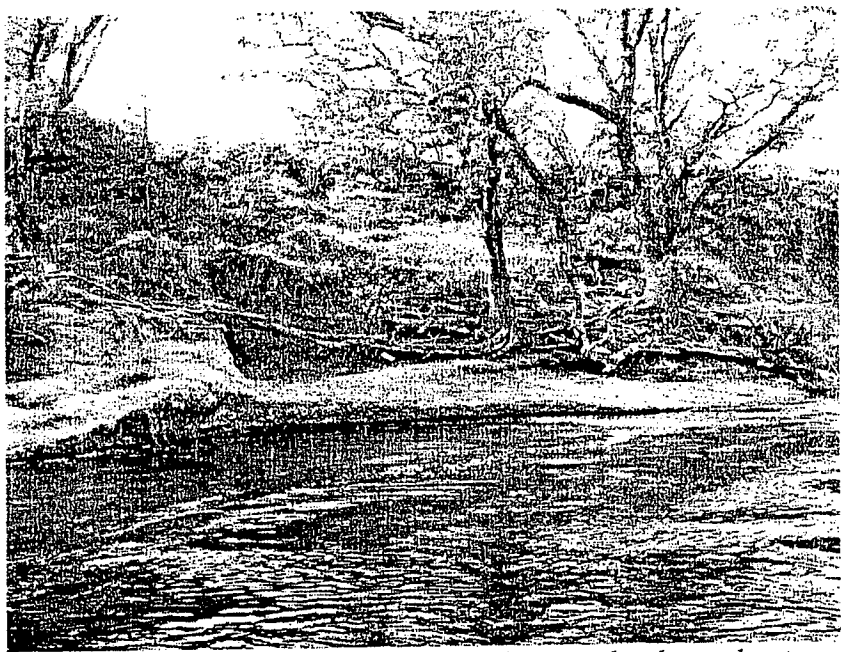


Figure 3. Losses of riparian habitat and stream bank are due to erosion on the west bank near the Vina Woodson Bridge and South Avenue.

Loss of aquatic, riparian, and adjacent terrestrial habitats between Kopta Slough and the river for use by migratory and neo-tropical birds that migrate along the Sacramento River corridor, listed species and other wildlife species are shown below from site visit in November 2002.

Figure 4.

The below figure is the north side of Kopta Slough where it has been cut off due to rock revetment from the Sacramento River where it historically flowed for 42 years.

Figure 5.

Existing Conditions

Land Use and Land Ownership

Within the study area most of the land is in agricultural use and 20 percent is in riparian habitat. The remaining land is in urban or commercial uses or upland vegetation. Land ownership in the study area consists of government agencies, conservancies, and private. Tehama County owns two small parcels immediately adjacent (north and south) of the east abutment of Vina Bridge. This property includes a concrete surfaced boat launch and picnic area on the south side of the bridge. The Nature Conservancy manages an extensive tract of land owned by the State Controller's Trust about one mile north of Vina Bridge along the west bank of the Sacramento River.

Vegetation Types

Vegetation types in the study area include Mixed Riparian Forest, Herbland, Riparian Scrub, Cottonwood Forest and Valley Oak Woodland. Sensitive plants include those listed as "rare, "threatened" or "endangered" under Federal and State law. Sensitive plants that could potentially occur with the study area include the silky cryptantha and rose mallow. While these plants have not been observed in the study area a field reconnaissance rose mallow should be conducted during August-September blooming period, and for silky eryptantha during April-May.

Fish and Wildlife

Several State or federally listed and candidate species occur or potentially occur within the study area including the bald eagle, Swainson's hawk, western-billed cuckoo, bank swallow, willow flycatcher, and valley elderberry longhorn beetle. Other species of concern may occur within the project area at some point during the year include: golden eagle, merlin, sharp-shinned hawk, Cooper's hawk, long-early owl, California gull, double crested cormorant, osprey, ferruginous hawk, purple martin, common yellowthroat, yellow breasted chat, common loon, northern harrier, black-shouldered kite, long-billed curlew, Vaux's swift, California horned lark, loggerhead shrike, burrowing owl, Townsend's big eared bat, and western pond turtle. Five Species of fish are state or federally listed as threatened or endangered, or are candidates for listing. These are spring-run Chinook salmon, winter-run Chinook salmon, fall and late-fall Chinook salmon, steelhead, and Sacramento splittail.

Streamflows and Precipitation

The annual precipitation averages about 20 inches with most of the rainfall from December through March. The peak of the flood flows in the Sacramento River increases downstream between Red Bluff And Vina. The Vina gage at River Mile 218.3 next to the State Recreation Area has a watershed of 10,930 miles. According to DWR, the average annual discharge at this station is 13,590 cfs. About 4,000 cfs on average are diverted between Keswick and Vina. Flow duration analyses for this station show that

flows exceed 90,000 cfs one percent of the time (one of every 100 days), 10,000 cfs 50 percent of the time, and 4,000 cfs 99 percent of the time.

Channel Migration

The zone of land north of Woodson Bridge State Recreation Area extending above Copeland Bar (at river mile 221) has historically been a very dynamic area of channel migration. To minimize the problems of agricultural crop losses due to this historical bank erosion, the Corps of Engineers installed rock revetment (riprap) in 1963 to the outside bend of Copeland Bar and the cut-bank immediately downstream. The downstream cut-bank at Woodson Bridge State Recreation Area was treated during the 1980s with an experimental bank stabilization treatment called palisades, which was largely unsuccessful and was mostly removed in 1997. Certain areas of the upstream palisading have seemed to succeed in increasing local deposition. The left cut-bank at Woodson Bridge state Recreation area has continue to erode and threatens the loss of some of the rarest, larges and oldest stand of Valley Oak still existing on the upper terrace of the Sacramento River riparian ecosystem.

Geology

The river is primarily an alluvial stream, in that it flows across its own sedimentary deposits of sand, silt, and gravel. The underlying structure and geologic units also influence the meander rates, sinuosity, and gradient. Pleistocene folding and faulting have affected the Sacramento River by exposing the erosion-resistant Tehama Formation in the banks and the bed. Geologic evidence shows that the northern part of the Sacramento River is now actively being lifted.

Geologic units in the study area include the Tehama and Tuscan Formations, Red Bluff Formation, Terrace Deposits, and Quaternary Alluvium.

Soils

The Department of Water Resources collected soil type data along the Sacramento River from Keswick to Verona and created a geographic information system project map that identified soils. In the project area, only two soil units are represented: the Columbia series and Riverwash.

The Columbia series consists of gently sloping brown, well-drained, neutral soils that are medium-textured to moderately coarse-textured. These soils formed on recent flood plains along the Sacramento River. Vegetation including crops grows well in these soils.

Riverwash consists of sand and gravel bar deposits, some of which are mined for aggregate outside the project area. The deposits have no agricultural value but they serve as a source for spawning gravel recruitment.

Geomorphology

The floodplains, river channels, oxbow lakes, meander scrolls, and point bars are a direct result of an actively meandering river constantly reshaping and reforming the valley floor.

Geomorphic units are recent fluvial deposits that are identifiable on aerial photographs. The Department of Water Resources identified four geomorphic units found in the project area and mapped them in the 1998 *Woodson Bridge State Recreation Area Long-Term Solutions Study Report*. These units include the historic meander belt, the 100-year meander belt, undifferentiated stream alluvium, and geologic control.

The historic meander belt includes an unspecified amount of time, somewhere between 100 and 1000 years ago. Oxbow lakes meander scrolls, sloughs, and curved lines of riparian vegetation are indicators of old river channels.

The 100-year meander belt is smaller than the historic meander belt. The belt was delineated using old survey maps, topographic maps and aerial photographs showing actual river channels at specified times. Department of Water Resources mapped this meander belt in 1984. In 1991, Department of Water Resources updated the delineation using aerial photographs.

Undifferentiated stream alluvium is deposited by the river but does not show the distinctive fluvial features found in the 100-year of historic meander belts, either because of changes with time or extensive agricultural development.

Geologic control consists of geologic units that are older, more consolidated and generally less susceptible to erosion. These units include the Tehama and Tuscan Formations, the Modesto Formation, and the Riverbank Formation. In most areas where geologic control is present, the Tehama and Tuscan are present in the lower streambank under the overlying terrace deposit. The Modesto and Riverbank formations are the overlying terrace deposit.

Future Without-Project Conditions

- The river will erode approximately 40 or more acres over the next 25 years with no action

- Existing topography will change as banks continue to erode and the channel will change as the river continues to erode the banks

- Reduction in mature stands of Valley Oak Woodland and Great Valley Mixed Riparian Forest will occur. It is estimated that approximately 15.3 acres of mature Valley Oak Woodland, 8.3 acres of Great Valley Mixed Riparian Forest and 0.4 acres of Cottonwood Forest will erode into the river. The Mixed Riparian Forest contains served remaining stands of extremely old sycamore trees, which

are not found in other stands within the study reach. The loss of plant communities would than cause loss of habitat for birds and wildlife as well

- Over the long-term channel changes could impact, through flooding or erosion, the loss of South Avenue and Vina Woodson Bridge, campgrounds, crops, orchards, and other structures

- Some hiking and nature trails at the State Recreation Area would be lost. The gravel bar upstream of the bridge used for boating, fishing, swimming and sunbathing could be lost as well.

Restoration Opportunities

The potential Corps project in partnership with the State Reclamation Board and Tehama County would include:

- Restore up to 300 acres aquatic, riparian, and associated terrestrial wildlife habitat along Sacramento River Riparian Corridor

- Reconnect the Sacramento River to its historic floodplain

- Utilize bioengineering method that combines rock with new riparian vegetation to help stabilize river banks and provide wildlife habitat

CHAPTER 3 – PLAN FORMULATION

Planning Objectives

The objective of the proposed modification is to restore the biological (aquatic and riparian communities) along the Sacramento River riparian corridor between River miles 218 and 221 and physical components (channel hydraulics) of the Sacramento River near Kopta Slough and Vina Woodson Bridge, affected by former bank protection projects, gravel mining, riparian vegetation removal, flow regulation, and flood control projects from the1950's, to a more naturally functioning and self-sustaining state. Specific objectives for the Vina Woodson Bridge/Kopta Slough restoration are as follows:

- Re-connect the Sacramento River to its active flood plain near River Mile 220 by modifying the existing Corps bank protection project
- Restore aquatic, riparian, and adjacent terrestrial habitats between Kopta Slough and the river for use by migratory and neo-tropical birds that migrate along the Sacramento River corridor, listed species and other wildlife species
- Remove exotic invasive plan species and replace with native plants that help stabilize banks near Vina Woodson Bridge
- Restore stability and river form and pattern of the hydrology, hydraulics, sediment transport, and morphologic functions near River Mile 220
- Reduce bank erosion (that threatens the road and bridge) to improve water quality by reducing non-point source sediment in the Sacramento River, which would provide benefits to the aquatic ecosystem of the Sacramento River

Planning Criteria and Constraints

Criteria

Four criteria have been established to explain the planning objectives and to provide a uniform set of guidelines for further formulation and evaluation.

Completeness. Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planning objectives. To satisfy this criterion, an alternative should:

- Address one or more of the planning objectives.

- Be capable of consistently and reliably providing ecosystem restoration of aquatic, riparian, and terrestrial habitat areas along the Sacramento River riparian corridor.

- The total quantitative and non-quantitative beneficial ecological effects are equal to or exceed the total short-term effects associated with construction.

- Be capable of being physically implemented and consideration should be given to the safety, health, and social well being of the affected communities.

- Historical, archeological, and other cultural resources should be preserved.

Effectiveness. Effectiveness is the extent to which an alternative plan alleviates the identified problems and primarily achieves the planning objectives of restoring riparian habitat and preserving the ecosystem along the Sacramento River near Vina Woodson Bridge and Kopta Slough.

Efficiency. Efficiency is a measure of the extent to which an alternative plan is the most cost-effective means of alleviating the identified problems while realizing the specified objectives, consistent with protecting the environment. One way efficiency is measured is by comparing estimated monetary costs and benefits of the alternatives. Another measure of efficiency is the extent to which a plan can contribute to restoring ecosystem values relative to other plans:

- Plan scales are shown so that the public and decision makers know at what level of incremental and total output the costs of the incremental units just equals the subjective valuation of worth.

Acceptability. Acceptability is the workability and viability of the alternative plans with respect to acceptance by Federal and non-Federal entities and the public, and compatibility with existing laws, regulations, and public policies. Two measures of acceptability are:

- Degree to which an alternative plan is supported by other Federal and non-Federal agencies, organizations, and the public.

- Be feasible from technical, environmental, economic, financial, political, legal, institutional, and social perspectives.

Constraints

General planning constraints include a number of specific plans, laws, and principles that have been identified as having an effect on the outcome of the study. Basically, measures and alternatives must be consistent with Federal, State, and local plans, laws, regulations, and policies; minimize displacement of people and business; ensure public health and safety; preserve the quality of the natural environment; and

compensate for any unavoidable environmental effects. For example, any proposed restoration work could not jeopardize the continued existence of a federally listed threatened and endangered species.

Restoration Measures

A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. Measures are the building blocks of which alternative plans are made. A feature is a "structural element" that requires construction or assembly on site. An example of a feature would be the installation of a water pump and/or constructing channel modifications. An activity is a "nonstructural element" that can be a one time occurrence or periodic occurrence. An example of an activity would be seeding or cutting vegetation or applying pesticides. Based on the problems and opportunities at Kopta Slough and Woodson Bridge site, a number of possible measures was identified that could be used in restoring a self-sustaining ecosystem at the site. These measures are briefly discussed below

Vegetation Management on Nature Conservancy Managed Land (between Kopta Slough and the Sacramento River)

There are up to 300 acres of degraded riparian and adjacent upland vegetation along the west side of the Sacramento river, as well that are in need of vegetative management to restore the habitat to a healthier condition. Many native plants species could be fostered from existing populations or reintroduced to the area to establish representative natural plant communities. Nonnative plant species could be removed. Revegetation of native plant species is a key component of any restoration plan. Revegetation can be accomplished using several of the following methods:

Container Plantings. This measure consists of two techniques for planting woody vegetation. Pits for planting container plants would be excavated either by (1) digging holes in the soil and cobble by hand or (2) punching holes through soil and cobble with a heavy steel probe or hydraulic hoe ram attached to a bobcat, backhoe, or tracked excavator.

Pole Cuttings. This measure consists of collecting cuttings and planting them in pits excavated either by (1) digging holes in the soil and cobble by hand or (2) punching holes through soil and cobble with a heavy steel probe or hydraulic hoe ram attached to a bobcat, backhoe, or tracked excavator.

Live Plugs. This measure consists of planting plugs of herbaceous plant material harvested onsite or from similar habitats locally.

Natural revegetation. This measure consists of removing exotic species, providing ongoing weed control measures such as hand weeding, and selective as well as spot herbicide treatments. This would allow native species to grow and proliferate naturally with reduced competition from invasive exotic weeds species.

- Restore up to 300 acres of disturbed riparian area by planting native vegetation such as cottonwoods, willows, sycamores, grasses etc. (ask Sid about vegetation types)

River Restoration – Overflow Floodplain Connection at Kopta Slough and Rock Site at River mile 220. 5

There are several measures to restore the Sacramento River meander between River Miles 216 and 223 that have been previously studied by the Department of Water Resources and UC Davis Education Department. A new computer hydraulic model will be run for both the bankfull and 50 year runoff events used to analyze the impacts of the project measures and alternatives on the river system in the project reach. There are two main project components, which include: rock site at river mile 220.5 and overflow floodplain connection of the Sacramento River to Kopta Slough. Here are some of the proposed measures.

- No rock removal - Discontinue maintenance of the rock revetment at Copeland Bar at River Mile 220. If this rock is not repaired and maintained in the future, erosion at the site will resume, increasing the likelihood that the river will recapture Kopta Slough.

- Partial Rock removal at RM 220.5 - actively remove or disturb existing rock revetment in order to allow erosion at the site.

- Full Rock removal at RM 220.5 - Another option would be to use heavy equipment to remove revetment to let the river recapture Kopta Slough

- No improved channel at RM 220.5 – overflow floodplain connection to Kopta Slough

- Pilot channel connection to Kopta Slough – used for overflow floodplain connection to Kopta Slough

- Channel connection to Kopta – used for overflow floodplain connection to Kopta Slough

Engineered Landform Stabilization near Vina Woodson Bridge and at the sewer Line outfall

There are approximately 1500 linear feet of riverbank to between the bridge and the sewer outfall line. There is opportunity restore vegetation and create wildlife habitat and prevent bank erosion utilizing bioengineering techniques, which could include:

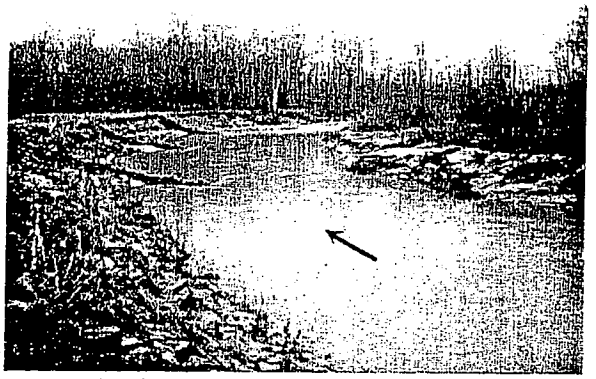
- **Bendway weirs at Woodson Bridge** – involves the installation of a series of low rock structures at the bend of an eroding stream channel. These structures redirect high-velocity flow and dissipate water energy – taking pressure off a stream bank.

Aquatic habitat is improved because the banks can be shaped and seeded with grasses or planted to trees or left untouched natural vegetation will then re-establish within one or two years. Weirs can be retrofitted after project completion to improve project effectiveness, and costs are lower than traditional methods. There are real world examples of successful bendway weir projects throughout the country.

Example of bendway weir immediately After construction

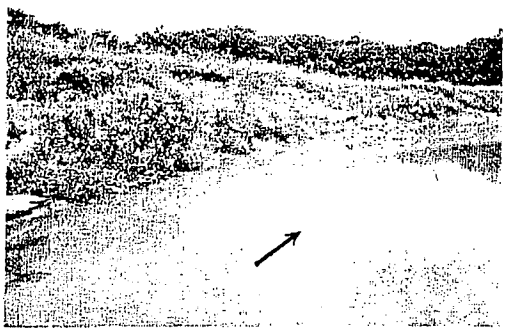
Reach 11 - Immediately after construction

Current redirection at mid-bank flow



Reach 11 - Current redirection at mid-bank flow

One year later (lush vegetation with Many 1-4 ft willows)



Reach 11 - One year later
(Lush vegetation with many 1-4 ft. willows)

- **Low berm with vegetation near Woodson Bridge** - Planting the tops of banks or berms with trees, shrubs, and grasses provides additional erosion control, buffering from agricultural and urban activities and helps filter polluted runoff before it enters the river. Berms may extend from the top of each bank a minimum

distance of two and one half times the channel width or 50 feet. For areas with severe bank erosion or in environmentally sensitive areas such as scenic rivers, 120 feet is recommended. Trees can be planted bare-root or transplanted from other sites. Plant spacings depend upon size and type of stock and soil conditions. Trees and shrubs, which provide food as well as cover for wildlife, should be considered for planting. Planting woody vegetation in stream corridors effectively protects soil, water, terrestrial and aquatic wildlife and recreational resources. These plantings are often used in conjunction with other conservation practices in order to effectively manage and restore stream corridors. Use of woody vegetation may not always solve slope stability problems but can often compliment other structural practices like rock rip rap or excavation. Furthermore, plantings can protect slopes from erosion until native vegetation reestablishes itself and the stream channel stabilizes

- **Dikes or groins near Woodson Bridge** – A structure designed (1) to reduce the water velocity as streamflow passes through the dike so that sediment deposition occurs instead of erosion (permeable dike) or (2) to deflect erosive currents away from the streambank (impermeable dike). These structures are used in river training as contraction works to establish normal channel width; to direct the axis of flow; to promote scour and sediment deposition where required; and to trap bedload to build up new banks.

  Groins must not cause an abrupt change in the direction of the current, but rather, train it gently into the desired course. Design Considerations: Control should begin at or before the point at which the current begins to deviate from the desired course. (fig 24). If the first groin is located downstream of this point, the current will likely thread its way around the wrong end of it. Isolated structures should be avoided at they may cause dangerous eddies that will aggravate the condition. A group of three groins is generally the smallest effective system. Experiments with models may be helpful if used wisely, but badly located groins may cause considerable damage at another point on the river.

  Example of groins

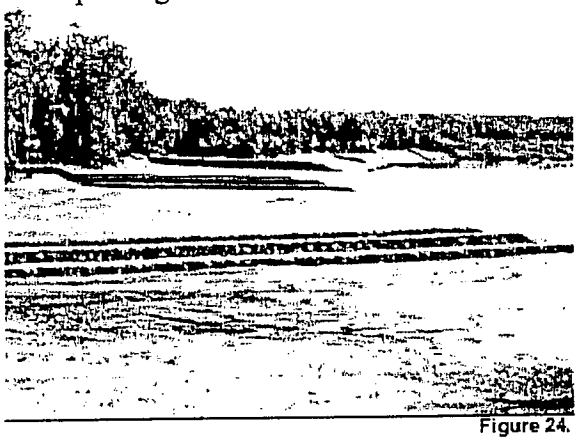


Figure 24.

- Bendway weirs/Upper bank vegetation at Sewer Line Outfall

- **Bank Armor with upper bank vegetation at Sewer Line Outfall** - Hard armor such as rock revetment and concrete bulkheads are considered by many to have little value for fisheries, wildlife, water quality, and aesthetic appeal. Softer solutions, such as bioengineering, which utilize living and nonliving plants, sometimes in combination with other construction materials such as rock, are being given preference (and sometimes required) as streambank protection methods. Regardless of the type of streambank protection used, there are general requirements that will always apply. Toe protection and control of streambed degradation are a necessary prerequisite to streambank protection, and the upstream and downstream ends of the revetment must be protected to prevent flanking.

- Lower berm with upper bank vegetation at Sewer Line Outfall