

Riparian Restoration Plan for the Nelson Slough Unit

Feather River Wildlife Area
Sutter County, California

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Prepared for:

California Department of Fish and Game

and



Wildlife Conservation Board



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TABLE OF CONTENTS

I.	INTRODUCTION.....	3
A.	Project Overview	3
B.	Cooperative Relationships	3
C.	Project Goals and Objectives.....	3
D.	Purpose of the Restoration Plan	4
II.	SITE DESCRIPTION.....	5
A.	Location.....	5
B.	Land-use History	5
C.	Soils.....	13
D.	Topography	15
E.	Hydrology	17
F.	Vegetation	18
G.	Wildlife.....	21
III.	CONCEPTUAL SITE MODEL	22
A.	Past Environmental Conditions	22
B.	Likely Successional Patterns without Restoration	22
C.	Comparison to Nearby Vegetation (Reference sites)	23
D.	Restoration Strategies for the Nelson Slough Unit	23
E.	Identification of Ecological Benefits and Targeted Wildlife Species	23
IV.	PLANTING DESIGN	27
A.	Design Considerations	27
B.	Rationale for Plant Communities	29
C.	Composition and Location of Plant Communities	29
D.	Planting Tiles and Baseline Data	37
V.	ENHANCEMENT	38
VI.	REGULATORY COMPLIANCE.....	39
A.	CEQA	39
B.	Reclamation Board Encroachment Permit.....	39
C.	VELB Memorandum of Understanding	39
D.	Cultural Resources.....	39
E.	Herbicide Permits.....	39
VII.	FIELD IMPLEMENTATION	41
A.	Cell Descriptions	41
B.	Row Orientation and Plant Spacing	48
C.	Site Preparation	48
D.	Irrigation System	49
E.	Plant Material Collection and Propagation.....	49
F.	Plant Installation.....	49
G.	Plant Maintenance	51
VIII.	MONITORING AND REPORTING.....	54
A.	Field Reports	54
B.	End of Season Monitoring.....	54
C.	Photo Points.....	54
D.	Avian Monitoring	54
E.	End of Season Reports and Final Report	55
IX.	SAFETY ISSUES.....	55
A.	Standard Field Procedures	55
B.	Flood and Fire Contingencies	55
X.	PROJECT IMPLEMENTATION TIMELINE	55
XI.	REFERENCES.....	57

List of Tables

Table 1. Summary of Project Goals, Objectives and Special Considerations for the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	4
Table 2. Neighboring Land Conservation Property to the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	5
Table 3. Summary of Typical Soil Conditions from the Soil Survey of Sutter County (USDA 1988) on Soils Found on the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, California.	13
Table 4. Federal and State-listed Endangered, Threatened, and Candidate Species Occurring or Potentially Occurring at the Feather River Wildlife Area.	21
Table 5. Summary of Neotropical Migrant Bird Habitat Requirements (RHJV 2004).	26
Table 6. Key Plant Design Considerations of the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	28
Table 7. Summary of Overall Proposed Plant Species at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	30
Table 8. Composition of Low Density Riparian Shrubland at Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	32
Table 9. Composition of Medium Density Riparian Shrubland at Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	33
Table 10. Composition of Great Valley Valley Oak Riparian Forest at Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	34
Table 11. Composition of Great Valley Mixed Riparian Forest at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	35
Table 12. Composition of Herbaceous Wildflower Meadow Association at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	36
Table 13. Species of Great Valley Riparian and Floodplain Meadow at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	36
Table 14. Species of Native Grassland Association at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	37
Table 15. Herbaceous Understory Species in Row Centers and Hedgerows at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	37
Table 16. Descriptions for Cells I & II at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	43
Table 17. Descriptions for Cells III & IV at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	44
Table 18. Standard Planting Materials and Times for Woody Species.	49
Table 19. Summary of Herbivore Control Methods at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	53
Table 20. Timeline for the Scope of Work Tasks at the Nelson Slough Unit Restoration Project – Cell II, Feather River Wildlife Area, Sutter County, California.	56

List of Figures

Figure 1. Location Map, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	7
Figure 2. Project Boundary, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	8
Figure 3. 1949 Aerial Photograph, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	9
Figure 4. 1968 Aerial of Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	10

Figure 5. 1975 Aerial of Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	11
Figure 6. 1987 Aerial of the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	12
Figure 7. Soils Map, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	14
Figure 8. Topography Map, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	16
Figure 9. Graph Depicting River Gage Height Near Nicolaus During the New Years Eve Storms of 2005-2006.	17
Figure 10. Photos of Current Vegetation Conditions on the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	19
Figure 11. Habitat Value of Native Riparian Plants (RHJV 2000).	25
Figure 12. Planting Associations and Enhancement Area, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	31
Figure 13. Understory Design for Cell I, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	45
Figure 14. Understory Design for Cells II & IV, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	46
Figure 15. Understory Design for Cell III, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	47
Figure 16. Planting Design Implementation for Herbaceous Meadow Species in Shrubland/Grassland Transition Zone, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.	50

List of Appendices

Appendix I	Official Soil Series Descriptions for Soils Occurring on the Nelson Slough Unit
Appendix II	Soil Pit Logs for the Nelson Slough Unit
Appendix III	Hydraulic Modeling Report for the Nelson Slough Unit
Appendix IV	Planting Association Tiles for the Nelson Slough Unit
Appendix V	VELB Memorandum of Understanding for the Nelson Slough Unit
Appendix VI	Hedgerow Design for the Nelson Slough Unit

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EXECUTIVE SUMMARY

The Nelson Slough Unit of the Feather River Wildlife Area was acquired by the California Department of Fish and Game in 1989. The parcel consists of 750 acres, of which about 30% is remnant and/or naturally regenerated riparian forest. The remainder of the property consists of abandoned agricultural lands that have failed to regenerate riparian forest after being retired from agriculture in the mid 1980's.

In 2007, River Partners received funding from the Wildlife Conservation Board to create a restoration plan for the 750-acre Nelson Slough Unit and to restore and enhance approximately 250 acres of riparian habitat that will benefit a broad range of special status species, migratory birds, gallinaceous birds and anadromous fish; increase connectivity with existing riparian habitat; and implement control measures for invasive non-native plant species. The Nelson Slough Unit is split into four cells, which will be restored in intervals. Current funding covers the restoration of Cell II, which is the most degraded cell.

The Nelson Slough Unit is surrounded by thousands of acres of land conservation ownership, including property owned by California Department of Fish and Game, US Fish and Wildlife Service, Audubon Society and Three Rivers Improvement Levee Authority. Restoring this piece of property will link together over 3,500 acres of contiguous habitat along the Feather River capable of supporting a number of threatened and endangered species, including the western yellow-billed cuckoo, Swainson's hawk and the valley elderberry longhorn beetle. In addition, the Nelson Slough Unit is adjacent to over 4,500 acres of conservation oriented properties located in the Sutter Bypass.

A detailed site evaluation examined soil texture, structure, stratification and depth to water table, as well as past land use and current conditions. Low Density Riparian Shrubland is the principal community to be planted on the Nelson Slough Unit. Additionally, Great Valley Valley Oak Riparian Forest, Great Valley Mixed Riparian Forest, Native Grasslands and Herbaceous Wildflower Meadows will be planted. Approximately 62,000 woody, native riparian plants will be planted on the property.

An herbaceous understory of mugwort (*Artemisia douglasiana*), gumplant (*Grindelia camporum*), telegraph weed (*Heterotheca grandiflora*), Spanish clover (*Lotus purshianus*) and native grass mix will be planted between all planting rows. Plugs of Santa Barbara sedge (*Carex barbarae*) will be planted at the base of valley oaks (*Quercus lobata*) and Fremont cottonwoods (*Populus fremontii*). Native herbaceous understory provides vital habitat for riparian wildlife and recent studies of riparian restoration in the Sacramento Valley have shown that natural recruitment in the understory is dominated by non-natives.

Riparian Restoration Plan for the Nelson Slough Unit, Feather River Wildlife Area, Sutter County, California

I. INTRODUCTION

A. Project Overview

In 2007, River Partners received funding from the Wildlife Conservation Board (WC-7051 SC) to plan and initiate habitat restoration on the 750-acre Nelson Slough Unit of the Feather River Wildlife Area. The unit is split into four cells and will be restored in intervals. Cell II will be the first to be restored as it is the most degraded cell.

The Nelson Slough Unit is part of the Feather River Wildlife Area and is adjacent to over 3,500 acres of conservation oriented properties along the Feather River and 4,500 acres of conservation oriented properties along the Sutter Bypass. The Nelson Slough Unit has great potential to provide a diversity of habitats for a wide array of riparian dependant species. However, the majority of the site is currently fallow land that is dominated by invasive, non-native weed species. Without intervention, weeds will continue to competitively exclude native plant species from establishing on site, resulting in poor wildlife habitat.

This project will plant approximately 62,000 native riparian trees, shrubs and vines on flood-prone land owned and managed by California Department of Fish and Game (DFG). River Partners will actively restore riparian habitat on 520 of the 750 acres at the Nelson Slough Unit. Enhancement activities will occur within 230 acres of existing riparian forest. Planting for Cell II is scheduled to begin in spring 2009 with the goal of three years of maintenance.

B. Cooperative Relationships

The project area is currently owned and managed by the California Department of Fish and Game. The levee on the northern border of the project area is maintained by Department of Water Resources - Maintenance Area 3 of Sutter County. During the planning of this project River Partners has worked closely with the aforementioned organizations.

C. Project Goals and Objectives

The primary project goal is to rapidly establish and enhance approximately 750 acres of high quality native riparian habitat that will benefit a broad range of special status species. Table 1 presents the proposed goals, objectives and special considerations for the project.

Table 1. Summary of Project Goals, Objectives and Special Considerations for the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Project Goal
• Restore and enhance riparian habitat on 750 acres and increase the connectivity of new habitat to existing riparian habitat (decrease fragmentation) in the Feather River Wildlife Area and Sutter Bypass. • Provide habitat for Federal and State-listed species including but not limited to Swainson's hawk, western yellow-billed cuckoo, western red bat, Chinook salmon, steelhead trout, valley elderberry longhorn beetle, and benefit other wildlife species, with particular emphasis on neo-tropical and gallinaceous birds.
Project Objectives
• Implement project using an adaptive management approach. • Provide specific habitat features for targeted wildlife species. • Establish self-sustaining native plant communities within a three-year period. • Use hydraulic analyses to develop a restoration design consistent with floodway management goals. • Develop a restoration design to meet management objectives. • Plant approximately 62,000 native trees, shrubs, and vines; incorporate a dense herbaceous understory planting; and establish perennial grasslands. • Minimize need for replanting by "overplanting" the site and anticipating some mortality. • Monitor project performance. • Build a partnership with Federal, State and local community groups.
Site Specific Conditions
• Coordinate restoration efforts with DFG Feather River Wildlife Area management to maximize habitat benefit for public use and cost savings. • Coordinate restoration design and implementation timing with DWR and Sutter County to complement their future levee improvement work at the Nelson Slough Unit and the surrounding reach of the Feather River and Sutter Bypass. • Aggressively control existing patches of non-native invasive species.

D. Purpose of the Restoration Plan

This restoration plan includes all four phases of this project. The purpose of the restoration plan is to:

- Identify project goals, objectives, management hypotheses and potential implementation challenges,
- Summarize the site land-use history, soils, hydrology, vegetation and wildlife,
- Outline our current understanding of the physical and biological factors that influence site ecology (a conceptual site model),
- Describe the plant design and the rationale for its selection,
- Describe the implementation process including field preparation, planting methods, irrigation design and schedule and methods of weed control,
- Outline project monitoring, and
- Provide a timeline for project tasks.

II. SITE DESCRIPTION

A. Location

The Nelson Slough Unit is located in Sutter County, California approximately 17 miles south of Yuba City (Figure 1). The Highway 99 Bridge passes over the site and the Feather River, running north/south through Cell I. The town of Nicolaus is located across the river from Nelson Slough on the east side of Highway 99. To the west of Nelson Slough is the Sutter Bypass, which is a floodwater bypass for when the Sacramento River is at flood stage.

The project area (750 acres) occupies river floodplain on the right bank of the Feather River between River Mile 7.5 and 10.5R (Figure 2). Limited remnant riparian habitat occurs along the northeastern and southwestern portion of the site, as well as along the south levee bank. The Feather River lies along the southern border of the restoration site. Private agricultural lands surround the northern boundary and are separated from the project area by a levee. No change to the surrounding private property will occur as a result of this project. The northeastern edge of the property abuts the Bobelaine Audubon Ecological Preserve. Surrounding the site are thousands of acres of land conservation ownership, as shown in Table 2.

Table 2. Neighboring Land Conservation Property to the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Property	Feather River River Mile	Management	Area
Star Bend Unit	19	FRWA- DFG	50 acres
O'Connor Lakes Unit	17-19	FRWA- DFG	296 acres
Lake of the Woods Unit	12.5-18	FRWA- DFG	639 acres
Bear River Levee Setback Project	12.5*	TRLIA	695 acres
Bobelaine Wildlife Sanctuary	11-14	Audubon Society	436 acres
Abbott Lake Unit	20-22	FRWA- DFG	439 acres
Sutter Bypass		SBWA- DFG	3,204 acres
Sutter National Wildlife Refuge		USFWS	2,600 acres

*River Mile for Bear River

B. Land-use History

Prior to the arrival of Europeans, Native Americans of the Valley Nisenan populations established villages along the Feather River and its tributaries in the vicinity of the site. No prehistoric resource sites have been recorded in this area.

The Nelson Slough Unit lies within the region deeded to John Sutter under the New Helvetia Land Grant in the 1840's. He built Hock Farm, a rancho near the site which allowed cattle to graze freely along the Feather River (Josselyn *et al.* 1988). A property ownership map of the Feather River from approximately 1880 shows Sam Brannon as the property owner. A 1912 U.S. Army Corps of Engineers map shows that the area had not yet been cleared for agriculture at that time, with willows and cottonwoods throughout. The exact dates are unknown, but men by the names of Mr. Richards and Mr. Hamatani owned the property prior to Mr. Tom Nevis purchasing it (Whitmore, personal communication). Based on historical aerials, the majority of the riparian

woodland on site was cleared sometime between the 1950's and mid-1960's (Figures 3 & 4). Up until the late 1970's, the property remained primarily fallow and was used for cattle grazing, which was the primary land use along the Feather River at that time (Figures 4 & 5). The property was developed for agriculture in the late 1970's to early 1980's by Mr. Nevis. The land was partially cleared and rice fields were put in Cell II and the southern portion of Cell I, as shown in the 1987 aerial (Figure 6). The business proved to be unsustainable for commercial production and the high value that rice had in the early 1980's fell in the late 1980's, causing the practice to be unsuccessful (Whitmore, personal communication). After this happened, the insurance company that loaned the money to Mr. Nevis to establish the rice fields, Aetna Insurance Company, repossessed the property. In 1989, DFG purchased the property from Aetna Insurance Company (Whitmore, personal communication).

The Nelson Slough Unit is located in an area of the Central Valley that floods regularly. Early European settlers built simple dirt levees to combat seasonal floods (SBFCA 2008). Due to major flooding that occurred during the beginning of the 20th century, an intricate network of levees and bypasses were created in the Sutter Basin, including the Sutter Bypass. In 1917, levees were constructed along the Sutter Bypass to help control flows and prevent flood damage. The Sutter Bypass was completed in 1930 and collects Sacramento River flood overflow water that has passed through Butte Slough and the Butte Sink (SBFCA 2008). The Sutter Bypass originates at Highway 20 and runs through the Sutter Basin, rejoining the Sacramento River near the Feather River and Sacramento River confluence. To prevent flood waters from overtopping levees by holding sudden storm water surges, dams were built along the main rivers in the area, including Oroville Dam on the Feather River in 1968 (SBFCA 2008). Although major construction occurred to control floods, levee breaches still occurred in 1917, 1955, 1986 and 1997, including a break at Yuba City and Nicolaus in 1955 which flooded almost 100,000 acres and caused 38 deaths and 3,200 injuries (SBFCA 2008).

Figure 1. Location Map, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

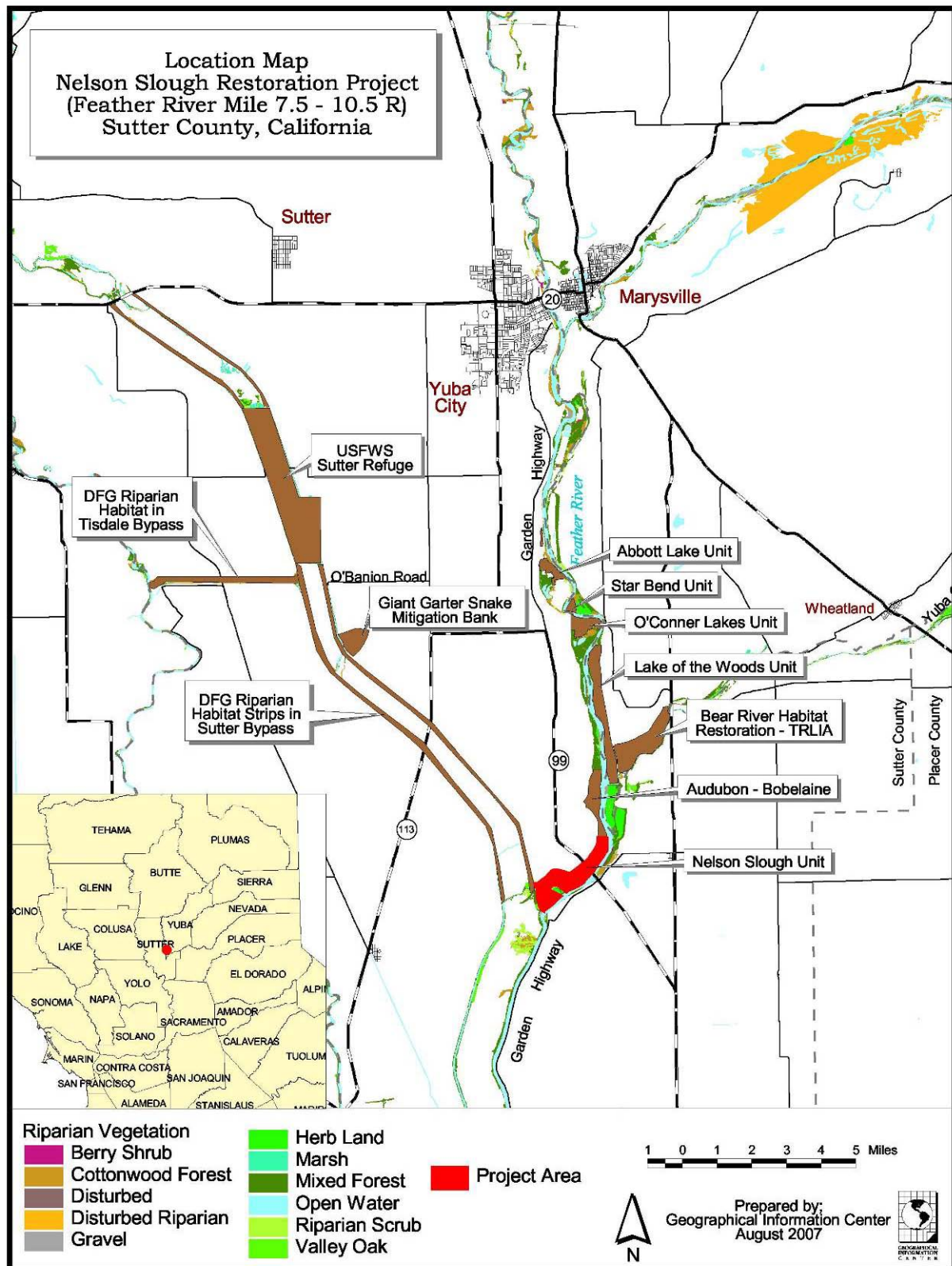


Figure 2. Project Boundary, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

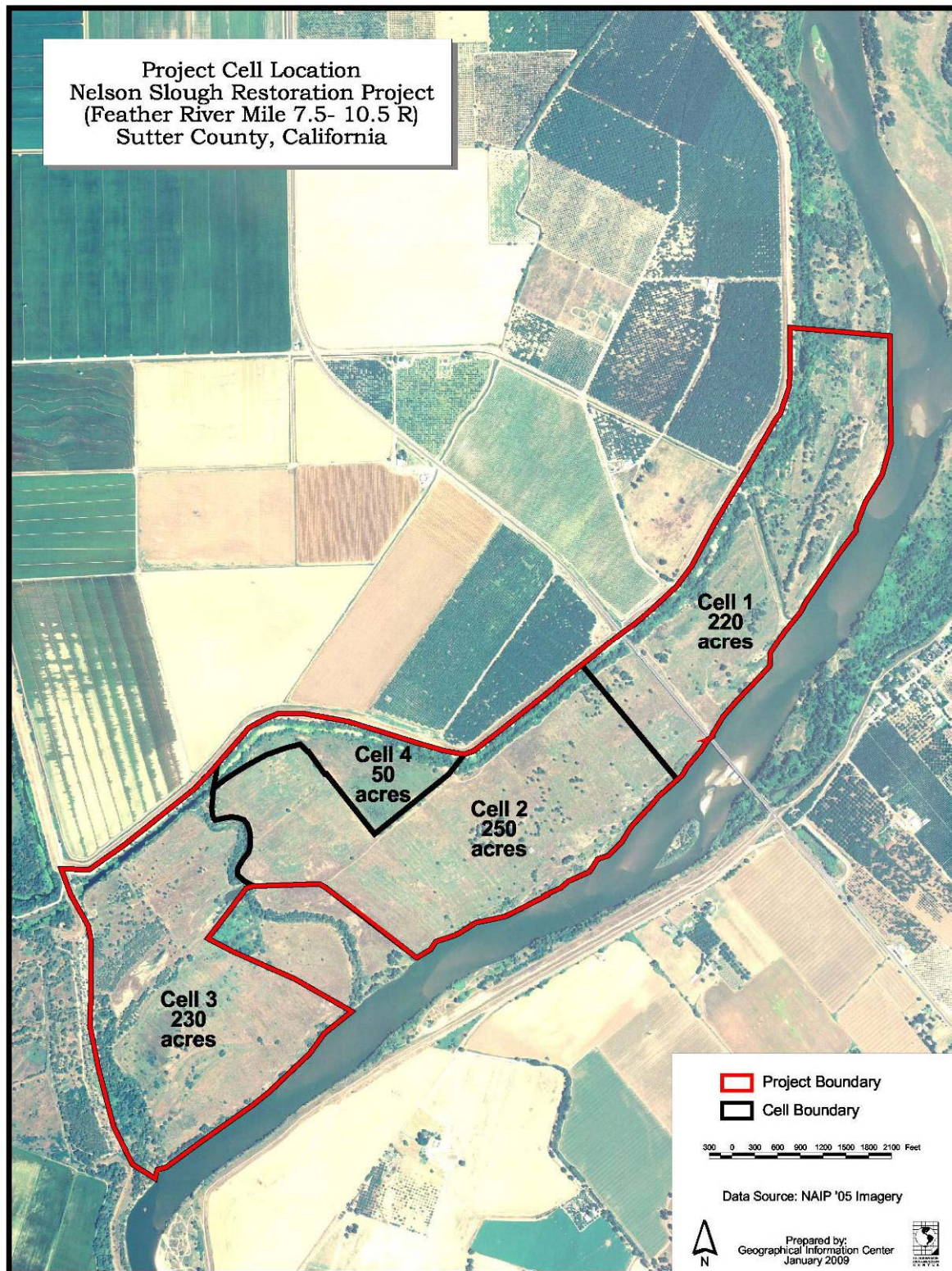
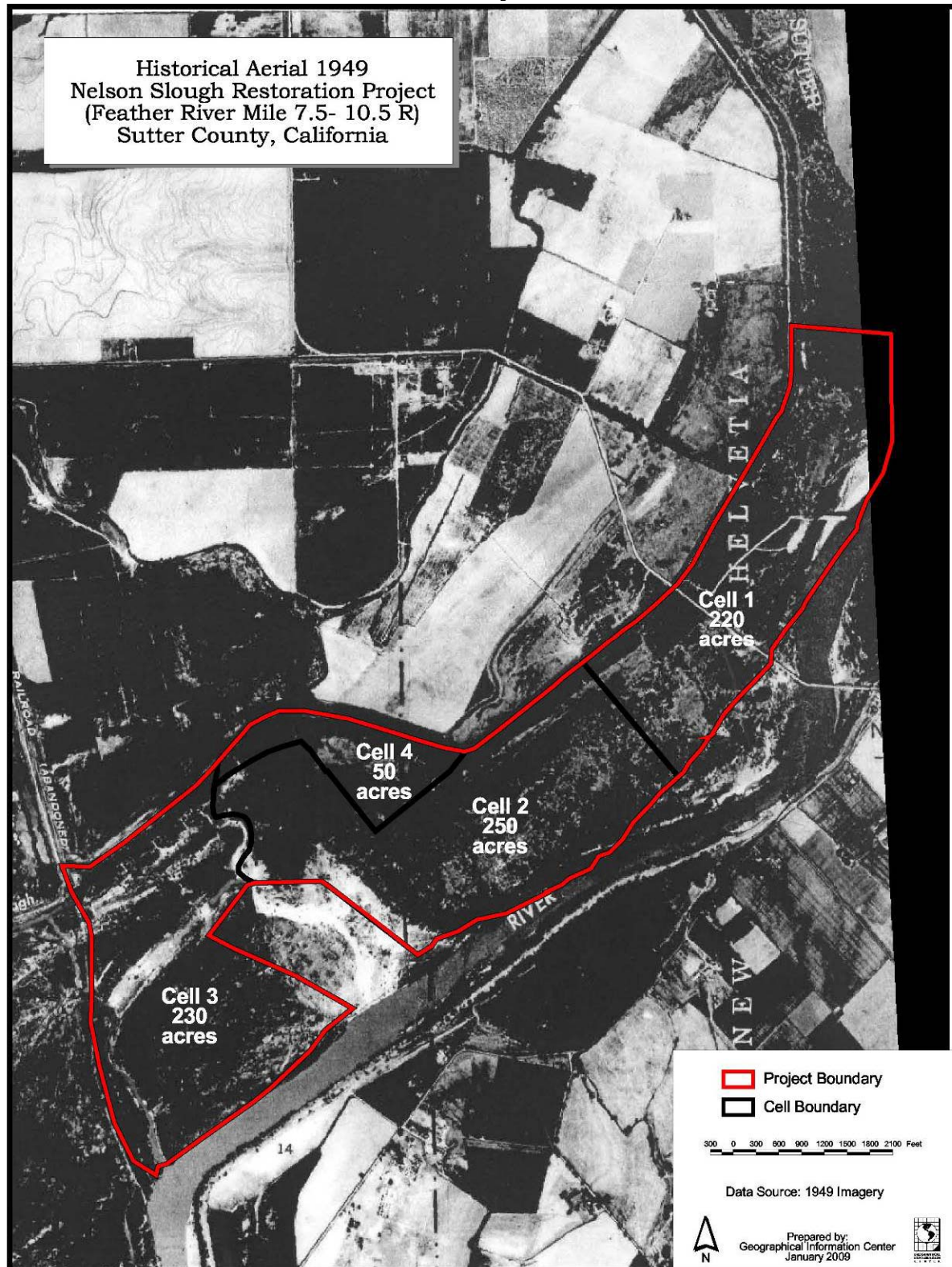
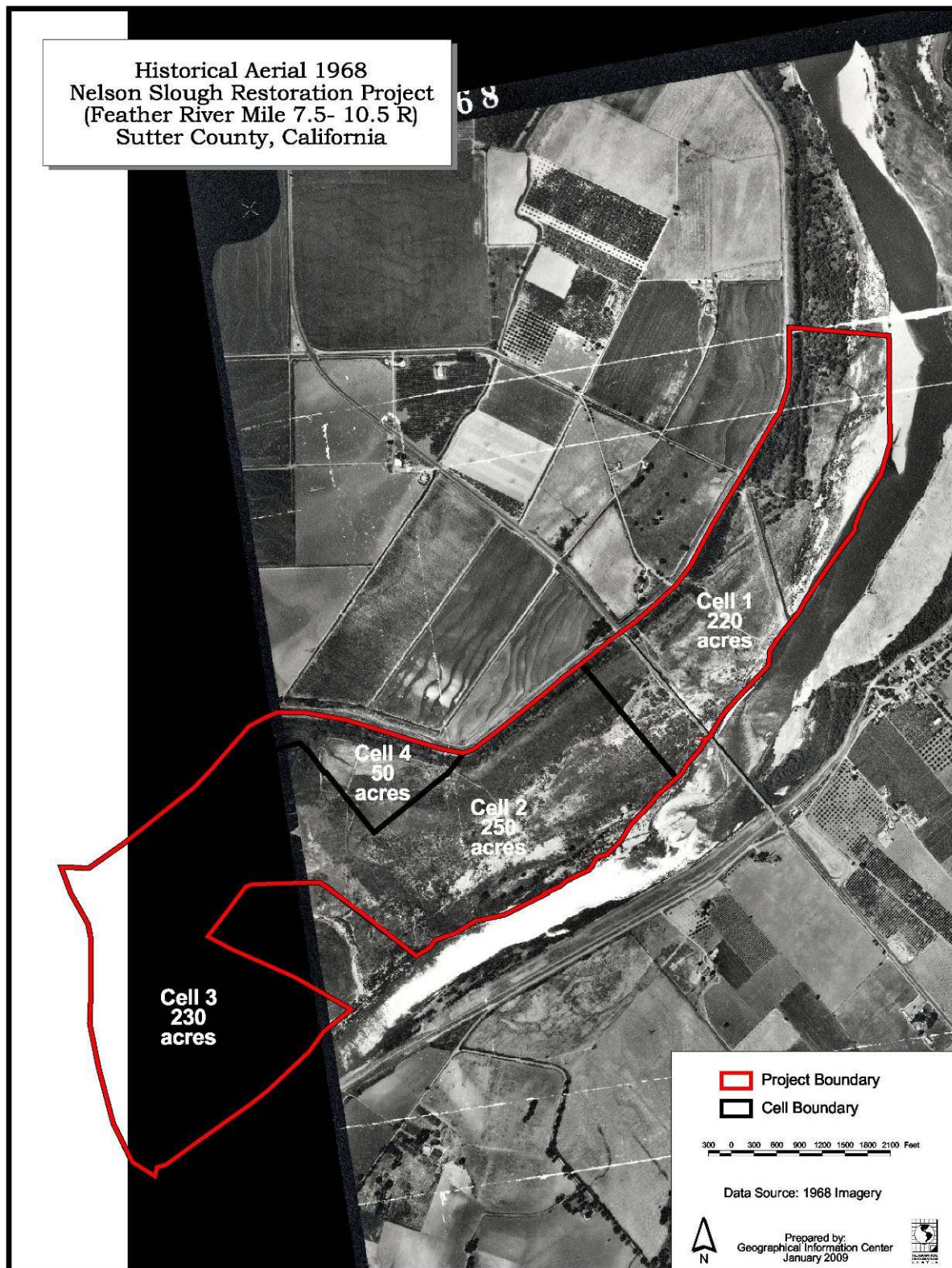


Figure 3. 1949 Aerial Photograph, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



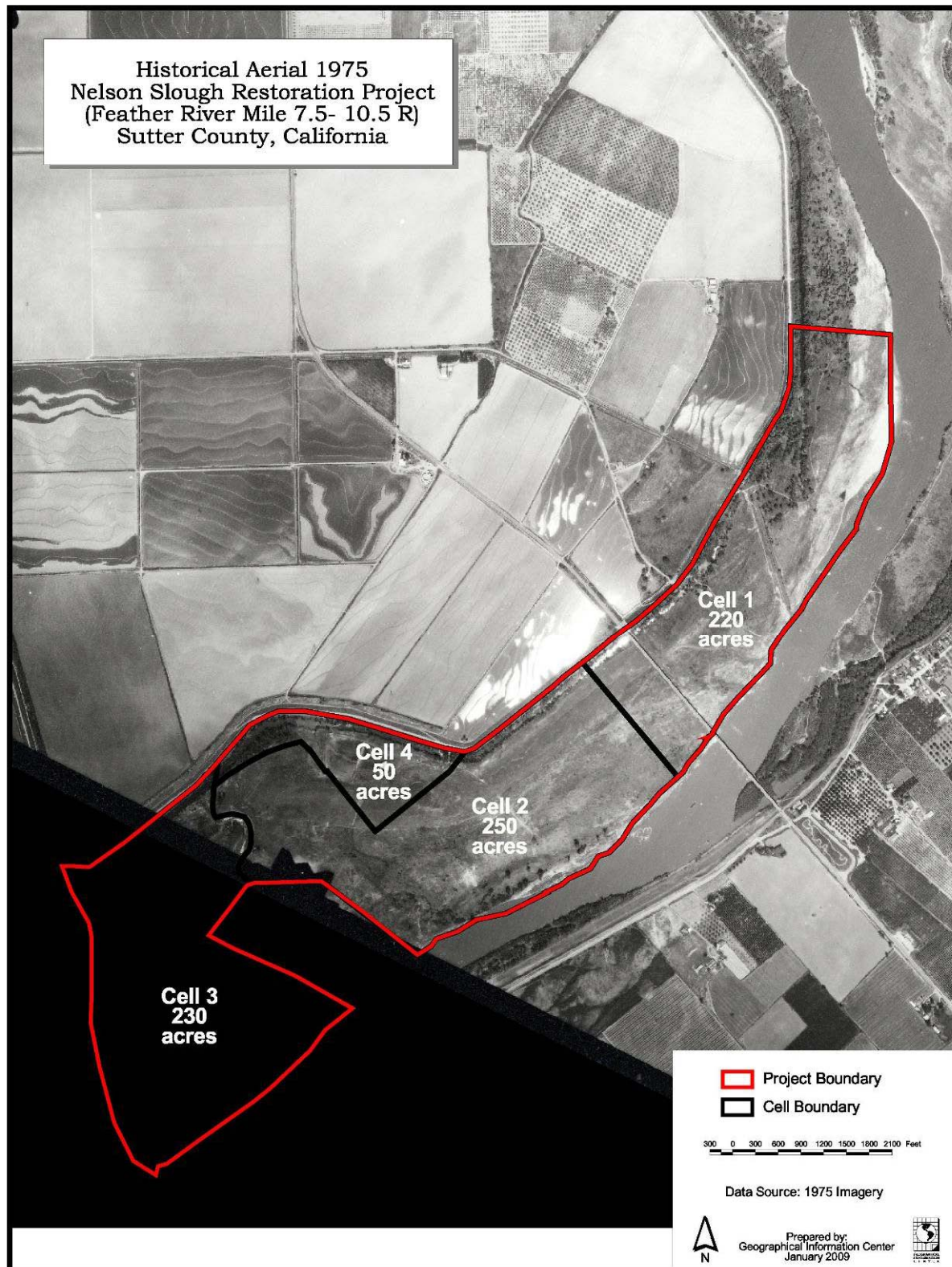
Woodland community with mature trees were still present on the majority of the site, with sand depositions scattered throughout.

Figure 4. 1968 Aerial of Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



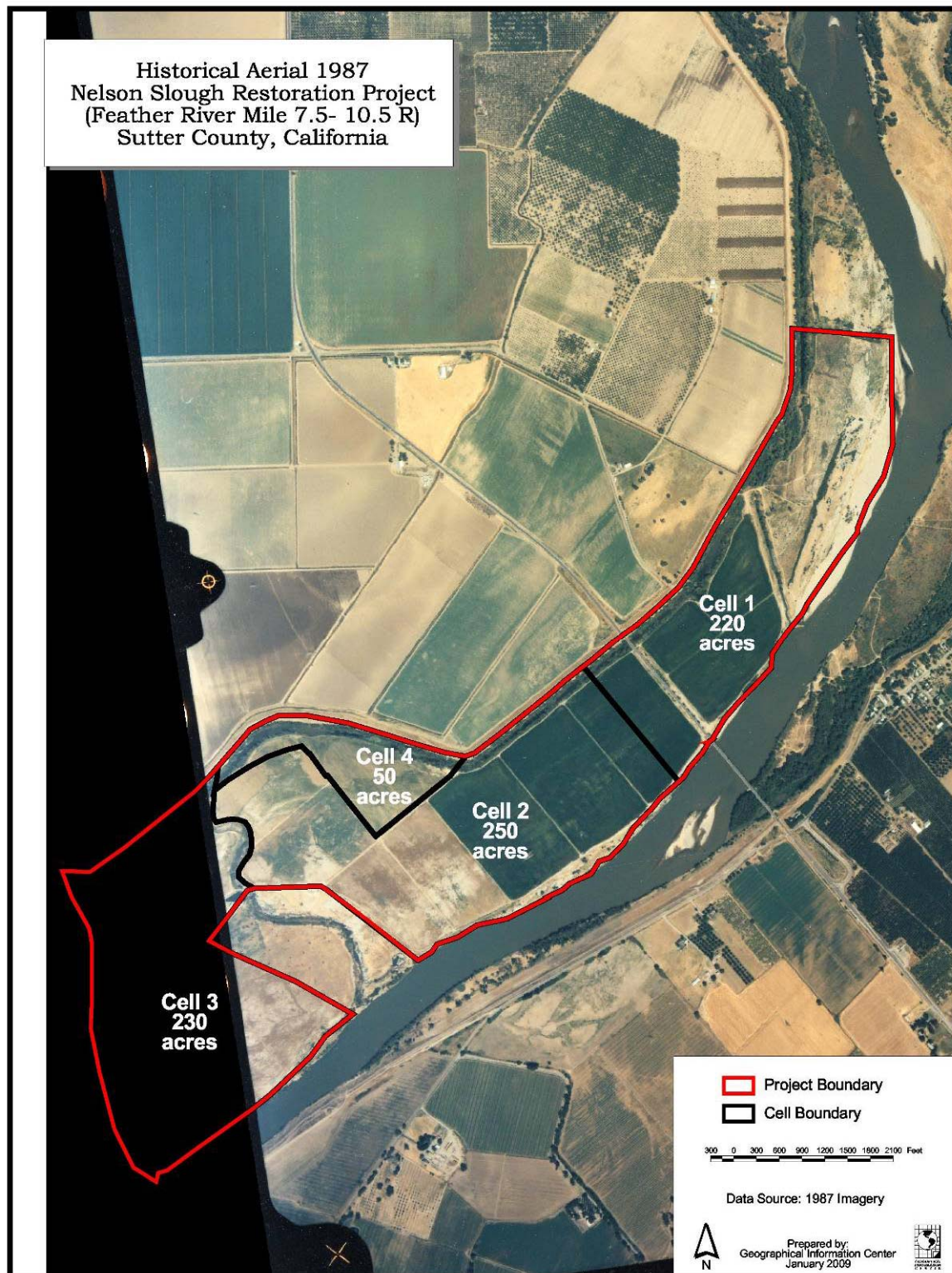
The woodland community has been cleared from the majority of the site, with mature trees only remaining in the northeastern corner. During this time period, the main land use along this section of the Feather River was livestock grazing.

Figure 5. 1975 Aerial of Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



The majority of the site remains cleared of mature trees and a woodland community, with livestock grazing still the primary land use.

Figure 6. 1987 Aerial of the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



Rice fields were constructed in the late 1970's to early 1980's and farmed for only a few years. The mature trees in the northeastern corner of the site were also cleared, roads were installed and the ground was altered. The land usage on this portion of the property during this time period is unknown.

C. Soils

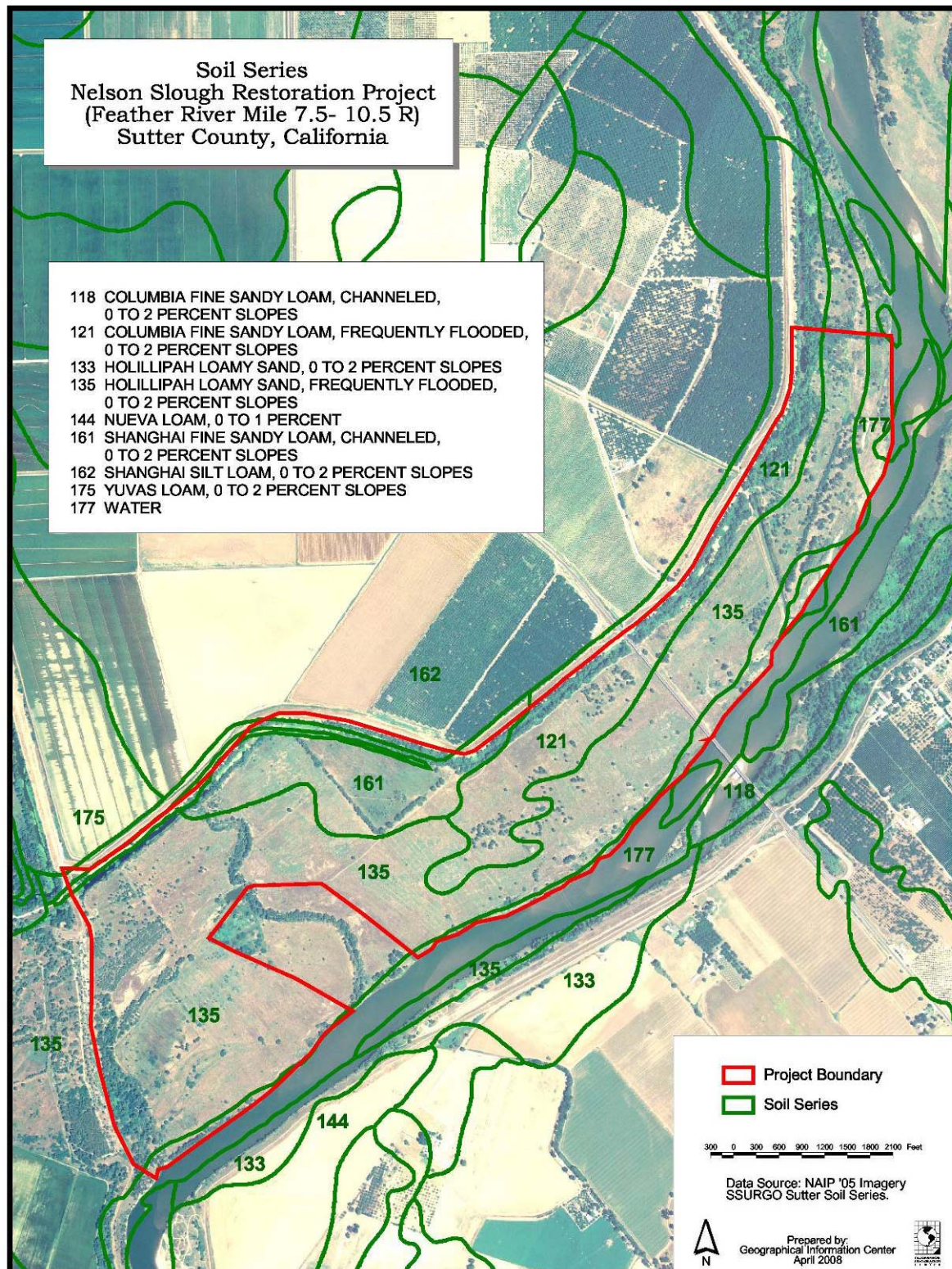
1. General Soil Series Information

There are three official soil series found on site, Columbia, Holillipah and Shanghai. The project area is made up almost entirely of Holillipah soils (Figure 7). This series consists of deep sand, which is stratified and somewhat excessively drained. They are derived from mixed alluvium and are frequently flooded (USDA 1988). Table 3 describes typical soil properties of the series' found at the Nelson Slough Unit. A full description of each soil series can be found in Appendix I.

Table 3. Summary of Typical Soil Conditions from the Soil Survey of Sutter County (USDA 1988) on Soils Found on the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, California.

Soil Property	Columbia fine sandy loam, frequently flooded	Holillipah loamy sand, frequently flooded	Shanghai fine sandy loam, channeled
Mapping Unit	121	135	161
Percent Slope	0-2%	0-2%	0-2%
Texture	sandy loam	loamy sand	sandy loam
Depth of Soil	very deep	very deep	very deep
Drainage	moderately well	somewhat excessively	somewhat poorly
Permeability	moderately rapid	moderately rapid	moderate
Available Water Holding Capacity	moderate	low	high
Plant Growth Limitations	Long periods of flooding in December to April.	Long periods of flooding in December to April.	Soils may develop tillage pans. Long periods of flooding in December to April.

Figure 7. Soils Map, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



2. Soil Pit Results

In addition to the information provided by the Sutter County Soil Survey, River Partners excavated 5 soil pits in 2008 within the Nelson Slough Unit (Appendix II). Observations from these samples include:

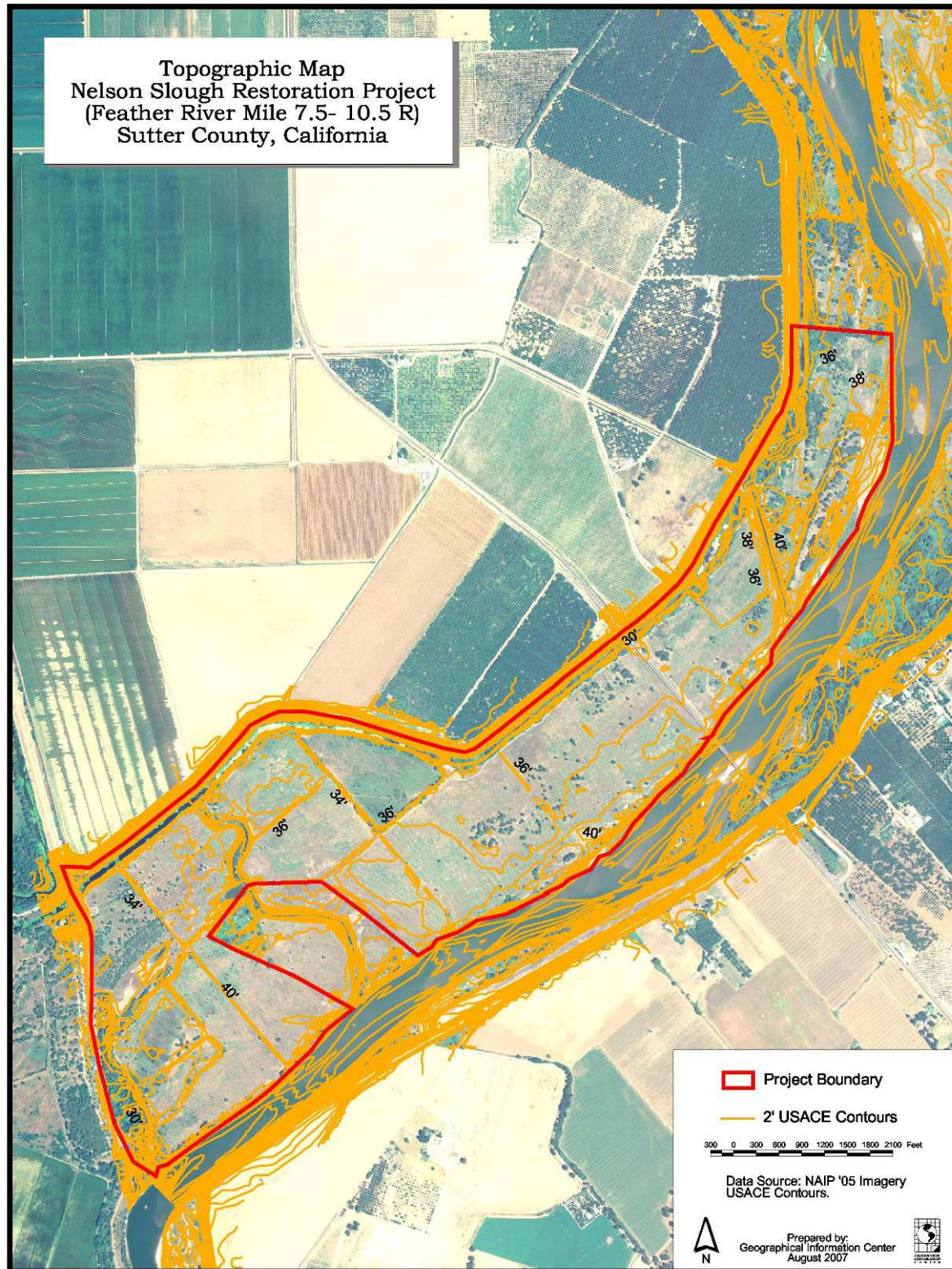
- Soil texture and structure,
- Stratification,
- Depth to water table, and
- Rooting depth of vegetation

Sampling occurred mostly in Cell 2 (4 pits) where most of the active restoration activities will be concentrated. In areas closest to the river, predominantly silt to silt loams with alternating layers of sand were observed, demonstrating exposure to river processes. Less deposition and sand layering was observed in pits closer to the Feather River levee. Soil textures transitioned into more of a homogeneous layer of silt. No barriers to root growth were found as roots reached down to the bottom of the pits (approximately 10 feet). Evidence of mottling depicted seasonal flooding or inundation for a period of time. The last pit, located in Cell 3, along the edge of an existing elderberry grove and open annual grasslands area, exhibited layering of 3 feet of silt on a 2 foot layer of sand.

D. Topography

The topography on the Nelson Slough Unit is relatively flat, with a slight change in gradient in a few locations (Figure 8). The elevation on site ranges from 30 to 40 feet above mean sea level. The highest points on site occur along the bank of the Feather River, creating a natural levee along the property. This levee ranges from 5 to 10 feet tall and was created by overbank deposition during flood events. In the southeastern portion of the site (Cells II and III), there is a gradual decrease in elevation, which causes these areas to flood during high flow events. In Cells I and II, remnant rice checks still exist from past agricultural practices on the site, which will be removed during the restoration process.

Figure 8. Topography Map, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



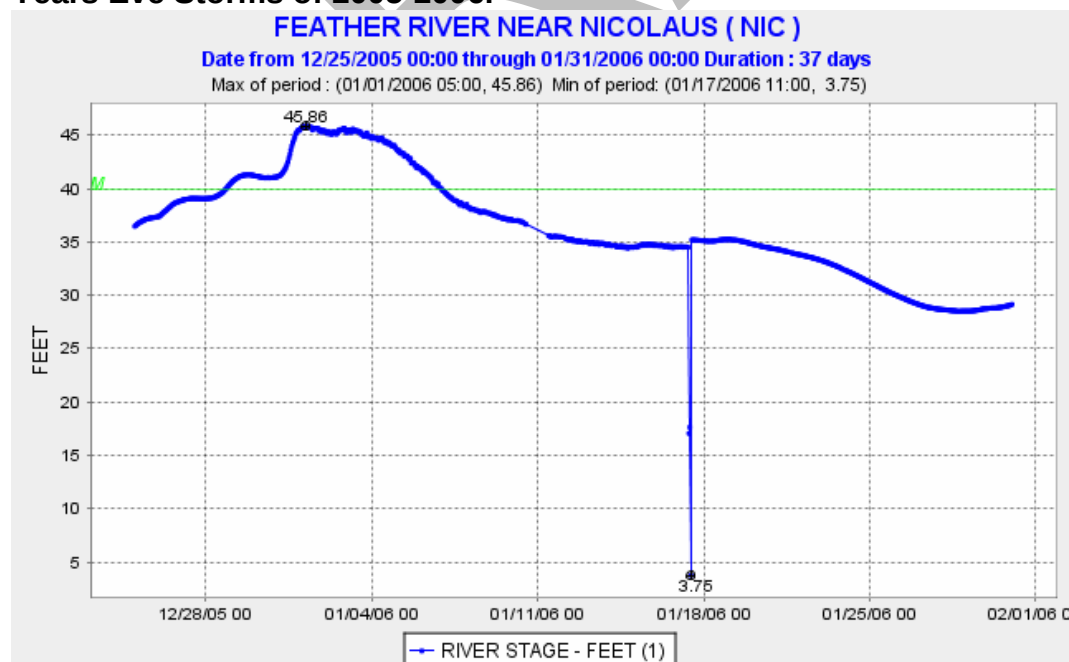
E. Hydrology

The average annual rainfall in the area of the Nelson Slough Unit is 17.63 inches (DWR 2007). The approximate flood recurrence is every 5-10 years (Whitmore, personal communication). Flood waters enter the site from the north and are slowed by the rock weir built along the southwestern boundary of the property. The rock weir was designed to filter out the sediment and silt from the Feather River during flood events prior to the water entering the Sutter Bypass (Whitmore, personal communication). This structure significantly slows down the water on the south end of the property and deposits large amounts of silt and sediment into Cell III. The exact construction date of the rock weir is unknown but dates back to at least the 1940's, as shown on the 1949 aerial photograph (Figure 3).

1. Flood Stages

Extremely high flows resulting in the loss of life and billions of dollars in damages in California's Central Valley have occurred in 1917, 1955, 1964, 1986 and 1997. Most recently, large storms hit northern California in 2005-2006 and caused regional flooding. Coined the New Years Eve Storms, they brought substantial amounts of precipitation. Small and quick-responding rivers such as the Russian and Napa experienced heavy flooding. However, dam releases on large and highly controlled rivers such as the Sacramento and Feather in anticipation of the heavy rains lessened the impacts, but high water still occurred. The Feather River water levels in the vicinity of the project area reached monitor stage (above 40.0 feet), resulting in the river rising above bankfull and flooding areas within the levees. The river crested at 45.86 feet near Nicolaus, which is just north of the project site, the morning of January 1, 2006 (Figure 9) (DWR 2007).

Figure 9. Graph Depicting River Gage Height Near Nicolaus During the New Years Eve Storms of 2005-2006.



2. Hydraulic Modeling

As part of the Encroachment Permit Application for the project, MBK Engineers conducted a hydraulic analysis of the proposed restoration project to ensure that the planting design is flood neutral (MBK Engineers 2008, Appendix III). A 1-D HEC-RAS model was used to determine the hydraulic impacts associated with the proposed restoration at Nelson Slough. The HEC-RAS model was calibrated to the January 1997 flood event and includes the completed Bear River setback levee and the Feather River setback levee from RM 18 to 24. A 1-D model rather than a 2-D model was used due to insufficient amounts of data along this stretch of the Feather River. Although 2-D modeling exists along the Nelson Slough project area, the data stops at the southern boundary of the project area. However, in addition to evaluating the project site, a hydraulic analysis must review potential impacts that may result upstream and downstream. Because the 2-D modeling stops at the project boundary, only a 1-D model was possible.

To simulate the proposed planting plan, the Manning's roughness coefficient, which is the degree of flow resistance caused by vegetation during a flood event, was modified to reflect the long term vegetation condition at each planting area. In addition, a sensitivity analysis, which accounts for uncertainty in the selection of the Manning's roughness coefficient, was performed for the proposed planting areas by increasing the predicted roughness by 20%. Both 100-year flood events and 200-year flood events were simulated. Based on the simulation results, MBK concluded the following:

- The modified roughness coefficient of the riparian planting on the Nelson Slough Unit would have less than significant impacts to the water surface elevations. For example, at river mile 9.27 there would be a 1/10th of a foot increase in water surface elevation during a 100 or 200 year flood event, which is within the margin of error and considered insignificant.
- The increase in water surface elevation would not have a significant impact on the freeboard along the east and west levee of the Feather River. The minimum freeboard at river mile 9.75 would be approximately 4.5 feet in a 100-year flood event and approximately 2 feet in a 200-year flood event.

F. Vegetation

The majority of the site is dominated by annual herbaceous non-natives, including annual ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), soft chess (*Bromus hordeaceus*), yellow starthistle (*Centaurea solstitialis*), wild radish (*Raphanus sativus*) and black mustard (*Brassica nigra*), as well as perennial pepperweed (*Lepidium latifolium*) (Figure 10). In portions of the site, especially in Cell I, there are stands of native herbaceous species, including telegraph weed (*Heterotheca grandiflora*), mugwort (*Artemisia douglasiana*), Santa Barbara sedge (*Carex barbarae*), gumplant (*Grindelia camporum*), creeping wildrye (*Leymus triticoides*), Spanish clover (*Lotus purshianus*), dogbane (*Apocynum cannabinum*), evening primrose (*Oenothera elata*), lupine (*Lupinus* spp.) and California poppy (*Eschscholzia californica*). Remnant riparian forest occurs in the northern portion of Cell I, the northwestern portion of Cell III and

borders the levee along the northern portion of the site and the weir along the western portion of the site. Native tree and shrub species include Fremont cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), box elder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), Mexican elderberry (*Sambucus mexicana*) and coyote brush (*Baccharis pilularis*). California blackberry (*Rubus ursinus*), creeping wildrye, mugwort and Santa Barbara sedge make up portions of the understory. The remainder of the understory is non-natives, including Himalayan blackberry (*Rubus armeniacus*) and perennial pepperweed. Sparse remnant riparian forest occurs along the shore of the Feather River, including sandbar willow (*Salix exigua*), white alder (*Alnus rhombifolia*), arroyo willow (*Salix lasiolepis*), box elder, Fremont's cottonwood, Mexican elderberry and black willow. The southern portion of Cell III is dominated almost exclusively with mature Mexican elderberry and an annual grassland understory with large patches of Santa Barbara sedge interspersed without. Over 200 elderberry shrubs are present in this portion of the site.

Figure 10. Photos of Current Vegetation Conditions on the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



Annual grasslands composed of primarily invasive non-native species dominate the site.



Remnant riparian with native understory occurs in the northern portion of Cell I.



Elderberry grove with annual grassland understory is the dominant habitat in Cell III.

G. Wildlife

Numerous wildlife species have been observed on site, including coyote, California quail, lark sparrow, wood duck, Cooper's hawk, spotted towhee, Bullock's oriole, western kingbird, western bluebird, black-headed grosbeak, California towhee and house wren. The property supports a number of different raptor species that utilize open habitat for foraging, including Swainson's hawk, great-horned owl, barn owl, red-tailed hawk, white-tailed kite and northern harrier. Cliff swallow, house finch and great-horned owl were observed nesting in the Highway 99 Bridge which passes over Cell I. Table 4 lists the federally and state-listed species that occur or have a potential to occur at the Feather River Wildlife Area.

Table 4. Federal and State-listed Endangered, Threatened, and Candidate Species Occurring or Potentially Occurring at the Feather River Wildlife Area.

Name	Scientific Name	Status
Valley elderberry longhorn beetle	<i>Desmocerus californicus dimorphus</i>	FT
Chinook salmon, Sacramento River winter-run ESU	<i>Oncorhynchus tshawytscha</i>	FE, CE
Chinook salmon, Central Valley spring-run ESU	<i>Oncorhynchus tshawytscha</i>	FT, CT
Chinook salmon, Central Valley Fall-run and late fall-run ESU	<i>Oncorhynchus tshawytscha</i>	CSC
Green sturgeon SDP	<i>Aspenser medirostris</i>	FT, CSC
Steelhead, Central Valley ESU	<i>Oncorhynchus mykiss</i>	FT
Western red bat	<i>Lasiurus blossevillii</i>	CSC
Bald eagle	<i>Haliaeetus leucocephalus</i>	CE
Least Bell's vireo (extirpated)	<i>Vireo bellii pusillus</i>	FE, CE
Peregrine falcon	<i>Falco peregrinus anatum</i>	CE
Swainson's hawk	<i>Buteo swainsoni</i>	FSC, CT
Western yellow-billed cuckoo	<i>Coccyzus americanus occidentalis</i>	FC, CE
Willow flycatcher	<i>Empidonax trailii</i>	FSC, CE

ESU – Evolutionary Significant Unit
 FE – Federal-listed Endangered Species
 FT – Federal-listed Threatened Species
 FC – Federal Candidate Species
 FSC – Federal Species of Concern

CE – California State-listed Endangered Species
 CT – California State-listed Threatened Species
 CSC – California Species of Concern

III. CONCEPTUAL SITE MODEL

This conceptual site model:

- Presents our understanding of the physical and biological factors that influence site ecology,
- Outlines our restoration strategy,
- Provides an overview of the plant design, and
- Identifies ecological benefits and targeted wildlife species.

The principles described in this section will guide the implementation of the project.

A. Past Environmental Conditions

During the 1800's, gold mining operations, including hydraulic mining, occurred along the upper Feather River. Hydraulic mining practices blasted mountainsides with water, introducing large quantities of sediment into the river system. Each winter, unnatural proportions of sand were washed downriver and deposited along the river bank. When the dams and levee systems were built in the 20th century, the natural flow regime and structure of the Feather River was altered from a meandering system of oxbow lakes to an immobile river with relatively consistent flows that were regulated by water discharge from the dams. The altered flooding regime inhibited the sand from washing away as quickly as it would under natural flood conditions, resulting in sandy banks and floodplains. Because sand is much more erodible than the naturally occurring fine textured soils, large amounts of bank incision have occurred.

Throughout most of the 20th century, land-use on the Nelson Slough Unit consisted primarily of livestock grazing. This destroyed much of the native vegetation on site, leaving the area exposed to invasive, non-native species. The remaining native trees and shrubs in Cells I and II were cleared for agricultural crops in the late 1970's. These practices stripped the majority of the site of its native vegetation, leaving the soil exposed during flood events. Without the native vegetation to protect the soils during flood events, erosion occurs at a higher rate than normal.

B. Likely Successional Patterns without Restoration

The Nelson Slough Unit has remained fallow since agricultural practices on the site ended in the late 1980's. Since that time, the property has been invaded by aggressive, non-native species, including yellow starthistle, ripgut brome and wild radish. Of particular concern is perennial pepperweed, which forms dense monocultures that easily displace desirable vegetation. It is a persistent weed and can spread by sprouting from its roots. There are numerous large patches within the project area and if left unchecked will likely become established throughout the site.

The alteration of the natural river processes, loss of historic disturbance regime, especially floods and fire, and the destruction of the native vegetation on site have made it almost impossible for a natural plant community to passively restore itself. The lack of flows has created a fairly static community, inhibiting the natural recruitment of vegetation by limiting seed dispersal and not providing water to seedlings at the

required development stage. In addition, heavy flood events and fire that would occur in natural conditions would destroy the existing non-native species, leaving the area open for reestablishment and activating the regenerative processes. New tree recruitment, primarily cottonwood and willow, on lower terraces is unlikely with the disturbed hydrograph. The abundance of non-natives creates heavy competition for the native recruits, this coupled with poor regeneration of natives results in conditions un-conducive for passive restoration.

C. Comparison to Nearby Vegetation (Reference sites)

The Bobelaine Audubon Ecological Preserve is directly upstream of the Nelson Slough Unit. This property is dominated with mixed riparian and valley oak woodland habitats, with mature riparian tree species, including cottonwood, valley oak and willows. Although the Nelson Slough Unit contains less woodland than the Bobelaine property, a 1912 U.S. Army Corps of Engineers topographic map and a 1949 aerial photograph shows that the site was historically as vegetated with woodland habitat as it's neighboring property (Figure 3).

D. Restoration Strategies for the Nelson Slough Unit

We recommend the following strategies for the Nelson Slough Unit:

- **Employ active restoration techniques to establish riparian vegetation.** The poor recruitment of native woody species and the site's strategic location near existing riparian vegetation makes the Nelson Slough Unit a good candidate for active restoration. Active restoration employs modern farming techniques to efficiently and rapidly establish riparian vegetation.
- **Develop a plant design based on current site conditions, flood management and management objectives to address wildlife habitat.** River Partners will develop a plant design to address wildlife needs, hydraulic considerations, neighbor requirements and other factors. The plant design is not based strictly on a "historical" or "climax" vegetation target, but is intended to provide high quality early succession-stage habitat for targeted wildlife.
- **Use an adaptive management approach to the project.** River Partners uses an adaptive management approach (River Partners 2008) to provide a framework to evaluate project progress and respond to new information.

These practices have resulted in high plant survival rate, accelerated natural recruitment of native species (through changes in microclimate and presence of seed sources) and documented wildlife benefits in short periods of time (three years).

E. Identification of Ecological Benefits and Targeted Wildlife Species

Riparian ecosystems harbor the most diverse bird communities in the arid and semi-arid portions of the western United States (Knopf *et al.* 1988, Dobkin 1994, Saab *et al.* 1995), and may also provide the most important avian habitat in California (Manley & Davidson 1993). Therefore, a restored site will provide vital habitat and conditions for neo-tropical migratory birds and other riparian dependent avian species (Figure 11). The Riparian Habitat Joint Venture (RHJV) has identified several species of birds as indicators of ecologically healthy riparian systems (RHJV 2004). These species are

termed riparian focal species and collectively their habitat requirements serve as an umbrella for all riparian bird habitat needs. Table 5 presents some of the habitat requirements for each of these species. There is a wide range of spatial and structural habitat requirement among this diverse assemblage of riparian bird species.

Habitat requirements for other targeted species will be incorporated into the plant design. For example, to provide habitat for the western yellow-billed cuckoo, we may plant a cottonwood forest in close proximity to riparian scrub (scattered elderberries, coyote brush with tall herbaceous forbs). Planting elderberry shrubs, which are the host plant for the valley elderberry longhorn beetle (VELB), in a mixed riparian forest will benefit this species. Additionally, the plant design, which may integrate habitat elements such as shaded riverine aquatic (SRA) and large woody debris (LWD), coupled with floodplain reconnectivity will enhance and restore native fish populations.

Figure 11. Habitat Value of Native Riparian Plants (RHJV 2000).

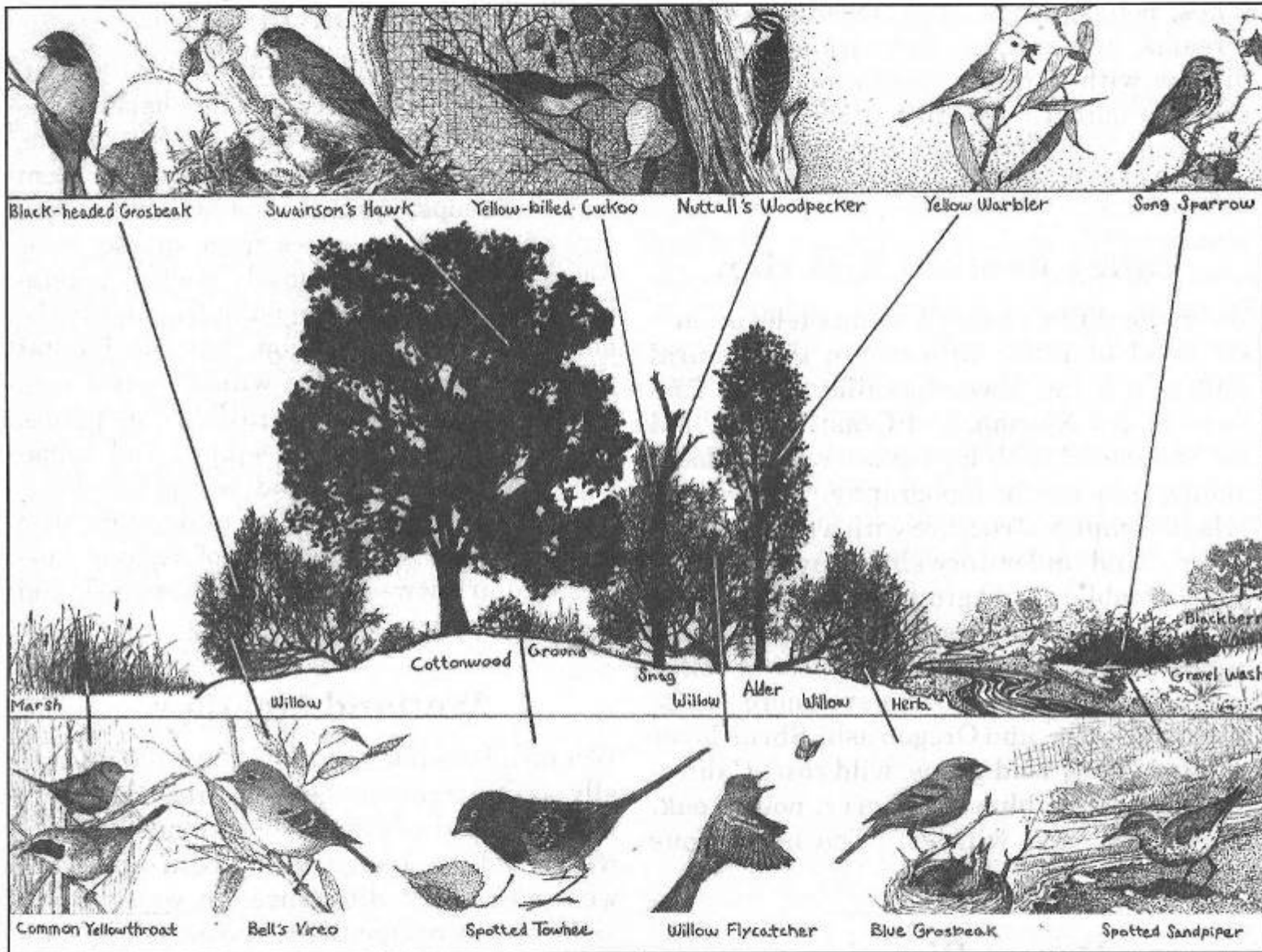


Table 5. Summary of Neotropical Migrant Bird Habitat Requirements (RHJV 2004).

Bird Species	Territory/Patch Size	Proximity to Water	Vegetation Structure	Nesting
Least Bell's vireo (<i>Vireo bellii pusillus</i>)	0.8-1.2 ha (2-3ac); >250m wide patch	Within 300m	Dense willow shrubs 3-5m tall; mugwort understory	Nest low, within 1m of ground
Black-headed grosbeak (<i>Pheucticus melanocephalus</i>)	200m x 50m	50-300m	Vertical complex - Cottonwood, willows, wild grape	Nest height 3-4m
Blue grosbeak (<i>Guiraca caerulea</i>)	----	In riparian zone	Low herbaceous, upright stems, open canopy	Nest height 0.6-3m
Common yellow-throat (<i>Geothlypis trichas</i>)	0.4-2 ha (1-5 ac)	In riparian zone	Tall emergent wetland edges	Nest height 0-0.6m
Song sparrow (<i>Melospiza melodia</i>)	Variable	Near, within 50m	Open canopy; dense herbaceous layer; gumplant, evening primrose	Low to ground; <1m
Swainson's hawk (<i>Buteo swainsoni</i>)	Variable, depending on proximity to foraging habitat	Not riparian obligate	Tall trees in riparian zone near open foraging areas	Nest in tall trees
Willow flycatcher (<i>Empidonax traillii</i>)	<1.0 ha (<2.5 ac)	Nests near water	Dense willows; 0-3m height of dense cover, low tree cover	Nests near water; height 0.6-3m
Yellow-breasted chat (<i>Icteria virens</i>)	<5 ha (<12 ac)	Prefers near wetlands	Dense thickets of willows and blackberries	Nests in vines and shrubs
Yellow-billed cuckoo (<i>Coccyzus americanus</i>)	8-40 ha (19.8-98.8 ac)	Nests near or over water	Willow-cottonwood thickets	Nest 1.3-13m high
Yellow warbler (<i>Dendroica petechia</i>)	0.06-0.75 ha	Wet areas	Willows, cottonwoods, early successional	----

IV. PLANTING DESIGN

River Partners has developed a site-specific planting design that represents a synthesis of the available information on site conditions, using the principles of landscape ecology (Silveira *et al.* 2003, USFWS 2005), project objectives and PRBO recommendations (Geupel *et al.* 1987).

Plant communities are based on the terrestrial natural community descriptions of the Holland classification system (Holland 1986). The Holland classification system includes descriptions of site factors and distribution that allows us to fit the appropriate vegetation with site specific characteristics. The community concept provides a useful descriptive label but does not specify arrangement, density or other quantifiable factors that must be addressed to translate the conceptual design to field implementation. Plant communities of the same name will differ in species composition (especially plant species frequency) and density due to physical factors and management considerations. The following sections will layout those factors for this project.

A. Design Considerations

River Partners considered the physical factors (soils, topography and hydrology) and historical vegetation of the site to determine what vegetation would potentially grow on site. The design also incorporates essential habitat elements to conserve, restore and enhance riparian habitat for threatened and endangered species, songbirds, other migratory birds, anadromous fish, resident native wildlife and plants, which is consistent with the mission of DFG. Additionally, recommendations from PRBO Conservation Science (PRBO) (Geupel *et al.* 1997) are integrated into the design in order to provide quality habitat for focal bird species. The plant design also accommodates the need for transitory storage and allows the conveyance of floodwaters across the floodplain. Thus, plant communities will describe the densities for trees and shrubs. For hydraulic considerations, we classify woody plants based on structural resistance to flows. Trees will be defined as plants with rigid structures and shrubs as plants with flexible structures. Table 6 lists key considerations of the plant design of the Nelson Slough Restoration Project.

Table 6. Key Plant Design Considerations of the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Objective/Factor	Example of Project Design Considerations
Maintain general flood flow conveyance patterns	Orient rows parallel to general flow direction and do not direct flows toward levees.
Provide immediate (< 3 years) habitat benefits and high probability of long-term survivorship	In the short term, relatively transient species (cottonwood and arroyo willow) will provide several generations of targeted bird species with nesting and foraging habitat. Planting a mixed riparian forest, maximizes quality habitat as the slow growing, but shade tolerant oaks mature. Coyote brush, rose, elderberry and blackberry grow quickly and will create gallinaceous and passerine bird habitat.
Minimize sources of weeds, provide habitat along project edges	Use native plants to displace weeds in areas outside the main plantable area. We will use spreading plants (e.g., native blackberry) and native understory species to outcompete perennial pepperweed and other invasive species that currently grow on site.
Maintain high plant species and vegetative structural diversity	PRBO data suggests that bird diversity is highest in areas with 5-7 shrub species over a 50-m ² area. Design considerations include varying density across the site to allow light gaps and create structural differences (grouping trees together will create pockets of shade and light gaps), creating vegetation patches (grouping small shrubs together will mimic larger plants and may attract desirable wildlife species faster than if they were grown apart), and considering herbaceous plantings between plant rows.
Provide foraging and nesting sites for Swainson's hawk	Tall riparian trees will provide nesting and perching areas. Perennial grassland (RHJV 2000) provides consistent access to and good availability of prey.
Provide valley elderberry longhorn beetle habitat while minimizing potential impacts to neighbors	Elderberry shrubs will be incorporated into the different plant communities across the site. The southern portion of Cell III already has approximately 200 mature elderberry shrubs on site. These will be planted as a native grassland in a way to preserve and protect these existing elderberry shrubs.
Provide foraging, roosting and nesting habitat for neotropical and riparian dependant bird species.	Dense shrub clusters will provide cover for roosting and protection from predators. Annual vegetation, such as doveweed, sunflower and fiddleneck, will provide foraging habitat for seed eaters. A 300 foot wide mixed riparian plant community along the curvature of the river and a 92 acre valley oak riparian forest will provide habitat for woodland species. Native grasslands will provide habitat for species who utilize open habitat.
Create migratory and nesting/roosting corridor for yellow-billed cuckoo and western red bat.	Plant a high density of cottonwood trees along the curvature of the river within a 300 foot wide mixed riparian plant community. Research in the Central Valley of California suggests that red bats are "strongly associated with riparian habitats, particularly mature stands of cottonwood/sycamore" (Pierson <i>et al.</i> 2004).
Minimize disturbance to wildlife	Use vegetation as a screen and plant in curved rows.
Minimize future impacts to maintenance areas.	No woody species will be planted within 30 feet of any levee, road, or other infrastructure.

B. Rationale for Plant Communities

Using our knowledge of the site factors and design considerations, River Partners developed six different plant communities. The physical layout or pattern of individual plants will follow the recommendations from PRBO. Studies by PRBO suggest that shrub cover is the most important variable influencing nest site and there is a positive relationship between tree and shrub richness and bird diversity (Small *et al.* 2000, Geupel *et al.* 1997).

River Partners expects at least 70% survival for its restoration plantings at the end of the three year maintenance period. Over the years after maintenance, some mortality is expected based on differences of soil textures and water table depths. Plant mortality creates areas of open canopy, patchiness and snags, all of which create structure and habitat for birds and other animals.

C. Composition and Location of Plant Communities

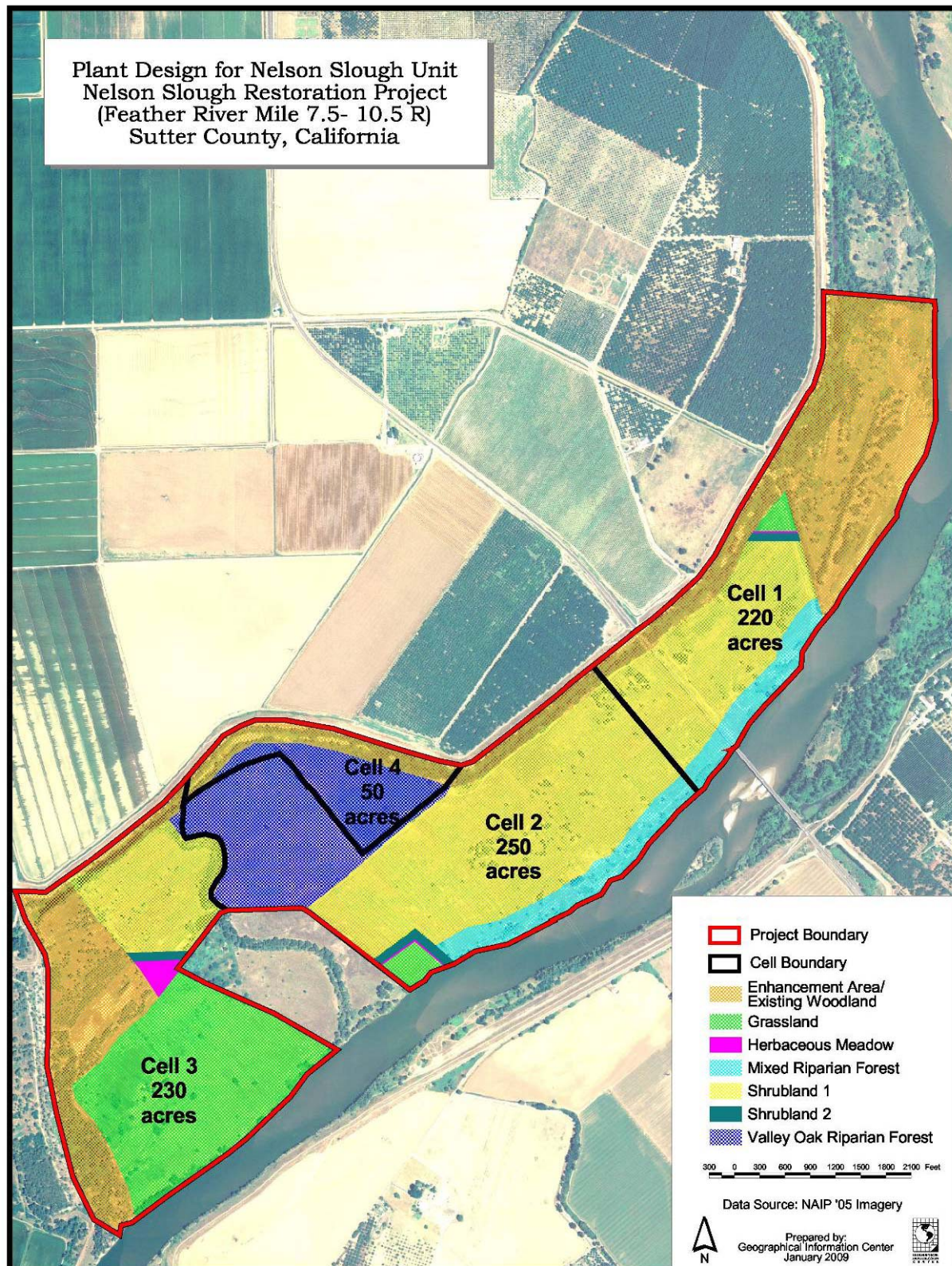
We propose planting different communities on the site based on the varying hydrological and biological conditions of the property. We suggest planting a combination of Great Valley Mixed Riparian Forest, Great Valley Valley Oak Riparian Forest, Low and Medium Density Riparian Shrubland, Native Grassland and Herbaceous Wildflower Meadow communities (Figure 12, Table 7). Tree and shrub densities and compositions (Tables 8 – 11) will vary across the site. Relatively open areas will be planted with a valley oak, shrub or grassland community. Mixed riparian forest will be planted along the bank of the Feather River. An integral component of the design is a native herbaceous understory, which will also be planted in drainage ways to help transmit floodwaters.

Table 7. Summary of Overall Proposed Plant Species at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Total Acres:		518 (223 planted with woody species)		
Common name	Scientific name	Species composition (%)	Density (plant/acre)	Total Number
Tree Species				
Arroyo willow	<i>Salix lasiolepis</i>	6.5	5.3	4,001
Box elder	<i>Acer negundo</i>	4.1	3.4	2,540
Elderberry	<i>Sambucus mexicana</i>	9.4	7.7	5,797
Fremont's cottonwood	<i>Populus fremontii</i>	2.1	1.7	1,311
Oregon ash	<i>Fraxinus latifolia</i>	3.2	2.6	1,951
Valley oak	<i>Quercus lobata</i>	7.7	6.3	4,731
Western sycamore	<i>Platanus racemosa</i>	3.8	3.1	2,352
Total Trees		36.8	30.1	22,683
Shrub Species				
Buttonbush	<i>Cephalanthus occidentalis</i>	2.1	1.8	1,326
California blackberry	<i>Rubus ursinus</i>	10.8	8.9	6,673
Clematis	<i>Clematis ligusticifolia</i>	3.7	3.0	2,271
Coyote brush	<i>Baccharis pilularis</i>	10.7	8.8	6,627
Dutchman's pipevine	<i>Aristolochia californica</i>	3.0	2.5	1,871
Mule fat	<i>Baccharis salicifolia</i>	7.2	5.9	4,431
Poison oak	<i>Toxicodendron diversilobum</i>	5.4	4.4	3,321
Wild rose	<i>Rosa californica</i>	12.1	10.0	7,512
Total Shrubs		55.0	45.3	34,032
Herbaceous Species				
Dogbane plugs	<i>Apocynum cannabinum</i>	4.1	3.4*	2,551*
Sunflower plugs	<i>Helianthus bolanderi</i>	4.1	3.4*	2,565*
Total Herbaceous		8.2	6.8*	5,116*
TOTAL		100.0	82.2	61,831

*Represents the number of occurrences of these species within the plant design. Six plugs will be planted at each location, increasing the total number of each species by six.

Figure 12. Planting Associations and Enhancement Area, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



1. Low Density Riparian Shrubland (Shrubland 1)

The Low Density Riparian Shrubland (Table 8) makes up the majority of the planting matrix of Cells I and II. This community is comprised almost entirely of woody shrub and vine species. Arroyo willow is included in this community to provide greater habitat structure and a trellis for vine species. Clumps of herbaceous species (dogbane and native sunflower) are included to create open spaces in the shrubland for structural diversity and open foraging habitat; six plugs will be planted at each location. The understory between the row centers and hedgerows will be comprised of mugwort, gumplant, telegraph weed, Spanish clover and a native grass mix. This habitat community will occur in Cells I, II and III.

Table 8. Composition of Low Density Riparian Shrubland at Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Total Acres:		261 (131 planted with woody species)		
Common name	Scientific name	Species comp. (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	<i>Salix lasiolepis</i>	8.0	9.7	2,536
Elderberry	<i>Sambucus mexicana</i>	10.0	12.1	3,170
Total Trees		18.0	21.8	5,706
Shrub Species				
Buttonbush	<i>Cephalanthus occidentalis</i>	4.0	4.8	1,268
California blackberry	<i>Rubus ursinus</i>	12.0	14.5	3,804
Clematis	<i>Clematis ligusticifolia</i>	4.0	4.8	1,268
Coyote brush	<i>Baccharis pilularis</i>	10.0	12.1	3,170
Dutchman's pipevine	<i>Aristolochia californica</i>	4.0	4.8	1,268
Mule fat	<i>Baccharis salicifolia</i>	10.0	12.1	3,170
Poison oak	<i>Toxicodendron diversilobum</i>	6.0	7.3	1,902
Wild rose	<i>Rosa californica</i>	16.0	19.4	5,072
Total Shrubs		66.0	79.8	20,922
Herbaceous Species				
Dogbane plugs	<i>Apocynum cannabinum</i>	8.0	9.7*	2,536*
Sunflower plugs	<i>Helianthus bolanderi</i>	8.0	9.7*	2,536*
Total Herbaceous		16.0	19.4*	5,072*
Totals	TOTAL	100.0	121.0	31,700

*Represents the number of occurrences of these species within the plant design. Six plugs will be planted at each location, increasing the total number of each species by six.

2. Medium Density Riparian Shrubland (Shrubland 2)

The Medium Density Riparian Shrubland (Table 9) will border the open grassland and meadow communities. This community has a greater number of woody shrubs with fewer vines and herbaceous species than the Shrubland 1 community to create a dense canopy cover for a fast escape from predators for wildlife foraging in the bordering open habitat. The Medium Density Riparian Shrubland (Shrubland 2) will transition from the open grassland and meadow habitat into the Low Density Riparian Shrubland community (Shrubland 1). Clumps of herbaceous species (dogbane and native sunflower) are included in this community and will be planted with six plugs per location. The understory between the row centers and hedgerows will be comprised of mugwort, gumplant, telegraph weed, Spanish clover and a native grass mix. This habitat community will occur in Cells I, II and III.

Table 9. Composition of Medium Density Riparian Shrubland at Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Total Acres:		6 (3 acres planted with woody species)		
Common name	Scientific name	Species comp. (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	<i>Salix lasiolepis</i>	14.0	16.9	102
Elderberry	<i>Sambucus mexicana</i>	12.0	14.5	87
Total Trees		26.0	31.4	189
Shrub Species				
Buttonbush	<i>Cephalanthus occidentalis</i>	8.0	9.7	58
California blackberry	<i>Rubus ursinus</i>	16.0	19.4	116
Clematis	<i>Clematis ligusticifolia</i>	2.0	2.4	15
Coyote brush	<i>Baccharis pilularis.</i>	16.0	19.4	116
Dutchman's pipevine	<i>Aristolochia californica</i>	2.0	2.4	15
Mule fat	<i>Baccharis salicifolia</i>	8.0	9.7	58
Poison oak	<i>Toxicodendron diversilobum</i>	4.0	4.8	29
Wild rose	<i>Rosa californica</i>	12.0	14.5	87
Total Shrubs		68.0	82.3	494
Herbaceous Species				
Dogbane plugs	<i>Apocynum cannabinum</i>	2.0	2.4*	15*
Sunflower plugs	<i>Helianthus bolanderi</i>	4.0	4.8*	29*
Total Herbaceous		6.0	7.2	44*
Totals	TOTAL	100.0	120.9	727

*Represents the number of occurrences of these species within the plant design. Six plugs will be planted at each location, increasing the total number of each species by six.

3. Great Valley Valley Oak Riparian Forest

The Great Valley Valley Oak Riparian Forest Community (Table 10) will be planted in areas where deeper, fine-textured soils occur. The understory will be comprised of mugwort and a native grass mix. Santa Barbara sedge, which is a common understory species found near oaks, will be planted as plugs at the base of the planted valley oaks. These understory species were selected because they will be able to tolerate the shady conditions that will occur as the woody species in this associate mature. This habitat community will occur in Cells II and IV.

Table 10. Composition of Great Valley Valley Oak Riparian Forest at Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Total Acres:		92 (46 acres planted with woody species)		
Common name	Scientific name	Species comp. (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	<i>Salix lasiolepis</i>	4.0	8.7	802
Box elder	<i>Acer negundo</i>	8.0	17.4	1,603
Elderberry	<i>Sambucus mexicana</i>	8.0	17.4	1,603
Oregon ash	<i>Fraxinus latifolia</i>	6.0	13.1	1,202
Valley oak	<i>Quercus lobata</i>	18.0	39.2	3,607
Western sycamore	<i>Platanus racemosa</i>	8.0	17.4	1,603
Total Trees		52.0	113.2	10,420
Shrub Species				
California blackberry	<i>Rubus ursinus</i>	10.0	21.8	2,004
Clematis	<i>Clematis ligusticifolia</i>	4.0	8.7	802
Coyote brush	<i>Baccharis pilularis</i>	12.0	26.1	2,405
Dutchman's pipevine	<i>Aristolochia californica</i>	2.0	4.4	401
Mule fat	<i>Baccharis salicifolia</i>	6.0	13.1	1,202
Poison oak	<i>Toxicodendron diversilobum</i>	6.0	13.1	1,202
Wild rose	<i>Rosa californica</i>	8.0	17.4	1,603
Total Shrubs		48.0	104.6	9,619
Totals	TOTAL	100.0	217.8	20,039

4. Great Valley Mixed Riparian Forest

The Great Valley Mixed Riparian Forest (Table 11) will be planted along the boundary of the river and will be 300 feet wide. It will be planted within the natural levee that runs along the river bank. This community will be comprised of a mixture of fast-growing species (cottonwood and arroyo willow) and slow-growing species (sycamore and oak), which provides short-term and long-term wildlife habitat. An understory of mugwort will be planted between planting rows and Santa Barbara sedge will be planted as plugs at the base of the planted valley oaks and cottonwoods. This association will create a corridor of mature cottonwood trees for nesting/roosting and migratory habitat for yellow-billed cuckoo and western red bat; both of which require dense stands of mature cottonwood. Western red bat research in the Central Valley of California suggests that this species is strongly associated with riparian habitats, particularly mature stands of

cottonwood and sycamore that are greater than 50m in width (Pierson *et al.* 2004). This habitat community will occur in Cells I and II.

Table 11. Composition of Great Valley Mixed Riparian Forest at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Total Acres:		43			
Common name	Scientific name	Species comp. (%)	Density (plants/acre)	Total Number	
Tree Species					
Arroyo willow	<i>Salix lasiolepis</i>	6.0	13.1	562	
Box elder	<i>Acer negundo</i>	10.0	21.8	937	
Elderberry	<i>Sambucus mexicana</i>	10.0	21.8	937	
Fremont cottonwood	<i>Populus fremontii</i>	14.0	30.5	1,311	
Oregon ash	<i>Fraxinus latifolia</i>	8.0	17.4	749	
Valley oak	<i>Quercus lobata</i>	12.0	26.1	1,124	
Western sycamore	<i>Platanus racemosa</i>	8.0	17.4	749	
Total Trees		68.0	148.1	6,369	
Shrub Species					
California blackberry	<i>Rubus ursinus</i>	8.0	17.4	749	
Clematis	<i>Clematis ligusticifolia</i>	2.0	4.4	187	
Coyote brush	<i>Baccharis pilularis</i>	10.0	21.8	937	
Dutchman's pipevine	<i>Aristolochia californica</i>	2.0	4.4	187	
Poison oak	<i>Toxicodendron diversilobum</i>	2.0	4.4	187	
Wild rose	<i>Rosa californica</i>	8.0	17.4	749	
Total Shrubs		32.0	69.8	2,996	
TOTAL		100.0	217.9	9,365	

5. Herbaceous Wildflower Meadow Association

The Herbaceous Wildflower Meadow Association will be planted along the edges of the grassland association transitioning into the Medium Density Riparian Shrubland (Table 12 & Figure 16). This association will be comprised of nine heavy seed producing plants (Table 12), both annuals and perennials, providing food sources for many different types of seed eaters, including passerine (perching birds/songbirds) and gallinaceous (ground feeding game birds) avian species. These flowering plant species also provide food sources to native and California endemic pollinators.

Instead of planting all understory species as plugs, they will be split into species that do well being planted as seeds or as plugs (Table 12). Species to be planted as plugs will be planted in the row centers at the edge of the Medium Density Riparian Shrubland habitat.

Table 12. Composition of Herbaceous Wildflower Meadow Association at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Common name	Scientific name	Planting Method	Planting Density
Blazing star	<i>Mentzelia laevicaulis</i>	Seed	2 lbs/acre
California aster	<i>Aster chilensis</i>	Plug	4 plugs/emitter
Deer grass	<i>Muhlenbergia rigens</i>	Plug	4 plugs/emitter
Doveweed	<i>Croton setigerus</i>	Seed	2 lbs/acre
Evening primrose	<i>Oenothera elata</i>	Seed	2 lbs/acre
Fiddleneck	<i>Amsinckia menziesii</i>	Seed	2 lbs/acre
Goldenrod	<i>Euthamia occidentalis</i>	Seed	2 lbs/acre
Western ragweed	<i>Ambrosia psilostachya</i>	Plug or transplant	4 plugs/emitter
Yampah	<i>Perideridia kelloggii</i>	Plug	4 plugs/emitter

6. Great Valley Riparian and Floodplain Meadow Association

The Great Valley Riparian and Floodplain Meadow will be planted near the pond on the southern boundary of Cell III and in open areas in Cell IV. Both of these locations have topography that hold moisture for longer periods of time than the surrounding areas and are more frequently inundated. The plant species in this association need frequent moisture during the dry season. This plant community will be planted as a small plot, approximately 100 feet by 20 feet in a discreet area that does not interfere with the implementation of the overall site. Nine flowering herbaceous perennials will be planted, depending on the availability of seed the year prior to planting (Table 13). These species are important to native, California endemic pollinators and many of them were once widespread throughout the valley prior to damming and levees and now only occur in scattered populations (Griggs & Silveira 2004).

Table 13. Species of Great Valley Riparian and Floodplain Meadow at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Common name	Scientific name	Planting Method	Planting Density
California loosestrife	<i>Lythrum californicum</i>	Plug	4 plugs/emitter
Baltic rush	<i>Juncus balticus</i>	Plug	4 plugs/emitter
Goldenrod	<i>Euthamia occidentalis</i>	Plug	4 plugs/emitter
Halberd-leaved vervain	<i>Verbena hastata</i>	Plug	4 plugs/emitter
Hedgenettle	<i>Stachys</i> sp.	Plug	4 plugs/emitter
Iris-leaved juncus	<i>Juncus xiphioides</i>	Plug	4 plugs/emitter
Narrow-leaved milkweed	<i>Asclepias fascicularis</i>	Plug	4 plugs/emitter
Santa Barbara sedge	<i>Carex barbarae</i>	Plug	4 plugs/emitter
Tall annual willowherb	<i>Epilobium branchycarpum</i>	Plug	4 plugs/emitter

7. Native Grassland Association

The Native Grassland Association will be planted in Cells I, II and III to provide open foraging habitat for numerous wildlife species, including raptors and gallinaceous birds. A total of two different native grass species will be planted, blue wildrye (*Elymus glaucus*) and creeping wildrye (Table 14). These grass species were selected based on their tolerance for drier, sandier soils, which are present on the majority of the project

site. The grassland in Cell I is designed with three acres, five acres in Cell II and 106 acres in Cell III, respectively.

The entire southern portion of Cell III will be planted as native grassland to work around the numerous existing mature elderberry shrubs and Santa Barbara sedge clusters. Due to the distribution and scattering of the elderberries in Cell III, it would be very difficult to create berms and install irrigation for planted rows. The native grassland will provide a large area of foraging habitat for open terrain species, such as red-tailed hawk, northern harrier, white-tailed kite, great-horned owl and western meadowlark, all of which have been observed on site.

Table 14. Species of Native Grassland Association at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Common name	Scientific name	Planting Method	Planting Density	Approximate Acreage
Blue wildrye	<i>Elymus glaucus</i>	Seed	4 pls lbs/acre	115 acres
Creeping wildrye	<i>Leymus triticoides</i>	Seed	3 pls lbs/acre	115 acres

8. Herbaceous Understory

To prevent establishment and limit the extent of invasive species, a dense, aggressive understory will be planted throughout the restoration (Table 15). Incorporation of herbaceous plants will provide important wildlife habitat, produce native plant seed sources and inhibit the establishment of invasive, exotic species. Mugwort is an especially important component of riparian communities and appears to be a good competitor against invasive non-native species. Mugwort, gumplant, telegraph weed and Spanish clover will be planted in the row centers. A native grass mix of creeping wildrye and blue wildrye will be planted in the 100 foot centers between the hedgerows.

Table 15. Herbaceous Understory Species in Row Centers and Hedgerows at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Common Name	Scientific Name	Planting Method	Planting Density	Approximate Acreage
Native Grass Mix		Drill seed		171 acres
Blue wildrye	<i>Elymus glaucus</i>		4 pls lbs/acre	
Creeping wildrye	<i>Leymus triticoides</i>		3 pls lbs/acre	
Gumplant	<i>Grindelia camporum</i>	Broadcast seed	3 lbs/acre	27 acres
Spanish clover	<i>Lotus purshianus</i>	Broadcast seed	3 lbs/acre	27 acres
Mugwort	<i>Artemisia douglasiana</i>	Broadcast seed	2 lbs/acre	98 acres
Telegraph weed	<i>Heterotheca grandiflora</i>	Broadcast seed	1 lbs/acre	27 acres
Santa Barbara sedge	<i>Carex barbarae</i>	Plugs	4 plugs/emitter, planted within a 12-inch radius from emitter	N/A

D. Planting Tiles and Baseline Data

River Partners has developed a computer database system that identifies the plant species at a particular row and planting location within the field. This planning tool allows us to develop a site specific planting pattern that will create a vegetation mosaic

of structural patterns within the restoration planting (e.g. dense thickets, light gaps, groves of taller trees, etc.) and match plants to specific field conditions (e.g. flood tolerant species in wet areas) or management objectives (e.g. dense vegetation to serve as a wildlife screen). Each planting location will receive a computer-generated label that lists its field, row and plant number, species name and number code. The labels are installed in the field prior to planting, allowing us to clearly communicate the plan to the planting crew. The database is an important adaptive management tool because it allows us to discern patterns in a plant species' survival rate or growth patterns across the field. The arrangement of each planting tile is shown in Appendix IV.

V. ENHANCEMENT

Enhancement Area is a catch-all term for areas within the project boundary that are not intensively planted with woody or herbaceous species. Enhancement activities will occur on approximately 230 acres, including the remnant riparian along the levee bordering the northern boundary of the site, the remnant riparian in the northern section of Cell I and the remnant riparian along the weir on the western boundary of the site in Cell III. The primary focus of the Enhancement Areas is to target non-native invasive species removal. Because limited funding precludes treating a large area, River Partners recommends prioritizing areas and target species. Targeted species include Himalayan blackberry, perennial pepperweed, tree of heaven and arundo. The only active restoration to occur in the existing riparian habitat will be in the central portion of the northern half of Cell I and the northwestern portion of Cell III, where the non-native annual grassland that currently exists will be disked and a native grass understory will be planted.

VI. REGULATORY COMPLIANCE

A. CEQA

The Department of Fish and Game has approved a Categorical Exemption for the restoration project on the Nelson Slough Unit (State Clearinghouse Number 2008028173).

B. Reclamation Board Encroachment Permit

An Encroachment Permit issued by the Central Valley Flood Protection Board (CVFPB) is required for the Nelson Slough Restoration Project. The application requires review by the Board of Directors of CVFPB and is currently awaiting approval. Planting of woody species will commence once the permit is issued.

C. VELB Memorandum of Understanding

There is an existing Memorandum of Understanding (MOU) between the USFWS, DFG, and California Department of Parks and Recreation (DPR) (Appendix V). The purpose of the MOU represents an agreement “to mutually manage, monitor, restore, and enhance lands managed for fish, wildlife and plants” along the Sacramento and Feather Rivers in Tehama, Butte, Glenn, Colusa, Sutter and Yuba Counties, California; and to “enhance communication between agencies to prevent duplicating or prescribing conflicting land management and acquisition efforts”. It has been determined that this MOU applies to the Nelson Slough Unit. In accordance with the MOU, River Partners will plant approximately 5,000 elderberry shrubs on the site at an average density of 7 plants per acre. Additional measures will be taken to avoid any adverse effects during flood control and restoration maintenance activities.

D. Cultural Resources

A record search of the California Historical Resources Information System was done by the Northeast Information Center of the California Historical Resources Information Center on February 12, 2007. According to the search, no prehistoric or historic sites have been recorded in the restoration or Enhancement Areas. However, the project is in the vicinity of two recorded historic sites and is located in an area utilized by prehistoric and historic populations (Roeder 2008).

In the event archeological resources are uncovered during a ground preparation activity, staff members will stop all activity within the immediate vicinity of the discovery, unless safety concerns are an issue. Staff will make an effort to protect resources or remains by flagging off the area. After activity has stopped, staff will immediately contact the River Partners office and the California Department of Fish and Game via telephone. Written confirmation will also be turned in to DFG. Activities resulting in the inadvertent discovery may resume after a notice from DFG is received.

E. Herbicide Permits

Herbicides will be used on the project as approved by a DFG Region II biologist, and according to county and state permitting and reporting requirements. Roundup®

(glyphosate) and 2,4-D are likely to be the most commonly used herbicides on the project. Rodeo® (for areas adjacent to water bodies), Garlon™ (for woody species control) and Stalker® (for Arundo control) may also be used.

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VII. FIELD IMPLEMENTATION

This section provides field managers with information needed to implement the plant design. The subsections describe field layout and an approximate sequence of activities that will be carried out over the three-year term of the restoration project.

A. Cell Descriptions

This section describes the characteristics and conditions of each of the restoration cells at the Nelson Slough Unit. Cell boundaries were determined by planting type and management and implementation considerations.

1. Cell I

Cell I is 220 acres, the northern half of which is existing riparian habitat. This portion of the site will only have enhancement practices and is separated from the southern portion of the cell by a channel that runs north to south from the levee to the Feather River. The southern portion of Cell I will be actively restored (Table 16 and Figure 13). The majority of the cell will be planted with the Low Density Riparian Shrubland Community, with a 300 foot wide strip of Mixed Riparian Woodland Community bordering the bank on the Feather River. A three acre Native Grassland will be planted in the northern corner of the cell, with an Herbaceous Wildflower Meadow Association bordering it and transitioning into Medium Density Riparian Shrubland Community (Figure 16). Currently the field is dominated by herbaceous non-native species such as yellow starthistle, riggut brome and perennial pepperweed. Native species such as sandbar willow and elderberry are scattered throughout. Woody native species will be left undisturbed and incorporated into the planting rows. Figure 13 shows the design for the understory planting in the row centers and hedgerows.

2. Cell II

Cell II is 250 acres and will be managed in its entirety (Table 16 and Figure 14). The majority of the cell will be planted with the Low Density Riparian Shrubland Community, with a 300 foot wide strip of Mixed Riparian Woodland Community bordering the bank on the Feather River. A five-acre Native Grassland will be planted in the southern corner of the cell, with an Herbaceous Wildflower Meadow Association bordering it and transitioning into Medium Density Riparian Shrubland Community (Figure 16). Great Valley Valley Oak Riparian Woodland Community will occur in the northern portion of the cell adjacent to Cell IV. Currently the field is dominated by herbaceous non-native species such as yellow starthistle, riggut brome and perennial pepperweed. Native species such as coyote brush and cottonwood are scattered throughout. Any woody native species will be left undisturbed and incorporated into the planting rows. Figure 14 shows the design for the understory planting in the row centers and hedgerows.

3. Cell III

Cell III is 230 acres, the western half of which is existing riparian habitat. This portion of the site will only have enhancement practices. The eastern portion of Cell III will be managed (Table 17 and Figure 15). The northern section of the managed part of the cell will be planted with the Low Density Riparian Shrubland Community. The southern section of the managed part of the cell will be planted as a grassland to work around the

large elderberry grove that exists. An Herbaceous Wildflower Meadow Association will be planted between the grassland and the shrubland (Figure 16). Currently the cell is dominated by herbaceous non-native species such as yellow starthistle and ripgut brome. Any woody native species will be left undisturbed and incorporated into the planting. Care should be taken to avoid and preserve the large clusters of Santa Barbara sedge that are present in the southern portion of Cell III. Figure 15 shows the design for the understory planting in the row centers and hedgerows.

4. Cell IV

Cell IV is 50 acres and will be managed in its entirety (Table 17 and Figure 14). It will be planted with the Great Valley Valley Oak Riparian Woodland Community. A few small Great Valley Riparian and Floodplain Meadows will be planted in areas where water will pool frequently enough for the soils to remain moist. Currently the field is dominated by herbaceous non-native species such as yellow starthistle and ripgut brome. Any woody native species will be left undisturbed and incorporated into the planting rows. Figure 14 shows the design for the understory planting in the row centers and hedgerows.

Table 16. Descriptions for Cells I & II at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Cell Name	Acreage	Soil Type	Vegetation Community	Understory Community	Weeds On Site
Cell I	220	Columbia fine sandy loam (121), Holillipah loamy sand (135)	Low density shrubland (69 acres)	Mugwort, gumplant, telegraph weed, forb mix – alternating every row center Native grass mix – hedgerows	Yellow starthistle, perennial pepperweed and annual grasses
		Columbia fine sandy loam (121), Holillipah loamy sand (135)	Medium density shrubland (1 acre)	Mugwort, gumplant, telegraph weed, forb mix – alternating every row center Native grass mix – hedgerows	
		Columbia fine sandy loam (121), Holillipah loamy sand (135)	Mixed riparian woodland (18 acres)	Mugwort - row centers Santa Barbara sedge - 2 plugs at base of every cottonwood and valley oak	
		Columbia fine sandy loam (121), Holillipah loamy sand (135)	Grassland/Meadow (3 acres)	N/A	
Cell II	250	Columbia fine sandy loam (121), Holillipah loamy sand (135), Shanghai fine sandy loam (161)	Low density shrubland (145 acres)	Mugwort, gumplant, telegraph weed, forb mix – alternating every row center Native grass mix – hedgerows	Yellow starthistle, perennial pepperweed and annual grasses.
		Holillipah loamy sand (135)	Medium density shrubland (3 acres)	Mugwort, gumplant, telegraph weed, forb mix – alternating every row center Native grass mix – hedgerows	
		Holillipah loamy sand (135), Shanghai fine sandy loam (161)	Valley oak riparian woodland (60 acres)	Mugwort, native grass mix – alternating every two row centers Santa Barbara sedge - 2 plugs at base of every valley oak	
		Holillipah loamy sand (135)	Mixed riparian woodland (25 acres)	Mugwort - row centers Santa Barbara sedge - 2 plugs at base of every cottonwood and valley oak	
		Holillipah loamy sand (135)	Grassland/Meadow (5 acres)	N/A	

Table 17. Descriptions for Cells III & IV at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Cell Name	Acreage	Soil Type	Vegetation Community	Understory Community	Weeds On Site
Cell III	230	Holillipah loamy sand (135)	Low density shrubland (43 acres)	Mugwort, gumplant, telegraph weed, forb mix – alternating every row center Native grass mix – hedgerows	Yellow starthistle and annual grasses
		Holillipah loamy sand (135)	Medium density shrubland (2 acres)	Mugwort, gumplant, telegraph weed, forb mix – alternating every row center Native grass mix – hedgerows	
		Holillipah loamy sand (135)	Grassland/Meadow (109 acres)	N/A	
Cell IV	50	Shanghai fine sandy loam (161)	Valley oak riparian woodland (30 acres)	Mugwort, native grass mix – alternating every two row centers Santa Barbara sedge - 2 plugs at base of every valley oak	Yellow starthistle and annual grasses

Figure 13. Understory Design for Cell I, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

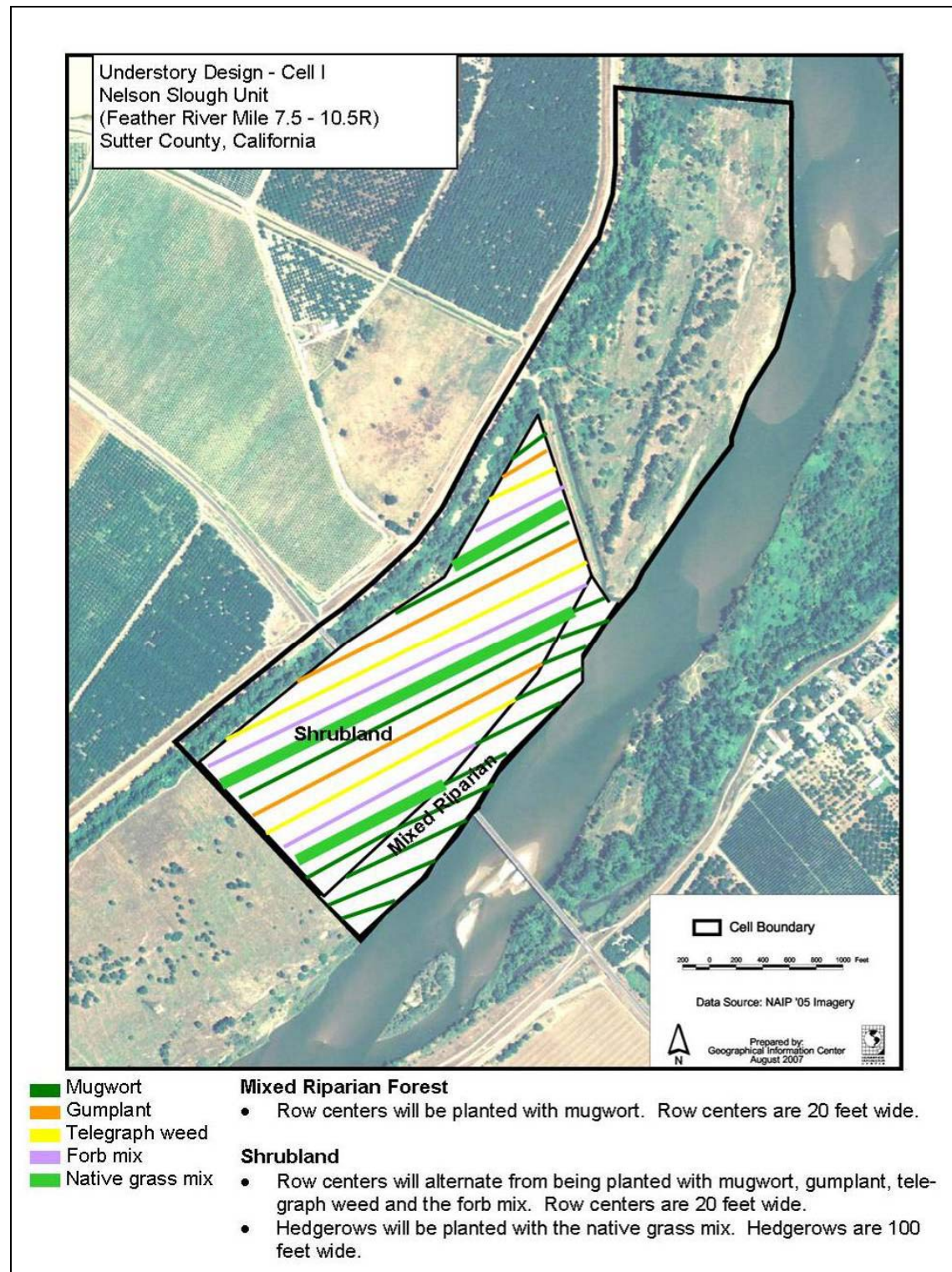


Figure 14. Understory Design for Cells II & IV, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

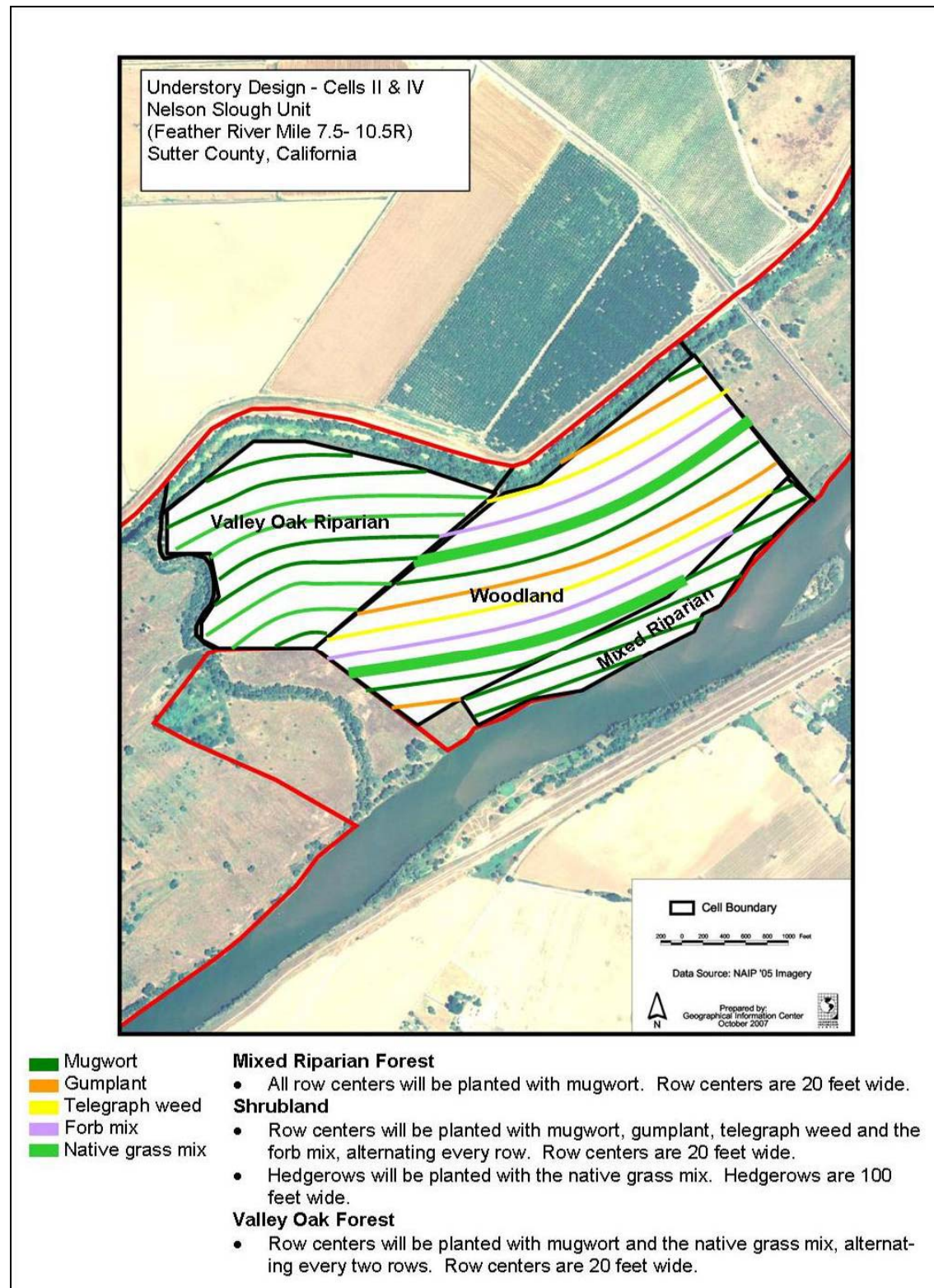
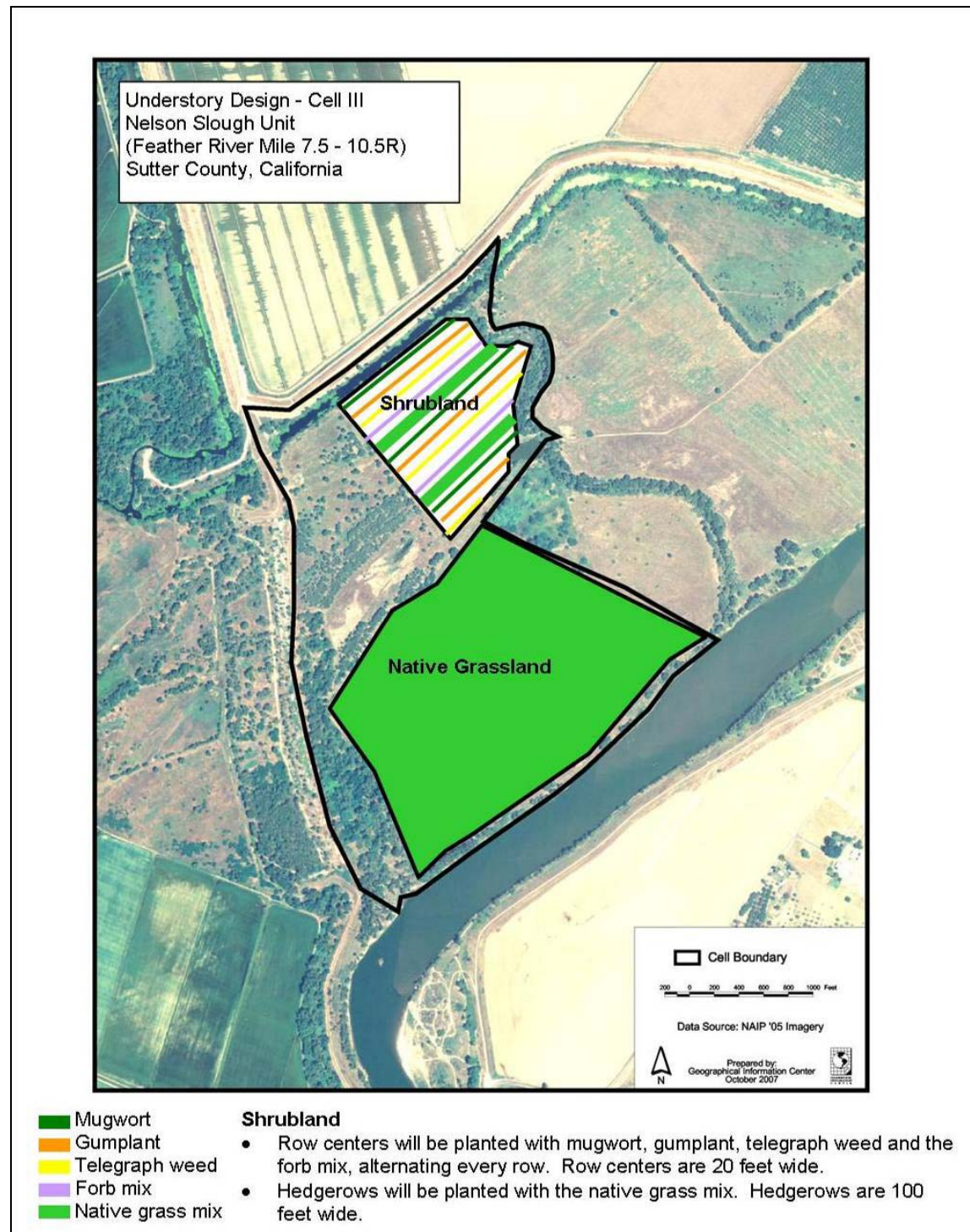


Figure 15. Understory Design for Cell III, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



B. Row Orientation and Plant Spacing

The Feather River flows northeast to southwest along the southern edge of the restoration site. Overbank flows move southward and westward across the site. All woody trees and shrubs will be planted in rows that will be oriented approximately parallel to flood flows.

Details of plant orientation and spacing are as follows:

- The planting rows of both the woodland and low shrub communities will be 20 feet apart; with in-row plant spacing at 10 feet. The hedgerows of the low shrub communities will consist of five rows 20 feet apart with 100 feet between each hedgerow. The woodland community will be planted adjacent to the low shrub community in the same rows, but the woodland will not have the 100 foot spacing of the hedgerows (Appendix VI). Rows will be curved and oriented in line with the natural flood event flows of the site (roughly a north-south orientation).
- Plant densities will vary across the project area to accommodate physical and biological parameters. The overall density of the site will range from 198 plants per acre, with significant areas that will be planted to low densities as described above. In addition, to allow for flood conveyance, a proportion of the plant communities will be comprised of flexible species such as California blackberry and California wild rose.

C. Site Preparation

1. Fallow Grassland

In winter of 2007, Cell II was disked and planted with safflower to help control weeds. Prior to restoration planting, all cells will be mowed and disked for weed control and soil preparation. When the ground is prepared, berms will be pulled and the irrigation system will be installed.

2. Existing Riparian Habitat

There are 230 acres of existing riparian habitat on the Nelson Slough Unit, including a large stand of remnant vegetation in the northern portion of Cell I and the southern portion of Cell III. Activities targeting specific non-native species will be the only enhancement activity conducted throughout the majority of the existing riparian habitat on site. The only active restoration to occur in the existing riparian habitat will be in the central portion of the northern half of Cell I and the northwestern portion of Cell III, where the non-native annual grassland that currently exists will be disked and a native grass understory will be planted.

D. Irrigation System

There are no existing wells on the project site. A well will be installed in the central portion of the property, along the northern border of Cell II. All irrigation lines will be run off this central well. In spring 2009, a test pump will be installed to determine the standing water level and recovery time.

All row plantings will be installed with an above ground drip line irrigation system. There will be three emitters per plant supplying water at a rate of 1.8 gallons/hour. The Herbaceous Wildflower Meadow Association will extend the lengths of the grassland border and will be approximately 20 feet wide. They will be irrigated with drip hose that is buried underground to allow the row centers to be mowed (Figure 16). Grasslands and Enhancement Areas will not be irrigated.

E. Plant Material Collection and Propagation

To preserve any ecotype differences, plant material will be collected from vegetation as near as possible to the site. All seeds for the herbaceous species will be collected or purchased from local ecotypes. Table 18 summarizes the types of plant propagation material to be used for woody species. Field cuttings should be collected in January or February when the trees are dormant.

F. Plant Installation

1. Woody Species

Acorns should be planted directly into the field during the fall. Cottonwood, willow and mule fat cuttings should be planted in February or March. Nursery material should be planted in the spring or fall when conditions are cool and moist (Table 18).

Table 18. Standard Planting Materials and Times for Woody Species.

Species	Nursery Grown		Directly Planted		Planting Time (primary method)
	Seeds	Cuttings	Seeds	Cuttings	
Arroyo willow	2	2		1	Feb-Mar
Black willow	2	2		1	Feb-Mar
Fremont cottonwood	2	2		1	Feb-Mar
Mule fat	2	2		1	Feb-Mar
Box elder	1				Oct-Apr
Buttonbush	1	2			Oct-Apr
California blackberry	1	2		2	Oct-Apr
California rose	1	2		2	Oct-Apr
Clematis	1				Oct-Apr
Coyote brush	1	1		2	Oct-Apr
Dutchman's pipevine	1				Oct-Apr
Elderberry	1				Oct-Apr
Poison oak	1				Oct-Apr
Oregon ash	1				Oct-Apr
Western sycamore	2	1			Oct-Apr
Valley oak	2		1		Nov-Dec

1-primary method, 2-secondary method

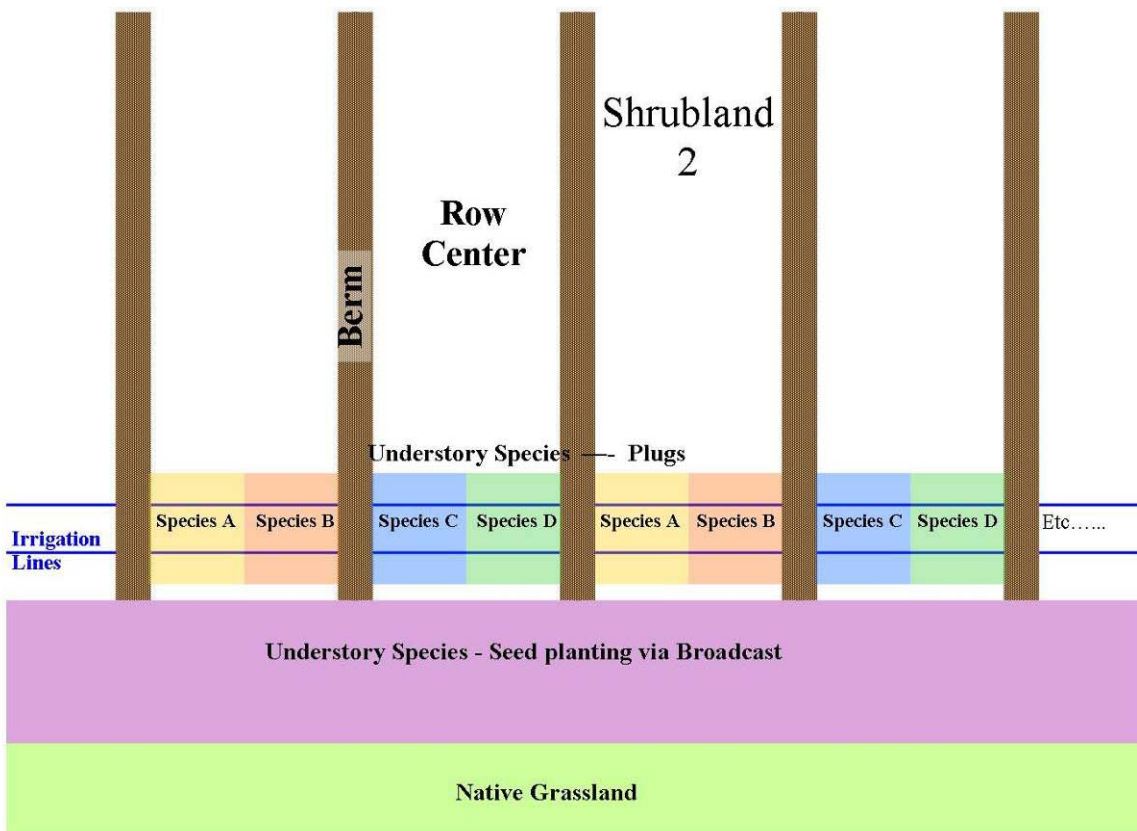
2. Herbaceous Species

The herbaceous understory species should be planted in year two to allow weed control during year one. Planting should begin in the fall to early winter, once rains have “flushed” winter weeds. Herbicides should be applied just prior to planting to kill sprouting winter weeds. See Section IV, Table 15 for a list of all herbaceous species to be planted in row centers.

3. Herbaceous Wildflower Meadow Association

Wildflower species in the Herbaceous Wildflower Meadow Association will be planted as either plugs or seed, depending on the species (Table 12). Species to be planted as plugs will be planted in the row centers at the edge of the Medium Density Riparian Shrubland habitat. Two species will be planted per row center; half of the row center will be planted with one species and the other half will be planted with another species. Two irrigation lines will be laid out perpendicular to the row centers and buried underground, with the plugs planted in clusters of four at the emitters along the irrigation line. Species to be broadcast as seed will be put just on the outside of the row centers bordering the grasslands (Figure 16).

Figure 16. Planting Design Implementation for Herbaceous Meadow Species in Shrubland/Grassland Transition Zone, Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.



G. Plant Maintenance

1. Plant Protectors

Plant protectors (one-quart milk cartons) should be installed with about 2 inches of wood shavings applied as mulch to hold soil moisture and minimize weed growth. These help protect the plant from desiccation, herbivory and drift from herbicide applications.

2. Weed Control

Weed control is necessary for the successful establishment of native plants and improvement of habitat. The weeds of greatest concern at the site are perennial pepperweed, yellow starthistle, ripgut brome and annual ryegrass. Various methods will be used to control these species. Pepperweed is very difficult to control due to the fact that it is a perennial and is also resistant to many herbicides. River Partners has had success in the past on pepperweed with the herbicide Telar® DF (Chlorosulfuron) and it will be used on this site.

During the growing season, weeds along the planting rows should primarily be controlled by the timely spraying of Roundup® (glyphosate) or a generic herbicide brand with glyphosate as the active ingredient. Rows will also be mowed with a side mower and weed eater as needed. The aisles between the planted rows (centers) should be mowed or disked to minimize weed growth and propagation. Spraying and/or mowing should be implemented every 3-6 weeks during the growing season for at least the first two years.

In areas to be planted with herbaceous species, we will spray and mow for an entire season before planting. Once the herbaceous species are planted, weed control methods will be mowing and if necessary spraying selective herbicide that kills either grasses or broadleaves, depending on the understory species.

3. Irrigation Schedule

Because of the dry summers typical of the climate in the area, irrigation will be required for plant establishment and survival. Irrigation will be applied with the goal that plants will become self-sufficient by the end of the third growing season.

In the first growing season, the rapidly growing seedlings have roots only in the surface (the top 1-2 feet) of the soil profile. The rooting zone must be kept moist through the season to ensure optimum growth and survival. Because of the sandy soils at the site and water table depths of over 20 feet, the soil moisture of the fields planted with woody species will need to be closely monitored. The intervals between irrigations are dependent upon soil texture, depth to water table, the weather conditions and plant water stress. Because we propose a mixture of species with different water demands, the plants must be carefully observed to maintain a balance of soil moisture that is acceptable for xeric species like valley oak and elderberry as well as more mesic species like cottonwood and willow.

The strategy for the second and third year is to train the roots to grow deep. Roots at depths of 5-15 feet will need less water and may be able to tap into the water table on the site and outcompete more shallow-rooted weeds. Less frequent, deep watering will encourage roots to grow deeper, well below the roots of the weeds, allowing the tree exclusive use of this deep moisture. As the tree's roots grow deeper, the times between irrigations become longer; this allows the soil surface layers to dry, thereby reducing weed vigor.

We anticipate that the well-drained, sandy soils and relatively deep groundwater present on the site will require frequent irrigations and careful observation of water stress. These areas may dictate the frequency of watering on the site. Field managers should use a combination of methods including evapotranspiration estimates, soil probes, gypsum blocks and plant water stress signs to assess soil moisture and alter the irrigation regime.

4. Herbivore Control

A number of measures can help control or minimize the effects of herbivores on young plants (Table 19). Cultural practices such as mowing or spraying can discourage most of these herbivores. One of the advantages of active restoration is that more plants are planted than the herbivores can eat. Some damage by herbivores is tolerable and should not impact the success of the planting.

Table 19. Summary of Herbivore Control Methods at the Nelson Slough Unit Restoration Project, Feather River Wildlife Area, Sutter County, California.

Herbivore	Type of Damage	Comment on measure(s) or plant response
Beaver (<i>Castor canadensis</i>)	Cut down woody species to build dams.	Dismantle dams or, if damage becomes severe, herbivore removal. Woody species can stump sprout.
Deer (<i>Odocoileus hemionus</i>)	Browsing sapling. Use trees to rub velvet off antlers.	Install heavy-gauge metal hoops and garlic capsules or other deterrent. Saplings can resprout.
Ground Squirrels (<i>Otospermophilus beecheyi</i>)	Dig up and shred plants and protectors. Eat the bark of willow and cottonwood saplings and limbs.	Flooding or disking can reduce populations.
Pocket Gophers (<i>Thomomys bottae</i>)	Eat root systems (probably killing more saplings than any other vertebrate pest).	Control of weed cover allows predators to hunt gophers. However, gophers can persist in an open, weed-free field. Frequent disking, weed mulch control, or flooding reduces populations. A variety of birds will prey on gophers if given the opportunity. Raptor perches and owl boxes may increase predation.
Rabbits and Hares (Family Leporidae)	Browse early spring growth.	Most seedlings resprout.
Voles (<i>Microtus</i> sp.)	Eat bark and cambium at the base of sapling, usually girdling the entire stem. Dig-up and eat recently planted acorns.	Saplings resprout, unless vole population is high. Voles live only in dense herbaceous (weed) cover and never stop moving when in the open to avoid predators. Remove dense weed cover through herbicides or mowing.

VIII. MONITORING AND REPORTING

River Partners has developed a science-based adaptive management program to respond to new information and changing conditions in order to “close the loop” between monitoring and project implementation (River Partners 2008). For each restoration site, River Partners staff makes monthly activity reports throughout the year and an annual quantitative survey between June and August. Towards the end of the growing season, monthly reports and the annual monitoring results are summarized and reviewed at a meeting on the project site. Recommendations for changes in field management are reported in the End of Season Report.

During the project, monitoring results will be recorded in the following ways:

- Monthly field reports,
- End of season monitoring,
- Annual photo points,
- Annual End of Season Reports, and
- Final Report.

These methods are described briefly below and explained more fully in our monitoring program plan (River Partners 2008).

A. Field Reports

Field managers and biology staff complete monthly reports documenting field activities and observations. These reports generally note planting and maintenance activities, irrigation schedules, weed pressure, plant growth, soil moisture, vandalism and herbivore damage. Soil moisture data (qualitative and/or quantitative) is also collected during the growing season.

B. End of Season Monitoring

At the end of the first growing season, we conduct a complete census of all woody species planted. These data are used to calculate survivorship and to determine any changes to or omissions from the planting design. During years two and three, we sample woody species plantings to determine survivorship, growth and coverage. If the budget allows, we also sample herbaceous understory plantings.

C. Photo Points

Biology staff will take pre- and post-planting photographs, which provide qualitative information on vegetation changes at the restoration site. The photographs are taken annually at established photo points late in the growing season.

D. Avian Monitoring

River Partners encourages avian monitoring of restoration projects. River Partners staff will monitor avian use of the Nelson Slough Unit to determine species richness, diversity, abundance and breeding status. Both existing riparian and future revegetated sites will be monitored so that comparisons can be made between the two. Data compiled at the sites will also be compared with nearby habitats of similar age.

E. End of Season Reports and Final Report

The End of Season and Final Reports will document the monitoring data, review site activities and recommend future management actions. River Partners will also document observations of natural processes related to flooding (erosion, sedimentation and debris deposition). Furthermore, we will analyze our activities in terms of the restoration plan and provide long-term management suggestions in the Final Report. Reports will be submitted to:

- Dale Whitmore, California Department of Fish and Game, Region II.

IX. SAFETY ISSUES

The health and safety of our employees are an integral part of our work. Prior to any work on the unit, River Partners staff will be briefed on safety issues associated with the site.

A. Standard Field Procedures

All employees will have a safety binder that describes safe work practices and they will be responsible for complying with these practices. In case of injuries or illnesses while on the job, employees will:

- Call 911, or
- Call Sutter North Medical Foundation, (530) 749-3403, located at 440 Plumas Blvd., Yuba City, California, and
- Contact the River Partners office at (530) 894-5401.

In addition, River Partner employees will comply with the requirements of the Drug-Free Workplace Act of 1990 (Government code Section 8350 et seq.).

B. Flood and Fire Contingencies

River Partners will remove all farm equipment from the site during the flood season (November 15 to April 15). In the event of a flood, flood debris will be cleared from the site following the flood season.

Throughout the implementation of the project, River Partners will periodically mow between rows and clusters and along the perimeter of project areas to reduce potential fire hazards.

X. PROJECT IMPLEMENTATION TIMELINE

The timeline for the project is shown for three years in Table 20.

Table 20. Timeline for the Scope of Work Tasks at the Nelson Slough Unit Restoration Project – Cell II, Feather River Wildlife Area, Sutter County, California.

Task	2008				2009				2010				2011			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Planning and Environmental Compliance																
Prepare Areas for Restoration																
Establish Layout for Restoration																
Install Irrigation System																
Collect and Propagate Plants																
Plant Riparian Vegetation																
Maintain Riparian Plantings																
Monitor and Report Results																

Note: Cells at the Nelson Slough Unit will be implemented in one year intervals and will each follow a similar timeline as Cell II.

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DRAFT

Appendix I. Official Soil Series Descriptions for Soils Occurring on the Nelson Slough Unit

LOCATION HOLILLIPAH CA
Established Series
Rev:DJL/WBS/TDC/DJE
8/98

HOLILLIPAH SERIES

The Holillipah series consists of stratified very deep, somewhat excessively drained soils that formed in alluvium from mixed sources. Holillipah soils are on flood plains and alluvial fans and have slopes of 0 to 2 percent. The mean annual precipitation is 18 inches and the mean annual temperature is 62 degrees F.

TAXONOMIC CLASS: Sandy, mixed, thermic Typic Xerofluvents

TYPICAL PEDON: Holillipah loamy sand - on a level flood plain of about 2 percent slope under annual grasses at 50 feet elevation. (Colors are for dry soil unless otherwise stated. When described on June 1, 1978, the soil was dry to 35 inches and slightly moist below.)

A--0 to 8 inches; pale brown (10YR 6/3) loamy sand, brown (10YR 4/3) moist; weak coarse granular structure; soft, loose, nonsticky and nonplastic; many very fine and fine and common medium roots; many very fine and fine interstitial pores; slightly acid (pH 6.5); clear smooth boundary. (5 to 10 inches thick)

C1--8 to 32 inches; white (10YR 8/1) sand, light gray (10YR 7/1) moist; massive; loose, nonsticky and nonplastic; many very fine and fine and common medium roots; many very fine and fine interstitial pores; neutral (pH 7.0); abrupt wavy boundary. (20 to 40 inches thick)

C2--32 to 35 inches; light yellowish brown (10YR 6/4) loamy sand, dark yellowish brown (10YR 4/4) moist; common medium distinct strong brown (7.5YR 4/6) mottles; massive; soft, very friable, nonsticky and nonplastic; common very fine tubular pores; neutral (pH 7.0); abrupt wavy boundary. (3 to 20 inches thick)

C3--35 to 47 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; many medium distinct brown (7.5YR 5/4) mottles; massive; slightly hard, friable, nonsticky and nonplastic; common very fine tubular pores; neutral (pH 7.0); gradual irregular boundary. (0 to 15 inches thick)

C4--47 to 61 inches; pale brown (10YR 6/3) loamy fine sand, dark brown (10YR 3/3) moist; massive; soft, very friable, nonsticky and nonplastic; few very fine tubular pores; neutral (pH 7.0).

TYPE LOCATION: Sutter County, California; approximately 5.6 miles south of Yuba City on Garden Highway then east 0.56 miles to about 400 feet from Feather River; 2,100 feet north and 3,000 feet east of the intersection of O'Banion Road and Garden Highway in the New Helvetia land grant, T. 14 N., R. 3 E. Olivehurst Quadrangle.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 60 degrees to 65 degrees F. The soil temperature is above 47 degrees F the entire year. The soil between depths of 14 and 43 inches is dry in all parts from May through October, and is moist in some or all parts from November through April unless irrigated. The difference between average July and average January soil temperature is 30 degrees to 33 degrees F. The soil is stratified with thick layers of sand, loamy fine sand or loamy sand and thin layers of fine sandy loam, sandy loam and silt loam. The particle-size control section averages loamy sand or coarser. Strata of sandy loam, fine sandy loam or silt loam 1/2 1 cm thick occur above 40 inches in depth. Organic carbon content decreases irregularly with depth. It is slightly acid to neutral.

The A horizon has dry color of IOYR 6/4, 6/3, or 6/2 and moist color of IOYR 4/4, 4/3, 4/2, or 3/3. It is sandy loam or loamy sand.

The C horizon has dry color of IOYR 8/1, 7/1, 7/2, 7/3, 7/4, 6/3, 6/4 or 5/3 and moist color of IOYR 7/1, 7/2, 6/2, 5/2, 5/3, 5/4, 4/2, 4/3, 4/4 or 3/3. Mottles may be relic from initial deposition and are associated with the finer textured stratified layers and not indicative of an intermittent high water table. Gravel content ranges from 0 to 5 percent.

COMPETING SERIES: These are the Metz series. Metz soils are neutral to moderately alkaline, are calcareous below the A horizon, and have a difference between mean summer and mean winter soil temperature of about 20 degrees F.

GEOGRAPHIC SETTING: Holillipah soils are on alluvial fans and flood plains. Slopes are 0 to 2 percent. The soils formed in stratified alluvium from mixed sources. Elevations are 20 to 150 feet. The climate is subhumid with hot dry summers and cool moist winters. Mean annual precipitation is 17 to 22 inches. January temperature is 45 degrees F., mean July temperature is 77 degrees F., and mean annual temperature varies from 60 degrees to 64 degrees F. Frost-free season is 260 to 280 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Columbia and Shanghai soils. Columbia and Shanghai soils are on similar flood plain positions, but usually are slightly lower in the landscape.

DRAINAGE AND PERMEABILITY: Somewhat excessively drained; very slow runoff; moderately rapid permeability. The soils are flooded unless protected by levees.

USE AND VEGETATION: This soil is used for irrigated orchards and row crops. In some areas next to rivers, the natural vegetation is valley oak, cottonwood and shrubs.

DISTRIBUTION AND EXTENT: Southeastern part of the Sacramento Valley. Soils are not extensive.

MLRA OFFICE RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Sutter County, California 1984. Series name is from a tribe of native Americans in the area who have now vanished.

OSD scanned by SSQA. Last revised by state on 2/87.

National Cooperative Soil Survey
U.S.A.

LOCATION COLUMBIA CA
Established Series
Rev. DJL/CAF/MAV/SBS/DWB
05/2006

COLUMBIA SERIES

The Columbia series consists of very deep, moderately well drained soils formed in alluvium from mixed sources. These soils are on flood plains and natural levees and have slopes of 0 to 8 percent. The mean annual precipitation is 12 to 25 inches, (305 to 635 mm) and the mean annual temperature is about 61 degrees F, (16 degrees C).

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, nonacid, thermic Oxyaquic Xerofluvents

TYPICAL PEDON: Columbia fine sandy loam, on a nearly level plowed field. (Colors are for dry soil unless otherwise stated.)

Ap--0 to 11 inches, (0 to 28 cm); pale brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) moist; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; few very fine tubular and many very fine interstitial pores; slightly acid (pH 6.4); clear smooth boundary. (7 to 12 inches, (18 to 31 cm) thick)

A--11 to 16 inches, (28 to 41 cm); pale brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots; common very fine tubular pores, slightly acid (pH 6.4); clear wavy boundary. (4 to 8 inches, (10 to 20 cm) thick)

C1--16 to 23 inches, (41 to 58 cm): pale brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) moist; massive; soft, very friable, nonsticky and nonplastic; common very

fine roots; many very fine interstitial pores; common fine prominent yellowish brown (10YR 5/6) masses of iron accumulations, strong brown (7.5YR 5/6) moist; slightly acid (pH 6.5); clear wavy boundary. (4 to 8 inches, (10 to 20 cm) thick)

C2--23 to 26 inches, (58 to 66 cm); pale brown (10YR 6/3) sand, dark brown (10YR 3/3) moist; single grained; loose, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; slightly acid (pH 6.5); clear smooth boundary. (0 to 5 inches, (0 to 13 cm) thick)

C3--26 to 31 inches, (66 to 79 cm); very pale brown (10YR 7/3) and reddish yellow (7.5YR 6/6) fine sandy loam; massive; slightly hard, very friable, nonsticky and nonplastic; common very fine roots; many very fine tubular pores; common fine prominent yellowish brown (10YR 5/4) and strong brown (7.5YR 5/6) masses of iron accumulations moist; neutral (pH 7.0); clear smooth boundary. (2 to 8 inches, (5 to 20 cm) thick)

C4--31 to 34 inches, (79 to 86 cm); very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; moderate medium prismatic structure; hard, friable, slightly sticky and slightly plastic; very few very fine roots; many very fine and fine tubular pores; many medium distinct reddish yellow (7.5YR 6/6), strong brown (7.5YR 5/6) masses of iron accumulations moist; slightly alkaline (pH 7.5); clear smooth boundary. (0 to 5 inches, (0 to 13 cm) thick)

C5--34 to 38 inches, (86 to 97 cm); very pale brown (10YR 7/3) fine sandy loam, brown (10YR 5/3) moist; massive; slightly hard, very friable, nonsticky and nonplastic; very few very fine roots; many fine tubular and common very fine interstitial pores; many medium distinct reddish yellow (7.5YR 6/6), strong brown (7.5YR 5/6) masses of iron accumulation; slightly alkaline (pH 7.7); clear smooth boundary. (2 to 10 inches, (5 to 25 cm) thick)

C6--38 to 41 inches, (97 to 104 cm); pale brown (10YR 6/3) sand, dark brown (10YR 3/3) moist; single grained; loose, nonsticky and nonplastic; common very fine roots; common very fine tubular and many very fine interstitial pores; neutral (pH 7.0); abrupt smooth boundary. (1 to 5 inches, (2.5 to 13 cm) thick)

C7--41 to 55 inches, (104 to 140 cm); pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; few very fine roots; many very fine, medium and coarse tubular pores; many medium distinct reddish yellow (7.5YR 6/6) and strong brown (7.5YR 5/6) masses of iron accumulation moist; moderately alkaline (pH 8.0); clear smooth boundary. (0 to 15 inches, (0 to 38 cm) thick)

Ab--55 to 59 inches, (140 to 150 cm); gray (10YR 6/1) silty clay loam, dark gray (10YR 4/1) moist; massive; hard, friable, sticky and slightly plastic; very few very fine roots; many very fine, fine and medium tubular pores; common fine distinct strong brown (7.5YR 5/6), dark brown (7.5YR 3/2) masses of iron accumulation moist; moderately alkaline (pH 8.0).

TYPE LOCATION: Solano County, California; 400 feet south of the south end of the bridge at the north end of Ryer Island. Not sectionalized, T.5 N., R.3 E.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 60 to 65 degrees F, (16 to 18 degrees C). The soil between depths of 8 and 25 inches, (20 to 64 cm) is moist in some or all parts from late October to late May or June and is dry in all parts the remainder of the year, unless irrigated. The 10 to 40 inches, (25 to 102 cm) particle-size control section is stratified fine sandy loam, very fine sandy loam, silt loam, loam, loamy sand, loamy fine sand, fine sand or sand and averages 10 to 18 percent clay, when mixed, and has greater than 15 percent fine sand or coarser. Up to 35 percent gravel may occur below a depth of 40 inches, (102 cm). Redoximorphic features occur between 10 and 48 inches, (25 to 122 cm). Content of organic matter decreases irregularly with depth.

The A horizon is 10YR 7/2, 6/4, 6/3, 6/2, 5/4, 5/3 or 5/2 and moist color of 10YR 5/4, 4/4, 4/3 or 4/2. Texture is sandy loam, sand, loamy sand, loamy fine sand, fine sandy loam, loam or silt loam and commonly is stratified. Reaction is slightly acid to slightly alkaline.

The C horizon is 10YR 8/4, 8/1, 7/4, 7/3, 7/2, 7/1, 6/4, 6/3, 6/2 6/1, 5/4 or 5/3 and moist color of 10YR 7/4, 7/3, 7/2, 6/2, 6/4, 5/4, 5/3, 5/2, 4/4, 4/3, 4/2, 4/1, 3/3, or 3/4. Redoximorphic features have hues of 10YR, 7.5YR, 5YR or 2.5YR with chroma of 3, 4 or 6. Texture is stratified sand to silty clay loam. Finer textures occur below 40 inches, (102 cm). Reaction is slightly acid to slightly alkaline but may be moderately alkaline in horizons underlain by an Ab horizon.

The Ab horizon is 10YR 6/1, 5/1, 4/1, 4/2, 3/1 or 2/1; 2.5Y 6/2. Moist colors are 10YR 5/1, 4/1, 3/1, 2/1; N 2/0; 2.5Y 3/2. Texture is mucky clay loam, clay loam, silty clay loam, silty clay or clay. Depth to a buried horizon ranges from 40 to 60 inches, (102 to 152 cm). Some pedons lack a buried horizon and some pedons are calcareous at 40 inches, (102 cm) or more. Reaction is neutral to moderately alkaline.

COMPETING SERIES: There are no other series in this family.

GEOGRAPHIC SETTING: Columbia soils are on flood plains with bar and channel topography in some natural areas or are on natural levees. These soils formed in alluvium from mixed sources. Elevations are 10 feet below sea level to 155 feet above sea level (47 m). The climate is subhumid with hot dry summers and cool moist winters. Mean annual precipitation is 12 to 25 inches, (304 to 635 mm). Mean January temperature is 45 degrees F, (7 degrees C), mean July temperature is 80 degrees F, (27 degrees C). Mean annual temperature varies from 58 to 63 degrees F, (14 to 17 degrees C). Frost-free period is 230 to 340 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Arvin, Clear Lake, Sacramento, Shanghai and Sycamore soils. Arvin soils are not saturated with water within 60 inches, (152 cm) of the surface and are in similar or slightly higher flood plain

positions. Clear Lake and Sacramento soils have clay textures and are in basins. Sycamore soils have less than 15 percent fine or coarser sand and are in similar flood plain positions.

DRAINAGE AND PERMEABILITY: Moderately well drained; negligible to medium runoff; moderately rapid permeability. Clay substratum phase has slow permeability below a depth of 40 inches, (102 cm). Sandy substratum phase has rapid permeability below a depth of 40 inches, (102 cm). Except where drained, these soils are saturated at 20 to 48 inches, (51 to 122 cm) for several months in the period from November to April. In areas not protected by levees or other flood control structures these soils are subject to occasional to frequent, brief to long periods of flooding in November to May. Rare flooding occurs in partly protected areas.

USE AND VEGETATION: These soils are used for irrigated hay, small grain, and orchard and row crops. Vegetation consists of a fairly dense cover of oaks, cottonwoods, willows, vines, shrubs and grasses near stream channels, but more open away from the channels.

DISTRIBUTION AND EXTENT: These soils occur in the central valley of California. The soils are moderately extensive in MLRA-16, 17.

MLRA OFFICE RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Reconnaissance Survey of Southwest Washington 1911.

REMARKS: The series was redefined in the Chico area of Butte County, California in 1925. The type location was moved to Madera County, California in 1959. The type location was then moved to Solano County, California 1970.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface to a depth of 16 inches, (41 cm) (Ap, A)

Oxyaquic subgroup - the zone from 20 to 48 inches, (51 to 122 cm) is saturated for several months.

CEC/Clay ratio estimated from similar soils with laboratory data in the W. Stanislaus Soil Survey Area and University Laboratory data.

Edit log: Runoff terminology adjusted 4/96 to adjective criteria of the Soil Survey Manual (10/93). 5/2003 Proposed edits for use in Butte County; Range in Characteristics: expand allowed gravel from 5 to 35 percent below a depth of 40 inches. A horizon: add textures sand, loamy sand, loamy fine sand, and add: commonly is stratified. C horizon: add colors moist 10YR 6/2 and 3/4. Geographic setting: expand elevation from 150 to 155 feet. In remarks added history of type location moves.

ADDITIONAL DATA: NO: 50-CAL-20-39-1-1 to 3 University of California, Madera County, Tehama County, and UC Berkley, 58-52-48.

National Cooperative Soil Survey
U.S.A.

LOCATION SHANGHAI CA
Established Series
Rev. ENV/DJL/TDC/CEJ/ET
03/2003

SHANGHAI SERIES

The Shanghai series consists of very deep, somewhat poorly drained soils that formed in alluvium from mixed sources. Shanghai soils are on flood plains and have slopes of 0 to 2 percent. The annual temperature is about 62 degrees F. and the annual precipitation is about 18 inches.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, nonacid, thermic Aquic Xerofluvents

TYPICAL PEDON: Shanghai silt loam - on a nearly level slope of less than 1 percent in an irrigated prune orchard at 30 feet elevation. (Colors are for dry soil unless otherwise stated. When described on April 9, 1979, the soil was moist throughout.)

Ap--0 to 11 inches; very pale brown (10YR 7/4) silt loam, brown (10YR 4/3) moist; common medium distinct yellowish brown (10YR 5/6) mottles, yellowish brown (10YR 5/8) moist; moderate very fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fine roots; common very fine tubular pores; neutral (pH 7.0); clear smooth boundary. (7 to 14 inches thick)

A--11 to 21 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 4/3) moist; common large distinct strong brown (7.5YR 5/6) mottles, dark yellowish brown (10YR 4/6) moist; massive; slightly hard, friable, slightly sticky and plastic; common very fine roots; common very fine tubular pores; neutral (pH 7.0); gradual wavy boundary. (3 to 10 inches thick)

C1--21 to 27 inches; pale brown (10YR 6/3) silt loam, yellowish brown (10YR 5/4) moist; many medium prominent yellowish brown (10YR 5/8) and many large prominent strong brown (7.5YR 4/6) mottles, dark yellowish brown (10YR 3/6) and dark reddish brown (2.5YR 3/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine and few fine roots; common very fine tubular pores; neutral (pH 7.0); gradual wavy boundary. (6 to 18 inches thick)

C2--27 to 36 inches; pale brown (10YR 6/3) silt loam, dark yellowish brown (10YR 4/4) moist; many medium prominent yellowish brown (10YR 5/8) and many large prominent strong brown (7.5YR 4/6) mottles, dark yellowish brown (10YR 3/6) and dark reddish brown (2.5YR 3/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; very fine tubular pores; neutral (pH 7.0); gradual wavy boundary. (9 to 16 inches thick)

C3--36 to 54 inches; very pale brown (10YR 7/3) silt loam, dark yellowish brown (10YR 4/4) moist; common medium distinct strong brown (7.5YR 5/8) mottles, dark brown (7.5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; common very fine tubular pores; neutral (pH 7.0); gradual wavy boundary. (8 to 18 inches thick)

C4--54 to 62 inches; pale brown (10YR 6/3) silt loam, dark brown (10YR 3/3) moist; many medium distinct yellowish red (5YR 5/8) mottles; massive; soft, friable, slightly sticky and slightly plastic; few very fine roots; common very fine pores; neutral (pH 7.0).

TYPE LOCATION: Sutter County, California; approximately 1.2 miles north of Yuba City on Live Oak Highway, then east on Rednall Road to levee; 2,000 feet north and 900 feet east of the intersection of Rednall Road and the western levee of the Feather River, approximately 800 feet from river, in the New Helvetia land grant T.15 N., R.3 E. Yuba City Quadrangle.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 60 degrees to 65 degrees F. The soil temperature is above 47 degrees F. the entire year. The soil between depths of 6 and 18 inches is dry in all parts from June through October and is moist in some or all parts from November through May unless irrigated. The difference between average July and average January soil temperature is 30 degrees to 33 degrees F.

The 10 to 40 inches control section is stratified layers of silt loam to fine sandy loam and silty clay loam, but is dominantly silt loam with less than 15 percent coarser than very fine sand. Clay content ranges from 20 to 35 percent. Content of organic matter decreases irregularly with depth. Reaction is slightly acid to moderately alkaline.

The A horizon has dry color of 10YR 7/4, 7/3, 6/4, 6/3, 5/4; 2.5Y 6/2 or 7/2 and moist color of 10YR 4/4, 4/3; 2.5Y 4/2, 3/2 or 3/3 with mottled colors dry and moist of 10YR 4/6, 5/6, 5/8; 7.5YR 5/6, 7/6 and 5YR 6/8. It is silty clay loam, silt loam or fine sandy loam.

The C horizon has dry colors of 10YR 8/4, 7/4, 6/4, 8/3, 7/3, 6/3; 2.5Y 6/2 or 7/2 and moist color of 10YR 6/6, 6/4, 6/3, 5/6, 5/3, 3/3, 5/4, 4/4; 2.5Y 5/2, 4/2, or 5Y 6/3 with prominent or distinct mottles. Some pedons have a clay layer at 40 to 60 inches.

COMPETING SERIES: There are no other series in this family.

GEOGRAPHIC SETTING: Shanghai soils are on flood plains with slopes of 0 to 2 percent. They formed in alluvium from mixed sources. Elevations are 20 to 150 feet. The climate has hot dry summers and cool moist winters. Mean annual precipitation is 14 to 22 inches. Average January temperature is about 45 degrees F., the average July temperature is about 77 degrees F., and the mean annual temperature is 60 degrees to 64 degrees F. The frost-free season is about 260 to 290 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Columbia and Holillipah soils. Columbia soils are on similar flood plain positions. Holillipah soils are on similar but slightly higher flood plain positions in areas adjacent to rivers.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; runoff is very slow; permeability is moderate, but may be slow below 40 inches. Unless protected, these soils are subject to flooding. Unless drained, in low lying areas and areas adjacent to levees, a water table is present at a depth of 30 to 60 inches in December through April and below a depth of 48 inches in May to November. In other areas, the water table is at 36 to 60 inches in December through April.

USE AND VEGETATION: This soil is used for irrigated orchards, small grains and row crops.

DISTRIBUTION AND EXTENT: Southeastern part of Sacramento Valley. Soils are moderately extensive.

MLRA OFFICE RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Sutter County, California 1984.

REMARKS: The activity class was added to the classification in February of 2003. Competing series were not checked at that time. - ET

Last revised by the state on 2/91.

National Cooperative Soil Survey
U.S.A.

Appendix II. Soil Pit Logs for the Nelson Slough Unit

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Appendix III. Hydraulic Analysis Report for the Nelson Slough Unit

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Appendix IV. Planting Association Tiles for the Nelson Slough Unit

Shrubland 1

Plant#/Row	1	2	3	4	5
1	PI	MU	RO	PO	RO
2	AW	MU	RO	BB	BB
3	AW	CB	SF	SF	AW
4	BB	CB	SF	SF	PI
5	MU	RO	BB	EB	BU
6	MU	RO	BB	AW	CB
7	EB	PO	RO	CL	EB
8	EB	BU	RO	PO	EB
9	DG	DG	CB	CL	BB
10	DG	DG	CB	MU	RO

	species	#	%
Arroyo willow	AW	4	8%
Box elder	BE	0	0%
Fremont cottonwood	CO	0	0%
Oregon ash	AS	0	0%
Valley oak	OK	0	0%
Western sycamore	SY	0	0%
Buttonbush	BU	2	4%
Coyote bush	CB	5	10%
Elderberry	EB	5	10%
Mule fat	MF	5	10%
California blackberry	BB	6	12%
Poison oak	PO	3	6%
Wild rose	RO	8	16%
Clematis	CL	2	4%
Dutchman's pipevine	PI	2	4%
Dogbane	DG	4	8%
Sunflower	SF	4	8%
TOTAL		50	100%

Shrubland 2

Plant#/Row	1	2	3	4	5
1	SF	RO	BB	CB	EB
2	MU	RO	BB	BU	BB
3	MU	AW	EB	RO	EB
4	CB	AW	EB	RO	CB
5	CB	AW	BB	DG	CB
6	BU	BB	PO	MU	BU
7	CL	EB	RO	MU	PI
8	AW	EB	PO	BU	AW
9	BB	AW	RO	CB	AW
10	SF	CB	CB	BB	BB

species	#	%
AW	7	14%
BE	0	0%
CO	0	0%
AS	0	0%
OK	0	0%
SY	0	0%
BU	4	8%
CB	8	16%
EB	6	12%
MF	4	8%
BB	8	16%
PO	2	4%
RO	6	12%
CL	1	2%
PI	1	2%
DG	1	2%
SF	2	4%
TOTAL	50	100%

Valley Oak Riparian

Plant#/Row	1	2	3	4	5
1	VO	CB	BB	AW	CB
2	VO	CB	BB	PO	SY
3	BE	BB	AS	CB	VO
4	BE	SY	EB	BE	VO
5	RO	VO	EB	VO	PI
6	RO	PO	AS	RO	BE
7	AS	PO	AW	RO	MU
8	CL	EB	SY	VO	CL
9	CB	BB	MU	EB	VO
10	SY	BB	MU	VO	CB

	species	#	%
Arroyo willow	AW	2	4%
Box elder	BE	4	8%
Fremont cottonwood	CO	0	0%
Oregon ash	AS	3	6%
Valley oak	OK	9	18%
Western sycamore	SY	4	8%
Buttonbush	BU	0	0%
Coyote bush	CB	6	12%
Elderberry	EB	4	8%
Mule fat	MF	3	6%
California blackberry	BB	5	10%
Poison oak	PO	3	6%
Wild rose	RO	4	8%
Clematis	CL	2	4%
Dutchman's pipevine	PI	1	2%
Dogbane	DG	0	0%
Sunflower	SF	0	0%
TOTAL		50	100%



Mixed Riparian

Plant#/Row	1	2	3	4	5
1	CB	SY	EB	EB	VO
2	CB	VO	BB	PI	BE
3	PO	AW	CO	SY	BE
4	EB	CO	CO	CB	VO
5	EB	CO	CO	CB	AS
6	AS	CO	CO	BE	VO
7	AS	CL	BB	BE	RO
8	VO	RO	BB	SY	RO
9	BE	RO	AW	EB	AS
10	BB	SY	AW	VO	CB

	species	#	%
AW	AW	3	6%
BE	BE	5	10%
CO	CO	7	14%
AS	AS	4	8%
OK	OK	6	12%
SY	SY	4	8%
BU	BU	0	0%
CB	CB	5	10%
EB	EB	5	10%
MF	MF	0	0%
BB	BB	4	8%
PO	PO	1	2%
RO	RO	4	8%
CL	CL	1	2%
PI	PI	1	2%
DG	DG	0	0%
SF	SF	0	0%
TOTAL		50	100%

Appendix V. VELB Memorandum of Understanding for the Nelson Slough Unit

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Appendix VI. Hedgerow Design for the Nelson Slough Unit

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