FINAL REPORT
SUISUN CREEK WATERSHED PROGRAM

California Sportfishing Protection Alliance
Laurel Marcus and Associates
California Land Stewardship Institute
April 2011

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Ca. State Water Resource Control Board
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California Land Stewardship Institute
550 Gateway Drive #108
Napa, CA. 94558
707 253 1226 Fax 707 253 1708

California Sportfishing Protection Alliance
1360 Neilson Street
Berkeley, CA 94702-1116
(510) 526-4049

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EXECUTIVE SUMMARY

The Suisun Creek watershed encompasses 53 square miles in Napa and Solano counties. The watershed has no urban areas. Three major creeks—White Creek, Wooden Valley Creek, and Suisun Creek—drain a watershed of steep, mountainous terrain and several large valleys into the Suisun Marsh and Suisun Bay (Figure 1). Steelhead trout (Oncorhynchus mykiss), a federally listed threatened species, have been found in the three main creeks of the watershed. The City of Vallejo owns and operates Lake Curry located on the northern end of Suisun Creek.

Land use in the watershed is almost entirely rural: cattle grazing and irrigated agriculture consisting of winegrapes, fruit and nut orchards and row crops. A small amount of urban development occurs along Suisun Creek from Rockville Road to Interstate 80. Major roads in the drainage include Suisun Valley Road, Wooden Valley Road, Gordon Valley Road, Highway 121 and Interstate 80. The main creeks in the drainage are primarily open undeveloped channels lined with native vegetation.

In 2001 the California Sportfishing Protection Alliance (CSPA) working with Laurel Marcus & Associates (LMA) received a grant from the California State Coastal Conservancy to prepare a watershed assessment and enhancement plan for the Suisun Creek watershed. Water temperature, water quality, and geomorphic monitoring were carried out for the watershed plan between 2001 and 2003. Extensive mapping of riparian forest and field studies of aquatic habitats was also completed. From this assessment the Enhancement Plan identified a number of actions and projects including:

- Restoring riparian forest on denuded channel areas to reduce water temperatures
- Eradication of invasive species in the riparian corridor to enhance the corridor and reduce water temperatures and create wildlife habitat
    - Giant Reed (*Arundo donax*) mapping, eradication strategy and implementation of removal projects
    - Native riparian revegetation and invasive plant removal projects
- Reducing erosion in the watershed, fine sediment in creeks and improving land management measures using:
    - Farm Conservation Planning program
    - Community workshops for rural residential landowners
- Evaluation of Lake Curry releases to enhance cold water habitat in Suisun Creek
- Continued monitoring to identify additional needed projects and limiting factors for Steelhead trout

In 2004 CSPA, working with LMA, received a grant from the CALFED Watershed Program for implementation of the recommendations of the watershed plan. The CalFed grant included:

- Monitoring of water quality, water temperature, fine sediment, and channel form
- *Arundo* removal and revegetation on 2 miles of Suisun Creek;
- Removal of other invasive plants on all three creeks;
- Revegetation in the riparian corridor on all three creeks;
- Implementation of the Fish Friendly Farming (FFF) Environmental Certification Program and implementation of FFF projects;
- Workshops for rural residents to reduce pollutants;
- Development of re-operation alternatives for Lake Curry.

In 2008, the State issued a stop work order on this and many other grants. In 2009, the State revised the grant agreement to be funded under the American Reinvestment and Reinvestment Act funding through a Clean Water State Revolving Fund agreement. This report summarizes the work completed under the CALFED grant and the ARRA agreement.

Implementation of these tasks has resulted in removal of invasive, non-native *Arundo donax* from three miles of Suisun Creek, removal of invasive, non-native Himalayan blackberry along 2 miles of creek, and installation of approximately 2,300 native plants and revegetation along nine miles of Suisun and Wooden Valley Creeks. An estimated 1,133 tons of sediment/year have been reduced through the implementation of BMPs on sites enrolled in the Fish Friendly Farming Environmental Certification Program. Monitoring of water temperatures and water quality at 32 stations in all three creeks, fine sediment monitoring at 31 locations and evaluation of riparian canopy on 16 miles of creek.

I. PROBLEM STATEMENT AND RELEVANT ISSUES

A. Geographic Setting

The Suisun Creek watershed drains fifty-three square miles in Napa and Solano counties, from the western flank of the Vaca Mountains to Suisun Marsh. Three major creeks—White Creek, Wooden Valley Creek, and Suisun Creek—drain a watershed of steep, mountainous terrain and several large valleys into the Suisun Marsh and Suisun Bay (Figure 1).

B. Background and Land Use History

The watershed is almost entirely rural and privately owned; approximately ninety percent of the land is open space and there are no incorporated cities. Land use consists of cattle grazing and irrigated agriculture such as winegrapes, fruit and nut orchards, and row crops. A small amount of urban development exists along Suisun Creek from Rockville Road to Interstate 80. Major roads in the drainage include Suisun Valley Road, Wooden Valley Road, Gordon Valley Road, Highway 121 and Interstate 80.

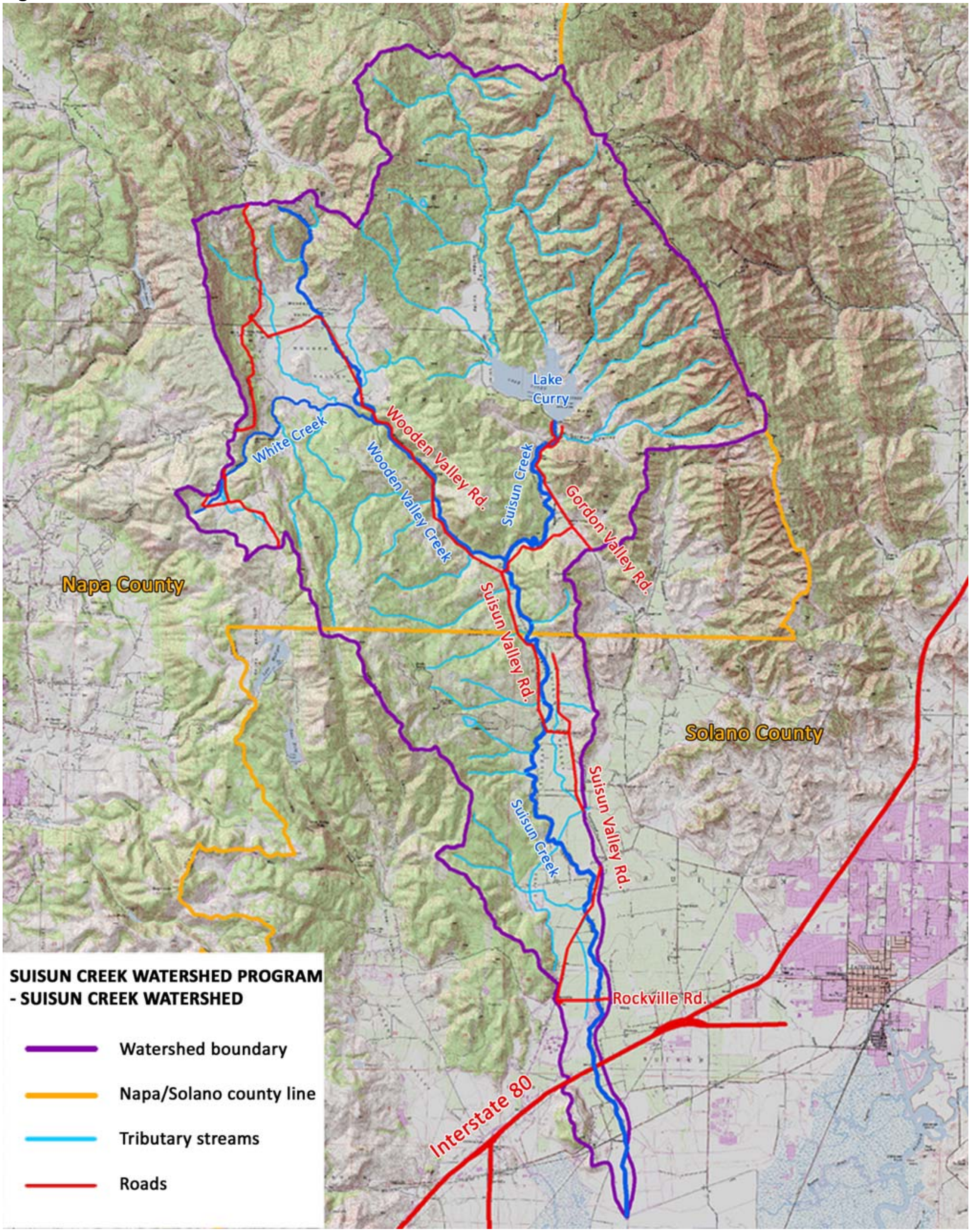
The headwaters of Suisun Creek are located to the north of Lake Curry in the mountainous northeastern portion of the watershed. Lake Curry is the only large reservoir in the watershed and covers 377 acres. The watershed area above Lake Curry is 17 square miles. Lake Curry was constructed in 1926 and is owned and operated by the City of Vallejo.

Suisun Creek derives its name from the Suisun or Suisunes people of the Patwin Indians, who lived in the area at the time of the arrival of the Spanish. Gordon Valley Dam was constructed on Suisun Creek by the City of Vallejo in 1926 for water supply. Wooden Valley Creek and its tributary, White Creek, drain a small agricultural valley and large area of wildlands to meet Suisun Creek several miles downstream of the dam.

In the early 20th century, Suisun Valley was a significant producer of stone fruits, including cherries, peaches, and apricots; grapes, walnuts, pears, prunes, and cattle were also shipped to markets in the Bay area and beyond. The cherries from this area were the first to arrive in winter-weary eastern cities; thus fruit from Suisun was highly desirable. Suisun Slough, the tidal area of Suisun Creek, had a port for shipping fruit and for oil tankers. The Suisun Valley Fruit Growers Association was founded in 1920. After World War I, 15-20 packing sheds operated in Suisun Valley, and 45,000 tons of pears per year were shipped out of the valley.

Over the past 40 years, agriculture in Suisun Valley has shifted away from pears and other fruits and toward wine grapes. Grapes made a comeback after Prohibition when phylloxera-resistant rootstock was developed. Nevertheless, a wide variety of crops are still grown in the valley, including tomatoes, strawberries, kiwi fruit, kumquats, and garbanzo beans, in addition to prunes, walnuts, pears, and stone fruits.

Figure 1: Suisun Creek Watershed



C. Existing Conditions

The lack of development in the watershed supports the watershed process of infiltration and runoff which create and sustain habitat for steelhead trout. Recent studies have named Suisun Creek as one of eight "anchor" watersheds in the Bay area supporting steelhead trout habitat. However, Suisun Creek watershed still has a number of environmental conditions which limit steelhead trout habitats. Monitoring and assessment from 2002-2010 found warm water temperatures in portions of all three creeks, inadequate riparian cover, low dissolved oxygen from limited stream flow and excessive fine sediment levels. This project addresses these limiting factors.

<u>Suisun Creek</u>

Suisun Creek from the Lake Curry outlet to Suisun Marsh is a 14-mile long, low slope, unconfined to partially confined channel with a pool/riffle pattern. Suisun Creek is semi-confined by bedrock and hillslopes in the four miles below Lake Curry. Near the Solano/Napa County line the creek enters Suisun Valley, a broad alluvial valley. Figure 2 depicts the slope and confinement of Suisun and Wooden Valley Creeks. Suisun Creek supports riparian forest, spawning habitat and, depending on the availability of cold water in summer, rearing habitat for salmonids in various locations along the channel. Suisun Creek largely flows through a drainage basin made up of Great Valley Sequence, a sedimentary rock formation. In general, Great Valley Sequence is not a water bearing formation. Wells which tap into cracks and fissures may produce water but larger aquifer areas are uncommon.

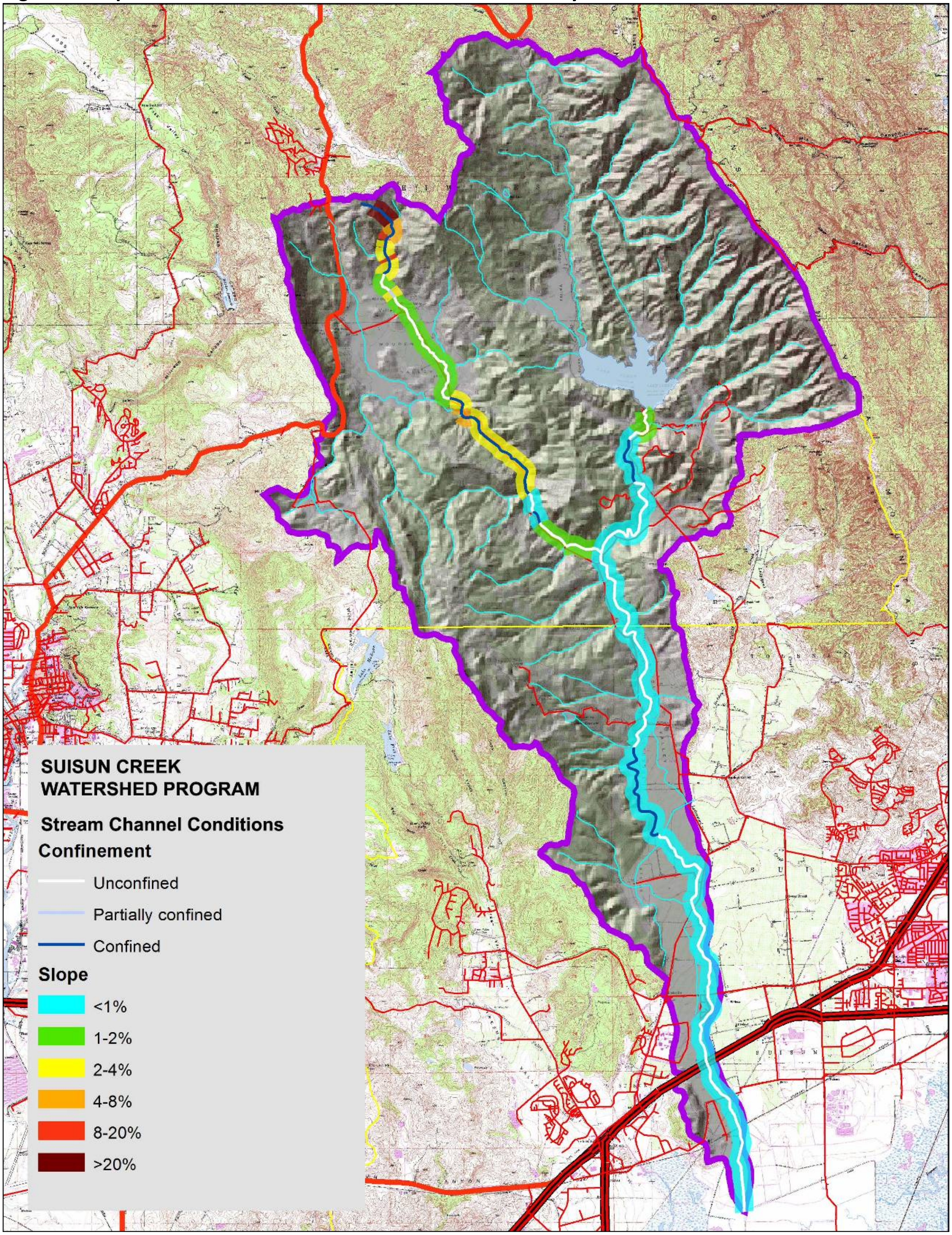
Lake Curry, a 10,700 acre-foot municipal reservoir, impounds the upper 17 square miles of the Suisun Creek drainage. Because the reservoir is relatively small, it typically fills and spills early in the rainy season on normal and wet years. The reservoir releases 3 cubic ft. per second (cfs) year-round. The reach of Suisun Creek just downstream of Lake Curry benefits from the cold water release, but the water rapidly warms and by the confluence with Wooden Valley Creek, it is often over 75^{o}F in the July/August period. Suisun Creek also has excessive levels of fine sediment from a variety of land uses, including agricultural and rural residential uses, roads, bank erosion from entrenchment, and landslides.

The riparian corridor averages 120 feet in width along Suisun Creek. The riparian corridor has a diversity of large and small native trees and habitat elements such as snags, logs and wildlife food plants; however, the corridor is relatively narrow. Although the riparian corridor provides some shade to the creek many areas have inadequate shade canopy which contributes to warming of the creek.

The channel of Suisun Creek downstream of the county line is undergoing channel entrenchment with bank erosion undercutting large oaks from the former, now abandoned, floodplain. As the channel deepens and widens the steep banks will fail and slump creating a new floodplain within the deepened channel. This process will result in a wider, deep channel with a new floodplain and seedling riparian trees offering little shade for many years. Active replanting of canopy trees along both the base of failed banks and the top of the bank is needed to replace lost trees.

Giant reed (*Arundo donax*) occurs in isolated clumps on Suisun Creek. A small amount of tree-of-heaven (*Ailanthus altissima*) is also present on Suisun Creek. Understory invaders—Himalayan blackberry *(Rubus discolor)*, blue periwinkle *(Vinca major)* and Harding grass *(Phalaris aquatica)*—are widespread along many creeks and their tributaries.

Figure 2: Slope and Confinement of Suisun and Wooden Valley Creeks



Wooden Valley Creek

Wooden Valley Creek extends approximately 7.0 miles from its origins 1.5 miles north of Wooden Valley to its confluence with Suisun Creek. The Wooden Valley watershed encompasses 14 square miles. There are a number of unnamed tributary creeks that drain the steep mountains surrounding Wooden Valley and conduct flow into Wooden Valley Creek; White Creek is the longest of these tributaries (LMA 2004). The Wooden Valley Creek watershed is predominately mountainous, undeveloped forest and meadows with vineyards on the valley floor and a few hillside locations. The western side of the Wooden Valley Creek watershed consists of Sonoma Volcanics while the eastern side is mostly Great Valley Sequence. The Sonoma Volcanic and the alluvium of Wooden Valley are typically water bearing.

Wooden Valley Creek varies from a set of steep headwater creeks to an unconfined alluvial channel in Wooden Valley to a low slope bedrock gorge to an unconfined channel (Figure 3). Because the channel does not become steep in its bedrock section, and flow is year round, it can support spawning and rearing habitat for salmonids, but has a limited area for riparian forest. The riparian corridor width averages 172 ft. on Wooden Valley Creek. Wooden Valley Creek is intermittent in some reaches with cold water pools and glides and retains flowing water in other reaches. Water temperatures and dissolved oxygen levels are adequate for salmonid rearing. Fine sediment levels in Wooden Valley Creek are high from a variety of sources including roads, bank erosion, and land uses.

White Creek

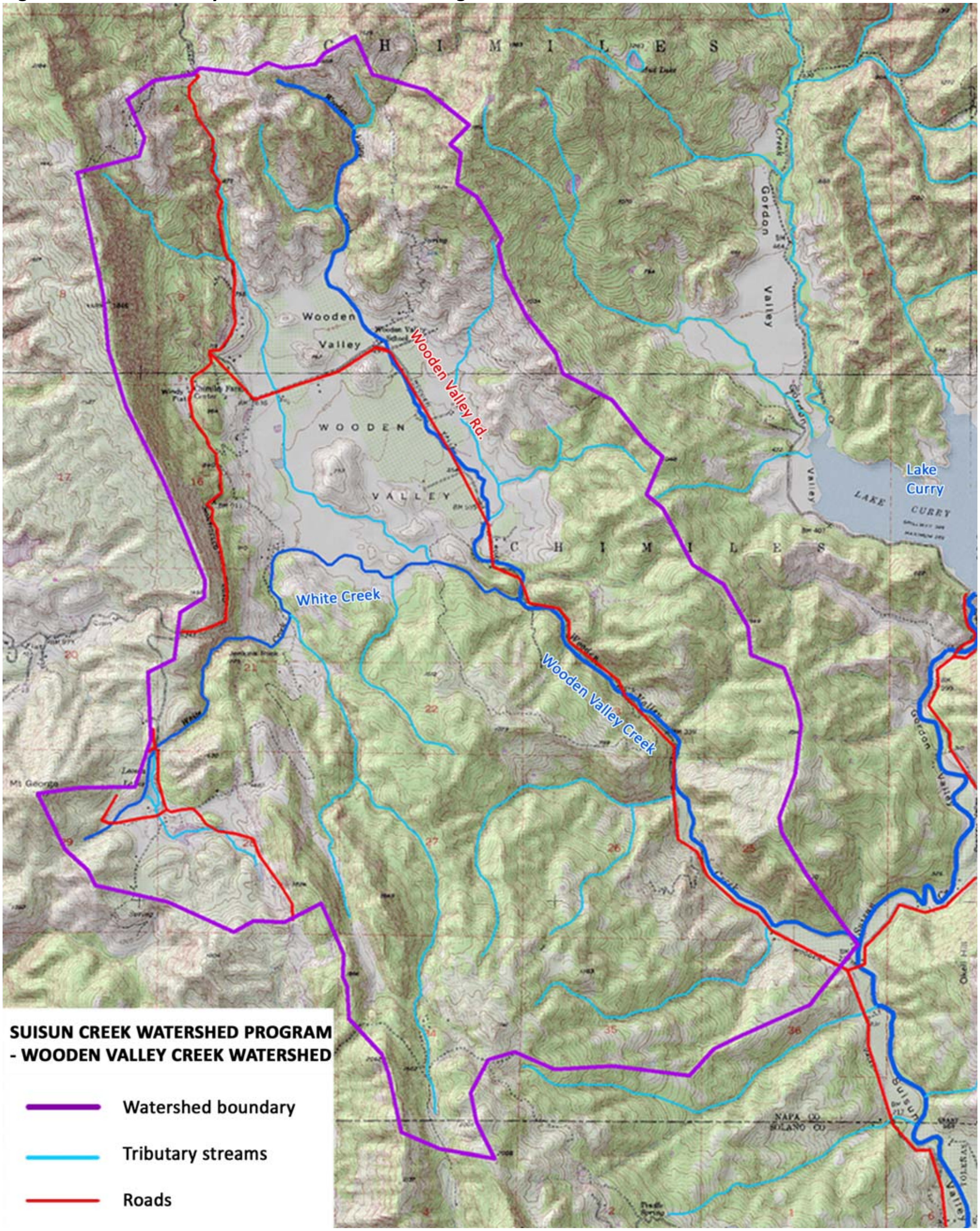
White Creek is a tributary stream to Wooden Valley Creek. White Creek has a watershed area of 6.6 square miles and is located along the northwestern edge of the Suisun Creek drainage. White Creek supports spawning and rearing habitat for steelhead trout.

The White Creek watershed consists of four separate tributary streams which come together 0.5 miles before White Creek meets Wooden Valley Creek (Figure 3). The headwaters of White Creek are on the western edge and the highest point in the drainage. Volcanic rock with chaparral and vineyards covers this area. Leoma Lakes is an on-stream reservoir built in the 1940s in the upper reaches of White Creek. As White Creek flows northeast off this high plateau, it descends a canyon and creates a waterfall visible from Monticello Rd.

Tributary 1 runs 0.95 miles from south to north along a steep topographic break on the western side of the watershed. This tributary is located in dense oak woodland with few roads and no development. Tributary 2 also courses south to north through oak woodland and undeveloped lands. Tributary 3 flows from north of Wooden Valley along the base of a hillside. Tributary 3 crosses through the vineyards and grasslands of Wooden Valley until it meets White Creek. Tributaries 1, 2, and 3 have seasonal flows only. White Creek has year-round water in the mainstem creek from the confluence with Tributary 2 downstream to the confluence with Wooden Valley Creek. In some years only isolated pools may remain in late summer, rather than continuous flow.

A number of faults mark the western side of the White Creek drainage. This area has steep vertical slopes of basalt with large landslide deposits along the base. The course of Tributary 1 follows the northern extension of the Green Valley Fault, a major fault in the San Andreas system.

Figure 3: Wooden Valley Creek Watershed including White Creek



D. Project Partners and Roles

The primary partners for this project are the California Sportfishing Protection Alliance, Laurel Marcus and Associates and the many landowners involved in this program. Additionally, implementation of projects has included the following partners:

- Shelterbelt Builders, Inc.: invasive plant removal specialists
- Center for Social and Environmental Stewardship (formerly Circuit Rider Productions, Inc.): native plant revegetation specialists
- Hydrologic Systems, Inc.: water resources engineers and hydrologists
- Dennis Jackson: hydrologist
- Drs. Alison Purcell and Matthew Cover
- Napa County Resource Conservation District: Jonathan Koehler, fish biologist

In 2008, the State issued a stop work order on this and many other grants. In 2009, the State revised the grant agreement to be funded under the American Recovery and Reinvestment Act funding through a Clean Water State Revolving Fund agreement. This report summarizes the work completed under the CALFED grant and the ARRA agreement.

II. PROJECT GOALS

A. Project Background

In 2001 a group of landowners formed the Suisun Creek Restoration Team (SCRT) and contacted the California Sportfishing Protection Alliance (CSPA) and Laurel Marcus & Associates (LMA) for assistance in protecting and enhancing salmonid habitat on Suisun Creek. Together with the City of Vallejo, National Marine Fisheries Service, and the Regional Water Quality Control Board, these groups collaborated to develop the Suisun Creek Watershed Program. Under a grant from the California State Coastal Conservancy, LMA worked with CSPA and the Suisun Creek Watershed Program to produce the Suisun Creek Watershed Assessment and Enhancement Plan (LMA 2004), which identified priorities for improving steelhead trout habitat in the watershed.

Recommended actions in the Enhancement Plan include:

- Restoring riparian forest on denuded channel areas to reduce water temperatures
- Eradication of invasive species in the riparian corridor to enhance the corridor and reduce water temperatures
  - Giant Reed (*Arundo donax*) mapping, eradication strategy and implementation of removal projects
  - Native riparian revegetation and invasive plant removal projects
- Reducing fine sediment in creeks and improving land management measures using:
  - Farm Conservation Planning program
  - Community workshops for rural residential landowners
- Evaluation of Lake Curry releases to create cold water habitat in Suisun Creek
- Continued monitoring to identify additional needed projects

B. Project Goals

The Suisun Creek Watershed Program implements the first set of actions identified as priorities by the Suisun Creek Watershed Enhancement Plan including: a set of restoration actions for riparian corridors and invasive plant removal, establishment of the Fish Friendly Farming (FFF) program to implement watershed management on private lands, study of re-operation of Lake Curry to improve downstream aquatic habitat, on-going monitoring activities to implement an adaptive management approach to restoration; and increasing local capacity amongst landowners and the community to address and sustain environmental quality in the area.

III. PROJECT DESCRIPTION

A. Summary: Table of Items Submitted for Review

Proposition 50 Grant Agreement No. 04-151-552-0: Table of Items Submitted for Review

Item	DESCRIPTION
1.0	**QUALITY ASSURANCE PROJECT PLAN and MONITORING PLAN**
1.1	Quality Assurance Project Plan
1.2	Monitoring Plan
1.3	CEQA Documents and Permits
2.0	**WORK TO BE PERFORMED**
2.3.1	Community meetings
2.4	Water Supply Reliability Study
2.4.1	Bathymetric map/survey
2.4.6	Summary report
2.5	Landowner Agreements
2.6	Arundo Donax Eradication
2.6.1	Map of Arundo area
2.6.2	Arundo eradication strategy
2.6.3	Arundo workshops for local landowners
2.6.4	Arundo removal projects
2.7	Native Vegetation Projects
2.7.1	Plans
2.7.2	Remove non-natives and re-plant with natives
2.7.3	Monitor riparian corridor
2.7.4	Workshops

Item	DESCRIPTION
2.8	Fish Friendly Farming (FFF) Program
2.8.3	FFF Workshops
2.8.5	Construct FFF projects
2.9	Implement Projects from Farm Conservation Plans
2.9.1	Prioritize project sites
2.9.2	Record of FFF projects
2.9.3	List of Certified Plans
2.10	Monitoring
2.10.1	Channel monitoring
2.10.2	Water Quality Monitoring
2.10.3	Benthic Macroinvertebrate Sampling
2.10.4	Draft Monitoring Report
2.10.5	Final Monitoring Report
2.11	Community Workshops
3.0	Draft and Final Project Report
3.1	Draft Project Report
3.3	Final Project Report

B. *Arundo donax* (Giant reed) Mapping, Eradication Strategy, and Implementation of Removal Projects

Arundo donax, or Giant reed, is a major invasive non-native plant infesting the riparian corridor of Suisun Creek. In order to address this problem, the extent of *Arundo* on Suisun Creek was mapped and a removal strategy was developed. This strategy was submitted to the California Department of Fish and Game for a Lake and Streambed Alteration Agreement (1600) permit (#1600-2006-0222-3) to remove the *Arundo*, and implementation was carried out between 2006 and 2010.

Arundo Mapping, Eradication and Control Strategy

There are five parts to the *Arundo* Strategy:

- Survey and map *Arundo* clumps along Suisun Creek using GIS.
- Eradicate the most upstream occurrences of the plant using current funding and seek additional funding to remove additional areas.
- Once eradicated, revegetate the infestation areas with native riparian vegetation.
- In addition, conduct an outreach and education program to educate local landowners on the hazards of this invasive plant as well as effective removal and revegetation techniques, and to help identify eradication projects.
- Complete monitoring of the riparian corridor at several eradication sites before and after the project.

Arundo donax clumps were mapped using very high resolution (1:575 ft.) geo-referenced aerial photography from Digital Globe GeoXplorer, taken November 2, 1999 (Figure 4). Giant reed was visible with a unique texture and color in this set of photography, and these areas were digitized. The areas mapped were then spot-checked. Additionally, a flight was taken in a small aircraft on March 11, 2005 and oblique photographs were taken of the creek from Suisun Marsh to Lake Curry. These were used to verify the clumps mapped.

The eradication strategy emphasized removal starting from the most upstream clump to reduce the likelihood of re-infestation downstream. Two methods were used. Using the cut-grow-spray technique, the canes were cut when the plant has senesced using loppers or other cutting tools, leaving a stump of about 12 inches. As soon as new foliage emerges, it was hand sprayed with foliar applications of Rodeo® at 2% and R-11® at 0.5% or, if treated in the spring, a mixture of Rodeo® and Habitat®. Overspray onto native riparian plants was avoided.

The other method used was a “cut and paint” technique. The canes were cut the same way as in the cut-grow-spray technique, except they were cut in the fall, just before the plant senesces. Another worker stands by to immediately paint the stump with either Round-up or Rodeo at a 50% concentration that has been colored to be visible when applied. The herbicide must be in contact with the stump in the first few minutes after having been cut or the plant will seal the wound rather than transport the herbicide.

In areas where *Arundo* occurs on both sides of creek, only one side was cut; the remaining side is cut the following year. Both the time of year and timing following cane cutting are critical. Arundo treatment needs to be performed in the fall, when the plant is senescing and will transport the herbicide to its roots, where it will have a systemic effect. The biomass that has been cut away in both techniques is moved to a location outside the floodplain and put in piles that will be burned during permitted burn days.

Revegetation was completed two years after the application of herbicide, when the stumps have rotted through. Emphasis is on planting native riparian trees that are fast-growing and will shade the creek. Species planted include: willow (*Salix sp*), box elder (*Acer negundo)*, big-leaf maple (*Acer macrophyllum*), Fremont cottonwood (*Populus fremontii*), Ca. buckeye (*Aesculus californica*), and valley oak (*Quercus lobata*).

Implementation: *Arundo* Removal Projects

The aerial photography and flight surveys identified 26 infestations of *Arundo* on 6 properties on upper Suisun Creek (Figure 4). These sites were selected as priorities for removal in order to eradicate the most upstream clumps. Between 2 and 5 applications of herbicide were required before *Arundo* re-growth was no longer observed on the infestation sites. These applications were primarily done in the fall.

To eradicate the *Arundo*, crews used the cut-grow-spray technique. The first round of removal began with cutting the stands of *Arundo* in fall 2006 and continued in spring of 2007. Re-growth was treated with herbicide in summer and fall 2007. Follow-up treatments of herbicide were applied in 2008, and some of the densest infestation patches required additional treatments in 2009 and 2010.

The seven largest infestation sites were selected for native plant revegetation due to the lack of riparian canopy. Native riparian tree and understory species were grown from local genetic stock collected within the Suisun Creek watershed, and included the following species:

- Trees:
  - California buckeye (*Aesculus californica*)
  - Oregon ash (*Fraxinus latifolia*)
  - Fremont cottonwood (*Populus fremontii*)
  - Willow, various species (*Salix* sp.)
  - Coast live oak (*Quercus agrifolia*)
  - California bay laurel (*Umbellularia californica*)
- Shrubs:
  - California wild rose (*Rosa californica*)
  - Snowberry (*Symphoricarpos albus*)

Revegetation specialists used species already present on each site to determine a site-specific native tree and shrub revegetation plan. Revegetation was done in the fall/winter rainy season once the ground was saturated to 10 inches or deeper. Willow cuttings 2-3 ft. in length were collected from local plants in the fall or winter once the source plants had become dormant and were installed at the foot of the banks with the budding tip pointing upward and all side branches trimmed. Container plants were installed with protective hardware including weed collars, weed control fabric, and protective mesh or plastic Tubex screens. LMA staff worked with the landowners to ensure that drip irrigation was installed for the container plants.

All of the identified infestation sites were documented with photos before the project began, and photo-monitoring continued annually from 2006 to 2010 or until no re-growth was observed on the site.

In October 2008 a workshop was held for local landowners to demonstrate *Arundo* removal techniques used in this project, as well as the successes and challenges of invasive plant removal and native plant revegetation. The workshop included a field visit to one of the project sites and discussion of appropriate native plant species and planting techniques.

Figure 4: *Arundo* Removal 2006-2010

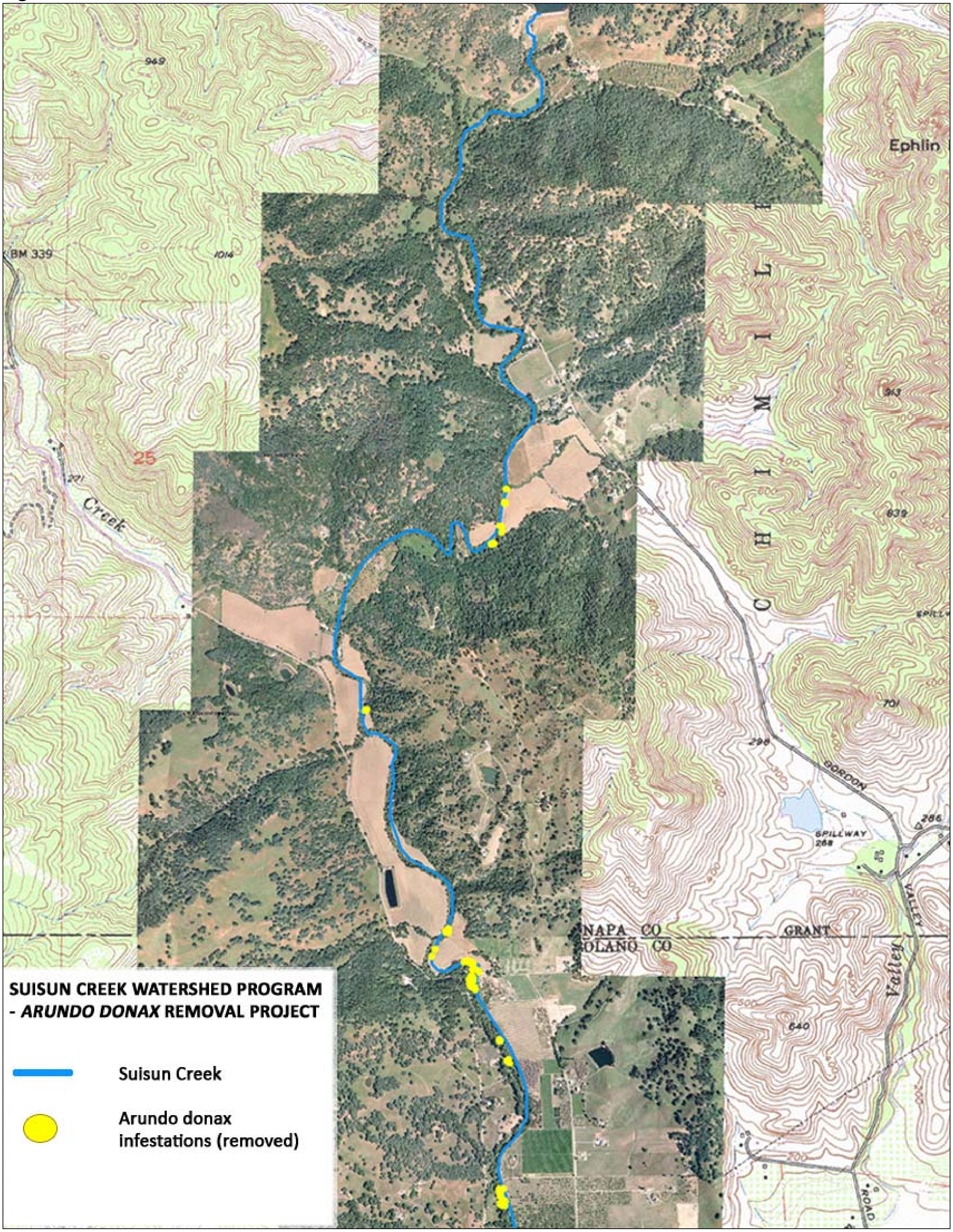


Figure 5: *Arundo donax* Removal and Native Plant Revegetation Map -Example

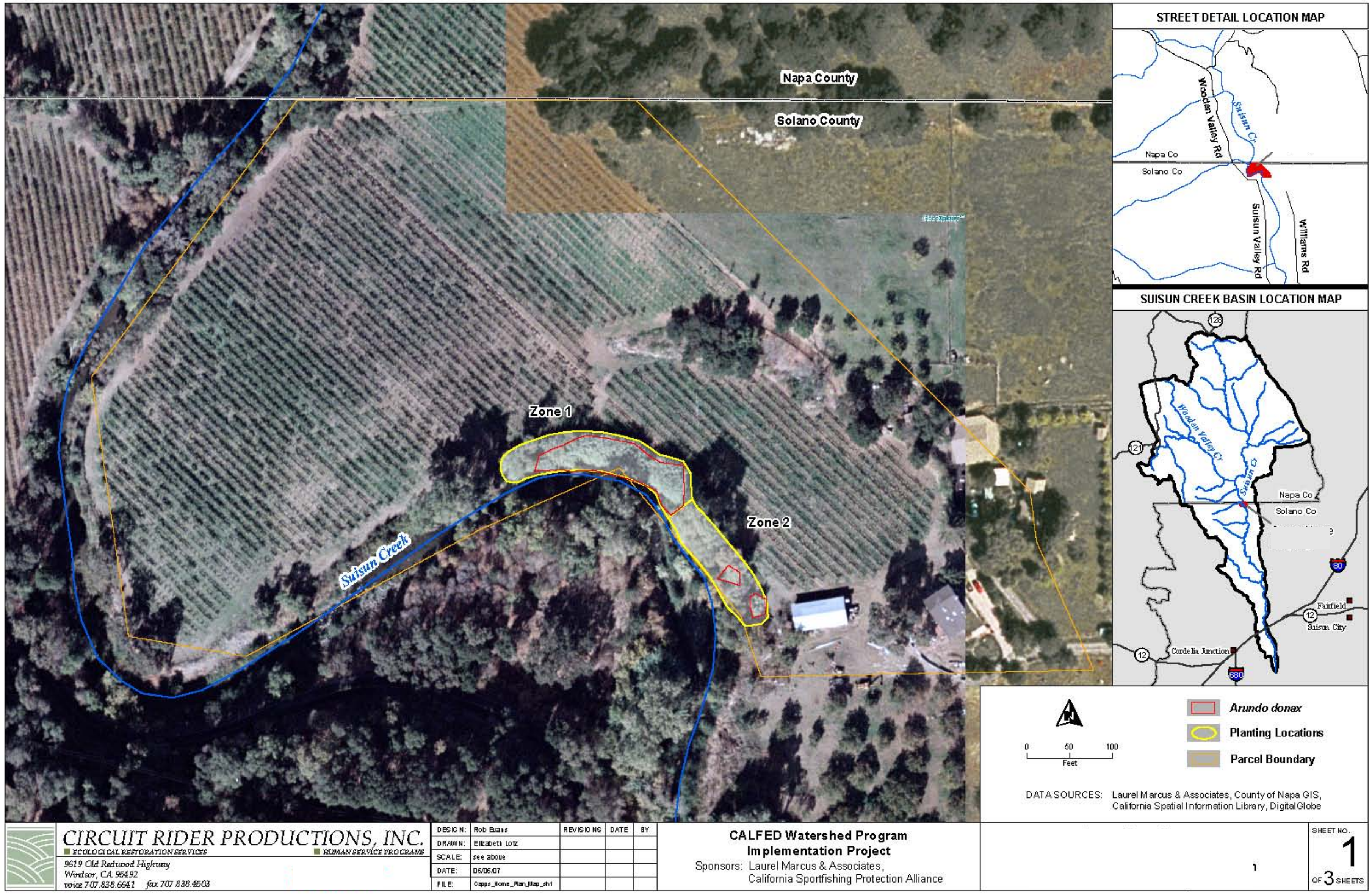


Figure 6: Native Plant Revegetation Species List and Planting Notes - Example

PLANTING NOTES:

1. The Native Plant Revegetation Plan is designed to enhance the riparian zone on the property after the removal of giant reed (*Arundo donax*). Selected plants are intended to create a riparian corridor of ecologically appropriate native plants along the top of bank and floodplain to provide canopy cover, wildlife habitat, and to aid in bank stabilization. It should be noted that high flows may cause bank erosion no matter how well vegetated stream and riverbanks are, and Circuit Rider Productions, Inc. (CRP) shall not be held liable in the event that erosion occurs. No plants known to be host plants for Pierce's Disease are included in the plan.
2. Planting shall be installed in the winter months, once rainfall has moistened the soil to a depth of 10 inches or greater. Planting shall be completed by March.
3. Planting technique shall be predominantly liner-sized seedlings (see Planting Details) propagated from seeds and cuttings collected within the North Bay Area, as close as possible to the revegetation site. Plants will be installed with protective hardware and weed mats that are appropriate to the site conditions.
4. Circuit Rider Productions, Inc., or sub-contractors supervised by qualified restoration ecologists, will install the planting.
5. No individual plant locations are shown. The final design will be developed in the field by a professional qualified in ecological restoration. Each planting spot shall be marked in the field with a color coded (to species) surveyor flag. Flags shall remain at each planting spot after plant installation.
6. The property owner will be responsible for maintaining the plants. To ensure survival, plants will require frequent irrigation during the first dry season after planting. Irrigation should begin in April and continue into October. Approximately one to two gallons of water shall be applied directly to the plant during each irrigation visit. Watering interval shall be 7 to 10 days depending on weather conditions.
7. Weeds shall be removed around each plant for a period of three years - twice in the spring and once in the fall.
8. The Arundo donax should be eradicated from the riparian zone prior to planting. Care shall be taken to avoid damage to native plants during the removal process. There are several non-toxic methods such as tarps and/or hand removal techniques that may be used. If the placement of tarps is used to control invasive plants in the riparian zone, they should be installed in the spring and removed in mid to late October, prior to high flows. Tarps generally need to be left in place for at least five months for the method to be effective.

   If herbicide is used, a method that prevents drift onto native vegetation and/or surface water shall be utilized. Consultation with the Napa County Agricultural Commissioner's office is advised, and depending on the herbicide used, may be required by law. Follow-up treatment for all methods of invasive plant eradication may be necessary in subsequent years.

   All biomass shall be disposed of properly to prevent cut stems from re-rooting and causing further reinfestation. Material will be stacked in piles located at least 20 feet from the top of bank. Material will be treated by either burning, chipping, composting, or hauled to landfill.

REVEGETATION PLANT LIST -

Scientific Name	Common Name	Number of Plant Locations			Container Size	Spacing (F.O.C.)
		Zone 1	Zone 2	TOTAL		
SHRUBS						
Rosa californica	California wild rose	150	20	**170**	tree band	3-5'
Symphoricarpos albus	snowberry	0	50	**50**	tree band	3-5'
TREES						
Aesculus californica	California buckeye	20	0	**20**	tree pot	8-12'
Fraxinus latifolia	Oregon ash	10	0	**10**	supercell	8-12'
Populus fremontii	Fremont cottonwood	10	0	**10**	dee pot	8-12'
DORMANT CUTTINGS						
Salix sp.	willow	100	20	**120**	cutting	4-10'
TOTAL:		**290**	**90**	**380**		

CIRCUIT RIDER PRODUCTIONS, INC.
ECOLOGICAL RESTORATION SERVICES — HUMAN SERVICE PROGRAMS
9619 Old Redwood Highway
Windsor, CA 95492
voice 707.838.6641 fax 707.838.4503

		REVISIONS	DATE	BY
DESIGN:	Rob Evans			
DRAWN:	Elizabeth Lotz			
SCALE:	see above			
DATE:	06/06/07			
FILE:	Cappe_Home_Notes_sh2			

CALFED Watershed Program Implementation Project
Sponsors: Laurel Marcus & Associates, California Sportfishing Protection Alliance

SHEET NO. 2 OF 3 SHEETS

Figure 7: Native Plant Revegetation Planting Specifications - Example

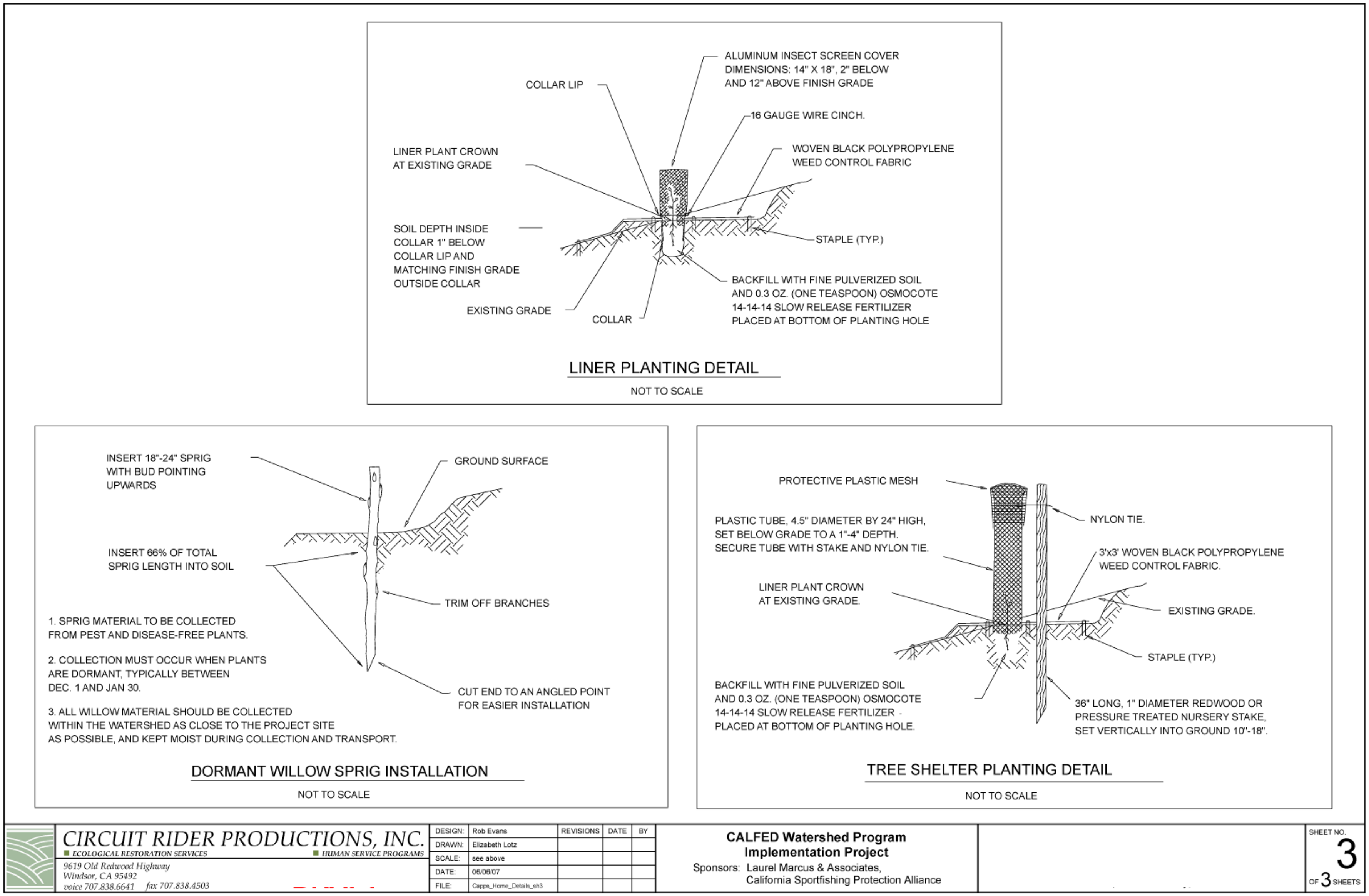


Figure 8: ***Arundo donax*** **Infestation Site prior to Removal**

Figure 9: ***Arundo donax*** **Removal**

Figure 10: *Arundo donax* Infestation Site after Removal

Figure 11: Revegetation on Suisun Creek

Figure 12: *Arundo donax* Workshop Field Visit

C. Native Riparian Revegetation and Demonstration Invasive Plant Removal Projects

In addition to the *Arundo donax* removal project, invasive plant removal and native riparian revegetation projects have been completed on a number of other sites in the Suisun Creek watershed with the goal of implementing priority recommendations of the Suisun Creek Watershed Assessment and Enhancement Plant.

Suisun Creek Riparian Habitat Enhancement Project
This project site is located approximately ½ mile downstream of Lake Curry on Suisun Creek in Napa County. The site encompasses 800 linear ft. of creek with a riparian corridor that varies from 50-75 ft. in width and totals approximately 0.9 acres.

Two transects along the corridor were established and plant diversity and density, understory and overstory plant species, and the percentage of canopy cover over the creek were measured. A detailed transect along the length of the corridor was also completed to map the extent of invasive species and to determine the necessary steps to enhance the corridor.

The riparian corridor in the project reach has a dense overstory of mature live oak, California bay laurel, Oregon ash, white alder, and mature willow. The understory has large patches of invasive, non-native species such as blue periwinkle, Himalayan blackberry, and fennel. Wild grape has also covered over several sections of the corridor. Due to the proximity of the vineyard, the wild grape, Himalayan blackberry, and periwinkle were a concern to the landowner due to their status as host plants for Pierce's Disease bacteria and its primary vector, the blue-green sharpshooter.

The goal of the project was to eradicate the invasive species and wild grape and to revegetate the corridor with native understory shrub species and tree species. Improvement of the corridor is expected to also allow for increased shade canopy and wildlife habitat.

A total of 2,650 sq. ft. of invasive plants were cut and treated twice with the Rodeo® formulation of glyphosate. The biomass was removed and the area was replanted with native tree and understory species.

After the removal of the blackberry, periwinkle, and wild grape was complete, the following native species were planted:

- Trees:
    - Oregon ash (*Fraxinus latifolia*)
    - Willow (*Salix* sp.)
    - Coast live oak (*Quercus agrifolia*)
    - Valley oak (*Quercus lobata*)
    - California bay laurel (*Umbellularia californica*)
    - White alder (*Alnus rhombifolia*)
- Shrubs:
    - California wild rose (*Rosa californica*)
    - Snowberry (*Symphoricarpos albus*)
    - Twinberry (*Lonicera involucrata*)
    - Spicebush (*Calycanthus occidentalis*)

- Grasses
  - Creeping wild rye *(Elymus triticoides)*
  - Fescues (*Festuca* sp.)

Data collected from water temperature monitoring demonstrates that this project has had a positive impact on riparian canopy and water temperatures. From 2005 to 2009, average canopy cover at water temperature monitoring Station SC-9 increased from 71% to 99%. Photo-monitoring conducted from 2006-2009 also indicates greater density in canopy cover over time.

<u>Wooden Valley Creek Riparian Habitat Enhancement Project</u>

The Wooden Valley Creek Riparian Habitat Enhancement Plan was designed to restore the riparian zone on 1.25 miles of lower Wooden Valley Creek given current hydrologic conditions and land use. Prior to the project, the site was a known thermal reach and contributed sediment due to bank erosion. Typical bank conditions in the upstream part of the project area showed bank erosion and lack of canopy resulting from a long-term history of grazing.

Water temperature and water quality were monitored in areas upstream and downstream of the project site for over 5 years before the project was installed. The goals of revegetation on this site were to: 1) reduce water temperatures and sedimentation; 2) create a riparian corridor of ecologically appropriate native plants along the bank and floodplain; 3) provide canopy cover and wildlife habitat; and 4) increase coldwater habitat for steelhead trout.

CLSI staff worked extensively with the landowner to prepare the site for project installation, including creating a fencing plan and an irrigation plan. Prior to revegetation the landowner installed electric fencing and trained his livestock in avoidance to protect the project site from grazing. The landowner also developed alternative water sources for the livestock and the drip irrigation system for the native plants, and installed the drip irrigation system.

Himalayan blackberry on the site was treated with foliar applications of Rodeo® in 2008 and 2009 during the summer, when Wooden Valley Creek dries completely through the project reach. Planting of native tree and shrub species was completed in 2010, following a year delay caused by the funding freeze. Under the plan, about 733 native trees and shrubs were planted along denuded sections of the creek from the base of the bank to about 15 ft. out from the top of the bank. 275 willow cuttings were placed along the base of the bank, and 458 container plantings of native trees such as California bay laurel, big-leaf maple, California buckeye, white alder, Oregon ash, coast live oak, blue oak, and valley oak were planted in the upper bank and floodplain. Plants were installed during the winter rainy season with appropriate grow tubes and weed mats, as with all the other revegetation projects.

An initial assessment of the container plantings in May 2010 showed a very high plant survival rate of 93%. The 275 willow cuttings, however, were installed during an unusual dry period and showed high mortality; therefore, an additional 100 willow cuttings were installed in January 2011. Plant survival will be assessed again in spring 2011 following the end of the rainy season.

In May 2010 a workshop was held at the restoration site to demonstrate electric fencing installation, irrigation installation, and riparian revegetation techniques to local landowners.

Figure 13: Native Riparian Revegetation and Demonstration Invasive Plant Removal Projects

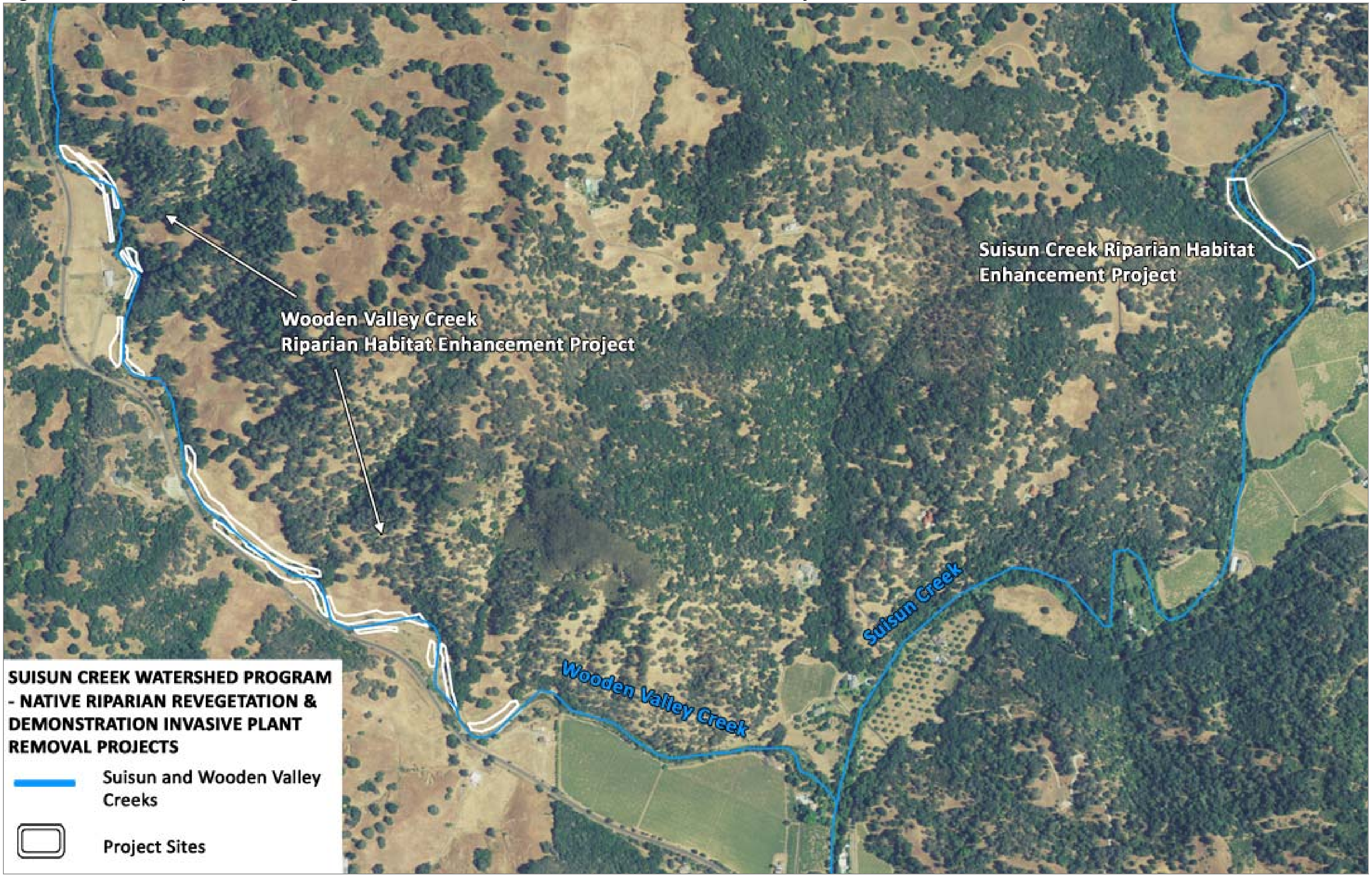


Figure 14: Wooden Valley Creek Riparian Habitat Enhancement Project – Revegetation Plan (North)

Figure 15: Wooden Valley Creek Riparian Habitat Enhancement Project – Revegetation Plan (South)

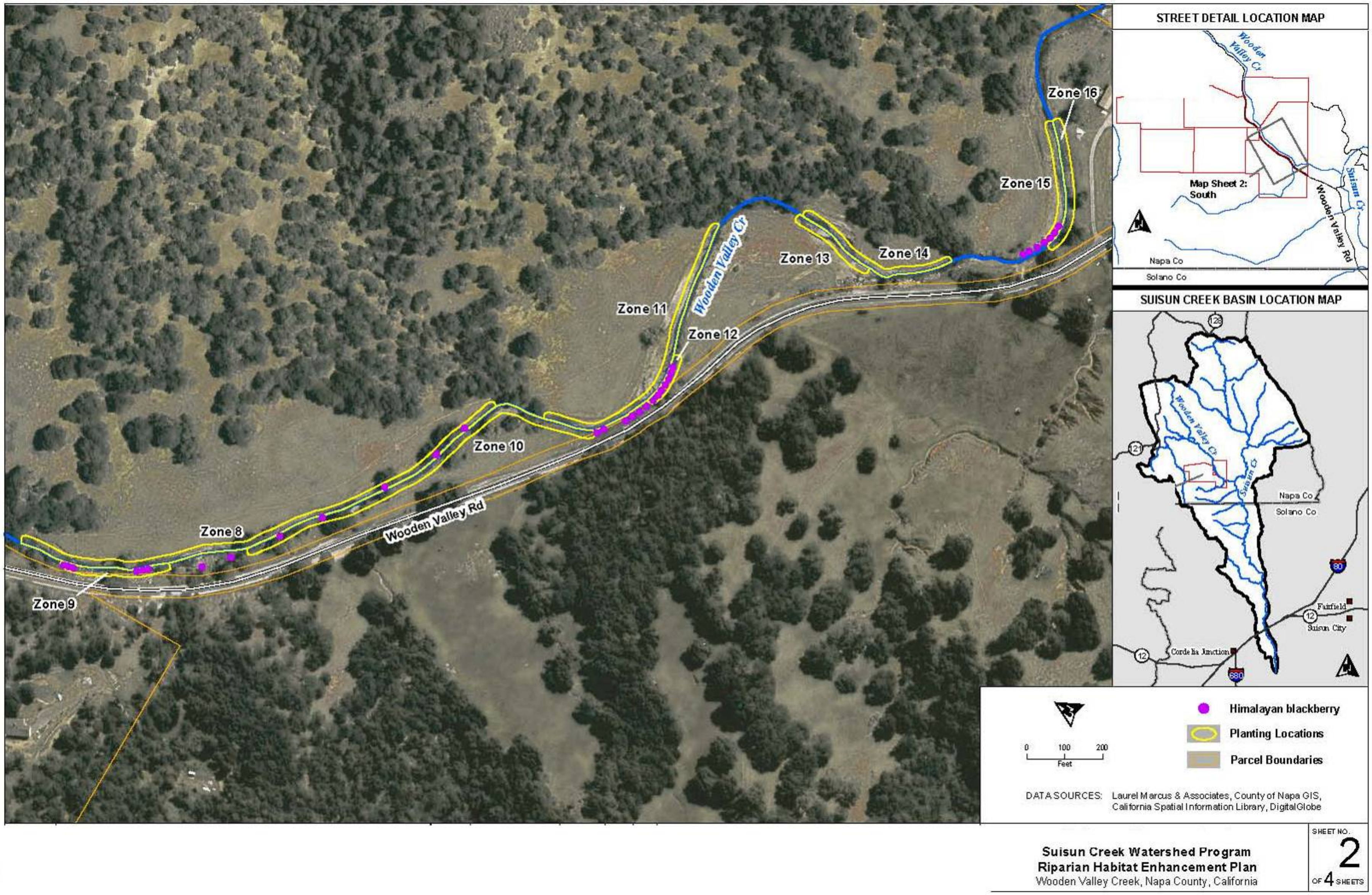


Figure 16: Wooden Valley Creek Riparian Habitat Enhancement Project - Native Plant Revegetation Species List and Planting Notes

PLANTING NOTES:

1. The Riparian Habitat Enhancement Plan is designed to enhance the riparian zone on the property given current hydrologic conditions and land use. Selected plants are intended to create a riparian corridor of ecologically appropriate native plants along the upper bank and floodplain to provide canopy cover and wildlife habitat. It should be noted that the proposed work may not prevent bank erosion or failure, and CRP shall not be held liable in the event that erosion occurs in the future.
2. Planting shall be installed in the winter months, once rainfall has moistened the soil to a depth of 10 inches or greater. Planting shall be completed by March.
3. Planting technique shall be predominantly liner-sized seedlings (see Planting Details) propagated from seeds and cuttings collected within the Napa River watershed, as close as possible to the revegetation site. Plants will be installed with protective hardware and weed mats that are appropriate to the site conditions.
4. Circuit Rider Productions, Inc., or sub-contractors supervised by qualified restoration ecologists, will install the planting.
5. No individual plant locations are shown. The final design will be developed in the field by a professional qualified in ecological restoration. Each planting spot shall be marked in the field with a color coded (to species) surveyor flag. Flags shall remain at each planting spot after plant installation.
6. A temporary fence shall be installed by the property owner to exclude livestock from the revegetation planting zones, which are from center of channel to approximately 15 feet out from the top of bank. The fence should remain in place until installed plants become established.
7. The property owner will be responsible for maintaining the plants. To ensure survival, plants will require frequent irrigation during the first dry season after planting. Irrigation should begin in April and continue into October. Approximately one to two gallons of water shall be applied directly to the plant during each irrigation visit. Watering interval shall be 7 to 10 days depending on weather conditions.
8. Weeds shall be removed around each plant for a period of three years - twice in the spring and once in the fall.
9. Himalayan blackberry, an invasive plant, should be removed from the riparian zone. Physical, as well as chemical control methods are outlined in "*The Weedworkers' Handbook*" (The Watershed Project, and California Invasive Plant Council, 2004), which can be found online at: http://ucce.ucdavis.edu/files/filelibrary/5319/18601.pdf.

   Care shall be taken to avoid damage to native plants during the removal process. There are several non-toxic methods such as tarps and/or hand removal techniques that may be used. If the placement of tarps is used to control invasive plants in the riparian zone, they should be installed in the spring and removed in mid to late October, prior to high flows. Tarps generally need to be left in place for at least five months for the method to be effective.

   If herbicide is used, a method that prevents drift onto native vegetation and/or surface water shall be utilized. Consultation with the Napa County Agricultural Commissioner's office is advised, and depending on the herbicide used, may be required by law. Follow-up treatment for all methods of invasive plant eradication may be necessary in subsequent years.

REVEGETATION PLANT LIST -

Scientific Name	Common Name	Number of Plant Locations by Zone																	Container Size	Spacing (F.O.C.)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL		
SHRUBS																				
Sambucus mexicana	blue elderberry	0	0	0	3	0	0	8	0	0	8	0	0	0	0	0	0	**19**	dee pot	5-10'
TREES																				
Acer macrophyllum	big-leaf maple	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	**4**	supercell	8-12'
Aesculus californica	California buckeye	0	0	0	0	0	0	7	0	0	10	5	0	0	0	0	0	**22**	tree pot	8-12'
Alnus rhombifolia	white alder	3	5	0	0	0	0	0	20	0	0	5	0	0	0	0	0	**33**	supercell	8-12'
Fraxinus latifolia	Oregon ash	0	0	0	0	0	0	0	5	0	0	0	0	0	5	15	0	**25**	supercell	8-12'
Quercus agrifolia	coast live oak	17	3	5	2	10	10	4	25	0	13	15	0	3	5	5	10	**127**	D-16	8-12'
Quercus douglasii	blue oak	8	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	**13**	D-16	8-12'
Quercus lobata	valley oak	8	3	4	3	10	10	3	35	0	5	25	0	4	5	10	7	**132**	D-16	8-12'
Umbellularia californica	California bay-laurel	8	0	2	2	6	5	10	10	0	15	10	0	0	5	5	5	**83**	supercell	8-12'
DORMANT CUTTINGS																				
Salix sp.	willow	20	5	0	5	0	25	20	90	40*	0	0	20*	0	0	0	50	**275**	cutting	4-10'
TOTAL:		**64**	**16**	**11**	**15**	**26**	**55**	**52**	**189**	**40**	**51**	**60**	**20**	**7**	**20**	**35**	**72**	**733**		

* = pole cutting

Suisun Creek Watershed Program
Riparian Habitat Enhancement Plan
Wooden Valley Creek, Napa County, California

SHEET NO. 3 OF 4 SHEETS

Figure 17: Wooden Valley Creek Riparian Habitat Enhancement Project – Before Project

Figure 18: Wooden Valley Creek Riparian Habitat Enhancement Project – Before Project

Figure 19: Wooden Valley Creek Riparian Habitat Enhancement Project – Plant Installation

Figure 20: Wooden Valley Creek Riparian Habitat Enhancement Project – After Project

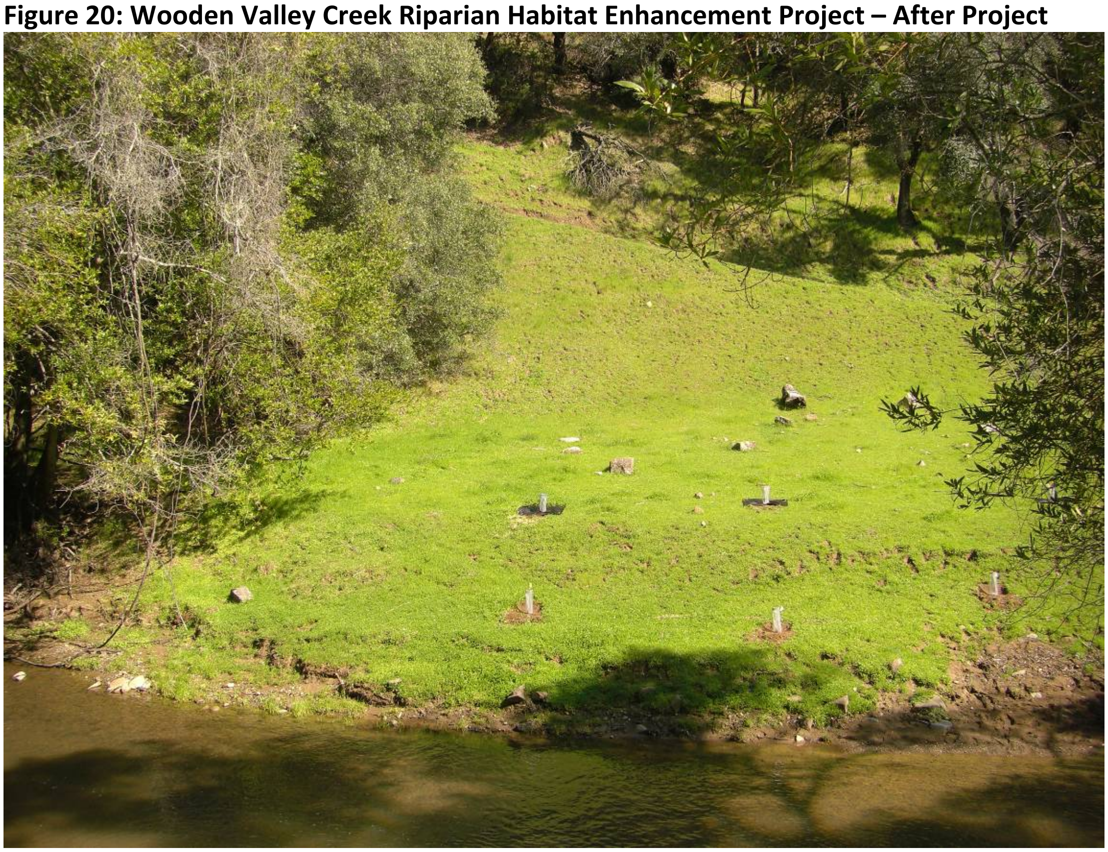


Figure 21: Wooden Valley Creek Field Day Workshop

D. Fish Friendly Farming Environmental Certification Program and Projects

Figure 22 depicts the properties enrolled in the Fish Friendly Farming Environmental Certification Program. Table 1 provides detailed information on these sites and projects completed.

Figure 22: Sites enrolled in the Fish Friendly Farming Program

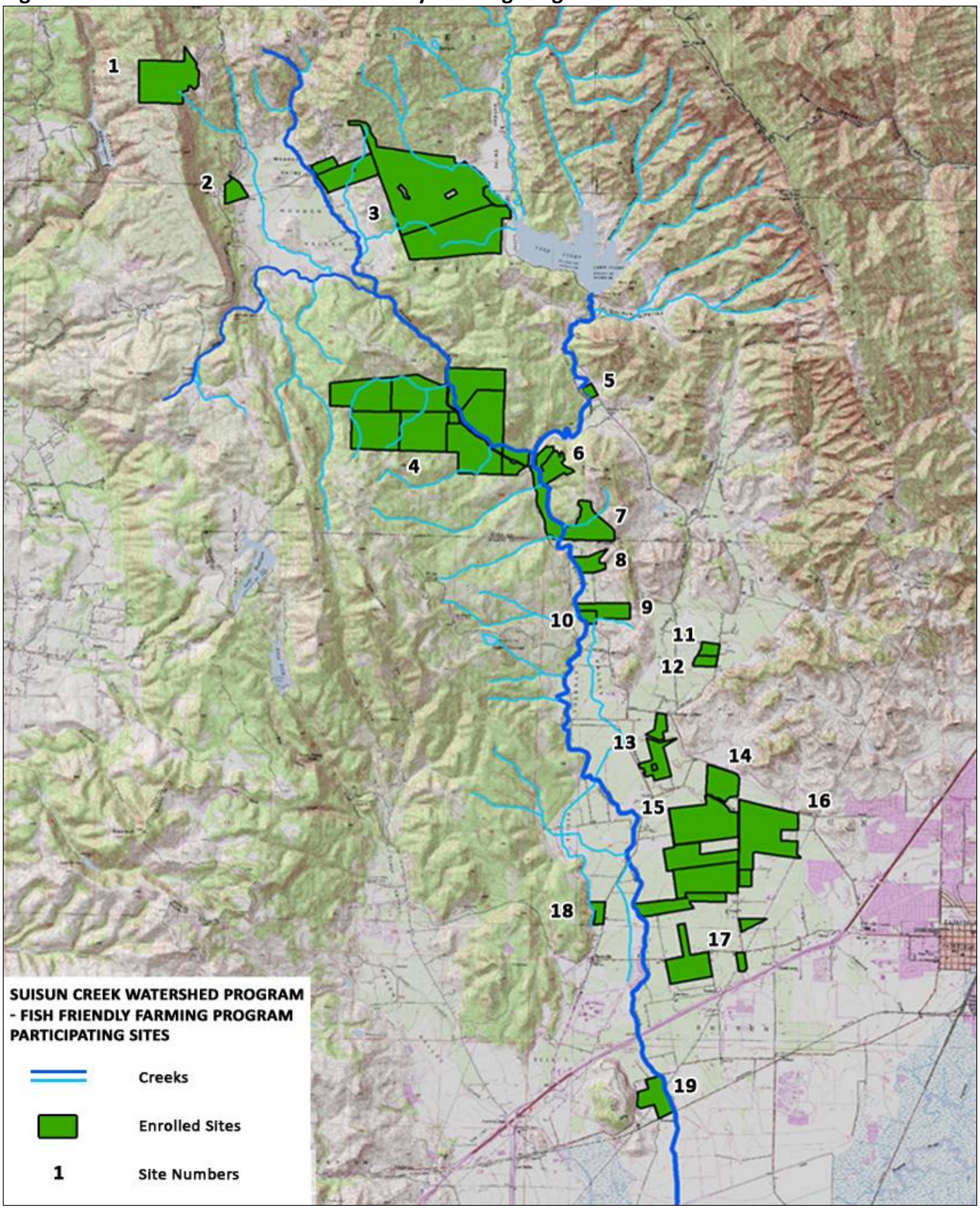


Table 1: Quantitative Record of Projects on Priority List

Fish Friendly Farming (FFF) Environmental Certification Program Participants										
Site Number	**Count y**	**Vineyard Acres**	**Orchard Acres**	**Total Acres**	**Certification Date**	**Miles of Road Assessed**	**Sediment Reduction (tons /year)**	**Linear ft. of Creek**	**Creek Restoration Project Funded by Agreements #08-344-550 and #04-151-552-1**	**Acres of Restoration, if applicable**
1	Napa	72	0	221	Not yet certified	Not yet assessed	Not yet assessed	N/A	N/A	N/A
2	Napa	0	0	32.57	Not yet certified	Not yet assessed	Not yet assessed	N/A	No project identified	N/A
3	Napa	70	0	1080	7/2/2008	5.18	84	2215	Landowner implemented revegetation	N/A
4	Napa	0	0	1110	Not yet certified	6.0		6730	Completion of Himalayan blackberry removal and native plant revegetation in 2010	6.31
5	Napa	9	2	13	7/2/2008	No roads	13	800	Invasive non-native plant removal and native plant revegetation completed in 2005	1.15
6	Napa	100	0	240	7/12/2008	0.57	120	7400	Completion of Arundo donax removal and native plant revegetation in 2009	0.31
7	Napa	6	0	100	Not yet certified	2.05	7.2	750	Completion of Arundo donax removal and native plant revegetation in 2008	0.08
8	Solano	11	0	19	Not yet certified	No roads	13.2	1144	Completion of Arundo donax removal in 2010	<0.01

Fish Friendly Farming (FFF) Environmental Certification Program Participants										
Site Number	**Count y**	**Vineyard Acres**	**Orchard Acres**	**Total Acres**	**Certification Date**	**Miles of Road Assessed**	**Sediment Reduction (tons /year)**	**Linear ft. of Creek**	**Creek Restoration Project Funded by Agreements #08-344-550 and #04-151-552-1**	**Acres of Restoration, if applicable**
9	Solano	10	30	55	7/2/2008	0.3	48	490	Completion of Arundo donax removal and native plant revegetation in 2008	0.30
10	Solano	0	16	16.5	6/9/2008	0.1	19.2	1180	Completion of stream bank erosion repair and revegetation project in 2010	0.35
11	Solano	0	16.7	20.39	Not yet certified	0.46	20.04	1300	No project identified	N/A
12	Solano	0	15	21	6/9/2008	0.24	18	776	No project identified	N/A
13	Solano	0	85	86.65	Not yet certified	1.3	102	1075	No project identified	N/A
14	Solano	110	0	113	6/9/2008	2.95	132	N/A	No project identified	N/A
15	Solano	279	0	400	6/9/2008	2.48	334.8	2440	No project identified	N/A
16	Solano	0	14.7	17.64	Not yet certified	2.56	17.64	8030	No project identified	N/A
17	Solano	0	121	125	Not yet certified	No roads	100.8	N/A	N/A	N/A
18	Solano	0	15	21	6/9/2008	0.36	18	N/A	N/A	N/A
19	Solano	0	71	72	Not yet certified	1.26	85.2	2460	No project implemented to date	N/A
TOTAL		**667**	**416.4**	**3734.75**		**25.81**	**1133.08**	**36,790**		**8.5**

Table 2 Additional Restoration Sites

Restoration Projects (Non-FFF Participants)										
Project Number	**County**	**Vineyard Acres**	**Orchard Acres**	**Total Acres**	**Certification Date**	**Miles of Road Assessed**	**Sediment Reduction (tons /year)**	**Linear ft. of Creek**	**Creek Restoration Project Funded by Agreements #08-344-550 and #04-151-552-1**	**Acres of Restoration, if applicable**
1		N/A	N/A	N/A	N/A	N/A	N/A	1900	Completion of Arundo donax removal and native plant revegetation in 2009	0.12
2		N/A	N/A	N/A	N/A	N/A	N/A	4900	Completion of Arundo donax removal in 2008	0.1
3		N/A	N/A	N/A	N/A	N/A	N/A	3600	Completion of Arundo donax removal in 2010	0.30
TOTAL	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**10,400**		**0.52**

Suisun Creek Streambank Repair and Riparian Revegetation Project

The Suisun Creek Streambank Repair and Riparian Revegetation Project restored a stream bank with active lateral erosion on a point bar in order to reduce fine sediment loading and to revegetate a known thermal reach on Suisun Creek. The reach is approximately 500 feet in length and makes a sweeping right meander from the upstream end of the property to the bottom. As the flow moves through this meander, the left bank (east bank) receives most of the force of flood flows and prior to the project was actively eroding at a rate of several feet per year. Pre-project bank conditions on the site indicated that lateral erosion has been very active recently, and periodic bank failures were likely to continue as the channel undercuts the toe of the slope. The rapid influx of fine-grained sediment was overwhelming the stream channel, leaving pools filled with sediment and gravel embedded with fines. The project goals were to: stabilize a section of stream bank on Suisun Creek that is actively eroding, reducing sediment delivery to the creek; revegetate with appropriate native tree species in order to increase wildlife habitat and reduce water temperatures.

CLSI staff worked with the Natural Resources Conservation Service (NRCS) and the landowners to design and implement this project. Along the upstream portion of the site, the project involved shaping and setting back the banks to a more stable 2:1 or 3:1 slope, installing toe rock to stabilize the two most eroding areas of the bank, and keying five stream barbs into the bank. The NRCS designed the bank stabilization elements of the project, including the bank setback, toe rock, and stream barbs. The barbs were intended to direct flow away from the eroding bank, increase deposition at the toe of the bank and increase scour of the point bar.

The Suisun Creek channel was de-watered during construction activities and 13 juvenile steelhead trout were rescued and relocated to the creek downstream with oversight from a biologist. A temporary bypass channel was constructed through an existing instream gravel bar. A silt fence and berm were used to direct streamflow above the project area into the bypass channel, and a silt fence below the project area protected the bypass channel from sediment. The biologist was onsite to monitor the installation of the temporary bypass channel and to rescue and remove any caught fish. Stranded steelhead were removed with dip nets and kept in 5-gallon buckets with aeration. Ice bottles were available to maintain coldwater temperatures, and buckets were not over-crowded during the transfer process. Recovered fish were relocated to suitable habitat downstream.

Native plants were sourced from local genetic stock and installed by hand with protective hardware during the rainy season. Willow cuttings were collected and installed during the fall at the recommendation of the NRCS; because the cuttings were not collected from dormant plants, they were irrigated until the onset of the rainy season. Over 400 willow stakes cut from local sources were installed on the lower portion of the stream bank.

Jute netting, native grass seed, and native grass plugs were installed on the stream banks and were watered with a small sprinkler by the landowner until the seeds germinated and the rainy season began. In January 2011, 70 riparian tree seedlings grown from local genetic stock were installed along the top of the bank. Species installed included big-leaf maple, box elder, California bay laurel, Fremont cottonwood, Oregon ash, coast live oak, and valley oak. Fencing was installed around the perimeter of the project.

Figure 23: Suisun Creek Streambank Repair and Riparian Revegetation Project

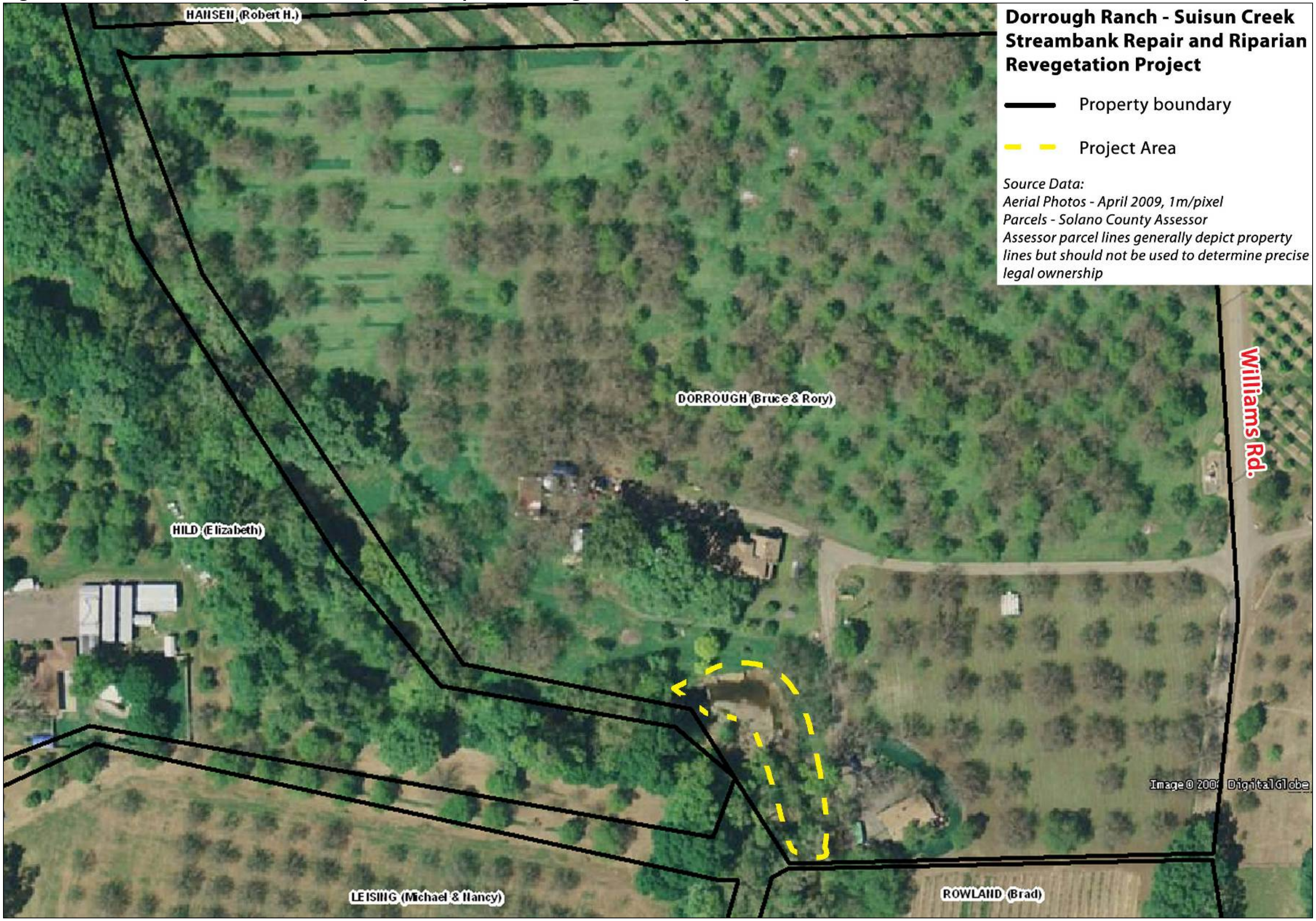


Figure 24: Suisun Creek Streambank Repair and Riparian Revegetation Project Design

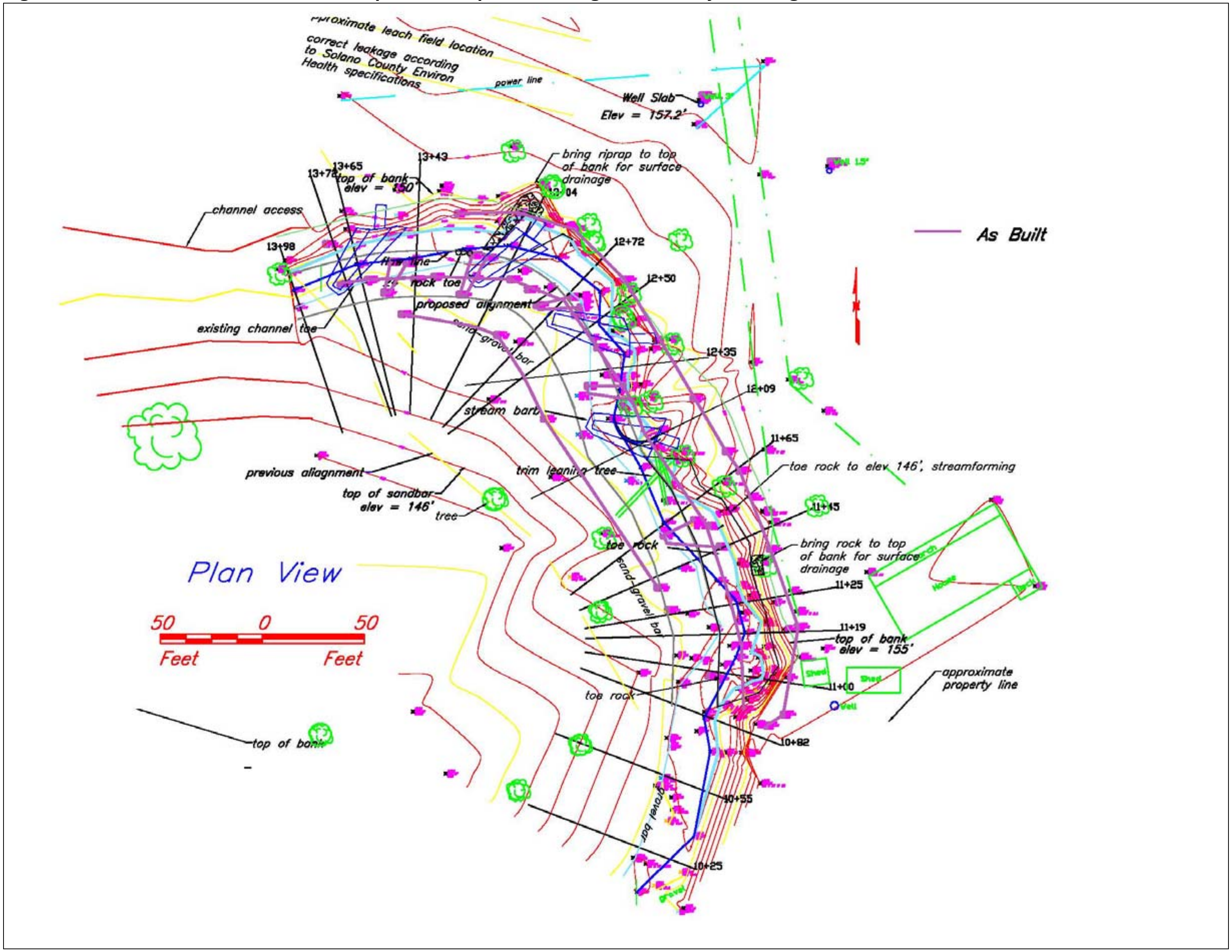


Figure 25: Suisun Creek Streambank Repair and Riparian Revegetation Project – Before Project

Figure 26: Suisun Creek Streambank Repair and Riparian Revegetation Project – Before Project

Figure 27: Suisun Creek Streambank Repair and Riparian Revegetation Project – Construction

Figure 28: Suisun Creek Streambank Repair and Riparian Revegetation Project – Construction

Figure 29: Suisun Creek Streambank Repair and Riparian Revegetation Project – Revegetation

Figure 30: Suisun Creek Streambank Repair and Riparian Revegetation Project – After Project

E. Monitoring Report

The CALFED Watershed Program grant for implementation of the recommendations of the watershed plan included a monitoring task for water quality, water temperature, fine sediment, channel form, riparian canopy and benthic macroinvertebrates. It also included a study of the options for operating Lake Curry to maximize cold water habitats in Suisun Creek. The results of this study and the monitoring are briefly discussed here and a more detailed summary report is also available.

As part of the monitoring program a Monitoring Plan (MP) and Quality Assurance Project Plan (QAPP) were completed and approved by the Regional Water Quality Control Board. Data quality objectives for each parameter include: accuracy, precision, completeness, and representativeness. Laurel Marcus and Associates worked with hydrologist Dennis Jackson to analyze water temperature and water quality data.

<u>Water Temperature and Water Quality</u>

Water temperature and water quality monitoring were carried out at 32 stations depicted on Figure 31 from 2002-2010. Over the course of the monitoring program, stations were added and several were re-located due to changes in the creek channel. Hobotemp dataloggers were deployed to continuously monitor water temperature between May and November. Dataloggers were placed in pools and glides which serve as warm weather refugia for salmonids. The width and depth of the wetted channel and the canopy cover are measured at deployment.

In 2005 and 2006, the water temperature, pH, specific conductance, dissolved oxygen and water depth were measured at various locations on Suisun Creek, Wooden Valley Creek and White Creek using two YSI 600 sondes. The sondes were deployed for a two week period at two of the water temperature monitoring stations and then retrieved and moved to a different pair of stations.

Specific conductance measures the ability of water to pass an electrical current. An increase in specific conductance would indicate an increase in the salt content of the water. The longer groundwater is in contact with earth materials the more salts it contains and so has a higher specific conductance than water that passes through the groundwater system quickly. The type of earth materials also affects the specific conductance. Pollution from septic tanks and agricultural operations can also increase the specific conductance. The sonde measures specific conductance as milli-Siemens per centimeter (mS/cm) which is equivalent to milli-mhos/cm. Conversion to parts-per-thousand (ppm) is approximate, conversion factors range from about 1.0 mS/cm = 640 ppm to 1.0 mS/cm = 700 ppm.

The pH of stream water tends to have a diurnal cycle driven by the shift from photosynthesis to respiration. During the day aquatic plants are undergoing photosynthesis and respiration but there is a net production of oxygen. At night only respiration is occurring so only carbon dioxide (CO_2) is produced. The carbon dioxide disassociates to produce a small amount of carbonic acid which would lower the pH reading.

The dissolved oxygen (DO) in a stream is produced by mechanical mixing of the flowing water and by photosynthesis. DO is consumed by respiring bacteria and other organisms. There is also an inverse relationship between water temperature and the maximum dissolved oxygen concentration that the water can hold. Groundwater entering a stream channel tends to be devoid of oxygen.

The objective of the water temperature monitoring is to assess habitat suitability for steelhead trout and to identify projects needed to increase habitat values. The effects of warm water on steelhead trout are complex. We identified quantitative criteria to determine when stream water is too hot for fish based on information in the literature. Sullivan et al. 2002 report that growth of juvenile steelhead trout declines when water temperatures exceed 68.9^{o}F or if water temperatures fall below 58.1^{o}F. Growth of juvenile steelhead trout is an important factor in determining the probability of whether a young steelhead trout will survive in the ocean and eventually return to spawn. Larger juveniles have a higher probability of returning to spawn. For this study, we selected 68^{o}F as the threshold for the onset of chronic stress on juvenile steelhead trout, due to elevated water temperature.

Water Temperature and Water Quality: Suisun Creek

Extended exposure to water temperatures above 75.2^{o}F can result in mortality for steelhead trout. Sullivan et al. 2002 combine information from the literature on the relationship between LT10 and LT50 to create equations to estimate the exposure time to a given temperature above 75.2^{o}F, required to cause mortality in 10% of the population of steelhead trout and several species of salmon. For this study, only the exposure of fish to water temperatures greater than 80.1^{o}F for more than 2.7 hours was used to determine if water temperatures could cause acute mortality.

Table 3 shows the number of times the water temperature exceeded 80^{o}F for more than 2.7 hours. Station SC-6 had periods when the temperature exceeded 80^{o}F for more than 2.7 hours in four of the seven years that were monitored. However, in 2005 the dataloggers were not deployed until July 22 due to delays in state agreement issuance and so it is possible that some high water temperature events were not recorded that year. In 2006, stations SC-7 downstream to SC-3 reported periods when the water temperature exceeded 80^{o}F for more than 2.7 hours. In 2007 stations SC-6 and SC-7 reported periods when the water temperature exceeded 80^{o}F for more than 2.7 hours.

The water temperature monitoring data for Suisun Creek collected from 2002 through 2010 shows that acutely lethal water temperatures regularly occur in the vicinity of SC-6 and SC-7 and occasionally can extend downstream to SC-3 (Figure 32). Stations near the dam (SC-10 to SC-7.5) and stations near the marsh (SC-1 to SC-2) did not experience acute lethal risk from elevated water temperatures. The water released from Lake Curry is warming up between SC-10 and SC-7.5. We speculate that the cooling influence of Suisun Bay moderates the water temperatures at SC-3 down to SC-1.

Table 4 shows dissolved oxygen monitoring for station on Suisun Creek which have high water temperatures. However the oxygen levels are generally good due to the movement of the water and mixing in of oxygen as the creek flows over rocks and through riffles.

Figure 31: Suisun Creek Watershed Monitoring Stations

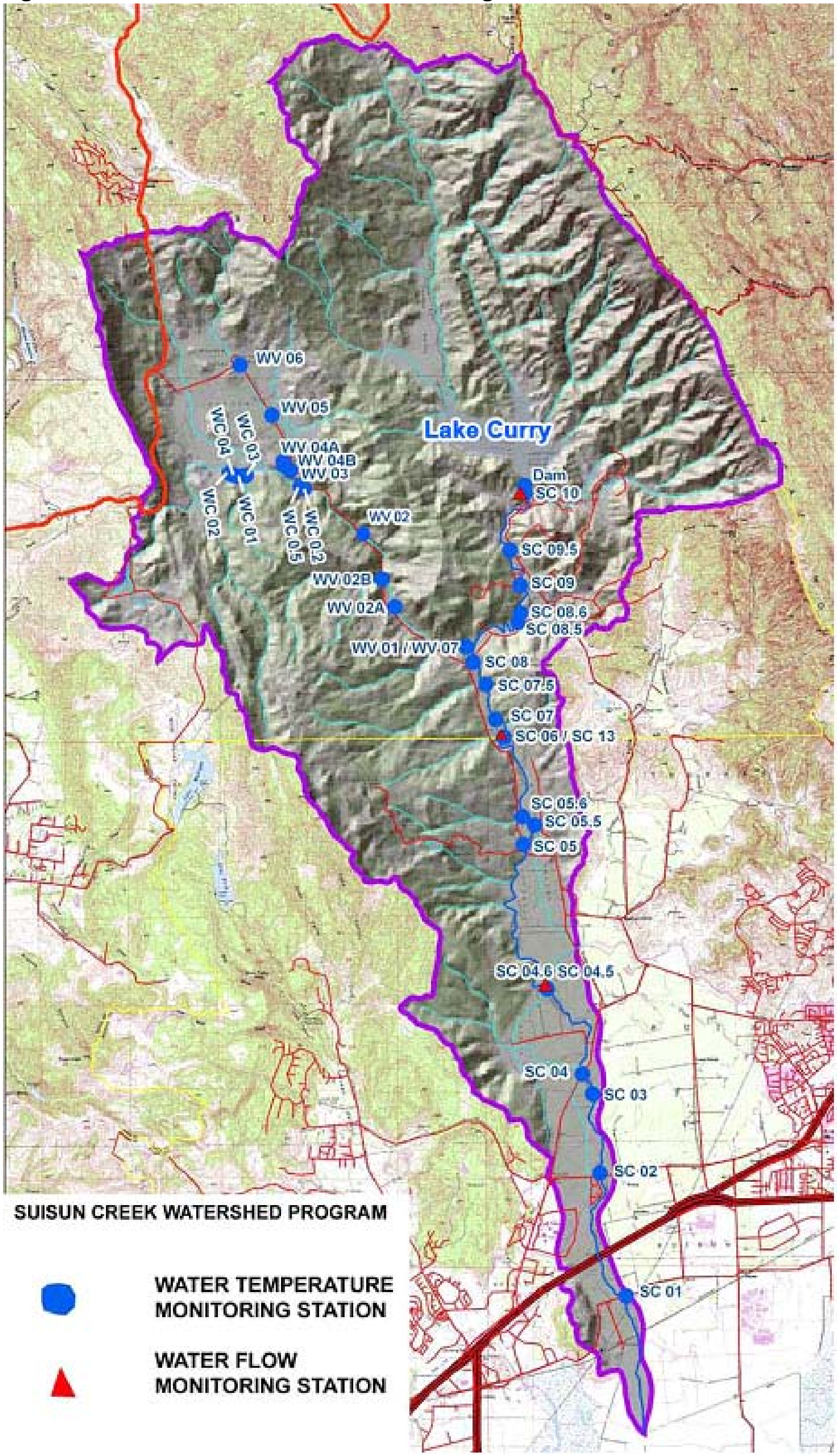


Table 3: The number of occurrences when the water temperature exceeded 80°F for more than 2.8 hours. Formulas in the literature suggest that 10% of steelhead subjected to 80 degree water for 2.8 hours would be expected to die. Data includes days when the channel was dry or the temperature recording unit was exposed to air. The number of times the air temperature exceed 80°F for more than 2.8 hours included for comparison.

Station	2002 No. Times Temp ≥ 80°	2003 No. Times Temp ≥ 80°	2005 [j] No. Times Temp ≥ 80°	2006 No. Times Temp ≥ 80°	2007 No. Times Temp ≥ 80°	2009 No. Times Temp ≥ 80°	2010 No. Times Temp ≥ 80°
WV-7 Air	**144**	**65**	**76**	**53**	**111**	**111**	**91**
SC-13 Air	--	**64**	**34**	**62**	**91**	**81**	**82**
SC-10	--	0	0	0	0	0	
SC-9.5	--	--	--	0	0	0	0
SC-9	0	0	0	0 [I]	0	0	--
SC-8.6	--	--	--	0	--	--	--
SC-8.5	--	--	--	--	0	0	--
SC-8	0 [c]	0	0	0	0	0	--
SC-7.5	--	--	0	0	--	--	--
SC-7	0	0	0	**2**	**7**	--	0
SC-6	**4**	**2** [d]	0	**6**	**8**	0	0
SC-5.6	--	--	0	**4**	0	--	--
SC-5.5	--	--	0	**2**	0	--	--
SC-5	0	0	--	-- [g]	--	--	--
SC-4.6	--	--	--	**5** [k]	0 [h]	0	
SC-4.5	--	--	--	**5** [k]	--	0 [l]	0
[a] SC-4	0	0	-- [e]	**5**	--	--	--
[b] SC-3	0	0	0	**4**	0	--	--
SC-2	0	0	0	0	--	0	--
SC-1	0	0	0	0	--	0	--
Water-year Precipitation	25.69”	33.30”	30.92”	41.88”	14.90”	21.3”	28.9”
Percentile Rank	63.7%	81.3%	74.5%	97.0%	9.8%	43.2%	68.2%
Exceedance Probability	36.3%	18.7%	25.5%	3.0%	90.2%	56.8%	31.8%

Notes on temperature stations:

[a] After 2002, SC-4 was relocated 1,000 feet downstream.
[b] After 2002, SC-3 was relocated 1,000 feet upstream.
[c] SC-8 is missing August and September for 2002.
[d] Neighbor removed SC-6 datalogger between July 12 to July 27, 2003
[e] SC-4 was not used in 2005 due to bridge construction at the site.
[g] SC-5 was deployed in 2006 but when it was retrieved on August 18, 2006 its case was damaged and the data was judged to be questionable.
[h] Data for SC-4.6 is missing between 7/28/07 and 8/14/2007
[I] Datalogger launched on 8/22/2006 at SC-9
[j] **All** dataloggers launched on July 21 in 2005
[k] Dataloggers at SC-4.5 and SC-4.6 launched on 7/10/2006
[l] Site of datalogger was dry on 10/12/2009. Site may have dried up on 9/15/2009.

Figure 32: The Maximum Annual MWAT (7-day moving average of maximum water temperatures) versus Distance Downstream from lake Curry. The water discharged from the dam was significantly warmer in 2007 because it was a very dry year and the volume in the reservoir was low. There is a tendency for the largest MWAT to occur at SC-6. In 2006, the maximum MWAT at SC-4.6, SC-4.5 and SC-4 was larger than the MWAT at SC-6. In 2006 SC-9 was launched on 8/22/06 and so missed the hot weather of July and early August.

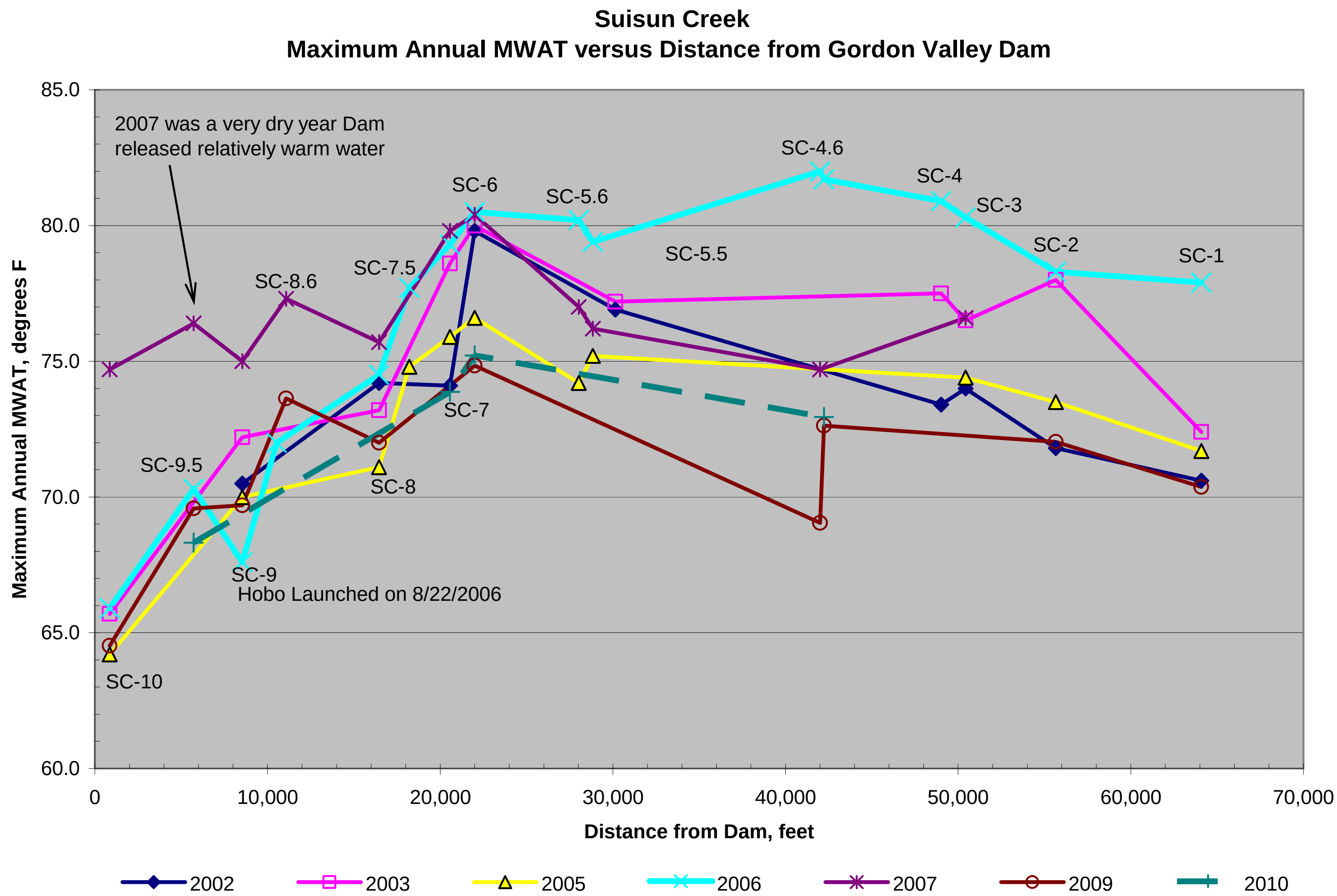


Table 4: The percentile rank of dissolved oxygen concentration for different salmonid growth impairment levels at SC-9 from 6/30 to 7/7/2006 and from 8/24 to 9/8/2006; SC-6 and SC-5.5 from 7/10 to 8/4/2006; and SC-4.6 from 10/2 to 10/18/2006.

Impairment Level	Level of Effect Water Column DO (mg/L)	SC-9 6/30 to 7/7/2006 Dissolved Oxygen Percentile	SC-9 9/15 to 9/29/06 Dissolved Oxygen Percentile	SC-6 7/10 to 8/14/2006 Dissolved Oxygen Percentile	SC-5.5 7/10 to 7/21/06 Dissolved Oxygen Percentile	SC-4.6 10/2 to 10/18/2006 Dissolved Oxygen Percentile
No Production Impairment	8	none	18.0%	68.0%	57.6%	15.8%
Slight Production Impairment	6	none	3.3%	11.1%	0.0%	none
Moderate Production Impairment	5	none	1.0%	4.4%	none	none
Severe Production Impairment	4	none	0.3%	0.5%	none	none
Limit to Avoid Acute Mortality	3	none	0.2%	none	none	none
Maximum Oxygen Conc. mg/l		12.14	10.24	11.12	10.68	10.71
Median Oxygen Conc. mg/l		9.53	8.78	7.58	7.64	8.50
Minimum Oxygen Conc. mg/l		8.44	1.68	3.32	5.99	7.5

Lake Curry

One of the tasks in the CALFED grant was to evaluate how to manage Lake Curry to enhance cold water salmonid habitat in Suisun Creek. Hydrologic Systems, Inc. (HSI) conducted an analysis to determine the quantity of cold water that would be available for release to the creek under wet, normal, and dry conditions. The analysis considered the availability of cold water in the reservoir as well as the impact that increased low flow releases would have on the end-of-year water level in the lake.

In 1992 the City of Vallejo had to close the drinking water filtration plant at the dam due to changes in Federal drinking water standards. Once the plant was closed, the City had to revise the way it moved water from Lake Curry to its primary drinking water treatment plants in Green Valley and Vallejo. The City worked with Congressman Miller to pass legislation which would allow the Lake Curry water to be put into Putah South Canal, a federal facility which moves water for irrigation and domestic use from Lake Berryessa to numerous users. The City reviewed several alternatives: piping water from Lake Curry to the canal or releasing it down Suisun Creek and diverting it near the crossing of Putah South Canal and Suisun Creek. The City began a CEQA process for the project. For a number of reasons, however, the City did not complete a CEQA document and has not pursued further changes.

The analysis of Lake Curry operations was envisioned as a way for the reservoir to provide for both fish habitat and water supply. The concept at the beginning of the study was that the City could divert water from the creek into Putah South Canal during the wet season when the creek has abundant flow and when the canal has adequate space. During the summer reservoir releases would provide cooler water to Suisun Creek.

Lake Curry Analysis

The analysis consisted of developing two separate models. The first model was a watershed simulation to evaluate the quantity of water entering the lake. The second model was a lake water temperature model. The runoff data from the watershed model was input to the temperature model to create a continuous simulation of discharge and water temperature for the 1994 through 2007 period.

The temperature-watershed model was run for the 1994 through 2007 water years to evaluate the effect of releasing additional cold water downstream to Suisun Creek. Several different discharge alternatives were evaluated. The low-flow release of 2.5 cfs would be increased between May 1 and November 1 of each year. During the remainder of the year the low flow would be maintained at 2.5 cfs. Model runs were conducted to evaluate low flow releases of 2.5, 3, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 7.0, and 8.0 cfs. The increase in the discharge affects lake elevation as well as temperature of the discharge. The ultimate change that any one release scenario will have on the lake will vary from year to year depending on the runoff into the lake and the climatologic conditions for the year.

Table 5: Duration of Cold Water Release for each Scenario. Releases occurred from April 1st through November 1st of each year.

	Median Date at which Water at the Specified Temperature is Exhausted				
Release Scenario	**53.6°F**	**59.0°F**	**64.4°F**	**68.0°F**	**71.6°F**
Existing Condition (2.5 cfs)	7/7	9/1	Still available	Still available	Still available
3.0 cfs	6/30	8/19	Still available	Still available	Still available
3.5 cfs	6/25	8/10	9/27	Still available	Still available
4.0 cfs	6/21	8/2	9/14	Still available	Still available
4.5 cfs	6/19	7/27	9/4	Still available	Still available
5.0 cfs	6/16	7/22	8/21	Still available	Still available
5.5 cfs	6/13	7/17	8/15	Still available	Still available
6.0 cfs	6/11	7/13	8/9	10/5	Still available
7.0 cfs	6/6	7/4	7/28	9/28	Still available
8.0 cfs	5/26	6/18	7/9	8/15	Still available

The capacity for Lake Curry to release cold water (68° F and less) between April 1 and November 1 was analyzed. On a normal to wet year when the reservoir is filled to capacity (Table 5), a constant release of 5.5 cfs will supply water at 68°F for the April 1 to Nov 1 period. This is the maximum release level producing water with temperatures of 68° F This release rate would drain the lake to 350 ft. elevation. The small size of Lake Curry allows it to fill up most years regardless of how low the lake stage is at the end of the preceding year. On April 1st of each year, the classification of water year type for the lake can be identified according to the lake stage. Table 6 provides a listing of the year type classes and associated lake stage. Given this classification based on lake stage, a wet year would have basically the same April 1st elevation as a normal year because all of the excess water runs over the spillway. The reservoir release experiment in 2006 found that in years of abundant rainfall a release of 6 cfs only cools the upper two miles of Suisun Creek due to the large amount of warm water in the channel and the lack of riparian canopy. These findings suggest the need for an adaptive management program of in-stream monitoring with various reservoir releases to determine the most beneficial scenario.

Table 6: Normal and Dry Year Classifications of Lake Curry

Year Class	Pool Elevation on April 1 (ft. NGVD)	Frequency of Occurrence	Frequency in Years
Normal	> 375.	67%	7 out of 10
Dry	375. – 370.	20%	2 out of 10
Very Dry	< 370.	13%	1 out of 10

Lake Curry Water Release Experiment

Another experiment was conducted in the summer/fall of 2006 to determine if altering the magnitude and or timing of the releases from Lake Curry could reduce water temperature in Suisun Creek.
The experiment was conducted in seven phases as described below. All release rates (discharges) are nominal values. The outlet works of Lake Curry are controlled by a valve on the top of the dam. The actual discharge is measured at a weir below the dam. The dam operator uses a trial and error method of setting the valve position to achieve the target release rate. Table 7 describes the temperature and flow stations by their distance from Lake Curry and from Suisun Marsh.

- On July 11, 2006, at approximately noon, the release from Lake Curry was reduced from 3 cfs to a nominal rate of 2 cfs.
- On July 18, at about 10 AM, the release was increased to a nominal value of 4 cfs.
- On July 25 the release was increased to a nominal value of 6 cfs.
- On August 10 a daily pattern of releasing 6 cfs (nominal) during the day and 2 cfs (nominal) at night was begun.
- From August 17 to August 22 the release was set at a constant nominal rate of 2 cfs.
- On August 22 a daily pattern of releasing 2 cfs (nominal) during the day and 6 cfs (nominal) at night was begun.
- On August 30 the release rate was set at a constant nominal value of 3 cfs.

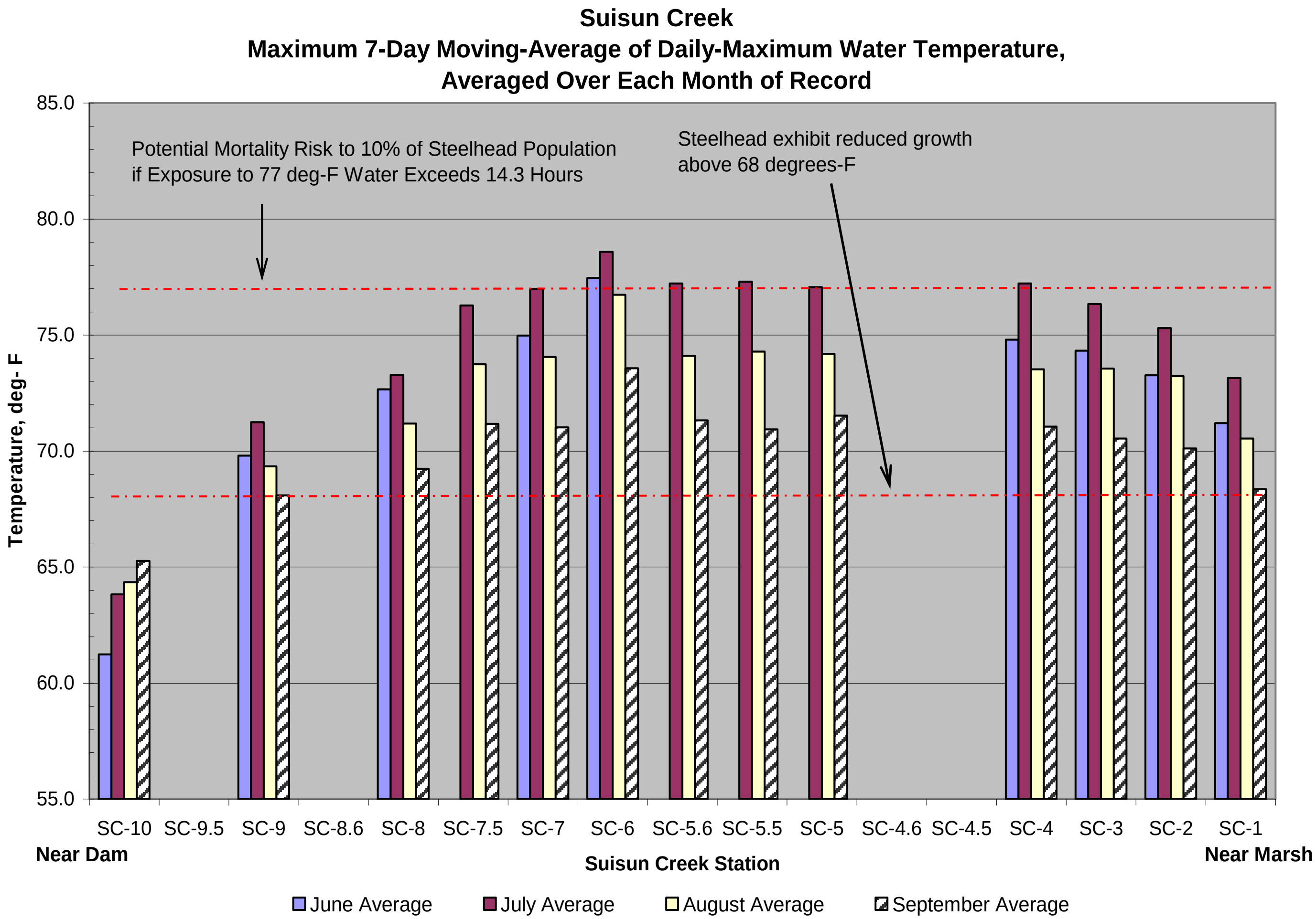
The 2006 water temperature monitoring revealed that the 7-day period with the warmest water temperatures occurred in July and that there was a strong relationship between the water temperature for individual monitoring stations and the distance of the station from Lake Curry. The 7-day maximum water temperature steadily increased over the first 4.2 miles downstream from the reservoir release (dam to station SC-6). Over the next 5.1 miles (stations SC-6 to SC-4) the 7-day maximum water temperature was roughly constant. The 7-day maximum water temperature decreased with increasing distance from the dam over the next 2.8 miles (stations SC-4 to SC-1).

During the summer of 2006, the water temperature equaled or exceeded 80^{o}F for 2.8 hours or more at the 8 stations between SC-7 and SC-3. The number of times the water temperature exceeded 80^{o}F for more than 2.8 hours varied from two to six times at each of the eight stations. The repeated exposure to water temperatures greater than 80^{o}F at the eight stations is predicted to have acute lethal effects on 19% to 47% of the juvenile steelhead population, if juvenile steelhead were actually present in Suisun Creek (Figure 33). The water temperature monitoring data evaluated for this report shows that juvenile steelhead in Suisun Creek would be expected to experience chronic stress from warm water and may occasionally experience water temperature conditions that are predicted to be lethal to 10% of the juvenile steelhead population

Table 7: River mile of each station on Suisun Creek. GIS was used to determine distance from a location in the Suisun Marsh. The stations are shown from downstream to upstream in the following table. The column labeled Upstream Reach Length gives the distance to the next station upstream. This study uses the cumulative distance from the dam to locate stations or to calculate the distance between stations. Figure 31 shows a map of the station locations.

STATION	Cumulative Distance from Marsh miles	Cumulative Distance from Marsh feet	Upstream Reach Length feet	Cumulative Distance from Dam feet	Cumulative Distance from Dam miles
Marsh	0.00		11,972	76,053	14.4
SC-1	2.27	11,972	8,426	64,081	12.1
SC-2	3.86	20,398	5,226	55,654	10.5
SC-3	4.85	25,625	1,414	50,428	9.5
SC-4	5.12	27,039	6,788	49,014	9.3
SC-4.5 Stream flow gage	6.41	33,826	224	42,226	8.0
SC-4.6	6.45	34,050	11,862	42,003	7.9
SC-5	8.70	45,912	1,305	30,141	5.7
SC-5.5	8.94	47,217	806	28,836	5.5
SC-5.6	9.10	48,023	6,029	28,030	5.3
SC-6 / SC 13	10.24	54,052	1,439	22,001	4.2
SC-7	10.51	55,491	1,718	20,562	3.9
Stream flow gage	10.84	57,210	634	18,843	3.6
SC-7.5	10.96	57,844	1,744	18,209	3.4
SC-8	11.29	59,588	5,394	16,465	3.1
SC-8.5	12.31	64,981	540	11,071	2.1
SC-8.6	12.41	65,521	1,992	10,532	2.0
SC-9	12.79	67,513	2,822	8,540	1.6
SC-9.5	13.32	70,335	4,860	5,718	1.1
SC 10	14.24	75,195	858	858	0.2
Dam Stream flow gage	14.40	76,053		0	0

Figure 33: **Maximum 7-Day Moving Average of Daily Maximum Water Temperature.** The maximum 7-day moving-average of the daily-maximum water temperatures (7-Day Max) was calculated for each month and then the overall monthly average 7-Day Max was computed for each station with at least two years of record. The graph suggests that there is an upward trend in the monthly 7-Day Max from SC-10 to SC-6. From SC-6 downstream to SC-4 the monthly 7-Day Max is roughly constant. Downstream of SC-4 there appears to be a tendency for the monthly 7-Day Max to decline. The increase in the monthly 7-Day Max from SC-10 downstream to SC-6 is a reflection that the cool dam release water rapidly heats as it travels downstream. The decrease in the 7-Day Max downstream of SC-4 is probably due to the cooling effects of the Suisun Bay such as higher humidity, breezes and fog.



Why Isn't Increasing the Dam Release More Effective?

The analysis shows that the increasing the dam release does not cool water temperatures enough during hot weather to provide significant relief for juvenile steelhead trout rearing. Reducing the water temperature in Suisun Creek requires cooling the large volume of water stored in the channel. A constant discharge of 6-cfs is estimated to take 30.5 hours to replace the volume of water in the Upper Reach between the dam and SC-7. It would take a 6-cfs discharge about 35.2 hours to replace the estimated volume of water stored in the Middle Reach between SC-7 and SC-4.6 and about 35.4 hours to replace the estimated volume of water stored in the Lower Reach.

The relatively long replacement times show that the volume of water stored in the channel is large in relationship to the magnitude of the dam release. The flow in Suisun Creek, at a particular temperature station, is a mixture of water that was recently released from the dam and water that has been stored in the channel for some unknown length of time. As the water released from the dam travels downstream it is heated by the air and by contact and interchange with the stored water.

There are significant areas where the open water visible on aerial photographs exceeded the average channel width of 25 feet. These wide areas of the wetted channel indicate places with little or no canopy to shade the water and are expected to significantly heat the stored water during the day and cool it during the night. Accordingly, reaches downstream of places where there is a significant amount of channel with no canopy should experience larger daily temperature ranges than reaches downstream of closed canopy over the channel.

Riparian Canopy Assessment

Riparian canopy surveys of the upper 5 miles of Suisun Creek were conducted between 2006 and 2010 using high-resolution aerial imagery. The preliminary assessment indicated a total open water area of 294,529 sq. ft. for the upper reach of Suisun Creek or approximately 45% of the estimated summer wetted channel area. 73 open water areas were identified along the 4.6-mile reach in 1999. A second aerial image assessment was conducted which indicated 61 open water areas totaling 105,837 sq. ft., or approximately 16% of the estimated summer wetted channel area in 2009. A comparison of the two aerial image surveys shows an overall reduction in open water areas between 1999 and 2009

Spherical densiometer readings were completed at approximately 600 ft. intervals along 1.5 miles of Suisun Creek located immediately below the confluence with Wooden Valley Creek. Due to the large percentage of open water area present, this reach was selected for an in-depth riparian canopy assessment. Spherical densiometer measurements were made on the left bank, mid-stream, and right bank of each interval. A 4-coordinate reading was done at each of the three points.

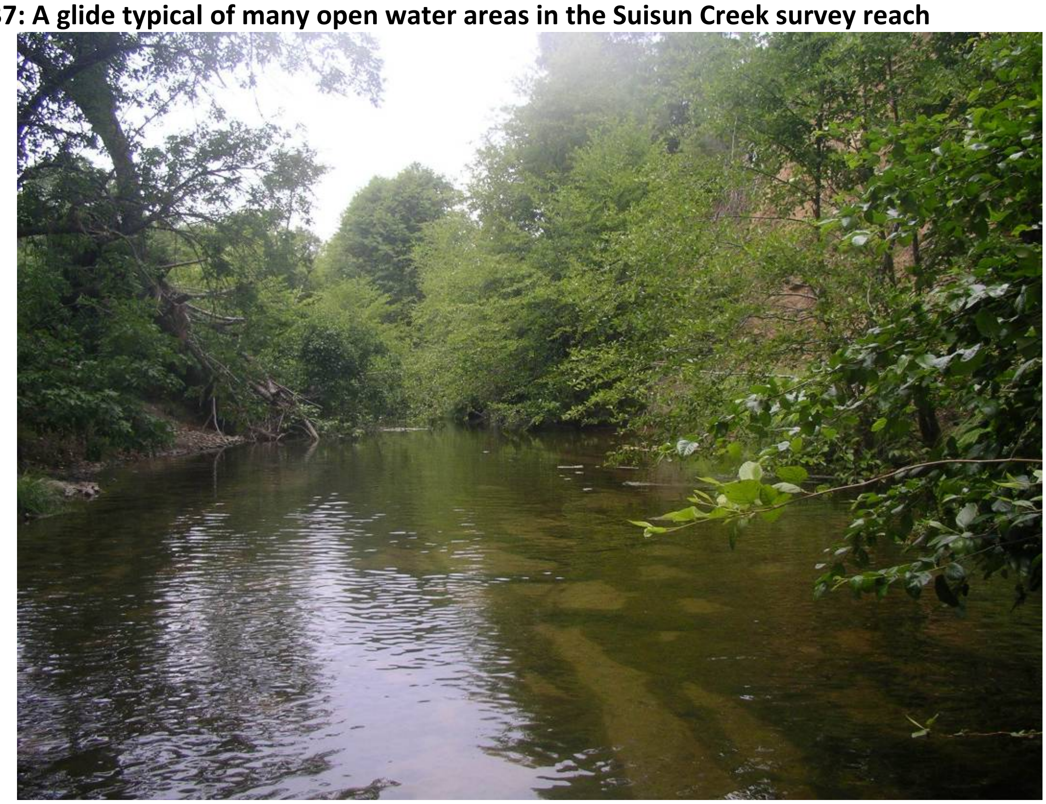
The optimal amount of shade canopy for steelhead trout habitat is contingent on many factors such as stream gradient, size of stream, and the temperature of the water coming into the system, among others. The California Department of Fish and Game (1998) suggests a riparian corridor with at least 80% canopy cover. Of the 13 points assessed, 8 had an average canopy cover of less than 80%, indicating a need for significant revegetation.

Figure 34: Flooding in 2005-2006 took out many riparian trees on Suisun Creek. On December 31-January 1, 2006, a storm delivered up to 16 inches of rain in several hours in the Suisun Creek watershed resulting in large landslides and the loss of many trees in the riparian corridor. The increase in riparian canopy observed through the surveys can be attributed in part to the natural processes of recovery and regeneration following this storm event.

Figure 35: Station SC-5.6 shows good riparian canopy cover

Figure 36: An open water area on upper Suisun Creek

Figure 37: A glide typical of many open water areas in the Suisun Creek survey reach



Fish Survey

As a result of the 2006 reservoir release experiment, several additional monitoring questions were raised:

- Does warm water in Suisun Creek create conditions for fish species which prey on steelhead trout juveniles?
- What is the summertime distribution of juvenile steelhead trout in Suisun Creek?

To determine fish assemblage composition, distribution, and habitat associations, a snorkel survey was completed. The survey was conducted by Jonathan Koehler and Chad Edwards of the NCRCD. A total of 9.9 miles of Suisun Creek was surveyed during the course of five field days (Figure 38). The survey began near Cordelia Road above tidal influence. No surveying was conducted in the tidally influenced estuarine portion of Suisun Creek due to poor water clarity. Landowner access was limited and approximately 1.6 total stream miles in Reach 5 were not surveyed. The unsurveyed section included approximately 5,400 feet of channel just downstream of the dam and an additional 3,500 feet just upstream of the Wooden Valley Crossroad.

A total of eleven fish species were documented in Suisun Creek, including seven native and four non-native species. Native species included Sacramento pikeminnow, California roach, Sacramento sucker, threespine stickleback, tule perch, steelhead (rainbow trout), and riffle sculpin. Non-native fish species were very sparsely scattered throughout the survey, with only a few individual sightings. The four non-native species observed were bluegill, carp, goldfish, and western mosquitofish.

Reach 1 was characterized as a low gradient plane-bed channel with abundant canopy and instream shelter. A few juvenile steelhead were observed in small pockets of high quality habitat in Reaches 1 and 2; however, there was very little suitable rearing habitat available in these reaches. A short section of Reach 2 and much of Reach 3 had intermittent stream flow with unsuitable stagnant isolated pools. Most of these pools had poor water clarity and contained no fish. However, a few isolated pools in Reaches 2 and 3 contained clear water and supported California roach, threespine stickleback, Sacramento sucker, and Sacramento pikeminnow.

A marked transition was noted in the uppermost section of Reach 3, where the channel gradient increased and habitat conditions were generally better for steelhead rearing. We observed an increase in stream flow at the top of Reach 3 (Figure 38), and instream cover from tree roots and undercut banks was more abundant upstream of this section. Juvenile steelhead abundance increased in this section as well (Figure 39), especially in areas with swiftly flowing water. Reach 4 and 5 had the highest densities of juvenile steelhead. Sacramento pikeminnow remained abundant in Reaches 4 and 5; however they tended to be restricted to pools and glides, while steelhead were always associated with riffles and runs.

Figure 38: Suisun Creek survey reach map.

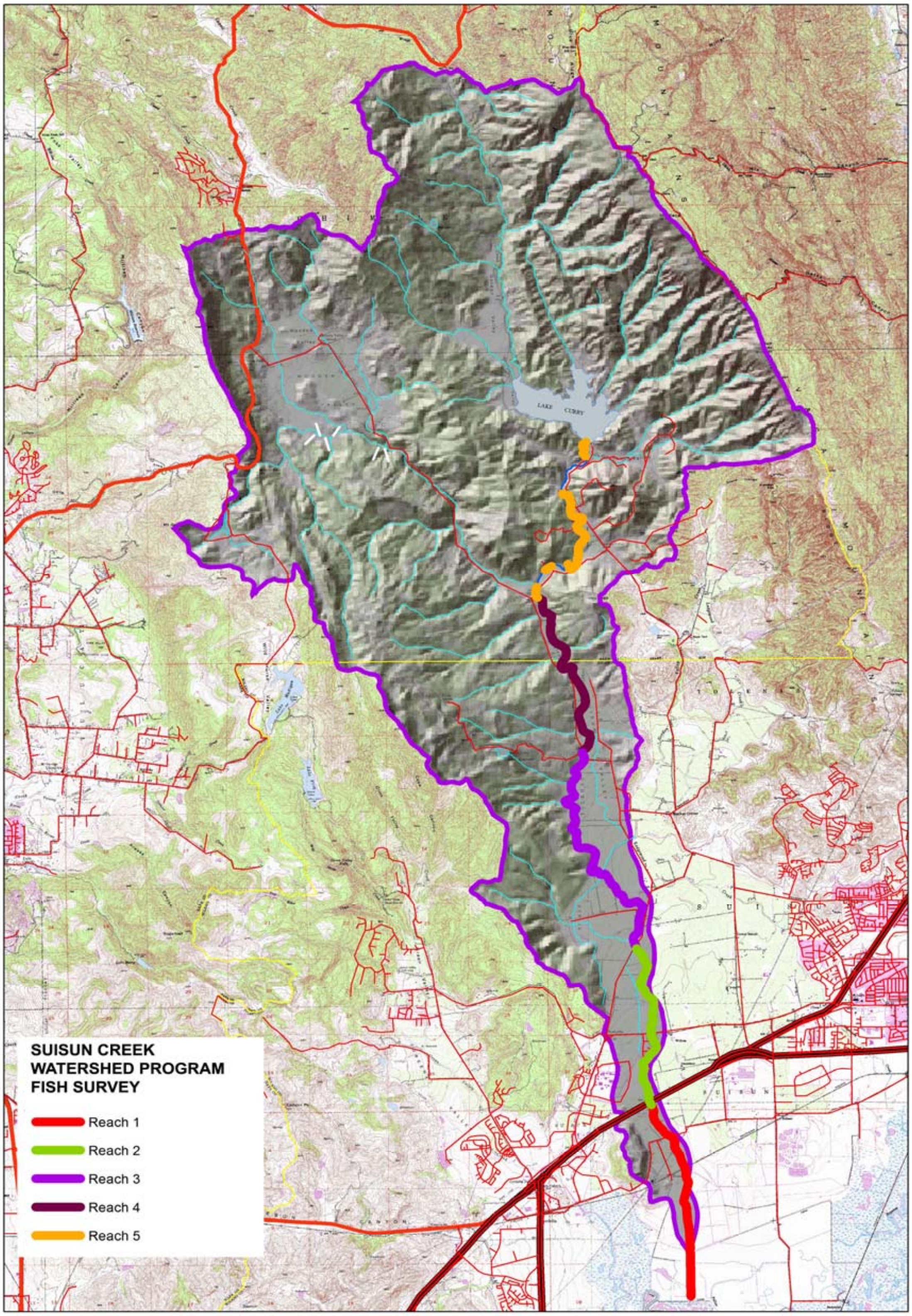


Figure 39: Juvenile steelhead observed in Reach 4, Suisun Creek.

Figure 40: California roach school in Reach 4, Suisun Creek.

Water Temperature Monitoring: Wooden Valley Creek

Wooden Valley Creek water temperatures were monitored at eleven stations (Figure 31).One air temperature station was also established. YSI sondes were deployed in 2005 and 2006 to monitor dissolved oxygen, water temperature, pH, and specific conductance. Wooden Valley Creek drains Wooden Valley, an alluvial valley with a number of creeks which converge at the downstream end of the valley into one channel. Wooden Valley Creek then courses through a rock gorge and spreads onto a floodplain about 1 mile upstream from the confluence with Suisun Creek. The water temperature stations were distributed along the lower and gorge reach of Wooden Valley Creek and one channel in Wooden Valley with the most consistent year-round flow. Wooden Valley Creek dries up in its lowest mile and becomes intermittent in the gorge and valley reach.

Table 8 gives the number of occurrences when the temperature exceeded 80 °F for more than 2.8 hours. Formulas in the literature suggest that 10% of steelhead subjected to 80 degree water for more than 2.7 hours would be expected to die. Data in Table 31 includes days when the channel was dry or the temperature recording unit was exposed to air. WV-2A and WV-7 reported occurrences of potential acute temperature mortality events that are not related to incidents when the datalogger was floating or was out of the water.

Sonde data was collected at WV-4B in August and September of 2005 and in July and September in 2006. Sonde data was also collected at WV-2B in October 2006. The relatively steep gradient in the gorge mechanically mixes oxygen into the water so the DO would be expected to be high at WV-2B.

The dissolved oxygen showed significant diurnal variation in all four monitoring periods (Table 9). The minimum DO was lower during the September monitoring periods than it was during the July or August monitoring periods. These suggest that declining flows induced less oxygen through mechanical mixing and potentially increasing algae mass consumed more oxygen through respiration.

Based on the potential for going dry WV-1 has the poorest conditions for fish on Wooden Valley Creek. WV-2B also goes dry. In both 2006 and 2007, problems with the placement of the datalogger lead to the recording of high temperatures at WV-2B. Since the station was only monitored in 2005 from September 7 to October 26, it is difficult to determine if high temperatures would limit growth of fish at WV-2B. There were times when high water temperatures would have had the potential to be acutely lethal to steelhead trout at WV-2A.

The water temperatures at WV-2 upstream to WV-6 appear to be able to support juvenile steelhead trout; however, there were occasions of elevated water temperatures (> 68 °F) that have the potential to impair juvenile growth. The DO data suggests that, in general, oxygen levels are adequate but they could be improved by increasing the minimum daily DO concentrations to 7 mg/l. Increasing the riparian canopy of Wooden Valley Creek is expected to decrease the maximum water temperatures and help keep algae growth in check

Figure 41: Installation of datalogger in Wooden Valley Creek and Station WV4A

Table 8: **The number of occurrences when the temperature exceeded 80 °F for more than 2.8 hours for Wooden Valley Creek.** Formulas in the literature suggest that 10% of steelhead subjected to 80 degree water for 2.8 hours would be expected to die. Data includes days when the channel was dry or the temperature recording unit was exposed to air. Only WV-2A reported occurrences of potential acute temperature mortality events that are not related to the datalogger floating or being out of the water.

Station	2002	2003	2005	2006	2007	2009	2010	Total Occurrences
WV-6	--	0	2 [a]	3 [a]	--	0	--	5
WV-5	0	0	0	0	0	0	0	0
WV-4	0	0	--	--	--	--	--	0
WV-4A	--	--	0	0 [a]	0	--	--	0
WV-4B	--	--	0	0	[e]	0	--	0
WV-3	7 [a]	0	0 [a]	0	0	--	--	7
WV-2.5	--	--	--	--	--	1 [b]	--	1
WV-2	0	0	--	--	--	--	--	0
WV-2B	--	--	0	7 [a]	21 [a]	75 [b]	36 [b]	139
WV-2A	--	1	--	5	0 [a]	-- [d]	2 [b]	8
WV-1	43 [b]	28 [b]	29 [b]	33 [b]	52 [b]	83 [b]	26 [b]	294
Water-year Precipitation	25.69”	33.30”	30.92”	41.88”	14.90”	21.30	28.90	
Percentile Rank	63.7%	81.3%	74.5%	97.0%	9.8%	43.2%	68.2%	
Exceedance Probability	36.3%	18.7%	25.5%	3.0%	90.2%	56.8%	31.8%	

[a] Datalogger floating or out of water.
[b] Channel went dry.
[c] Record from 9/7 to 10/26/2005
[d] Water too shallow at WV-2A to launch datalogger on 5/20/2009
[e] Unit malfunctioned, no data collected

Table 9: **Seasonal Variation in DO and Temperature.** The most stressful conditions at WV-4B occurred during the August 2005 monitoring period. The least stressful conditions at WV-4B occurred during the June 2006 monitoring period. There were no stressful conditions recorded at WV-2 during the October 2006 monitoring period.

	WV-4B 8/2/2005	**WV-4B 9/23/2005**	**WV-4B 6/30/2006**	**WV4B 8/24/2006**	**WV2 10/2/2006**
Temp ≤ 68° - DO ≥ 7 mg/l	53.0%	62.4%	73.3%	58.8%	100.0%
Temp ≤ 68° - DO < 7 mg/l	**31.7%**	**37.6%**	**26.7%**	**41.2%**	0.0%
68° < Temp < 77° - DO ≥ 7 mg/l	**4.5%**	0.0%	0.0%	0.0%	0.0%
68° < Temp < 77° - DO < 7 mg/l	**10.7%**	0.0%	0.0%	0.0%	0.0%
Temp ≥ 77° - DO ≥ 7 mg/l	0.0%	0.0%	0.0%	0.0%	0.0%
Temp ≥ 77° - DO < 7 mg/l	0.0%	0.0%	0.0%	0.0%	0.0%

Water Temperature Monitoring: White Creek

White Creek water temperatures were monitored at 6 stations. Stations WC-1 through WC-4 are located midway in White Creek while stations WC-0.2 and WC-0.5 are located on White Creek near the confluence with Wooden Valley Creek (Figure 31).

The channel dried up each year at WC-2 and WC-3, no matter how wet the water-year was. There appears to be a positive correlation between the water-year precipitation and the date that the channel becomes dry at the two stations. The wetter the water-year the longer the flow persists. A numerical correlation between the day the channel dried up and the annual rainfall was not possible to calculate since the day the channel dried up is only roughly known. For example, in 2006, the dataloggers at WC-2 and WC-3 were retrieved on July 24 but there were still pools in the channel bed. However, numerous dead steelhead trout were found at WC-1 and WC-3 indicating that a fatal combination of high water temperature and low dissolved oxygen had probably been reached prior to July 24.

The number of days since the last significant rainfall may also play a role in determining the date the channel dries up. Upstream water use may also play a role in determining how long surface flow and pools are maintained in the reach between WC-4 and WC-1. Pools persisted at WC-4 and WC-1 throughout each summer, no matter how dry the water-year was. However, surface flow between pools ceased each year. In three out of five years WC-2 (downstream of WC-3) dried up before WC-3 dried up. In 2007, the channel also dried up at WC-0.2 and WC-0.5 which are near the confluence with Wooden Valley Creek. The channel also dried up at WC-0.5 in 2009 and 2010.

Surveying a longitudinal profile of the channel between WC-1 and WC-4 would be useful in explaining why WC-2 tends to dry up prior to WC-3. The depth of the pools and the slope of the stream bed interact with the slope of the groundwater surface to determine if the bottoms of the pools penetrate the groundwater surface. WC-2 and WC-3 are in a losing reach and so there is no direct groundwater inflow during the summer. WC-1 and WC-4 appear to receive a significant fraction of groundwater.

WC-2 and WC-3 dried up each year the dataloggers typically were exposed to the air for a portion of the record and so recorded more hours of warm temperatures than the other White Creek stations. WC-4 is in a pool that appears to intersect the water table and so has low temperatures and low dissolved oxygen. WC-1 may receive flow through streambed gravels from the right bank tributary.

Table 11 compares the dissolved oxygen (DO) for the early summer reading in 2006 and the late summer readings from 2005, for both WC-1 and WC-4. The median DO at WC-1 was 2.86 mg/L in June of 2006 and was 2.39 mg/L in August 2005. The median DO at WC-4 was 0.12 mg/L in June of 2006 and was 0.06 mg/L in August 2005. The DO is probably low at WC-4 because the water is primarily groundwater.

Figure 42: Stations White Creek 1 (top) and White Creek 2 (bottom)

Table 10: The number of occurrences when the temperature exceeded 80 °F for more than 2.8 hours. Formulas in the literature suggest that 10% of steelhead subjected to 80 degree water for 2.8 hours would be expected to die. Data includes days when the channel was dry or the temperature recording unit was exposed to air. Numerous dead steelhead trout were found at WC-1 and WC-3 on 7/24/2006.

Station	2002	2003	2005	2006	2007	2009	2010
WC-4	0	4	0	0	2	0	--
WC-3	46	3	--	20	62	50	--
WC-2	9	0	--	16	40	54	--
WC-1	0	0	0	4	0	12	--
WC-0.5	--	--	--	--	14	37	56
WC-0.2	--	--	--	--	0	--	--
Water-year Precipitation	25.69”	33.30”	30.92”	41.88”	14.90”	21.30”	28.90”
Percentile Rank	63.7%	81.3%	74.5%	97.0%	9.8%	43.2%	68.2%
Exceedance Probability	36.3%	18.7%	25.5%	3.0%	90.2%	56.8%	31.8%

Table 11. Comparison of early and late summer dissolved oxygen (DO) values at WC-1 and WC-4. In 2005, sondes were deployed in late summer from 8/19 to 9/2/2005 at WC-1 and WC-4. In 2006, sondes were deployed in early summer from 6/13 to 6/27/2006 at WC-1 and WC-4. The early summer DO readings were higher than the late summer readings at both WC-1 and WC-4. The DO at WC-1 was less than 3.0 mg/l for 3 days and 9 hours between 6/20 and 6/24/2006. In 2005, the DO was less than 3.0 mg/l for two periods almost 3 days each. The DO at WC-4 is consistently below 3 mg/l for extended periods of time and therefore is judged to be too low to support steelhead.

Impairment Level	Level of Effect Water Column DO (mg/L)	WC-1 8/19 to 9/2/05 Dissolved Oxygen Percentile	WC-1 6/13 to 6/27/06 Dissolved Oxygen Percentile	WC-4 8/19 to 9/2/05 Dissolved Oxygen Percentile	WC-4 6/13 to 6/27/06 Dissolved Oxygen Percentile
No Production Impairment	8	N/A	N/A	N/A	N/A
Slight Production Impairment	6	99.0%	88.2%	N/A	N/A
Moderate Production Impairment	5	84.8%	80.5%	N/A	N/A
Severe Production Impairment	4	66.7%	64.0%	N/A	N/A
Limit to Avoid Acute Mortality	3	56.3%	52.5%	N/A	97.0%
Maximum Oxygen Conc. mg/l		6.1	7.75	2.32	3.57
Median Oxygen Conc. mg/l		2.39	2.86	0.06	0.12
Minimum Oxygen Conc. mg/l		0.04	0.2	0.04	0.10

Fine Sediment and Streambed Conditions

Three separate procedures were utilized to characterize the streambed of Suisun Creek and Wooden Valley Creek. The three streambed studies were: 1) repeat surveys of monumented cross-sections; 2) bed material analysis and pebble counts; and 3) permeability analysis.

Topographic surveys

The repeated topographic surveys of the two study reaches showed that the Wooden Valley Creek Study Reach experienced more change than the Suisun Creek Study Reach. The comparison of the thalweg profiles for Suisun Creek shows that roughly 0.8 feet of material has been deposited along the thalweg between 2001 and 2006 between Cross-section 1 and 4. The thalweg of the pool just upstream of Cross-section 4 deepened between 2001 and 2006. The riffle downstream from Cross-section 6 and 5 experienced a minor amount of deposition along the thalweg between 2001 and 2006. The amount of change observed in the Suisun Creek thalweg profile is within the range of expected annual variation on most moderate-sized streams.

The study reach on Wooden Valley Creek can be characterized as two low gradient sections separated by a steeper reach around Cross-section 4. The 2006 profile shows significant deposition, relative to 2001, above and below the constricted reach that extends up and downstream from Cross-section 4. The 2006 profile shows significant scour, relative to 2001, at and just upstream of Cross-section 3. Some minor scour is visible downstream of Cross-section 2 on the 2006 profile relative to the 2001 profile.

Significant willow growth has occurred in the Wooden Valley study reach between 2001 and 2006. The lower portion of the Wooden Valley Study Reach may be in the backwater area of the confluence of Suisun Creek and Wooden Valley Creek during very large discharges such as occurred in 2006. The deposition at Wooden Valley Cross-sections 1, 2, 5 and 6 may reflect a combination of backwater deposits and deposits due to the presence of the thick willow forest.

Bed Composition

Pebble counts were carried out at 12 locations with subsurface sediment samples collected at 10 locations. Table 12 shows the particle size distribution obtained by a surface pebble count and the average cobble embeddedness values for the Suisun Creek and Wooden Valley Creek sampling stations. Several stations do not have values for the D15 or the D10 because these diameters were less than 4 mm and so could not be measured with a ruler during the pebble count. Table 48 shows that the largest D85 (diameter of the rock that is larger than 85% of the rocks measured) occurs well downstream of the dam at the water level recorder that was installed downstream of SC-7.5 (Below SC-7.5). The pebble count data for stations SC-5.6 and SC-4.5 appear to be the coarsest for Suisun Creek, when all six of the percentile classes are considered. This suggests that local hydraulic conditions and bed material supply sources may be more important in determining the surface particle size distribution than the proximity of the dam or “hungry water” effects.

Table 12: The particle size distribution obtained by a surface pebble count and cobble embeddedness values for Suisun Creek and Wooden Valley Creek. The D85 is the diameter, in millimeters, of the rock size that is larger than 85% of the measured rocks. The D50 is the median rock diameter, in millimeters. The embeddedness values are the percentage of the rock diameter that was buried in the bed material. The *Number of Rocks Measured* is the number of rocks larger than 64 mm in diameter used to determine the average embeddedness at a station. The stations in the table are arranged from upstream to downstream. All values for D85-D10 are in millimeters.

Station	D85	D60	D50	D30	D15	D10	Embedded-ness	Number of Rocks Measured for embedded-ness
Suisun Creek								
SC-9.5	37.13	17.96	12.86	5.91	--	--	41%	20
SC-8.5	62.63	27.76	17.18	--	--	--	51%	17
Below SC-7.5	83.10	33.75	22.13	7.89	--	--	50%	19
SC-6B	30.23	14.89	11.41	6.59	--	--	53%	1
SC-6A	40.58	21.56	18.13	12.52	8.08	6.53	66%	7
SC-5.6	77.08	46.09	38.41	22.16	--	--	37%	17
SC-4.5	62.94	40.87	34.55	23.57	7.36	--	51%	29
SC-3	49.65	32.71	26.17	14.18	7.31	--	32%	16
Wooden Valley Creek								
WV Pebble #1	353.11	134.40	82.00	38.13	16.38	5.20	42%	17
WV Pebble #2	51.87	16.51	9.20	--	--	--	62%	17
WV Pebble #3	61.56	30.80	23.58	8.69	--	--	32%	28
WV Pebble #4	75.79	17.54	10.28	4.32	--	--	49%	25

Figure 43: Pebble Count Stations on Suisun and Wooden Valley Creeks

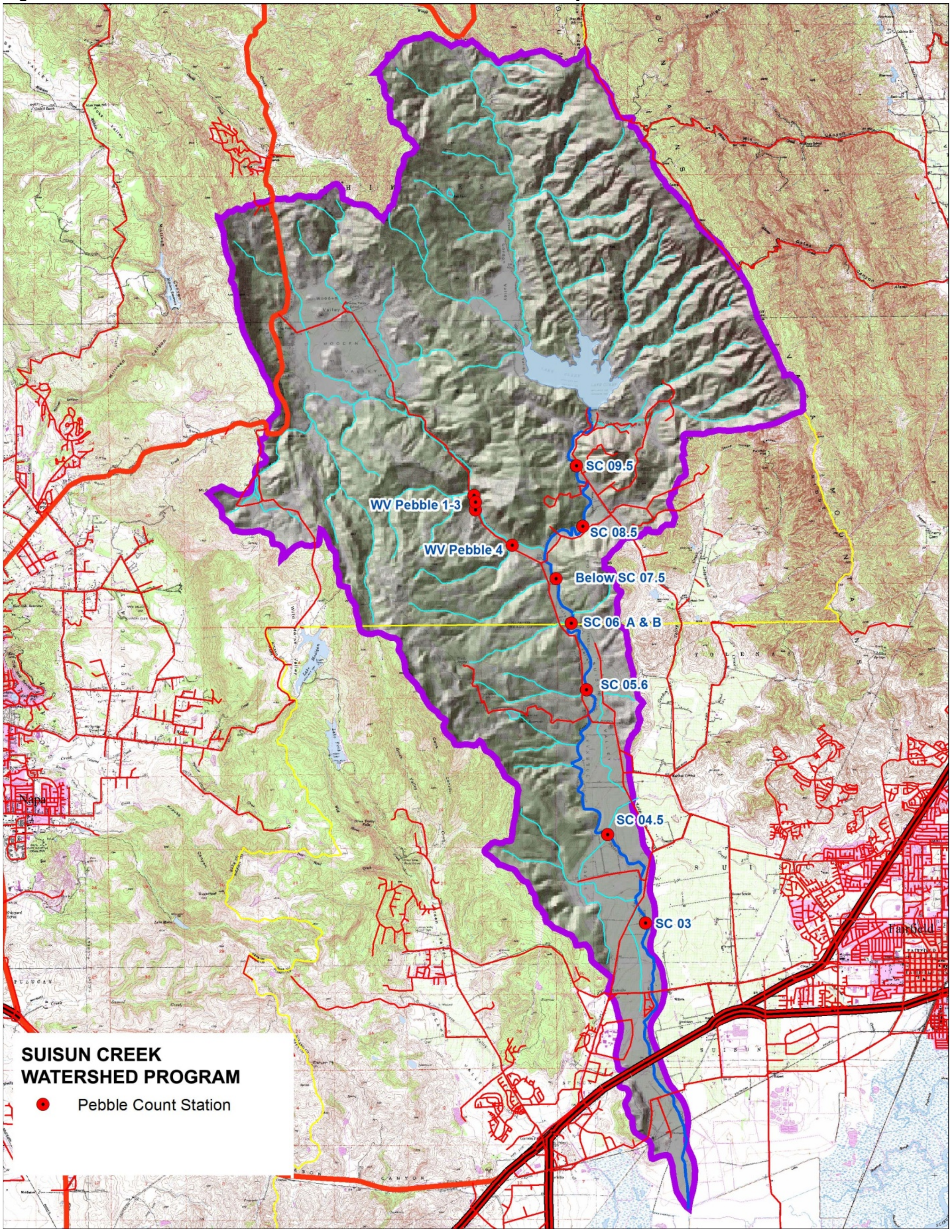


Figure 44: Subsurface Sediment Sampling Stations on Suisun and Wooden Valley Creeks

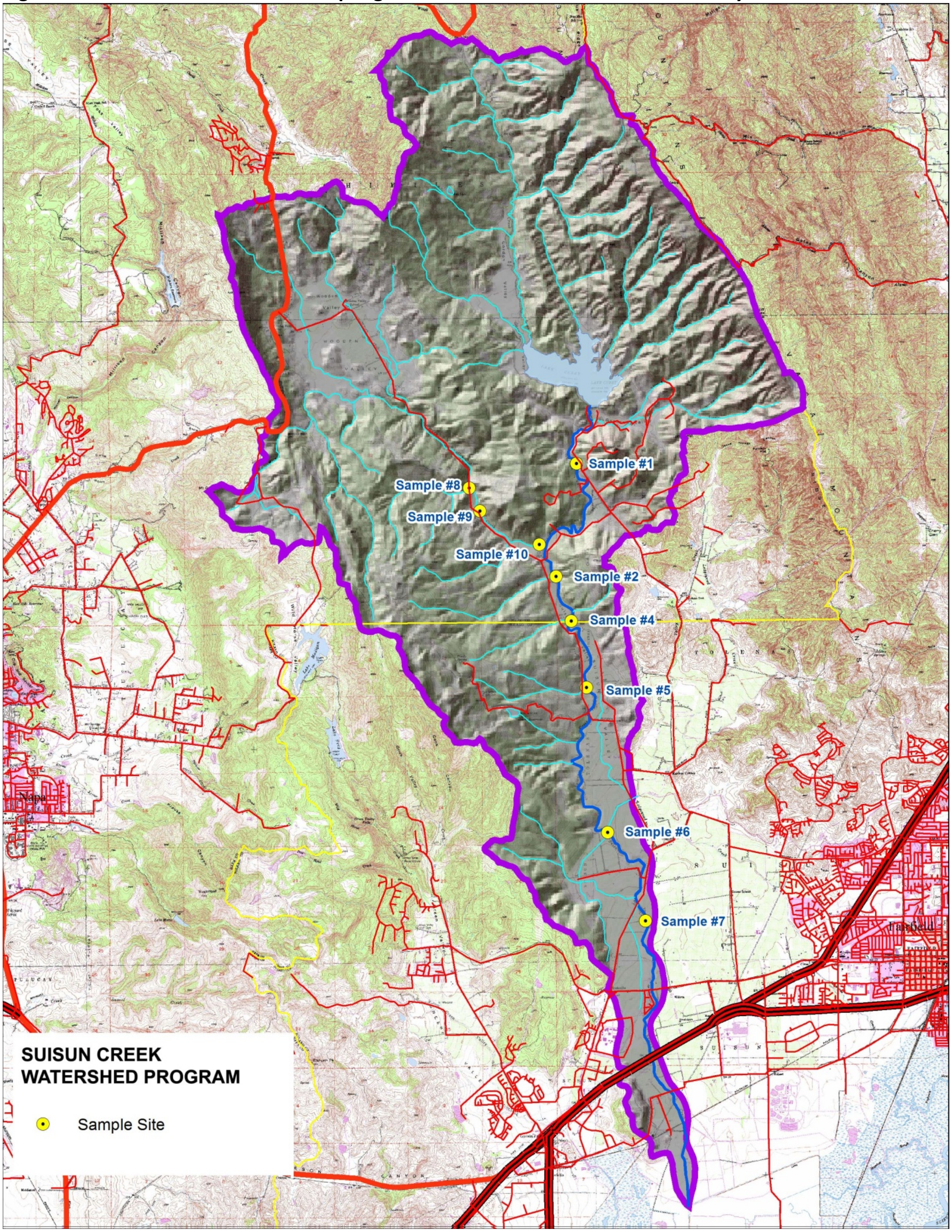


Figure 45: Permeability Sampling Stations on Suisun and Wooden Valley Creeks

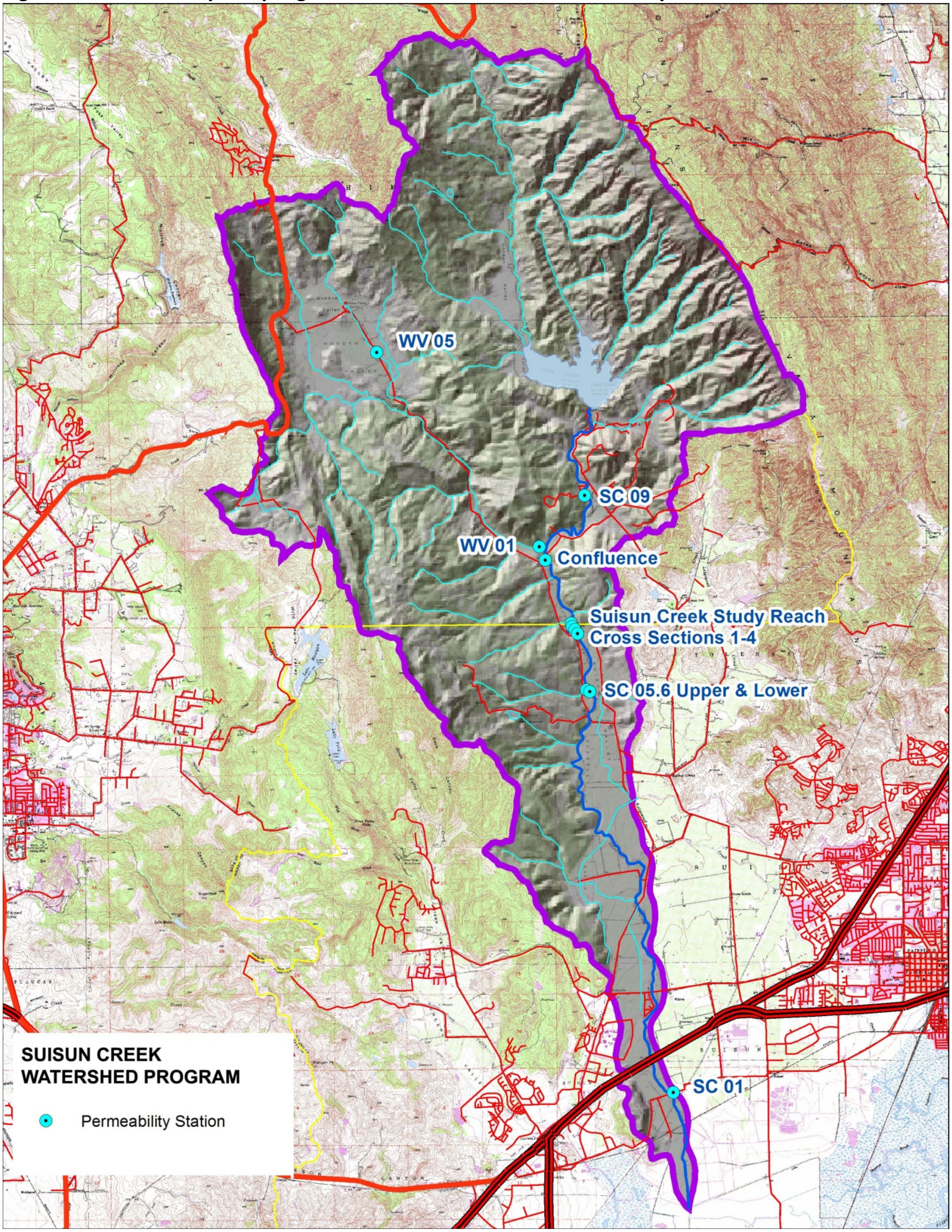


Figure 46: Pebble count (top) and channel surveying (bottom)

Permeability

Permeability was measured at nine places along Suisun Creek and at two places on Wooden Valley Creek during the summer of 2005. At each place, three to nine different locations on the streambed were sampled. The purpose of these permeability measurements was to get a general sense of the variation in permeability at selected sites. This study was not designed to evaluate the quality of spawning gravel throughout the Suisun Creek channel network.

Both of the Wooden Valley sites had medium permeability. Six of the Suisun Creek sites had medium permeability values and three of the sites had low permeability values. The only site with gravel permeability greater than or equal to 7,000 cm/hr was the confluence of Wooden Valley Creek and Suisun Creek.

Collecting permeability data appears to be more cost effective that bed material sampling, for the purpose of assessing the quality of spawning gravel. Permeability values were collected at eleven sites with either a one or two person crew. The raw field data were easily entered into a spreadsheet which produced estimates of survival-to-emergence.

Benthic Macroinvertebrates (BMI) or Aquatic Insects

Biological assessment, or bioassessment, is the evaluation of the condition of an ecosystem based on the taxa present in that environment. In recent years, bioassessment has been considered the most appropriate and efficient means to evaluate overall stream health, rather than a complete reliance on chemical and physical measurements. Benthic macroinvertebrates are the organisms most frequently used in aquatic bioassessment because they are ubiquitous in stream environments, have relatively long life cycles, a range of tolerance to perturbations, and provide a cost-effective way to assess water quality and habitat conditions. This study used benthic macroinvertebrates as biological indicators of water quality to compare ecological conditions within various sites in the Suisun Creek watershed in 2001 and 2007.

Seven sites were re-sampled of the 10 sampled by SWAMP in 2001 (Figure 47 and 48). The objective of this study was to evaluate biological (benthic macroinvertebrate) and physical habitat conditions in the Suisun Creek watershed by sampling sites along the main stem of Suisun Creek and two tributaries (Wooden Valley Creek and White Creek). The sampling results from April 2007 are compared to the biological results at similar sites in 2001 to determine if there has been any change in biological condition over the past 6 years.

Overall, the biological condition of local benthic macroinvertebrate communities within the Suisun Creek watershed have not changed significantly between 2001 and 2007. The lack of change between 2001 and 207 indicates that the conditions in the Suisun Creek watershed have not detectably declined or improved over the past six years. In addition, the biological condition among sites in the Suisun Creek watershed displayed similar conditions, with the exception of White Creek. The high quality of White Creek provides critical undisturbed habitat to sensitive invertebrate taxa and potentially other organisms such as fish, amphibians, and mammals.

Figure 47: Surface Water Ambient Monitoring Program (SWAMP) Monitoring Stations in Suisun Creek Watershed Sampled in 2001.

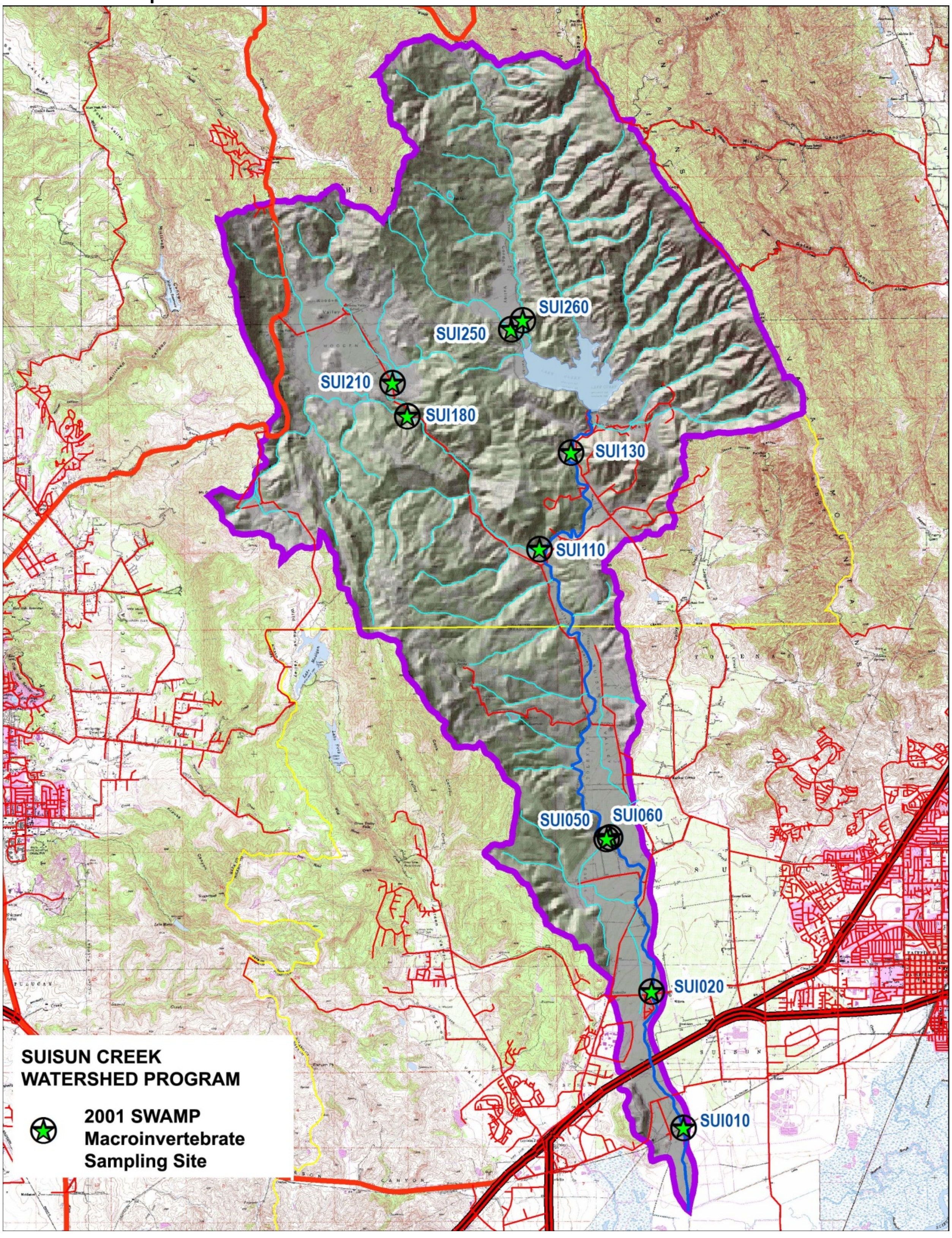


Figure 48: Benthic Macroinvertebrate Sampling Locations in 2007

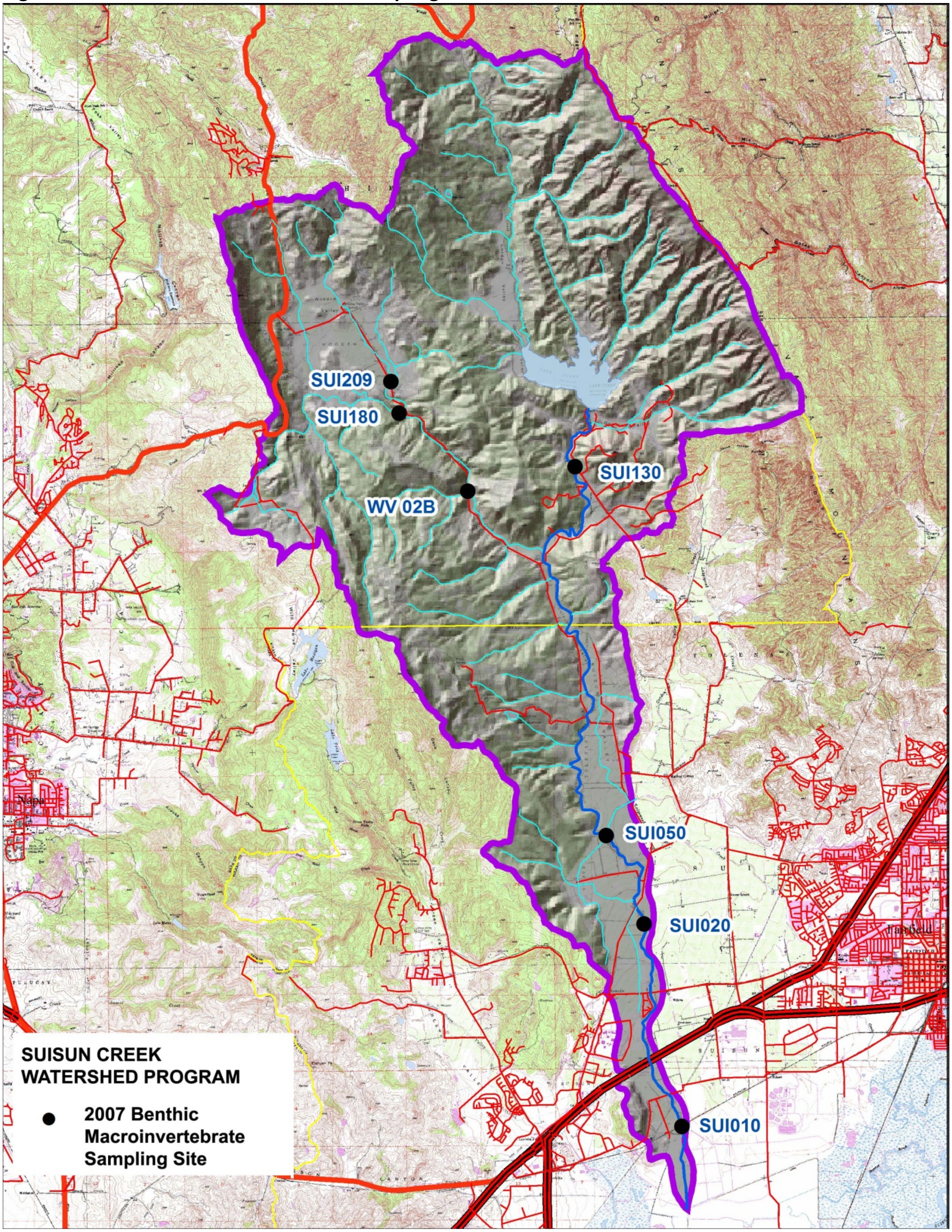


Figure 49: Alison H. Purcell PhD & Matthew R. Cover PhD Aquatic Ecologists sampling aquatic insects in Suisun Creek

MONITORING SUMMARY AND RECOMMENDATIONS

The monitoring of water temperature, water quality, fine sediment and riparian canopy has been used to direct projects and improvements in the Suisun Creek watershed. The watershed plan recommended the following projects which were implemented under the CalFed grant:

- An engineering study and model of Lake Curry to determine operational regimes to support the cold water fishery in Suisun Creek.
- Mapping of *Arundo donax* on Suisun Creek and development of an eradication strategy.
- Permitting and removal of *Arundo donax* along 4 miles of Suisun Creek in Napa County, with native revegetation to follow eradication.
- Removal of other invasive plants and revegetation of 1.3 miles of lower Wooden Valley Creek and revegetation on Suisun Creek.
- Implementation of the Fish Friendly Farming Environmental Certification Program on over 3,000 acres of irrigated agricultural lands to reduce fine sediment and improve riparian corridors.
- Community meetings and workshops, Suisun Creek Restoration Team meetings and additional outreach to watershed landowners. For the most part, Suisun Creek watershed is very sparsely populated; thus, one-on-one meetings are more effective than group meetings.
- Workshops for rural residents to reduce erosion and chemical use on these lands.

In 2008, the Ca. State Coastal Conservancy provided grant funding for the following projects:

- Extension of Arundo removal efforts down Suisun Creek in Solano County and revegetation with native trees.
- Engineered design for removal of a fish migration barrier on Wooden Valley Creek.
- Revegetation of Upper White Creek along with stream flow, water temperature and water quality monitoring to improve salmonid rearing habitat.

In 2009, the Ca. Department of Transportation provided funding for additional Arundo removal and native plant revegetation. Under a grant from the State Water Resources Control Board, a major bank erosion site was repaired. Revegetation was completed with CalFed grant funds. The San Francisco Foundation Bay Fund provided grants to remove Arundo and revegetate with native trees and for the fish survey. The Department of Conservation provided a watershed coordinator grant to allow for more outreach to landowners and facilitate project implementation.

Based upon the monitoring and analysis and ongoing project implementation we recommend the following future actions:

<u>Suisun Creek</u>

1. Lake Curry Operations

The study of Lake Curry concluded that during a normal or wet year, the reservoir is full on April 1 and can release 5.5 cfs from April 1 to November 1 of 68^{o} F water. The 2006 Lake Curry release experiment found that a maximum release of 6 cfs of cold water only created cold water conditions at Stations SC 10 to SC 8. The analysis of the 2006 experiment found that the stream temperatures warmed downstream of SC 8 largely due to the large volume of water in the creek channel heated by solar inputs and the lack of riparian canopy.

The release experiment provided one season of data for temperatures produced with different releases. Additional release experiments are needed to refine what temperatures can be achieved under various sets of environmental parameters. Target temperature objectives need to be established for a series of locations downstream of Lake Curry. These objectives would define the maximum allowable water temperature and the maximum number of continuous hours of the maximum allowable temperature for half-mile increments below the dam. The methods to achieve these objectives can be determined through a series of monitoring and release experiments.

Some of the summer release scenarios that need to be analyzed include:

- Release 5.5 cfs from April 1 to November 1 under normal/wet years and dry/very dry years with temperature and flow monitoring in Suisun Creek to determine effects on cold water habitat.
- Provide a nominal release of 2.5 cfs in normal/wet years and maintain Lake Curry level at full for dry/very dry years. It would be useful to evaluate the relationship of the reservoir level to rainfall and summer water temperatures through comparisons of long-term records of these three data sets. This evaluation will determine if dry winters are correlated with hot summers and therefore if conservation of reservoir water for release in dry/very dry years is important.
- Evaluate the long-term air temperature record from gages in the Lake Curry area. Define an air temperature that triggers the maximum water temperature objectives and therefore changes the release rate. This scenario would provide for a nominal release (2.5 cfs) until weather predictions forecast that air temperatures will reach the trigger air temperature and as a result water releases are increased to 6 or 8 cfs over the heat wave period.
- Release nominal amounts (2.5 cfs) until the hottest months of the summer—July/August—then increase releases to 6 or 8 cfs unless air temperatures are abnormally mild.
- In wet years, natural groundwater flows may provide cooler water than reservoir releases can. Stopping releases should be timed with water temperature and flow monitoring.

In addition to temperature dataloggers stream flow gaging stations need to be established for year round continuous monitoring.

As part of the Lake Curry evaluation, the agencies and organizations involved in the Watershed Program need to work with the City of Vallejo to revise their water right to allow for a high flow water diversion at Putah South Canal along with summer/fall water releases from Lake Curry for Suisun Creek fish habitat enhancement.

Another possible alternative for Lake Curry would be for a conservation organization or agency to purchase the reservoir from the City of Vallejo and operate the reservoir for the benefit of the salmonids downstream. The annual management cost might be covered by the revenue from the sale of the water once an agreeable method of diverting the 5,000 acre feet of water covered by license #5728 is completed and approved by the State Water Resources Control Board. It is possible that this alternative could also provide a new recreation area although the management of Lake Curry would need to address salmonid issues first and recreational management second.

Another question that should be evaluated is the timing each year of when flows go over the spillway of Lake Curry and thus may serve as attractant flows for spawning adult salmonids. It is not known if the reservoir significantly changes the timing of larger flow levels in Suisun Creek and therefore has any effect on the timing of adult migration and spawning. Investigation of this question will require establishing stream flow gages at a number of locations on both Suisun and Wooden Valley Creeks.

2. Riparian Canopy
In addition to varying water releases, a long-term program to increase riparian shade canopy along the creek and restore a more natural width to depth ratio will sustain cooler temperatures in Suisun Creek.

Planting trees to increase the riparian canopy over the stream is another action needed to reduce summer water temperatures in Suisun Creek. However, it will take over ten years of growth to significantly reduce the heat load on the creek. Large size native trees (1-5 gallon) if planted in winter and irrigated well over the summer months could reduce the time period for development of a shade canopy.

Another short-term measure that could temporarily reduce solar inputs would be to stretch shade cloth across the channel in summer. This could be tried after trees are planted. The effects on birds and other wildlife would need to be assessed. The most effective location for installing shade cloth would be between SC-10 and SC-7, the upper reach. The upper reach undergoes rapid heating as the water released from the dam moves towards thermal equilibrium. Shading or cooling the Upper Reach should decrease the rate the water heats up as it travels downstream and potentially reduce water temperatures further downstream.

The upper reach of Suisun Creek is the highest priority area for revegetation.

3. Fine Sediment
Find sediment levels continue to be too high and impair salmonid spawning and rearing habitat. The Fish Friendly Farming program and new Fish Friendly Farming for Rangeland program can be used to continue water quality improvements. Public and private roads as well as vineyards, rangeland and rural residential lands need to implement Best Management Practices to reduce fine sediment inputs.

Suisun Creek in Solano County has a highly entrenched channel with vertical stream banks of 20-30 ft. These vertical banks are likely to fail in floods. Near monitoring stations 5.5 and 5.6, there is a distinct change in the creek morphology and it appears that a major nickpoint is moving upstream. The geomorphologic processes in Suisun Creek from station 5.6 downstream need to be investigated in order to direct restoration measures. A longitudinal profile of the creek with channel cross sections at 500-1,000 ft. intervals is needed. Additionally, agencies and organizations working on bank erosion projects need to use bank setbacks to widen the channel and produce reductions in flow velocity as a primary design criterion not harden banks to stabilize them and increase erosion downstream.

4. Fish Surveys, Water Temperature and Stream Flow Monitoring
Additional fish surveys are needed to better document juvenile steelhead trout distribution along with water temperature and stream flow information. These studies are needed to determine the best options for operating Lake Curry releases.

5. Support Agricultural Land Uses
The Suisun Creek watershed is primarily rural and as such has physical processes of rainfall infiltration and runoff closer to natural levels than urbanized watersheds. It is important that agricultural land uses remain economically viable and therefore urbanization is limited.

Wooden Valley Creek

1. Riparian Canopy

There are a number of locations along Wooden Valley Creek where additional riparian canopy is needed. The project on the lower 1.3 miles of the creek should continue to be maintained and replanting implemented as needed.

2. Fine Sediment

Find sediment levels continue to be too high and impair salmonid spawning and rearing habitat. The Fish Friendly Farming program and new Fish Friendly Farming for Rangeland program can be used to continue water quality improvements. Public and private roads as well as vineyards, rangeland and rural residential lands need to implement Best Management Practices to reduce fine sediment inputs.

Portions of Wooden Valley Creek have a highly entrenched channel with vertical stream banks of 20-30 ft. These vertical banks are likely to fail in floods. A longitudinal profile of the creek with channel cross sections at 500-1,000 ft. intervals is needed. Additionally, agencies and organizations working on bank erosion projects need to use bank setbacks to widen the channel and produce reductions in flow velocity as a primary design criterion not harden banks to stabilize them and increase erosion downstream.

3. Fish Surveys, Water Temperature and Stream Flow Monitoring

Fish surveys are needed to document juvenile steelhead trout distribution along with water temperature and stream flow information. These studies are needed to determine future restoration projects

4. Fish Migration Barrier

Funding is needed to remove a fish migration barrier on lower Wooden Valley Creek. An engineered design has been completed.

White Creek

1. Riparian Canopy and Monitoring

In 2011, a revegetation project for upper White Creek will be implemented to increase shade canopy and reduce the channel drying at stations WC 2 and WC 3. This project will include the installation of a stream flow monitoring gage, shallow groundwater monitoring and a longitudinal survey. The data from these efforts will be used to evaluate how to increase stream flow and dissolve oxygen to improve steelhead trout rearing habitat.

There are additional areas downstream of station WC 1 where revegetation is needed to shade the creek.

IV. CONCLUSIONS

This project was successful in implementing the first set of actions identified in the Suisun Creek Watershed Enhancement Plan including:

- Revegetation of riparian forest along nine miles of Suisun and Wooden Valley Creeks to increase shade canopy and improve cold water habitats
- Removal of invasive non-native species Arundo donax and Himalayan blackberry from five miles of the riparian zone of Suisun and Wooden Valley Creeks
- Enrollment of over 3,700 acres of farm and rangeland in the Fish Friendly Farming Environmental Certification Program with application of Best Management Practices (BMPs) to control fine sediment pollutants from dirt roads, vineyards, drainage facilities and culverts and stream banks. The FFF program , while providing a thorough conservation review and certification program also allows for farmers to be involved in an environmental program and feel proud of their certification
- A broad monitoring program for water temperatures, water quality (dissolved oxygen, pH and specific conductance), fine sediment, stream channel form, benthic macroinvertebrates and riparian canopy was completed. The results of the monitoring have defined the next set of needed projects.
- A modeling study of Lake Curry was developed to determine the temperature of water releases at various release rates and for different water years. This information was used with a real time experiment looking at stream temperatures on Suisun Creek under various release levels. This experiment and modeling study led to a broader understanding of how Lake Curry can be managed for cold water habitat and what additional monitoring and evaluation is needed.

This project set out to improve collaboration between public and private parties, increase the number of informed citizenry and landowners/managers, and improve watershed ecosystem maintenance and enhancement as documented in the Project Assessment and Evaluation Plan (PAEP). Through implementation of the actions described in this report, crucial beneficial uses of the Suisun Creek watershed have been improved.

V. APPENDICES

A. Fish Friendly Farming Environmental Certification Program Implemented BMPs Table for the Suisun Creek Watershed (attached)

V. APPENDICES

A. Fish Friendly Farming Environmental Certification Program Implemented BMPs Table for the Suisun Creek Watershed (attached)

Site ID*	EL 3 : MANAGING THE VINEYARD																																								
	Soil Conservation					Drainage system						Pest and Disease Control													Water Supply and Conservation											Replanting					
	Winter cover crop use over entire vineyard floor and terraces by Oct. 15, use of a perennial cover crop, or if harvest is later than Oct. 15, install erosion control practices by Oct. 15, then seed cover crop post harvest.	No tilling in the vineyard until after end of rainy season and no sooner than April 1. Mowing to reduce frost damage is okay.	Winterization of turnarounds, roads and other areas in vineyard and adjacent areas by Oct. 15, or harvest is later than Oct. 15, install erosion control practices by Oct. 15, then seed cover crop post harvest.	Installation of vegetated filter strips by Oct. 15, or if harvest is later than Oct. 15, install erosion control practices by Oct. 15, then seed cover crop post harvest.	Emergency erosion control preparedness by Oct. 15	Drainage improvements in vineyard are designed at a minimum for the 50 to 100-year frequency rainfall event.	Farmer completes annual inspection and maintenance of drainage system including inlets and outlets.	Farmer completes winter inspections and repairs to drainage system as needed.	Farmer completes repairs to drainage system (resizing to increase capacity) as needed.	Revegetation of swales and ephemeral streams.	All outlets of drainage system have adequate energy dissipaters or basins.	Monitor insects prior to use of chemical control.	An integrated pest management system is used.	Limit use of pre-emergent, persistent herbicides and/or persistent pesticides (organophosphates) unless directed by Napa County Agricultural Commissioner.	Limit use or revise application methods for pesticides and herbicides within 50 ft. of waterways.	Manage riparian corridor to remove non-native and host plants to reduce Pierce's Disease.	Storage of chemicals follows County Agricultural Commissioner guidelines.	Chemical mixing and loading sites and rinse/wash practices are protective of surface and groundwater quality.	Wind and rain conditions are monitored before, during and after spray applications.	Spray applications follow a methodology that takes into account weather, drift, state of equipment neighbors, and other conditions.	Well head protection is in place and farmer is aware of GWPA zones and regulations.	A backflow protection system is in place and farmer has a spill prevention plan.	Farmer has hazmat plan if necessary.	Reservoirs are managed with environmentally friendly algaecides.	Water conserving irrigation practices are used.	Irrigation system is regularly checked for leaks.	Soil moisture/plant condition is monitored to determine irrigation needs.	Change irrigation blocks to allow for lower volumes of direct diversions and spread irrigation perio over longer time (only applies to direct diversions and riparian water rights).	Fish screens are installed.	French drain type pump used in gravel.	Wastewater is used in summer.	Water right permit/license issued.	Winter diversion (December 15-March 31) into off-channel reservoir.	Evaluation of change from on-channel to off-channel reservoirs.	Evaluation of change from summer riparian diversion to winter diversion and off-channel storage.	Replanting program includes soil conservation practices during installation.	Replanting program incorporates filter strips and relocation of vineyard roads away from creeks.	Replanting program includes upgrades to drainage and revegetation of ephemeral creeks.	Replanting program incorporates water conservation features.	Replanting program reviews fencing for wildlife migration.	Additional erosion control project identified and implemented
1	X	X	X	X	X	N/A	X	X	X	N/A	N/A	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2																																									
3	X	X	X	X	X	N/A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	X	X	N/A	N/A	N/A	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4																																									
5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6																																									
7																																									
8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A	X	N/A	N/A	N/A	N/A	X	N/A	N/A	N/A	N/A	X	N/A	X	X	X	X	X	X	X	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	N/A	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X
12	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	N/A	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	N/A	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	N/A	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	N/A	X	X	X	X	X	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

* Numbers in yellow refer to certified sites; numbers in brown refer to enrolled sites that have not yet been assessed

Site ID*	EL 5 : ROADS											EL 6A: CRK/RVR Unconfined								EL 6B: CRK/RVR Confined										EL7	EL 8	
	Completion of road survey and identification of road problems.	Changes in road drainage and surface design (for example, inslope to outslope).	Replacement and repair of ditches, ditch relief culverts, energy dissipaters.	Increase in frequency of water bars, rolling dips, or ditch relief culverts.	Closure or relocation of roads with continual erosion problems, those built on unstable ground, or too close to creeks. Plan should include road restoration and closure actions.	Repair/replacement of stream crossings with a minimum of seasonal crossings and use of bridges for year-round creeks.	Maintenance and inspection of all culverts, energy dissipaters, road surfaces, stream crossings, and ditches.	Winterization of all seasonal roads.	Winter inspection of all stream crossings and removal of wood and debris to avoid failures.	Periodic maintenance of road system with regular inspection program.	Additional road improvements identified and implemented.	Completed inventory of alluvial channel riparian corridor condition and other factors with maps, aerial photos, site photos and required information included.	Current management practices are reviewed and revisions recognized.	Assessment of necessary width for sustainable corridor is completed	If upslope problems such as on-channel reservoirs and roads are on the property, they are addressed in the other required elements of the farm plan.	If upslope or river channel problems are affecting the stream corridor, problem is identified and owner will work with the Fish Friendly Farming program instructor to address problem.	For highly altered corridors and moderately altered corridors, restoration and management strateg and timeline are attached.	For all other types of corridors - revegetation and management strategy with timeline is completed	Additional revegetation/restoration project planned and implemented	Completed inventory of confined channel riparian corridor condition and other factors with maps, aerial photos, site photos and required information included.	Completed Elements II, III, IV, and VII to address road crossings, erosion, water diversions and stewardship groups.	Stabilize landslides along channel and on canyon slopes.	Do not remove trees that fall into the stream unless a bridge or structure is threatened.	Revegetation of channel banks identified on inventory as bare or without canopy if revegetation with riparian species is appropriate.	Revegetation of slopes and hillsides with native species and forest to increase future supplies of large wood and increase canopy over stream, as well as reduce soil erosion and stabilize slopes.	Installation of large wood and stumps to increase fish habitat.	All activities on slopes near to the streams should avoid disturbing the channel or removing trees within 300 feet of the channel. Forestland studies have shown that large wood and canopy are provided by this 300-foot streamside buffer area.	Work with neighbors to reduce erosion and fine sediment from getting into the creek. Avoid increasing flood volume through avoidance of new road construction, vegetation clearing and urbanization.	Additional revegetation/restoration project planned and implemented	Participate in watershed stewardship and monitoring group if one is organized for your watershed	Provide map with sites for photo monitoring.	Complete photo-monitoring once you are certified.
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
2																																
3	N/A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
4	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X	X	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	X	X	X	X	N/A	N/A	X	X	X	X	N/A	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			
7																																
8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X
16	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	X	X	X

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