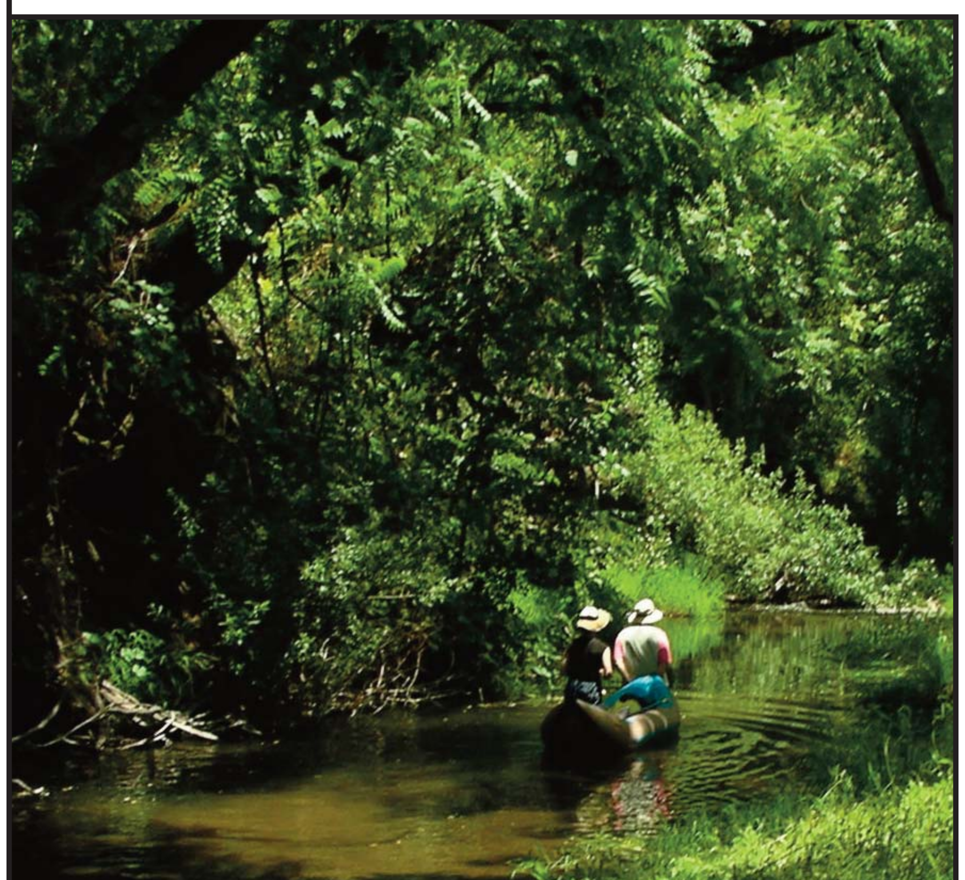
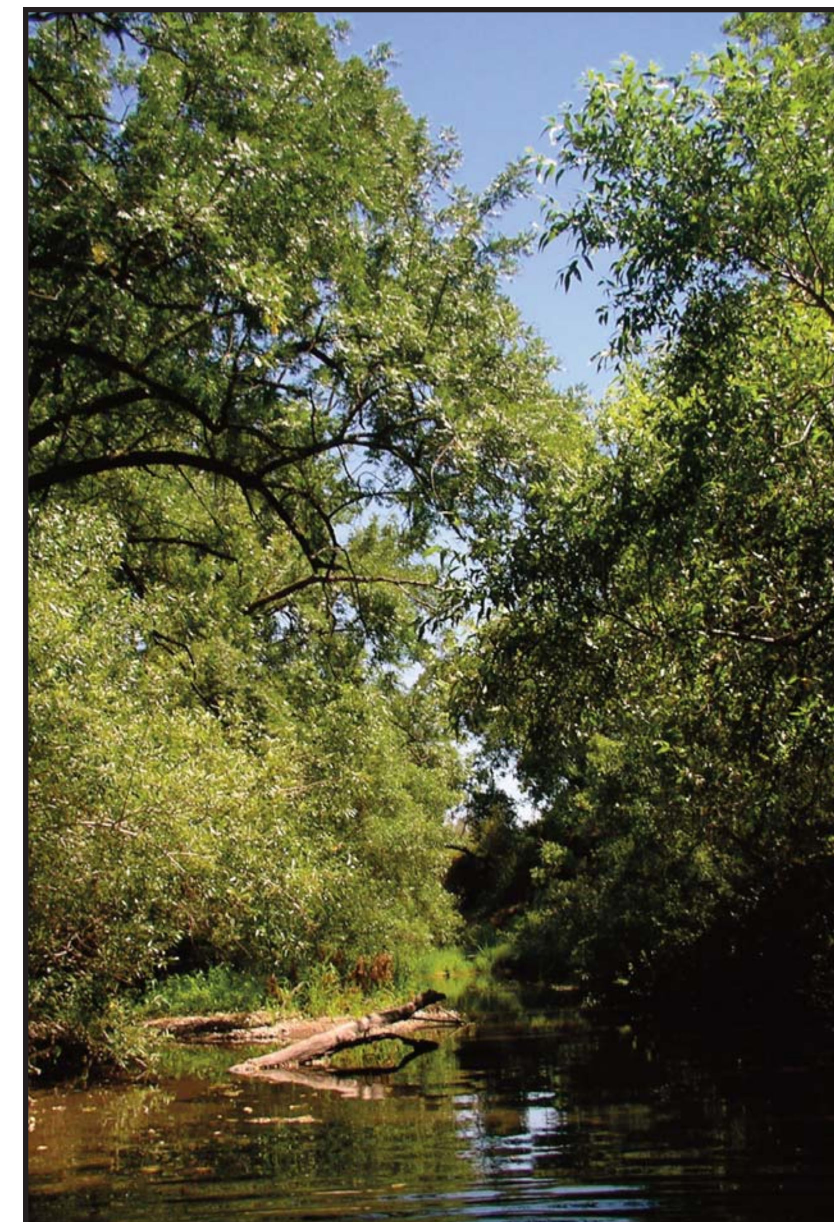
Napa River Sediment Reduction and Habitat Enhancement Plan: Oakville to Oak Knoll

CALIFORNIA LAND STEWARDSHIP INSTITUTE
with
PHILIP WILLIAMS AND ASSOCIATES
NAPA COUNTY RESOURCE CONSERVATION DISTRICT

FUNDING PROVIDED BY
STATE WATER RESOURCES CONTROL BOARD
NAPA COUNTY





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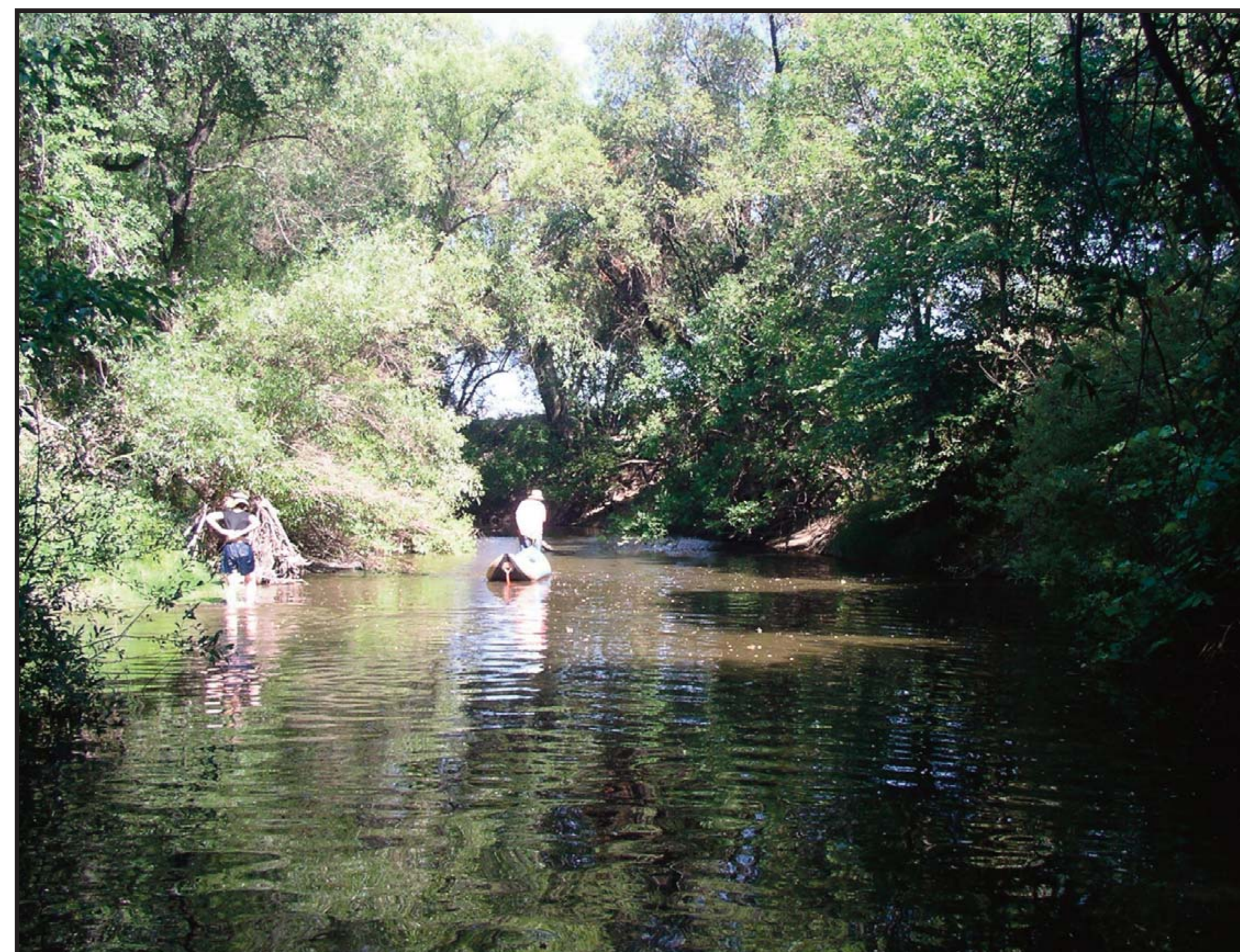
April 2011



Napa River Sediment Reduction and Habitat Enhancement Plan: Oakville to Oak Knoll

Introduction

In 2007 the California Land Stewardship Institute (CLSI) received funding from the California State Water Resources Control Board and Napa County (Measure A) to prepare an enhancement plan for nine miles of the Napa River between the Oakville Cross Road bridge and the Oak Knoll Avenue bridge. This reach of the Napa River is directly downstream from the Rutherford Reach where several years of restoration planning culminated in construction beginning in 2009.

The Oakville to Oak Knoll Reach suffers from channel incision with bank collapse, erosion of channel bedforms (riffles, bars, pools) important to salmonids and a reduced riparian corridor due to the lack of a functional floodplain. Channel erosion was studied in the Napa River Limiting Factors Analysis and identified in the 2005 Technical Report on the fine sediment TMDL for the Napa River as a major source of direct delivery of fine sediment. As the river erodes its bed and deepens the banks collapse directly contributing fine sediment to the river and impairing beneficial uses. The incision of the Napa River channel over the past fifty years has numerous causes including gravel mining and dredging, municipal reservoir development, channel clearing and straightening, and levee construction. Many of these practices such as mining, dredging, channel clearing and straightening are no longer used but their effects remain. Some of the causes, such as reservoirs, cannot really be revised to address the river's problems.

The effects of the incision of the main river channel are now progressing up tributaries, increasing erosion and loss of habitat. Because the base level drop in the main channel causes erosion in tributaries, the incision process is best addressed at its source—the river channel.

The Napa River is one of the only large watersheds in the San Francisco Bay Area which remains in a rural state. With agricultural uses protected and urbanization limited by local zoning, the Napa River has the potential for restoration with long-term benefits to riparian and aquatic habitats. Steelhead trout and Chinook salmon spawn and rear in the drainage with Chinook primarily using the river channel.

The scientific team for the plan is made up of three organizations:

The California Land Stewardship Institute (CLSI) is the lead organization for the plan and is coordinating the science team and Technical Advisory Group, administering the grant, carrying out landowner outreach and involvement, the riparian ecology assessment and water temperature monitoring

The Napa County Resource Conservation District (NRCD) is carrying out topographic surveys of the river channel and fish studies, and

Philip Williams and Associates (PWA) is carrying out geomorphic assessments and hydrodynamic modeling.

PLAN GOALS

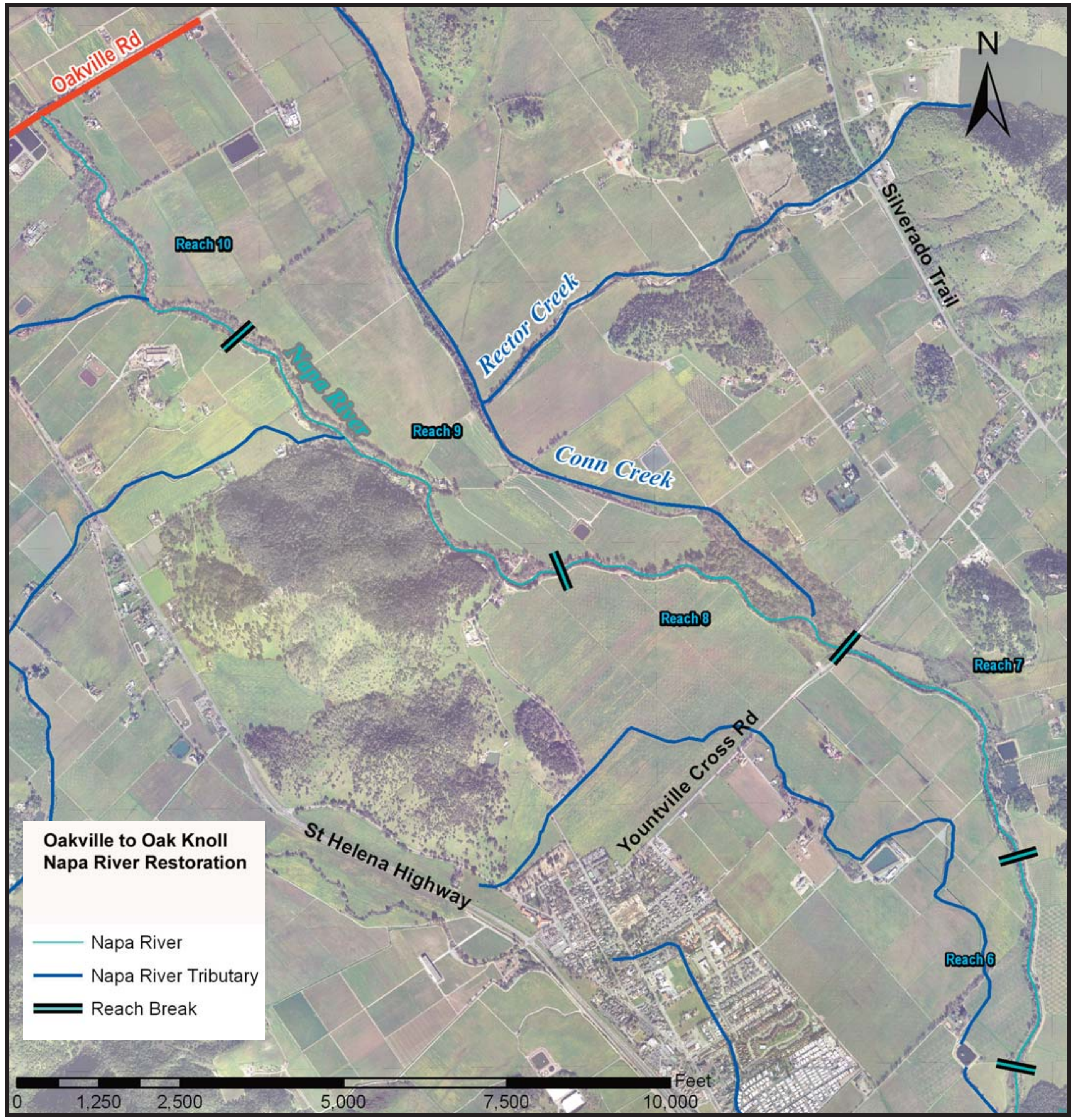
- Reduce property damage from floods and channel erosion
- Increase natural stability in the river system
- Predict and consider future changes in the river channel
- Improve the quality and sustainability of fish and riparian habitat
- Integrate economic use of the floodplain/river with environmental improvements
- Provide for an implementation strategy and timeline that recognizes both private and public needs

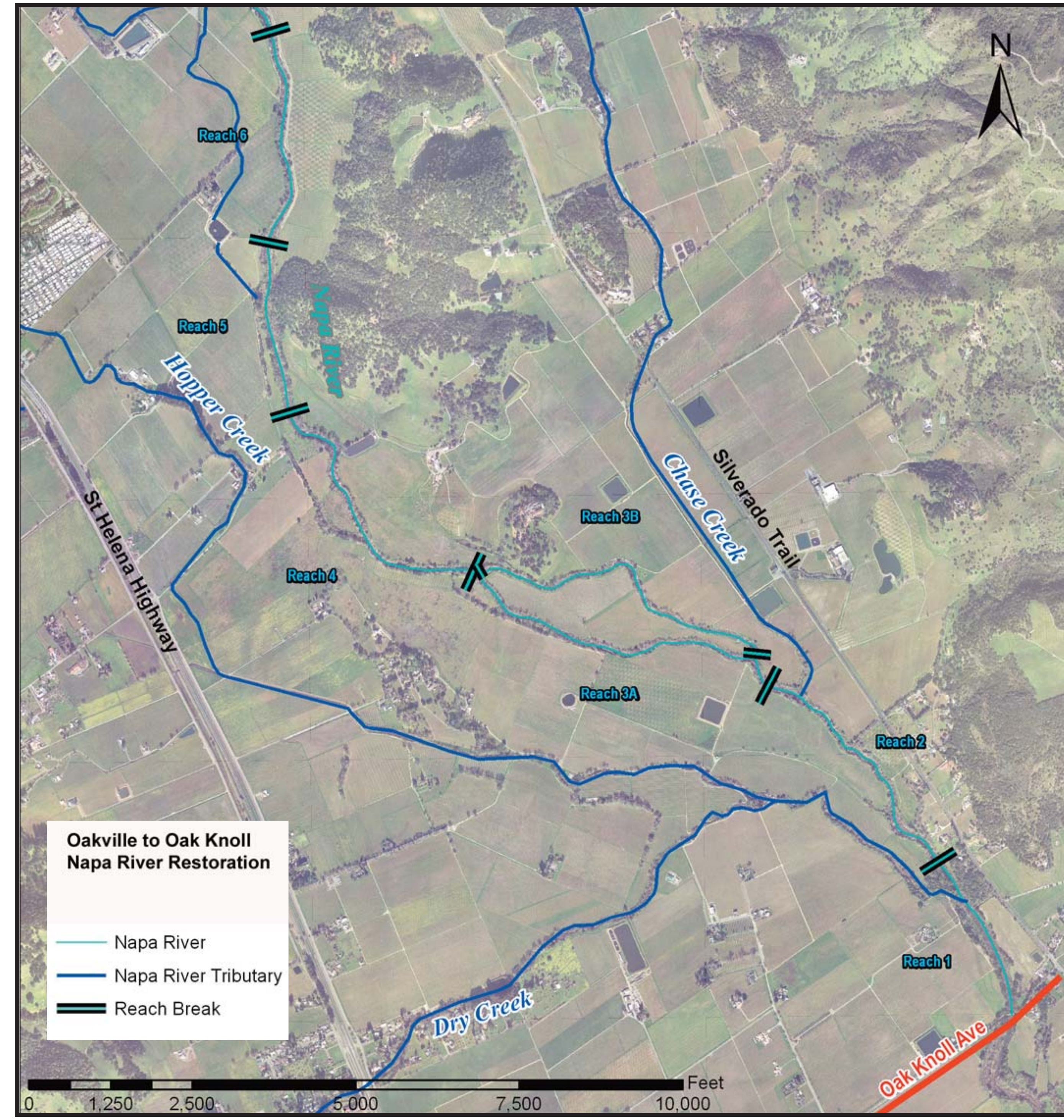
Landowner Involvement

Landowner involvement is critical to implementation of any restoration on the Napa River. The scientific team has held a number of group meetings with the landowners as well as a number of individual meetings. Overall the landowners are interested in improving the river, reducing bank erosion and reducing flooding. For many the worst flood problems are occurring from overland flow moving downstream through vineyards from St. Helena where the river overflows frequently during larger storms.

To address this need we have included additional modeling of this larger regional problem and have included an alternative to study the use of the agricultural floodplain for temporary flood detention with measures to reduce the erosion caused by this uncontrolled water coursing across roads and vineyards. This alternative may prove to benefit both the farmers and the river channel as it would allow for the reduction of peak flood flows and the channel erosion

Throughout the planning stages landowners will be integrally involved in the project and all restoration actions will require landowner approval prior to implementation.





The project area was separated into ten reaches through a review of geomorphic features. All of the field studies use these 10 reaches.

THE GEOMORPHIC AND HYDROLOGIC ASSESSMENT — INTRODUCTION

This section was prepared by Philip Williams and Associates and focuses on those geomorphic and hydrologic attributes that shed light on the problems of erosion, fine sedimentation and loss of salmonid spawning and rearing habitat in the project area. Our data came from five sources:

1. Base topographic mapping from LIDAR

LIDAR (Light Detection and Ranging) is a mapping technique that fires beams of laser light from an aircraft to the ground and measures elevation very precisely. LIDAR topographic data for the Napa River was collected and made available by Napa County.

2. River channel cross sections from Napa County Resource Conservation District (RCD)

Napa RCD surveyed 64 cross sections across the Napa River, from floodplain to floodplain in 2006, supplementing 39 surveys made in 1996. The 103 cross sections provide information on the channel morphology that the LIDAR was unable to capture (e.g. bathymetry) and are the basis for the channel portion of the hydrodynamic model (see below).

3. Hydrodynamic modeling using a 2 dimensional model of the channel and floodplain

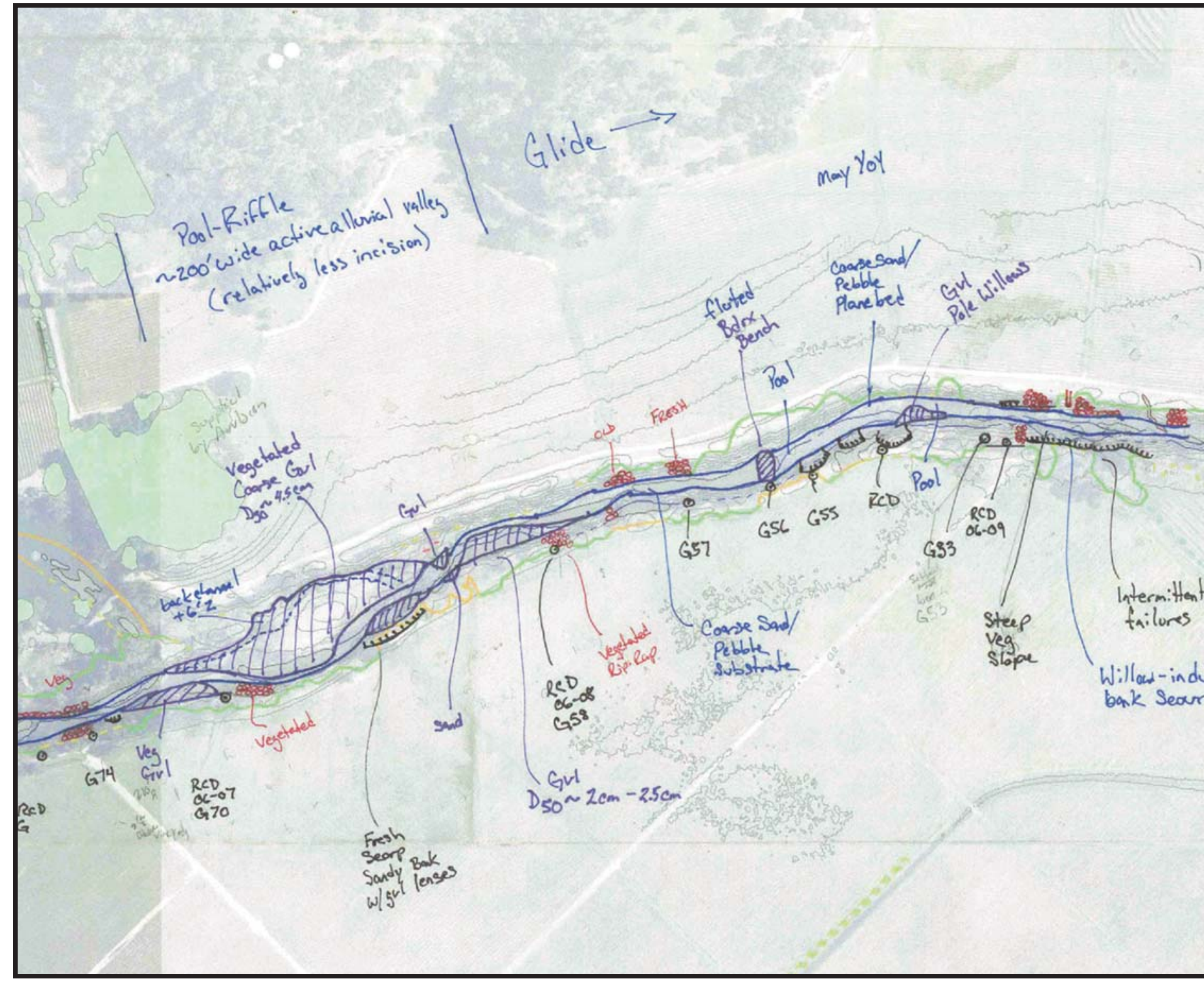
The hydrodynamic model takes inputs of discharge rate (cubic feet of water per second at upstream boundaries that include the Napa River at Rutherford Road, Conn Creek and Dry Creek) and routes the water through the RCD channel cross sections and (when channel capacity is exceeded) across the floodplain based on the County LIDAR topography. For the geomorphic report we extracted data on velocity and shear stress at each cross section and interpolated those results to the surrounding channel.

4. Field geomorphic mapping

Most of the 9 miles of the Oakville to Oak Knoll reach of the Napa River were mapped in the field. (In a few reaches we were unable to gain permission to visit one or both banks, or field conditions made access impossible). We mapped geomorphic features using a combination of handheld GPS and mapping directly onto topographic base maps generated using LIDAR. These were then combined to produce electronic Geographical Information System (GIS) layers. The features mapped are described below in the map key section.

5. Historic aerial photos

We compared aerial photos from the 1940s and the present time to see how the river has changed over time. The aerial photos show where the river has changed course and where it is still in the same location. We can also see changes in the width and form of the channel, the loss of secondary channels, changes in the amount of exposed gravel, and the width of the riparian corridor.

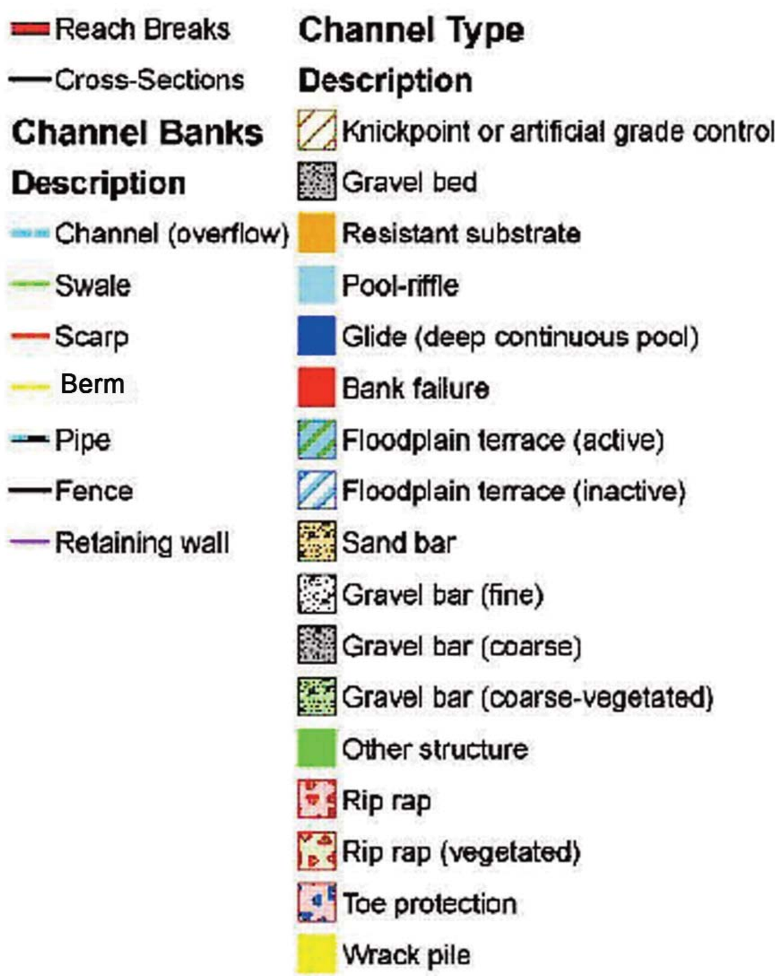


Example of hand drawn field mapping

Mapping channel features

Historic and contemporary aerial photos of the section mapped above.

The Map Key and Definitions



Reach Breaks – the project area was divided up into 10 reaches, labeled from downstream (Reach 1- Oak Knoll Bridge) to upstream (Reach 10 - Oakville Crossroad Bridge).

Cross sections – these refer to the RCD cross sections. Only the specific representative cross sections shown next to the maps are shown on the reach maps to avoid clutter. Typically we show cross sections that represent the range of conditions in the reach (widest, narrowest and average width:depth ratio).

Channel (secondary or overflow) – a well-defined, scoured channel that branches off the Napa River at a higher elevation, so that it is usually dry but can carry flow during floods.

Swale – a poorly defined, un-scoured channel that branches off the Napa River at a higher elevation, so that it is usually dry but can carry flow during floods.

Scarp – a sharp edge where the top of bank at its connection with the floodplain is actively eroding and retreating, indicating channel widening from the top.

Berm – a man-made feature that confines flow

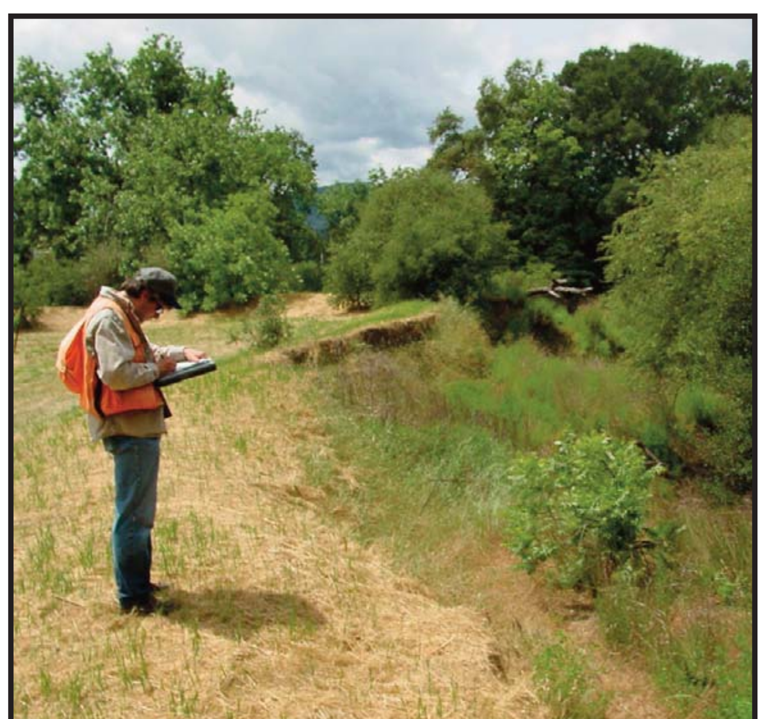
Pipe – a drainage pipe or other feature that is exposed on the bank of the river

Fence – self explanatory

Retaining wall – a structural wall that is holding up a vertical section of river bank

Knickpoint or artificial grade control – a vertical step in the channel bed (analogous to a small waterfall or head cut) that is taken to indicate vertical channel erosion on the downstream side, or a structure such as rip rap under a bridge that stabilizes a knickpoint.

Gravel bed – channel bed is covered primarily in gravel (particles between 2 mm and 2 cm diameter)



Resistant substrate – channel bed is composed of bedrock or highly cohesive clay

Pool – riffle – channel is made up of closely alternating riffles (shallow, steep, fast flowing sections with coarse material) and pools (deep, slow flowing sections with fine material) – see image on right.

Glide (deep, continuous pool) – channel is composed of a small number or single continuous pool that is not broken up by riffles

Bank failure – channel bank that is slumping as a series of massive blocks

Floodplain terrace (active) – area of floodplain that is closely connected to the river so as to receive flow every 1-2 years or more frequently

Floodplain terrace (inactive) – area of former floodplain that is less well connected to the river and that receives flow less frequently than 2 years. Assumed to be a terrace that was active before the channel incised, leaving it out of the path of frequent flows.

Sand bar – linear depositional feature alongside the channel composed of sand (coarse sediment smaller than 2 mm)

Gravel bar (fine) – linear depositional feature alongside the channel composed of gravel (sediment between 2 mm and 1 cm)

Gravel bar (coarse) – linear depositional feature alongside the channel composed of gravel (sediment between 1 and 2 cm) – see image to left.

Rip rap – rock tipped or placed on the bank to protect against erosion without any integral woody vegetation

Rip rap (vegetated) – as above but with woody vegetation planted through the rock to provide additional strength and shade

Toe protection – rock that is placed or keyed in to the bank toe rather than placed down the entire bank slope

Wrack pile – debris in the channel (e.g. dead trees washed from the banks)

Explanation of Physical Attributes

Width:Depth Ratio

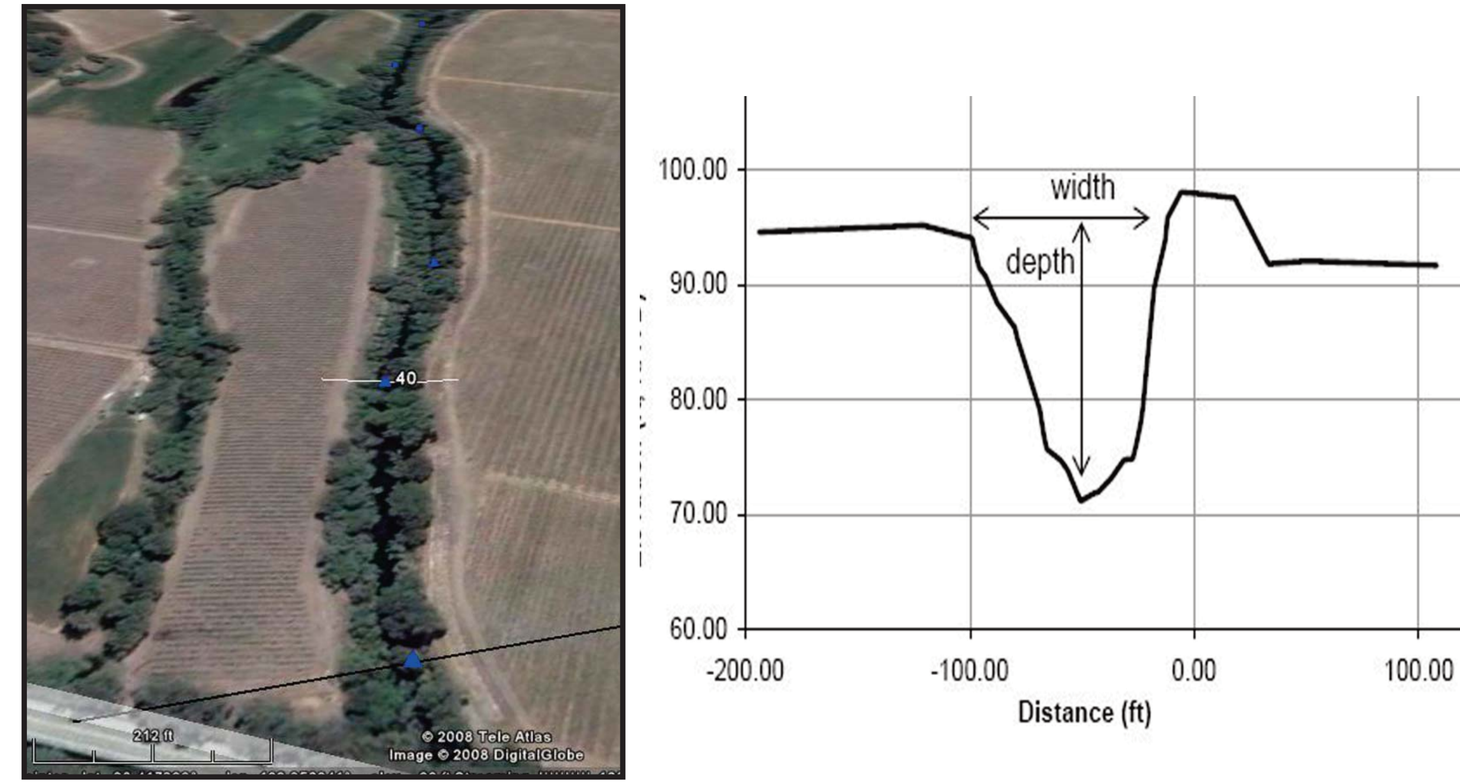
One of the key metrics examined in the Napa Oakville to Oak Knoll channel assessment is width:depth ratio. Width:depth ratio is the channel width at the point where a flow would spread out on the floodplain, divided by the distance between this break-out elevation and the deepest point in the channel thalweg (centerline). Width:depth ratio is a measure of channel confinement and entrenchment, with lower values indicating higher confinement. It is also an indicator of bank instability, since low w:d ratios indicate steep banks. Width:depth ratio is a function of many factors, including human modification, bedload concentration and size, flow characteristics, and the resistance of the bed and bank materials. Because all these factors vary there are not clearly defined 'target' values for w:d ratio in the literature, though within a river system we can recognize reaches that deviate strongly from typical values for that river. Examples of different w:d ratios for the Oakville to Oak Knoll Reach are shown on the right.

Rivers that are depositing surplus bedload generally have high w:d ratios (~20:1 or higher). Rivers that are vertically eroding generally have low w:d ratios (~10:1 or lower). Stable channels that transport their sediment load without net erosion or deposition typically have w:d ratios between these values. Studies of rivers in the San Francisco Bay Area show an average w:d ratio of ~20:1 for rivers with a watershed area of size similar to the Napa River (Leopold and Dunne, 1978). In general there is a positive correlation between w:d ratio and many of the geomorphic and aquatic processes that are desirable for the Napa River (i.e. the wider the channel the more diverse the physical morphology and the richer the biological habitat). For example, researchers have found positive correlations between w:d ratio and abundance of trout (Dunham et. al., 2002). The Napa River within the project area has a median w:d ratio of 5.5, with the vast majority of cross sections between 3.2 and 10.

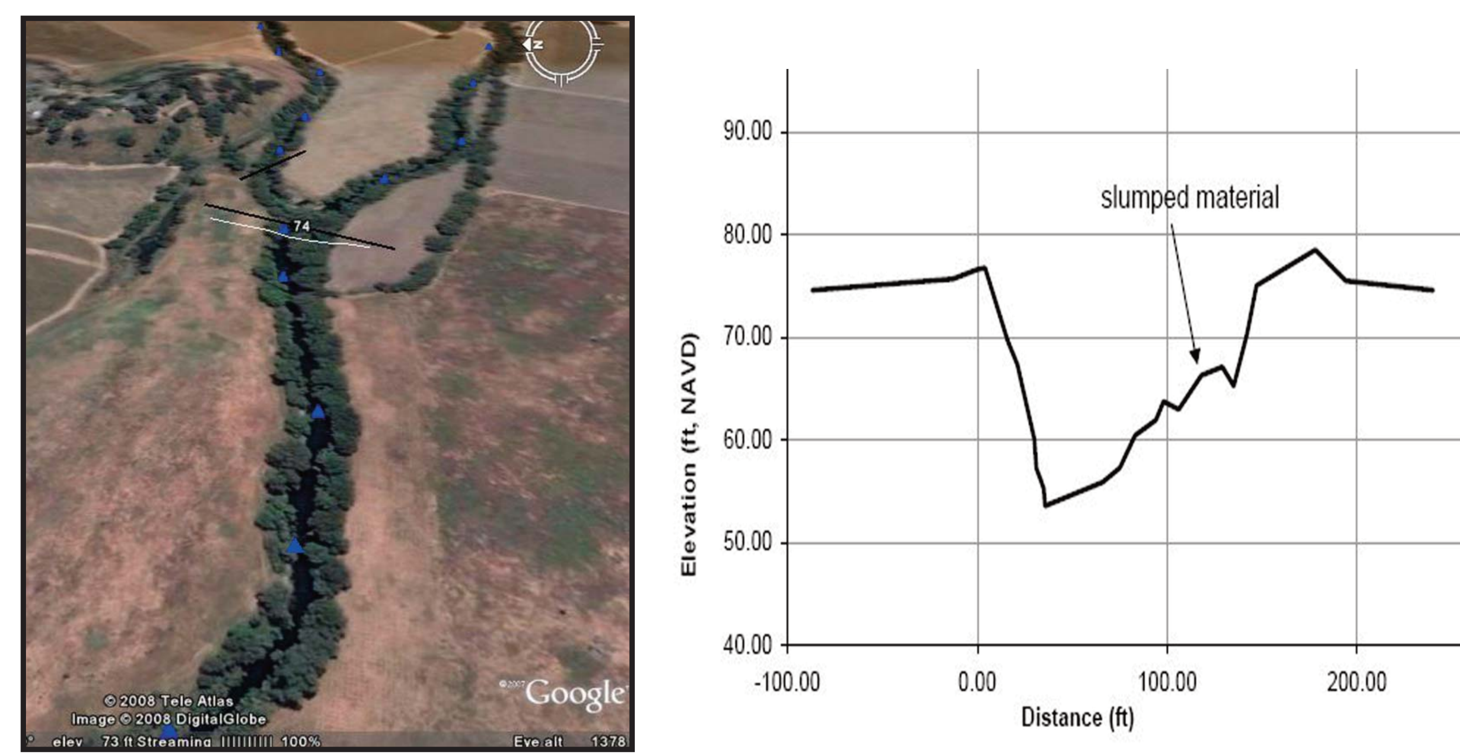
Width:depth ratios around 6:1 create 'trench-like' channels with steep, poorly vegetated banks that are prone to erosion and slumping, and lead to fast, uniform, straight flow lines during high flows. These homogeneous, fast flows scour out bed forms and create series of long pools or glides that offer few refuges for juvenile fish. Gravel is generally washed out of such reaches before it can create spawning riffles or point bars. Lack of riparian cover leads to water warming and algal blooms.

By contrast, wider channels tend to be more morphologically complex, which in turn creates better habitat. Wider, shallower channels have slower moving water, less erosive force and more cross currents. These factors allow gravel transported from upstream or eroded from the banks to be deposited into complex bar shapes that provide spawning habitat, and create refuges for fish during floods. The complex morphology creates more suitable conditions for complex vegetation stands of alder and willow, shading the river and creating a richer ecosystem for birds, animals and fish. Secondary flow currents and eddies produce better feeding conditions for fish.

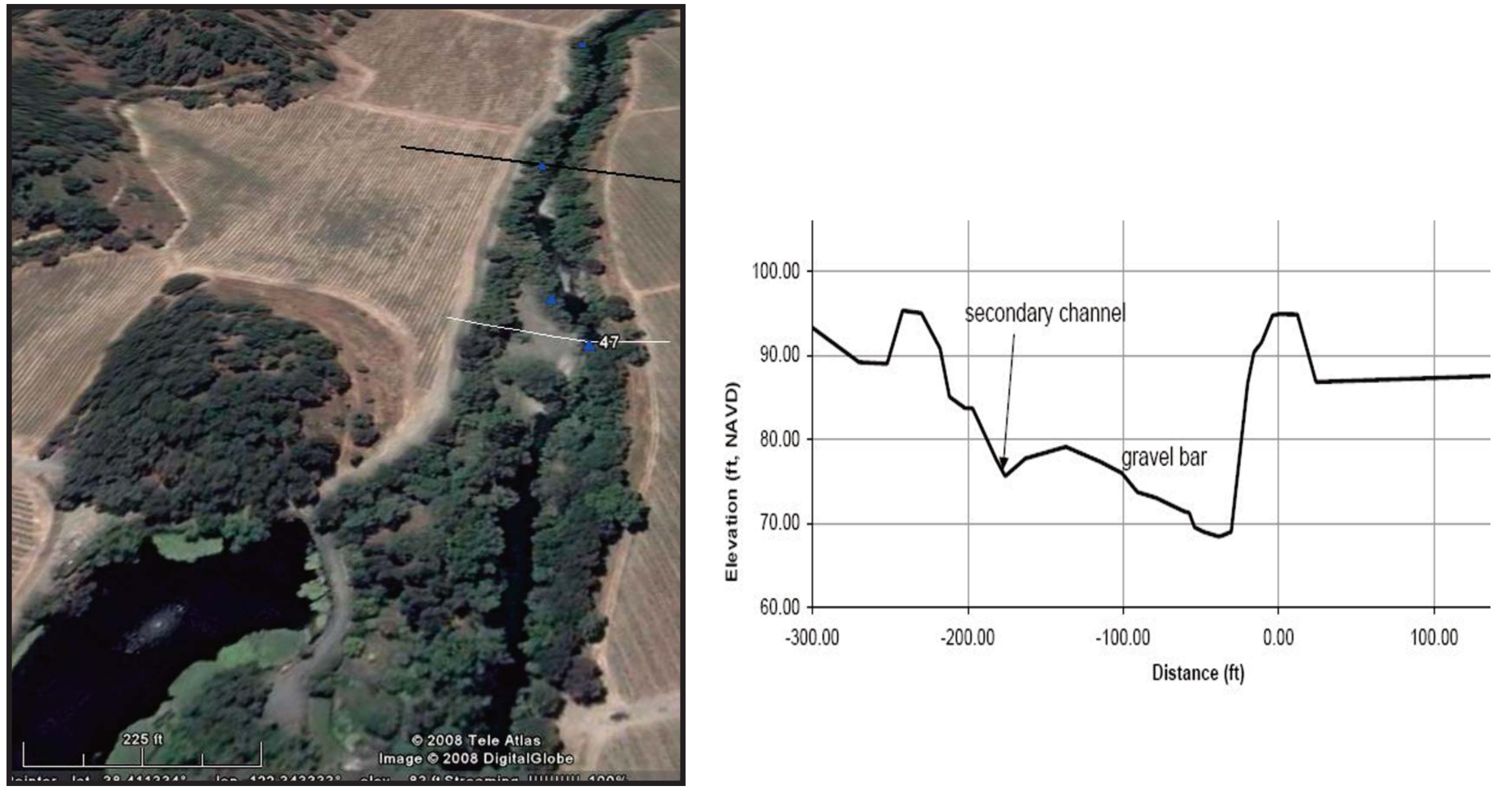
The Napa River appears to have a much lower w:d ratio now than in its past, and a corresponding decline in habitat quality and quantity. This is due to a combination of factors including; loss of secondary channels due to levee construction, coarse bedload trapping behind dams with resulting channel incision or deepening.



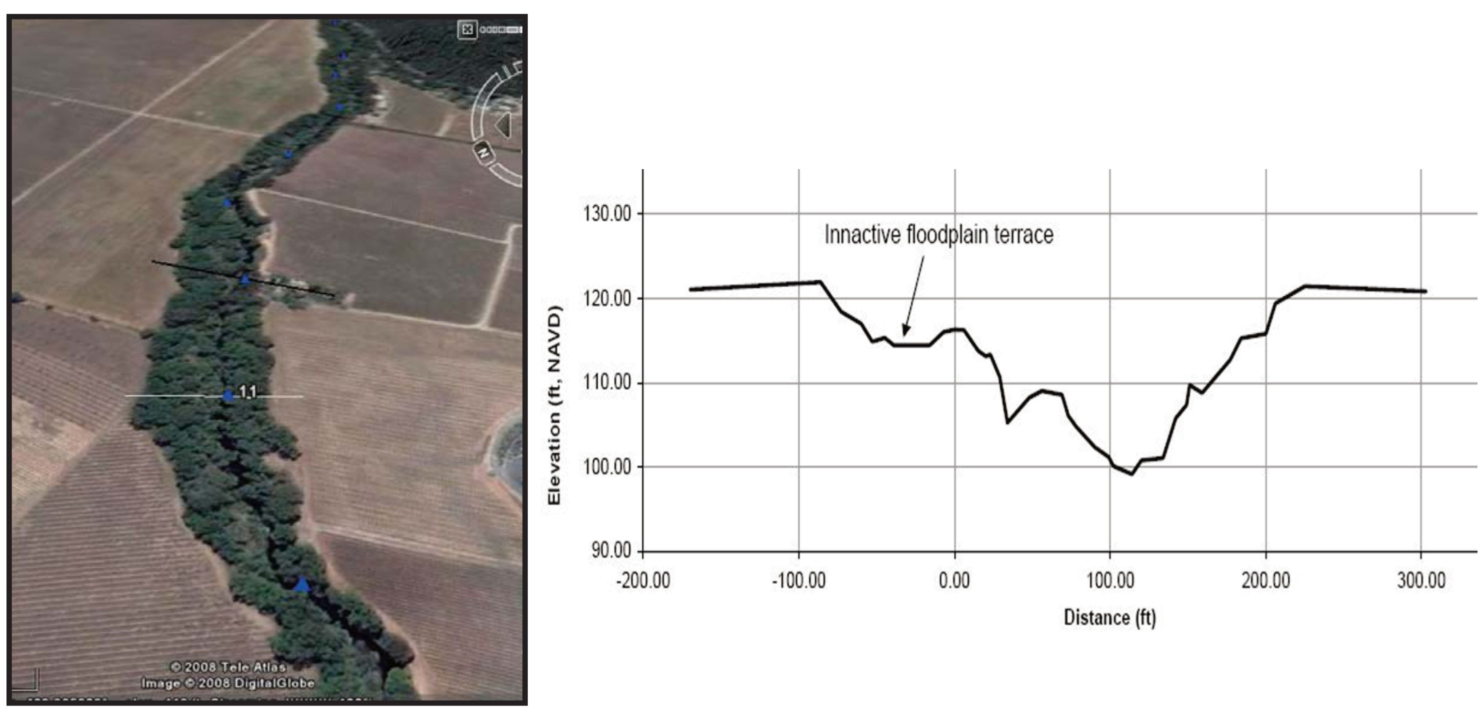
w:d = 3.8. These reaches tend to be dominated by continuous pools with little shelter for fish, have high rates of redd scour and erosion/slumping on both banks, and to have aging riparian trees that are not regenerating



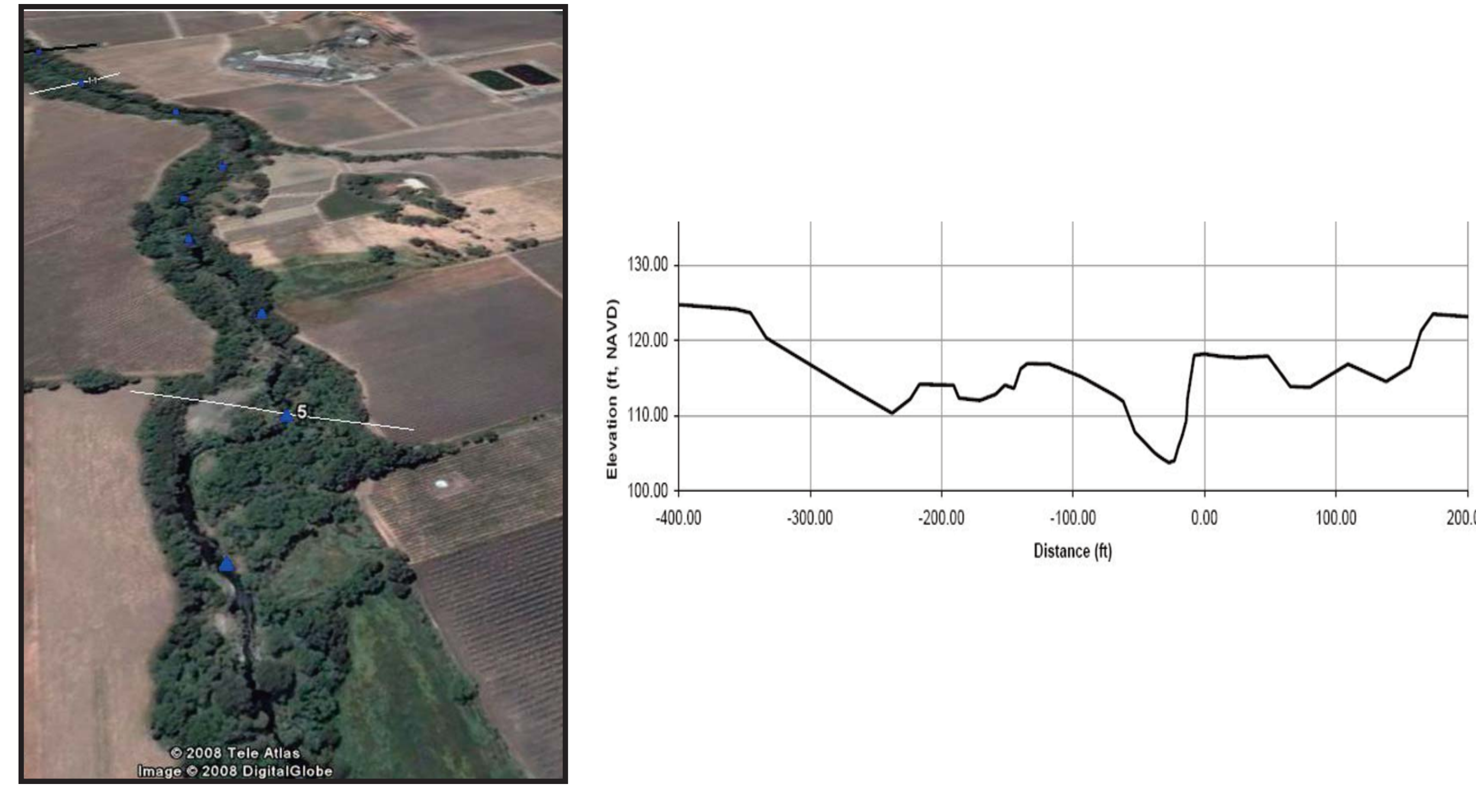
w:d = 6.2. These reaches often have an outside bank that is eroding and vertical, and an inside bank that has slumped to a more stable angle. Slumped material on the right bank provides a substrate for new riparian trees to grow, and areas of lower velocity flow that act as fish refuges during high flow.



w:d = 8.6. Reaches with a w:d ratio around 8-9 can start to allow gravel deposition in bars, and the formation of secondary high flow channels. These widths allow the channel to meander within the bank top constraints, further promoting riffle-pool formation and more diverse habitat conditions.



w:d = 13.9. Reaches with w:d ratios in this range can form a range of flood terraces and secondary channels that allow riparian cover to establish and provide multiple niches for fish and other animals.

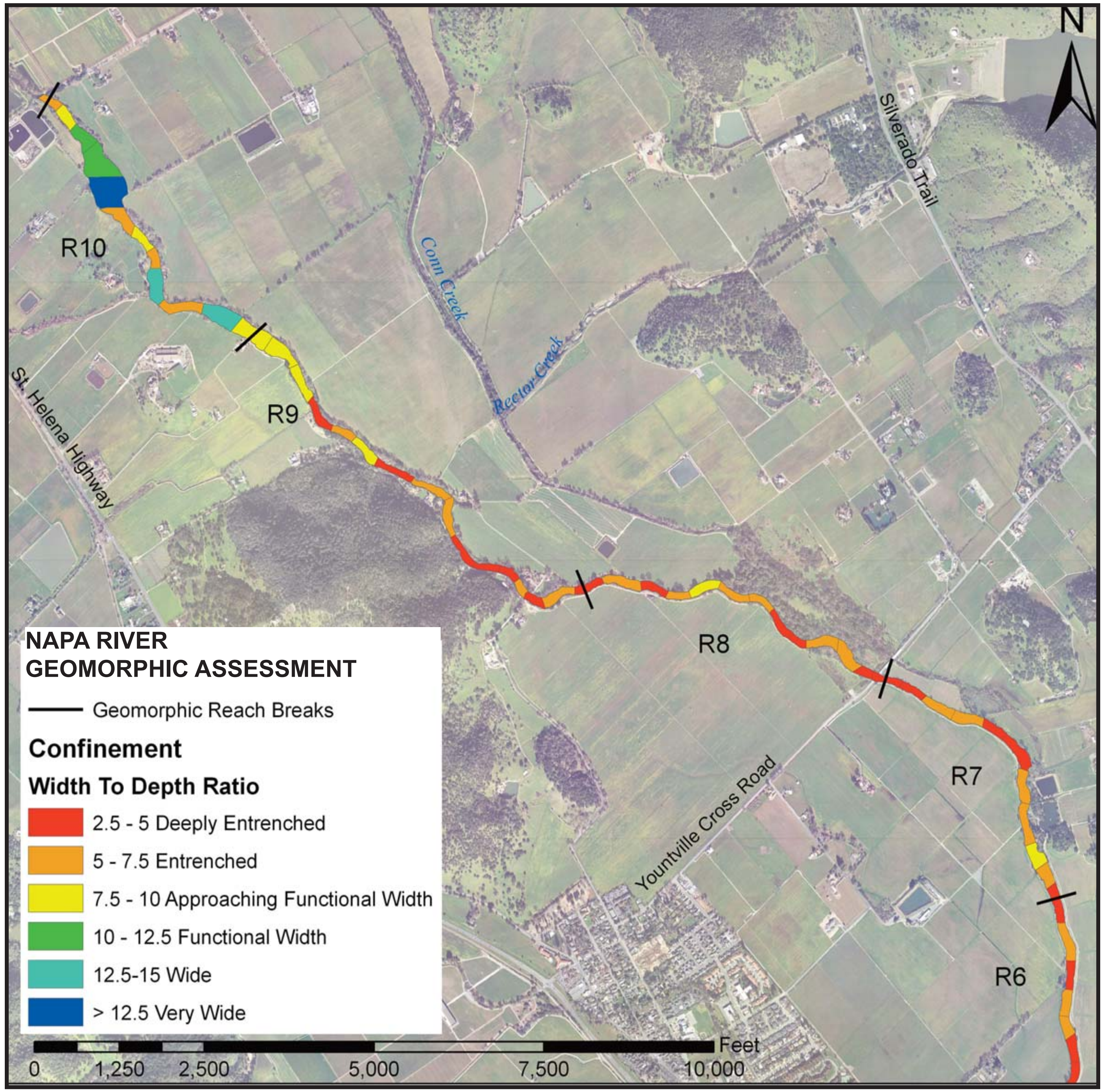


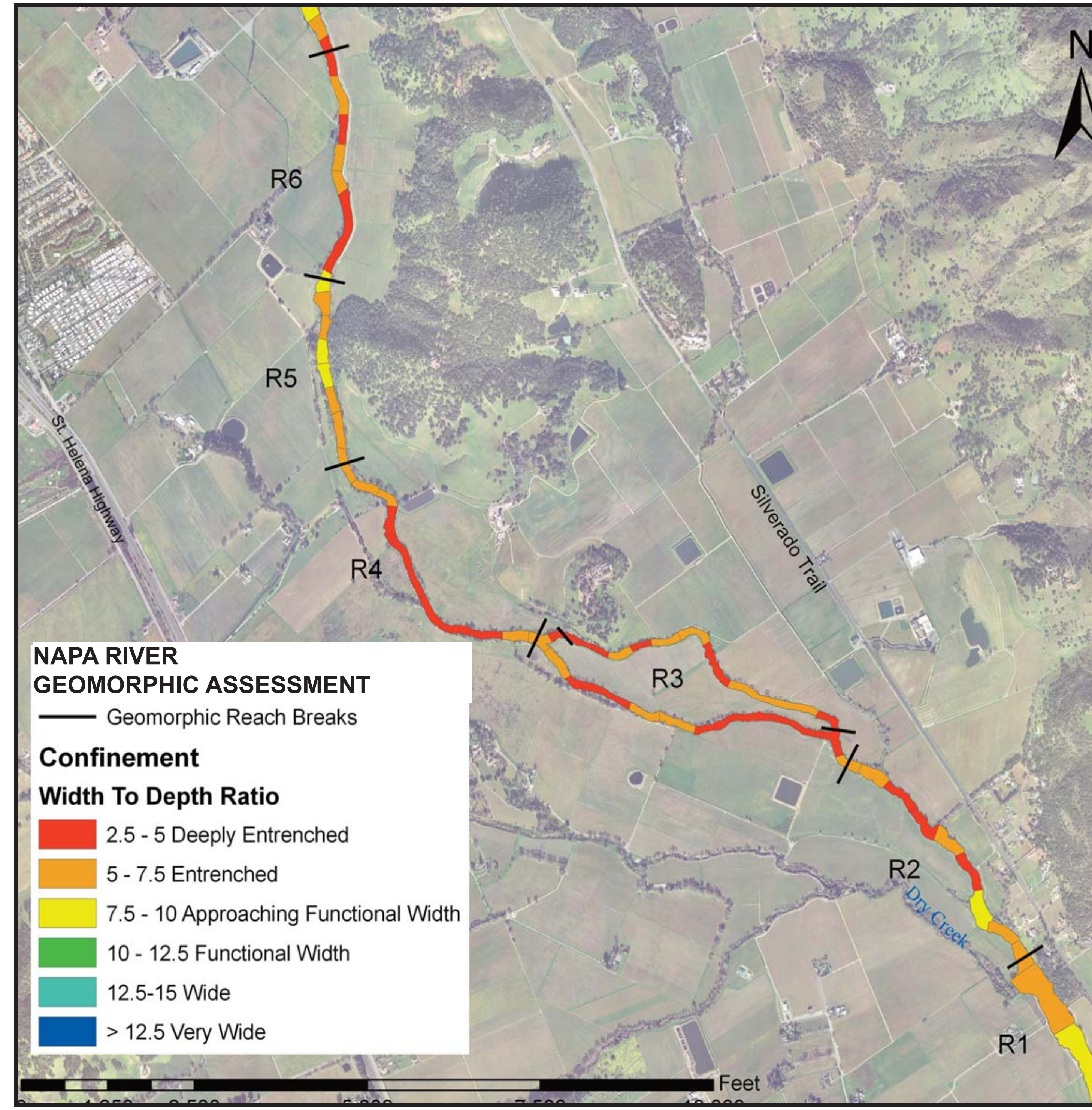
w:d = 21. Reaches with w:d ratios around 20:1 have very complex depositional forms with multiple side channels, gravel bars and flood terraces that are inundated at different flows.

How wide is wide enough?

The literature suggests that natural channel geomorphic functions such as gravel bar and riffle-pool formation do not occur until w:d ratios reach around 10:1 or higher. For example, Columbini et. al., (1987) found that a w:d ratio of 13 was required for alternate bars to develop. In the project area. In the Napa River we found well developed bars and riffle-pool formation starting to occur at a w:d ratio of around 7.5:1, especially in reaches that had width expansions that induce gravel deposition. The wider the channel, the more additional habitat features developed. A review of the RCD cross sections for a range of desirable geomorphic conditions including well defined low flow channel, active floodplain, secondary channels and floodplain benches, relatively gentle banks that support vegetation found reaches with these features had an average w:d ratio of 9:1. Cross sections with this ratio represent only 8% of the total. Another 11% of the cross sections had some of these desirable features, with an average w:d ratio of 8:1. It therefore seems reasonable to suggest that to restore a high degree of geomorphic function to parts of the Oakville to Oak Knoll reach requires channel w:d ratios of 10:1 and upwards, with some expansion and contraction around this ratio to induce alternating sediment deposition and scour. For a channel with an average depth of 22.7 feet an average total width of around 230 feet would be required. This is not to say that there can not be pockets of high ecological function in narrower channels. Biologists on the project team found such pockets in the project area. However, given the high cost and impact of any channel widening activity, the greatest cost:benefit ratio is likely to occur with reaches that have a w:d ratio of at least 10:1.

Width to Depth Ratio for the Project Area





Hydrodynamic Modeling

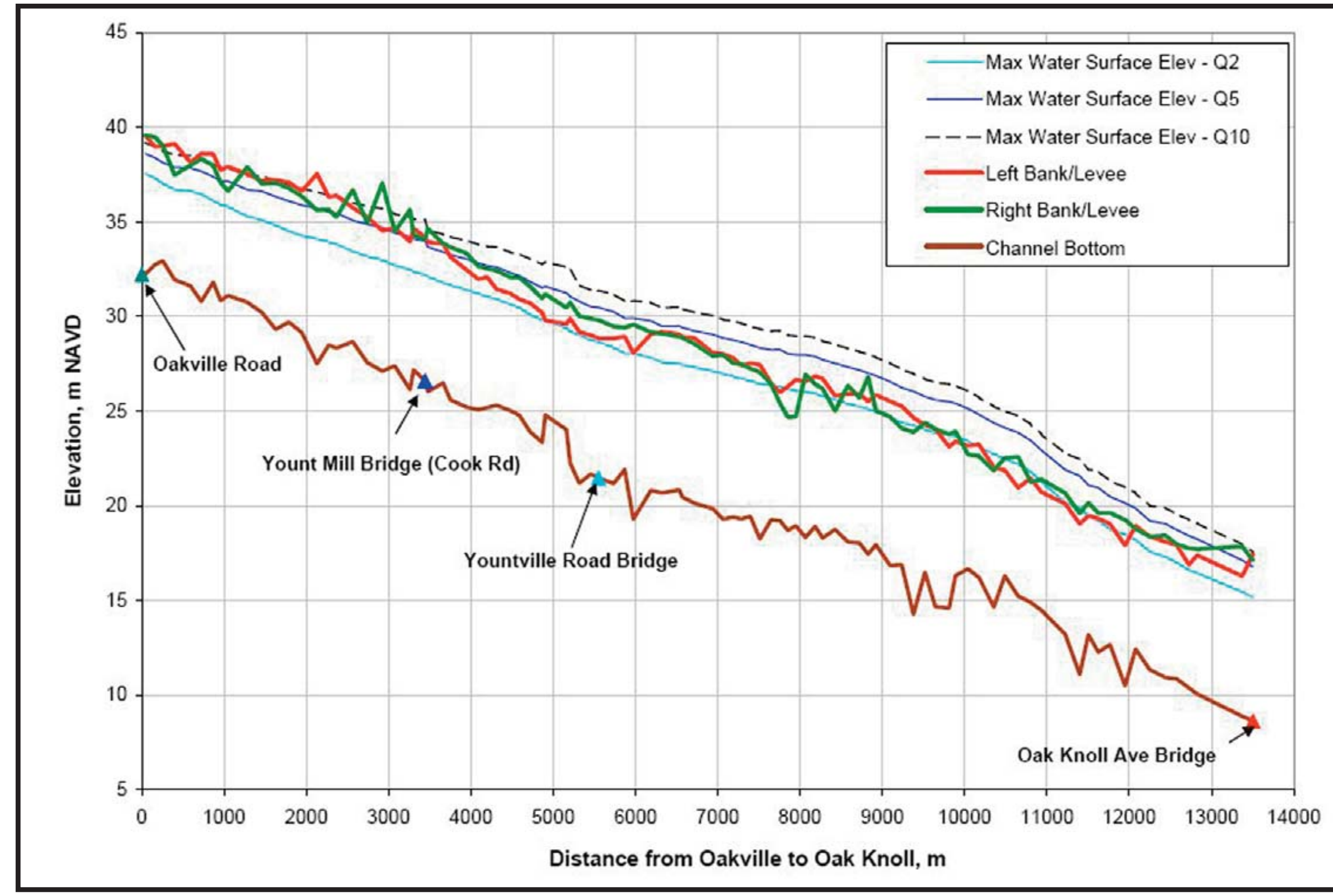
To evaluate flooding, flow velocity, erosion potential and redd scour we developed a hydrodynamic model of the Napa River, sometimes referred to as a hydraulic model. A hydrodynamic model is a computer simulation model that takes flow data for storms of different recurrence intervals and routes that flow down the channel and over thefloodplain to make predictions of the distribution, depth and velocity of flow. A recurrence interval is the volume of water passing a point per unit time, typically measured in cubic feet per second or cfs. The routing takes into consideration the cross section area of the channel, the gradient and the roughness of the channel, or friction due to vegetation.

The model was used to estimate the hydrodynamic conditions for existing conditions and to evaluate potential project alternatives. This will allow us to see both how effective alternatives are in reducing erosion potential or redd scour and to ensure that alternatives do not increase flooding. The model is developed in the software package MIKE-Flood, and is referred to as a coupled 1D-2D (one dimensional-two dimensional) model. The channel is modeled in 1D where the model assumes that all flow is straight down the channel, with uniform conditions throughout the whole cross section. This is a simplification of reality as flows are actually faster on the outside of bends and away from the bed. However this simplification can easily be corrected through calibration by comparing predicted and observed water levels and varying the channel roughness coefficient until the results agree. This channel calibration step was performed using flow depth data collected during the January 2008 peak flow. Flows that exceed channel capacity and escape onto the floodplain are modeled in 2D using a model that allows water to flow in any direction across the floodplain based on hydrodynamic pressure. This additional modeling allows more accurate predictions of flow path than would be the case with a 1D model. The model was calibrated for floodplain inundation using the December 31, 2005 flood, which is estimated to be a 10-25 year event at the Oak Knoll Bridge. The routing takes into consideration the cross sectional area of the channel, the gradient and the roughness of the channel due to vegetation.

The following table outlines flows which were simulated with the model.

Flood Peaks for the Napa River at St. Helena		
Recurrence Interval (years)	Peak Discharge (cfs)	
	FEMA (1998)	USACE (1998)
2	---	5,500
5	---	9,500
10	13,000	12,100
25	---	14,200
50	---	17,500
100	21,000	19,600
500	25,000	---

Note that the peaks estimated by FEMA and the USACE vary due to the use of different analytical methods. We used the USACE estimates for events less than the 100-year flood, and FEMA for the 100-year flood.

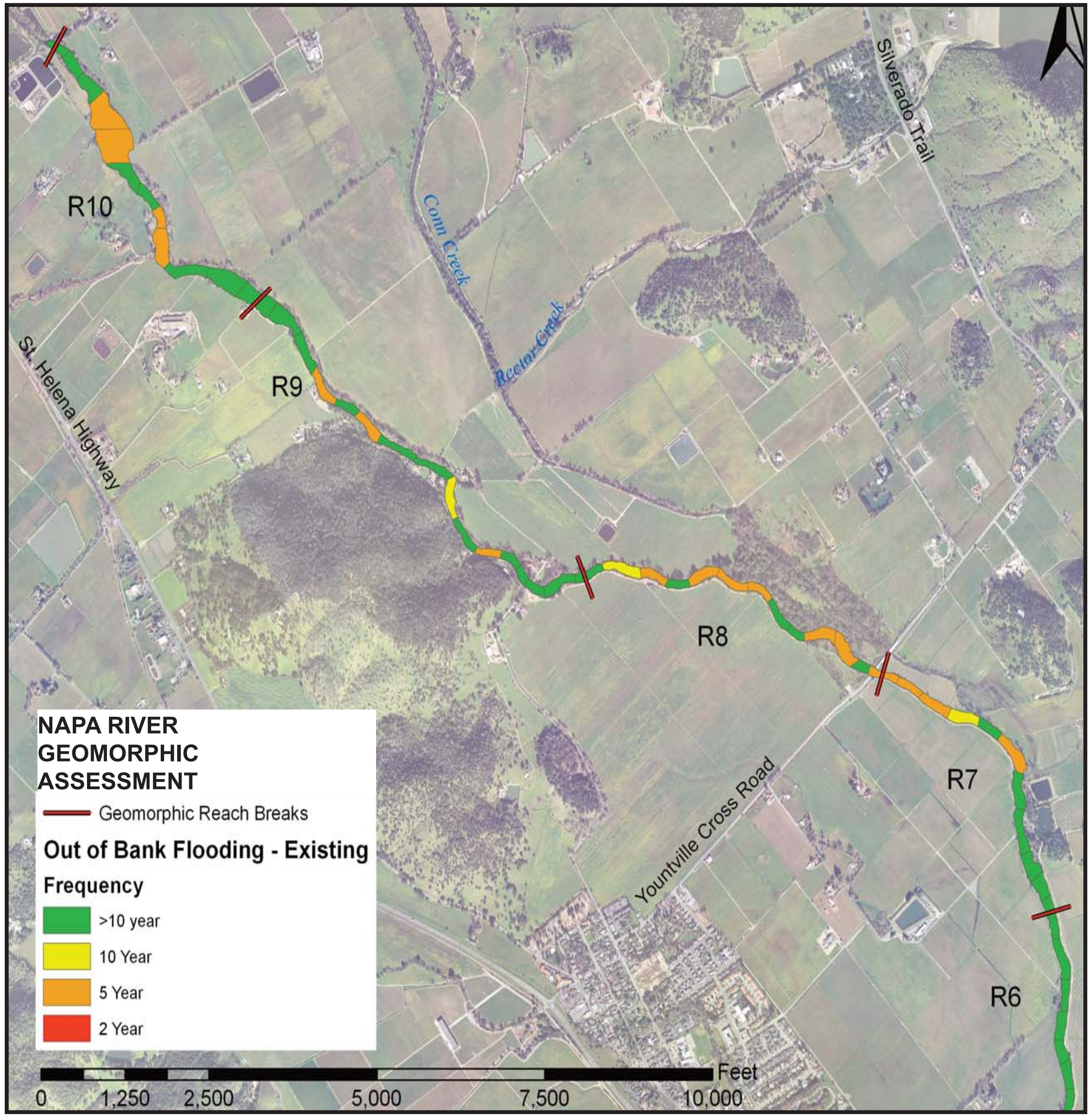


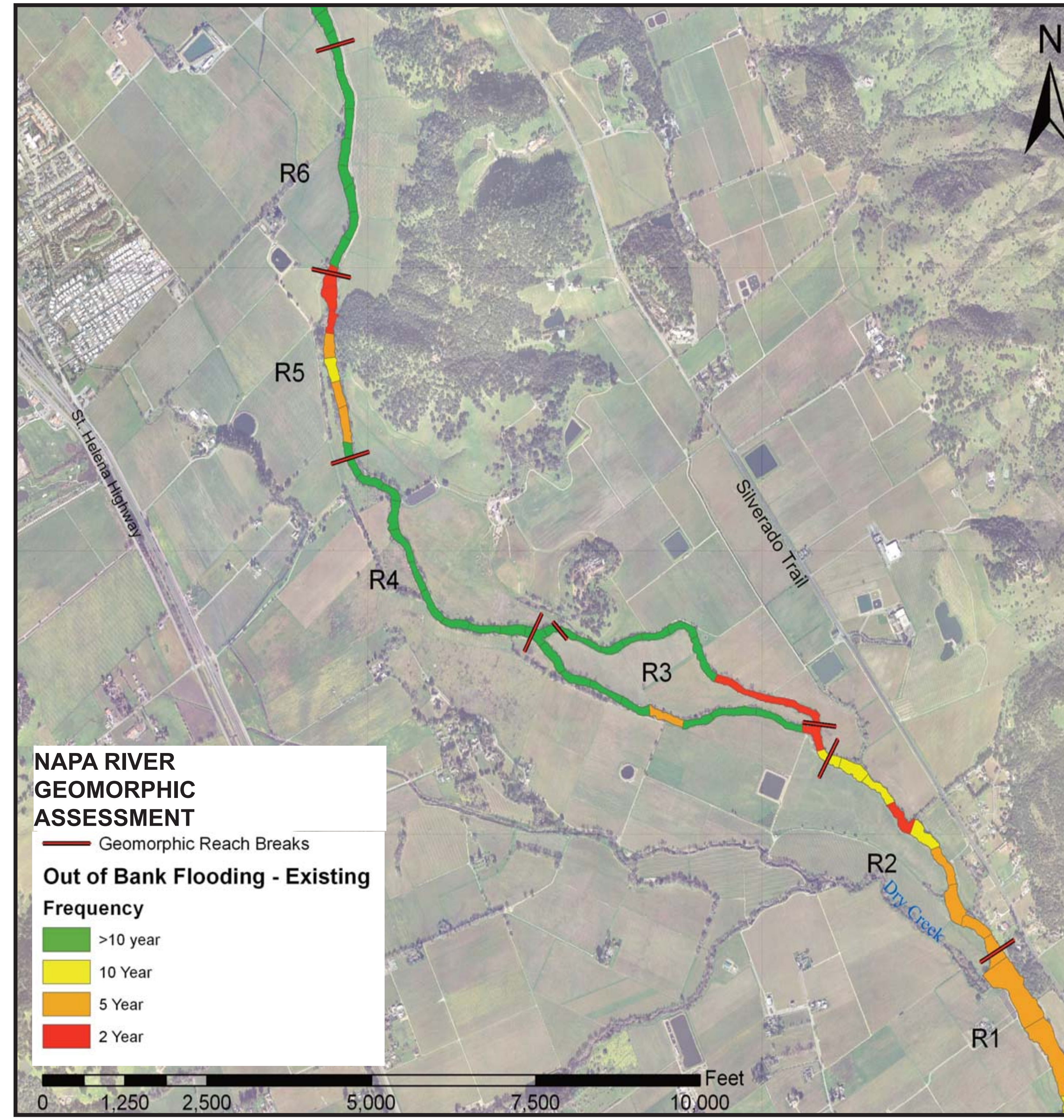
Estimated flow depth for the 2, 5 and 10-year recurrence flood on the Napa River.

The figure above shows the predicted flow depth for the smaller flood events, relative to left and right bank height. The results are shown in map format on the following page. The model estimates that the channel contains the 2-year flood event down to the upstream end of Reach 5, where it breaks out on the right bank. Downstream of this point there are several break out locations on both banks, most notably in Reach 3 (the most flood-prone reach in the project area) and to a lesser extent in Reaches 2 and 4.

The 5-year event breaks out intermittently in the upper reaches until Yount Mill Road, downstream of which it breaks out in almost all reaches. The 10-year flood breaks out in almost all the project area.

Estimated Flood Frequency for the Project Area





These figures show the average recurrence frequency of the event that will overtop the lowest point in the banks or levee for a given channel segment. For example, a segment marked “5 Year Discharge” will be over-topped during the event that occurs on average once every 5 years (also known as the event with a 20% probability of occurring every year). Note these figures do not account for water on the floodplain that has accumulated or escaped from somewhere else.

Redd Scour Potential

Chinook salmon

The Limiting Factors Report for the Napa River (Stillwater Sciences, 2002) identified scour of redds as a key factor limiting the population of salmonids. Chinook salmon lay eggs in December and January in nests (redds) that they create by excavating a circular depression in coarse gravel, laying their eggs, and covering the eggs with cleaned gravel (see image to right). The female fish typically bury the eggs in 6 inches of gravel after spawning, to protect them from erosion and predators. For 3-4 months after emergence the alevins live in the gravel pore spaces for safety (see image below). During the incubation period and immediately after emergence the eggs and alevins are very vulnerable to gravel scour. If the gravel bed is fully mobilized during the winter or spring the eggs or alevins will likely be destroyed or washed downstream. To assess the risk of this we used the hydraulic model to estimate bed shear stress during a 2-year flood. A 2-year flood has a 50% chance of occurring every year, generally during the period when redds are occupied.

Emerging alevin in river gravels.

This flow was selected because it occurs frequently enough to have a significant effect on salmon survival. We analyzed scour potential for gravel with a median diameter (d50) of 3 inches, which is considered a good size for spawning. Note however that smaller gravels will be eroded more than the maps show, and coarser gravels less so. Many of the potential spawning sites in the Napa River have gravel much smaller than 3 inches. For example, SFEI (personal communication, 2008) found the d50 for riffles in the project area to range from 5-9 mm (0.2-0.4 inches). The maps thus show relative erosion risk between reaches and should be viewed as somewhat optimistic.

Velocity Map

The velocity maps on the following page show the average velocity associated with the 10-year flood for individual cross sections in the project area. A 10-year flood has a 10% chance of occurring in any given year. These data were calculated from the hydrodynamic simulation model of the Napa River. From this we calculate average velocity at each of 103 cross sections in the project area. These values are shown in the figure. Velocity affects erosion with erosion as approximately proportional to the square of velocity High velocities can also wash juvenile fish out of their habitual reach into unfamiliar habitat or out to the estuary, increasing mortality. As a rule of thumb, velocities over 6 feet/second or greater pose a problem both for channel erosion and fisheries. The table to the right shows allowable velocities for different bank materials and treatments.

Table 2. Permissible Shear and Velocity for Selected Lining Materials[1]

Boundary Category	Boundary Type	Permissible Shear Stress (lb/sq ft)	Permissible Velocity (ft/sec)	Citation(s)
Soils	Fine colloidal sand	0.02 - 0.03	1.5	A
	Sandy loam (noncolloidal)	0.03 - 0.04	1.75	A
	Alluvial silt (noncolloidal)	0.045 - 0.05	2	A
	Silty loam (noncolloidal)	0.045 - 0.05	1.75 – 2.25	A
	Firm loam	0.075	2.5	A
	Fine gravels	0.075	2.5	A
	Stiff clay	0.26	3 – 4.5	A, F
	Alluvial silt (colloidal)	0.26	3.75	A
	Graded loam to cobbles	0.38	3.75	A
	Graded silts to cobbles	0.43	4	A
	Shales and hardpan	0.67	6	A
Gravel/Cobble	1-in.	0.33	2.5 – 5	A
	2-in.	0.67	3 – 6	A
	6-in.	2.0	4 – 7.5	A
	12-in.	4.0	5.5 – 12	A
Vegetation	Class A turf	3.7	6 – 8	E, N
	Class B turf	2.1	4 - 7	E, N
	Class C turf	1.0	3.5	E, N
	Long native grasses	1.2 – 1.7	4 – 6	G, H, L, N
	Short native and bunch grass	0.7 - 0.95	3 – 4	G, H, L, N
	Reed plantings	0.1-0.6	N/A	E, N
	Hardwood tree plantings	0.41-2.5	N/A	E, N
Temporary Degradable RECPs	Jute net	0.45	1 – 2.5	E, H, M
	Straw with net	1.5 – 1.65	1 – 3	E, H, M
	Coconut fiber with net	2.25	3 – 4	E, M
	Fiberglass roving	2.00	2.5 – 7	E, H, M
Non-Degradable RECPs	Unvegetated	3.00	5 – 7	E, G, M
	Partially established	4.0-6.0	7.5 – 15	E, G, M
	Fully vegetated	8.00	8 – 21	F, L, M
Riprap	6 – in. d_{50}	2.5	5 – 10	H
	9 – in. d_{50}	3.8	7 – 11	H
	12 – in. d_{50}	5.1	10 – 13	H
	18 – in. d_{50}	7.6	12 – 16	H
	24 – in. d_{50}	10.1	14 – 18	E
Soil Bioengineering	Wattles	0.2 – 1.0	3	C, I, J, N
	Reed fascine	0.6-1.25	5	E
	Coir roll	3 - 5	8	E, M, N
	Vegetated coir mat	4 - 8	9.5	E, M, N
	Live brush mattress (initial)	0.4 – 4.1	4	B, E, I
	Live brush mattress (grown)	3.90-8.2	12	B, C, E, I, N
	Brush layering (initial/grown)	0.4 – 6.25	12	E, I, N
	Live fascine	1.25-3.10	6 – 8	C, E, I, J
	Live willow stakes	2.10-3.10	3 – 10	E, N, O
Hard Surfacing	Gabions	10	14 – 19	D
	Concrete	12.5	>18	H

[1] Ranges of values generally reflect multiple sources of data or different testing conditions.

A. Chang, H.H. (1988).
B. Florineth. (1982)
C. Gerstgraser, C. (1998).
D. Goff, K. (1999).
E. Gray, D.H., and Sotir, R.B. (1996).
F. Julien, P.Y. (1995).
G. Kouwen, N.; Li, R. M.; and Simons, D.B., (1980).
H. Norman, J. N. (1975).
I. Schiechtl, H. M. and R. Stern. (1996).
J. Schoklitsch, A. (1937).
K. Sprague, C.J. (1999).
L. Temple, D.M. (1980).
M. TXDOT (1999)
N. Data from Author (2001)
O. USACE (1997).

Typical Napa resistant channel bed

Typical Napa bank materials

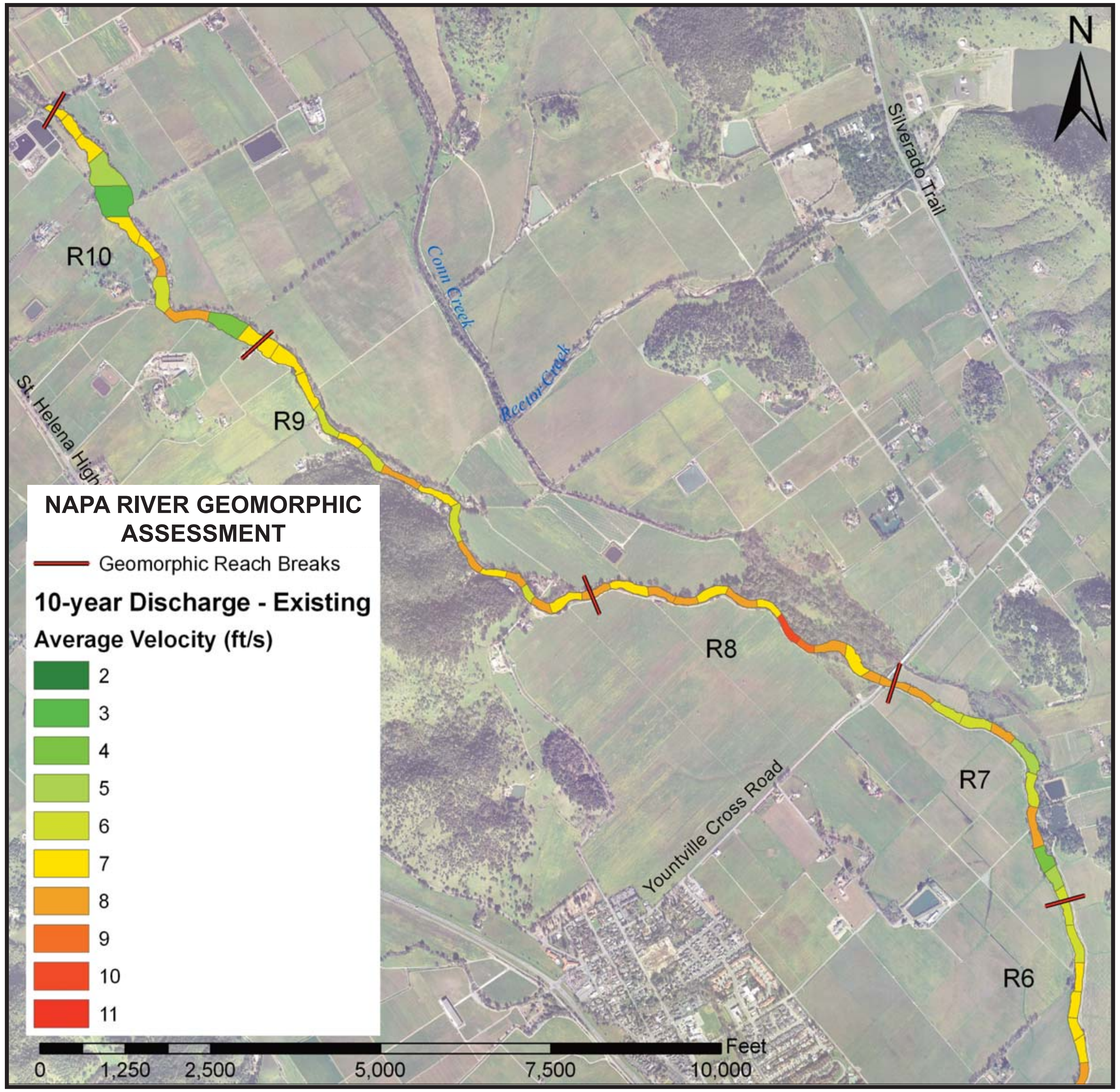
Typical Napa gravel bed

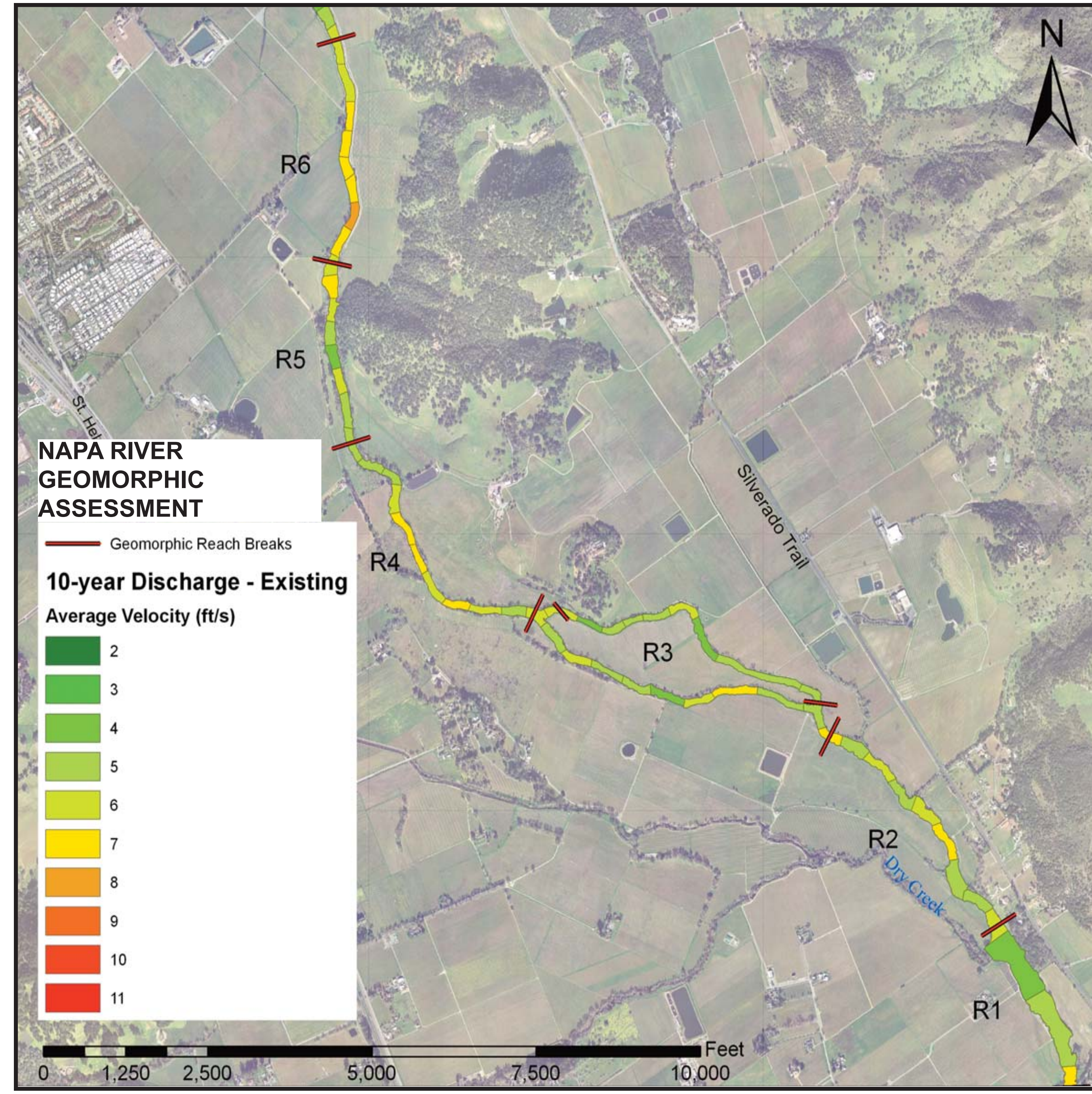
Typical Napa grasses

Typical rip rap

Willows new and established

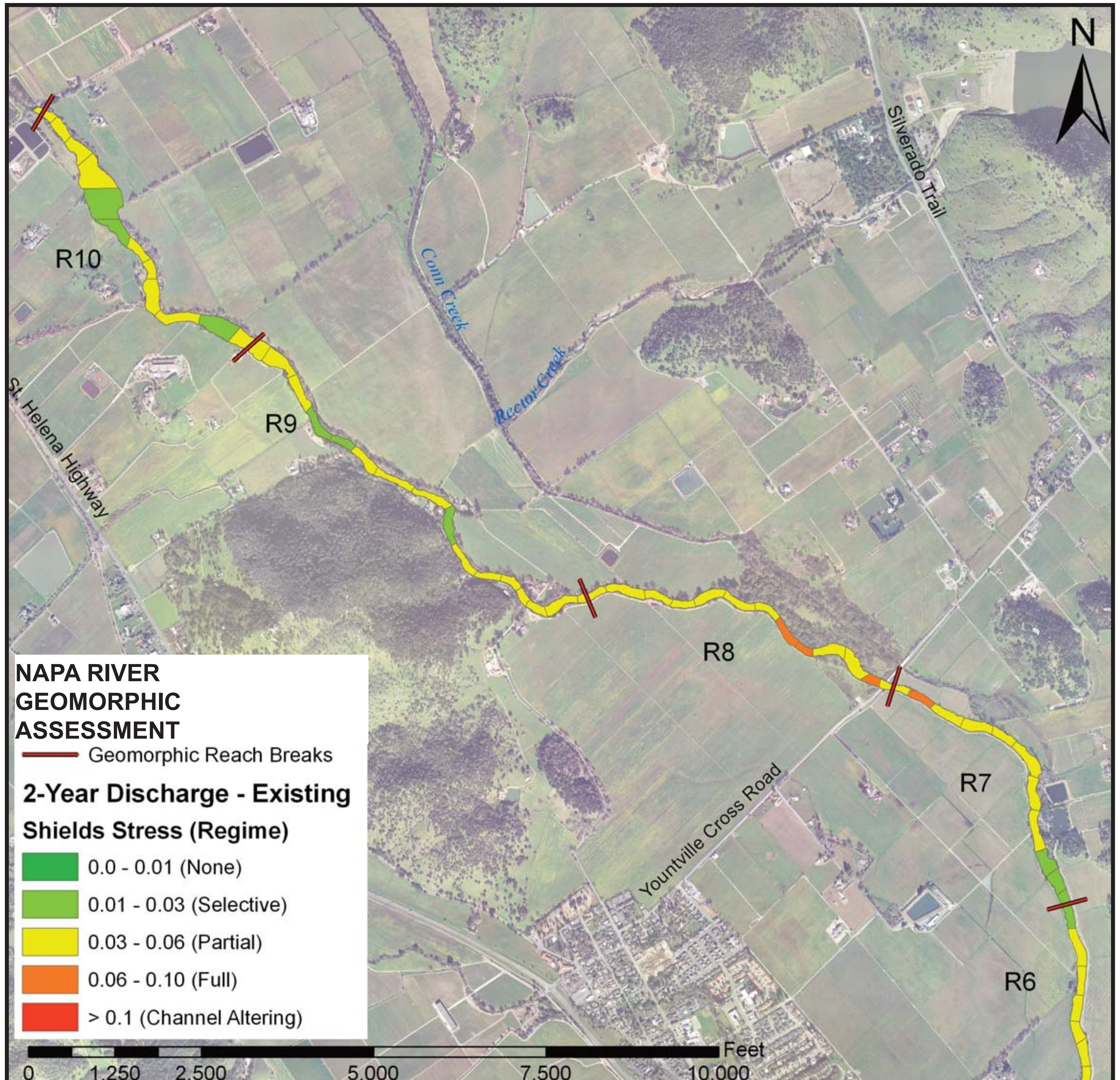
Average Velocity During the 10-year Flood for the Project Area

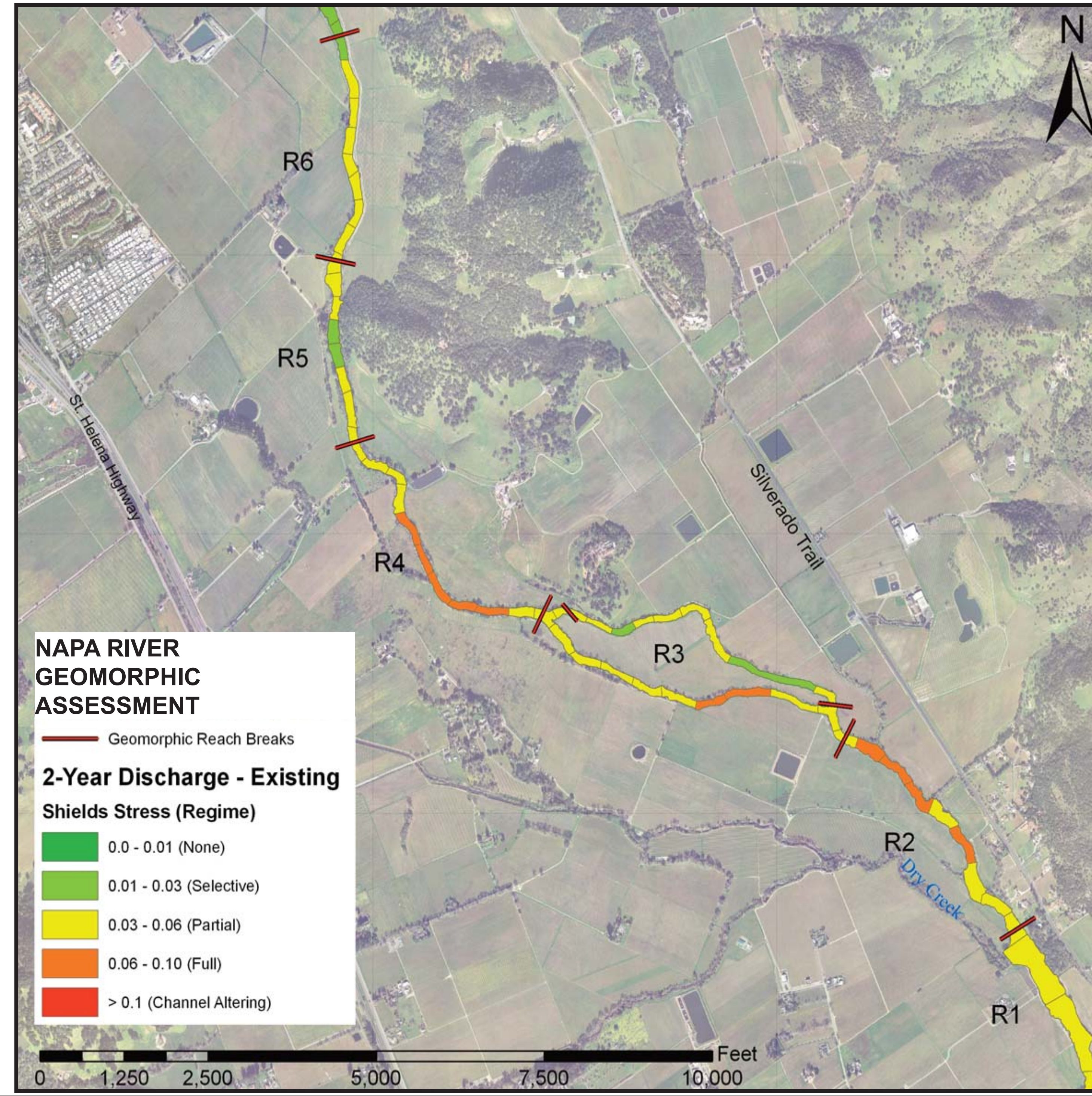




These figures show the average velocity in the channel during the flow that occurs on average once every 10 years. Flows less than 6 feet per second generally do not cause much erosion, can be navigated by fish, and can usually be withstood by biotechnical bank protection methods. Flows greater than 6 feet per second can wash fish downstream, pose more of an erosion risk and may require more structural methods to protect against erosion. Note the correlation between w:d ratio and velocity, except in the split channel (Reach 3).

Shield's Stress During the 2-year Flood for the Project Area





COLOR ON MAP	SHIELDS STRESS VALUE	EFFECTS ON RIVER AND BANKS
Green	0-0.01 None	No erosion of bed or banks likely
Pale green	0.01 - 0.03 Selective	A thin layer of spawning gravel or weaker unvegeted bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds.
Yellow	0.03 - 0.06 Partial	The upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.
Orange	0.06 - 0.1. Full mobilization	Gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegeted banks will experience erosion. After these flows gravel may reform bed features.
Red	>0.1. Channel altering flows	These flows will eliminate bed features (e.g. riffles and pools) and wash gravel out of the reach. Most unvegetated and some vegetated banks will experience severe erosion.

Historic Changes in the Napa River

Conversion from a multiple thread channel to a single thread channel

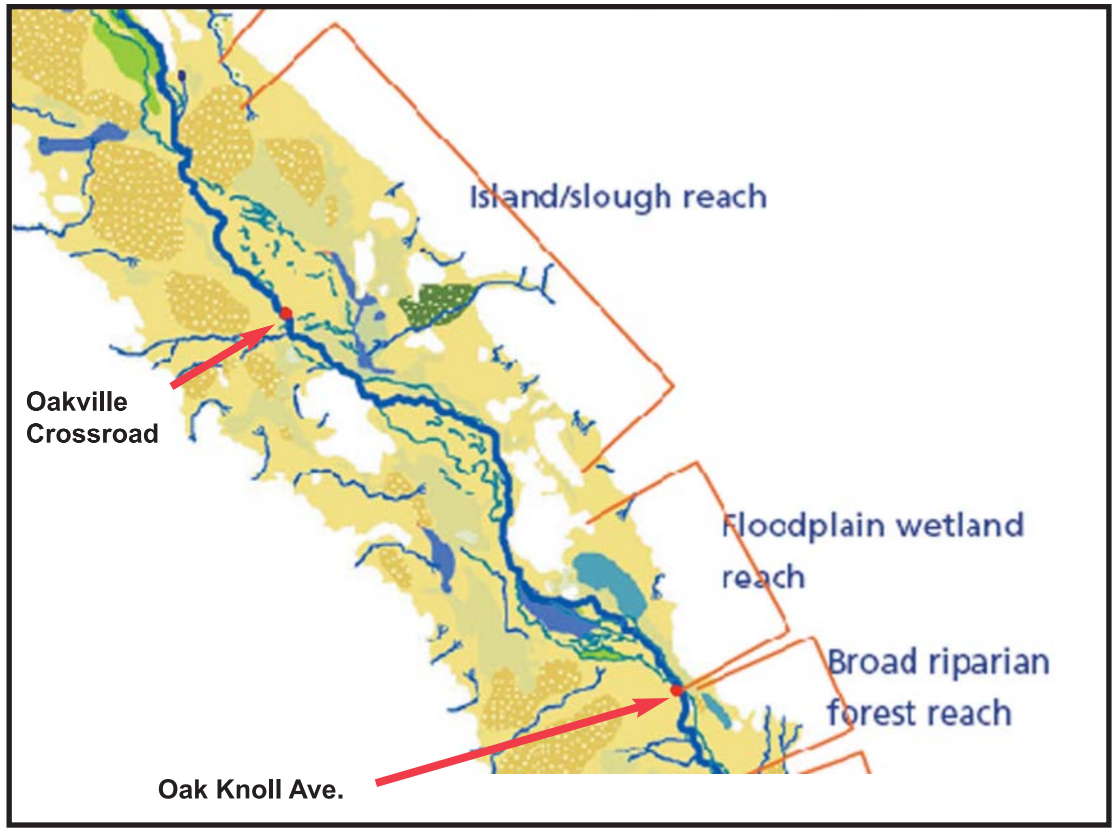


Figure courtesy of SFEI

Historic channel, secondary channel and wetland locations on the Napa River.

The following discussion relies heavily on the Napa River Watershed Historical Ecology Project completed by the San Francisco Estuary Institute (SFEI). The Napa River and its watershed have historically undergone a series of changes that help explain much of the river's existing condition. :Historical work (SFEI, 2008) has shown that at the time of Euro-American settlement many reaches of the Napa River in the project area were made up of multiple threads labeled "Island/slough reaches" in the map above. Some secondary channels were deep, persistent features with well developed riparian corridors, while others were more ephemeral overflow channels or swales. Reach 3 is a rare existing example of a persistent secondary channel, but we find evidence for similar conditions in Reaches 1-4 where Hopper Creek-Lower Dry Creek was formerly a side channel of the Napa River that was blocked off from the Napa River by a levee, in Reach 7 where a downstream extension of Conn Creek formed a channel now used for water storage ponds and in Reaches 8-9 where lower Conn Creek was a side channel of the Napa River until its separation and conversion to a flood control channel. Smaller sloughs with less permanent riparian corridors existed in Reaches 5-8 and 10. Other areas, classified as "floodplain wetland reaches" had less well defined channels that flowed through swampy floodplain areas.

Consequences of Change

As secondary channels were cut off from the mainstem by levees and filled in to allow farming, greater volumes of water were concentrated in fewer channels. Since channels adjust their cross sectional area in response to changes in hydrologic regime, the remaining mainstem channels have expanded through erosion to convey the increased flow. Expansion has typically been first by incision or bed lowering until the banks have become unstable, then by bank collapse and channel widening. Incision and widening has caused loss of land, and has had detrimental consequences for both aquatic life and the riparian corridor. Incision has caused increases in channel velocity due to flow concentration. This washes juvenile fish out of their secure hiding places during winter floods, reducing their chances of survival. It also scours and ultimately removes spawning gravel out of the channel, eroding the river down to a cohesive hardpan layer that is not suitable for spawning. Loss of gravel also reduces the production of benthic invertebrates that form an important part of the food chain for fish. Finally, the erosion of bed features and gravel bars simplifies the channel, creating a homogenous 'trench' that is poor rearing habitat for fish and that supports a more limited ecosystem. Incision also lowers the water table close to the river, preventing riparian species from regenerating.

Dam Construction

Since Europe-American settlement of the Napa Valley began people have constructed dams on the headwaters of the Napa River, primarily for water supply. These dams cut off much of the gravel and cobble or coarse sediment from the mountains reaching the river. Construction of Conn Dam and Rector Reservoir in the 1940s, combined with smaller reservoirs in the headwaters, disconnected the mainstem Napa River from between a third and half of its watershed, greatly reduced the coarse sediment supply.

Consequences of Change

Collecting the coarse sediment behind dams has had two major effects on the channel and riparian corridor. It has directly reduced the amount of gravel available for spawning. Secondly, it has changed the channel morphology. Rivers with a heavy gravel supply tend to deposit coarse sediment on their beds in the form of gravel bars, while eroding the finer material in their banks. The result is a wide, shallow riffle-pool channel (high w:d ratio) with low banks, large unvegetated gravel bars and multiple secondary channels. These channels often migrate laterally within a riparian corridor. When coarse sediment supply is reduced the channel tends to incise and become laterally fixed within the riparian corridor. Formerly active gravel bars become colonized by trees. This process can cause the density of trees in the riparian corridor to increase, but at the expense of channel complexity and salmon spawning and rearing habitat.

Channelization

Prior to settlement, parts of the project area of the Napa River were dominated by wetlands fed by distributary channels from alluvial fans on tributaries. This pattern was very common in Reaches 3, 9 and 10. These distributary channels were unstable and flood prone, spilling water onto the floodplain where it formed wetlands, slowly percolated and flowed into the river. This drainage pattern slowed flood waters from reaching the Napa River, though of course it also made the channels and surrounding land less suitable for settlement and farming. Over time the distributary channels were converted to more efficient drainage channels and the wetlands were drained and farmed. Vegetation and gravel bar removal and hard bank stabilization also took place in the mainstem.

Consequences of Change

The result of channelization in the watershed is a reduction in flooding and poor drainage in the floodplain and on the alluvial fans, but increases in both the volume and speed of flooding in the mainstem Napa River. "Flashier" flows have probably contributed to some of the flooding downstream, as well as some of the channel erosion as more water has been pushed through fewer channels. Channel maintenance in the Napa itself has made the channel smoother and more hydraulically efficient, increasing flow velocities and erosion.

RIPARIAN ECOLOGY

Vegetation

The plants growing along a meandering river or creek are termed the riparian corridor. “Riparian” means next to a water body and riparian areas are frequently flooded. The plants in this zone are able to withstand the inundation, silt build up and scour of winter floods as well as the low water and drought conditions of the California summer. Each riparian tree species is adapted to a particular range of conditions and will grow in a certain area of the corridor. In less developed river systems, riparian and wetland plants blanket the floodplain creating a rich patchwork of habitats.

As a river floods, moving sediment and eroding its banks, it both creates and destroys riparian habitats. Change in this ecosystem is continuous, determined by the flood cycles of the river, the conditions in the watershed, and direct management of rivers and creeks. The variety and intermixing of vegetation types gives the river ecosystem its richness. There is a continuous succession of plant species as the river channel meanders and floods it floodplain. Understanding the process of ecological succession, requires starting at one point in this continuum - the beginning of a new riparian forest after a flood.

In the Mediterranean climate of California, as the winter season ends, six months of drought begin. Willows and cottonwoods set their seed, timed to coincide with the recession of flood waters and prior to the onset of summer heat. Winter floods have left new sediment on the bar; this thin layer of moist soil is only viable for germinating seeds for a short while. Each willow and cottonwood tree produces thousands of windblown seeds, or cotton. Where the seed lands on the moist sediment, and if a late spring flood does not carry the seed away, small trees will germinate in great profusion. Thousands of the small willows and cottonwoods will cover the river bar. Willows do better in fine sediment and cottonwoods can grow in gravel. The roots of the seedlings grow quickly, extending downward to groundwater to assure a water source for the coming summer drought and to anchor the tree. Far fewer seedlings survive than germinate. The new trees that do survive can grow several feet in their first season. During extended drought, stream flow can be so reduced that there is little fresh alluvium for willow or cottonwood seeds and little germination and regeneration.

The future of the new trees is anything but secure. The willows and cottonwoods are growing on the edge of the channel where scour and inundation are common. Willow and cottonwood can tolerate inundation and oxygen deprivation for their roots for extended periods of time. These trees, unlike pines or other upland species, are very flexible and able to bend in a flood and endure relatively high water velocities without mechanical damage. Even if the floodwater rips the willow out and sends it downstream, it can take root and begin to grow again. However, if a seedling germinates in the active area of the channel, it is likely to be scoured out, and due to its small size, not re-root downstream.


WILLOWS BEND IN HIGH FLOWS


WILLOWS SPREAD BY ROOT RUNNERS


WILLOW COTTON


COTTONWOOD SEEDLINGS


WILLOW SEEDLINGS GERMINATE IN PROFUSION


ADVENTITIOUS ROOTS ON WILLOW ASSIST PLANT IN GETTING ADEQUATE OXYGEN WHEN INUNDATED


DEAD WILLOW SEEDLING


WILLOWS CAN WITHSTAND INUNDATION FOR DAYS

As the trees grow along the channel they slow water velocities and increase the sediment deposition around them. Willows and cottonwoods can be covered over with sediment, pop up and send out new roots along their trunks. With each seasonal cycle, the new willows and cottonwoods are subjected to extremes: floodwater scours the vegetation; the river buries the new trees with sediment, or in dry years, the groundwater level drops wilting and killing the young trees. The trees that survive spread through root sprouts and create large stands. There are a number of willow species in riparian areas - red willow, sandbar willow, arroyo willow, and others. Mulefat is another common "pioneer" riparian species as is Fremont cottonwood.

Alders may also grow adjacent to the channel. Alders drop seeds in the winter allowing seedlings to establish in early spring. Seedlings grip the low flow channel growing both above and below ground roots. Alder roots harbor nitrogen-fixing bacteria enhancing their ability to establish on mineral soil. Alders often occur along channels confined in gorges, and on alluvial fans where water velocities are high and bed-load may be particularly large and damaging to trees.

As the river channel moves laterally in its meanders it deposits sediment and moves away from "pioneer" willow and cottonwood trees which now grow on the floodplain. But while further from the channel, they are still frequently flooded. Over time they become mid-level habitat. Along the edge of the new channel, more willow and cottonwood seedlings germinate after floods.

As the willows and cottonwoods grow larger they create a shadier environment and a layer of organic material and duff. New and different plants invade. These species are not so tolerant of mechanical damage or flooding. Trees such as California walnut, big leaf maple, Oregon ash, box elder, and California bay laurel are common to this upper bar/floodplain area. These species produce large seeds and typically regenerate on the floodplain farther from the active scour channel.

Understory plants and vines such as snowberry, California blackberry, wild grape, coltsfoot, spicebush, wild rose, and Dutchman's pipe also grow in this diverse floodplain forest.

SEEDLINGS OF WHITE ALDER
ANOTHER PIONEER SPECIES

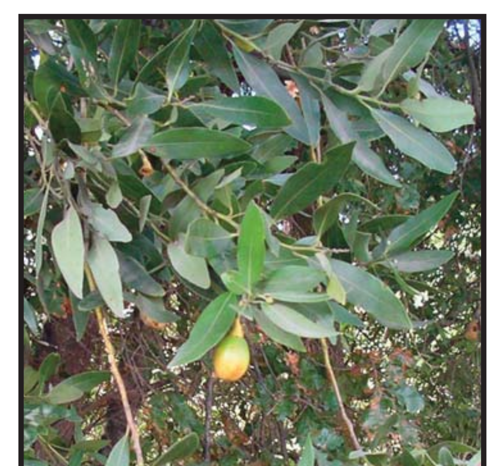
WHITE ALDERS HAVE ABOVE AND BELOW GROUND
ROOTS TO ANCHOR THE TREE

CALIFORNIA BLACK
WALNUT SEEDLING

BOX ELDER SEEDLING GERMINATES BENEATH WILLOWS

OREGON ASH GROWS IN THE MIDBANK
AREA ON THE NAPA RIVER

WILLOWS SLOW WATER VELOCITY
AND COLLECT SEDIMENT



CA. BAY LAUREL IN THE MID AND
MATURE LEVEL VEGETATION

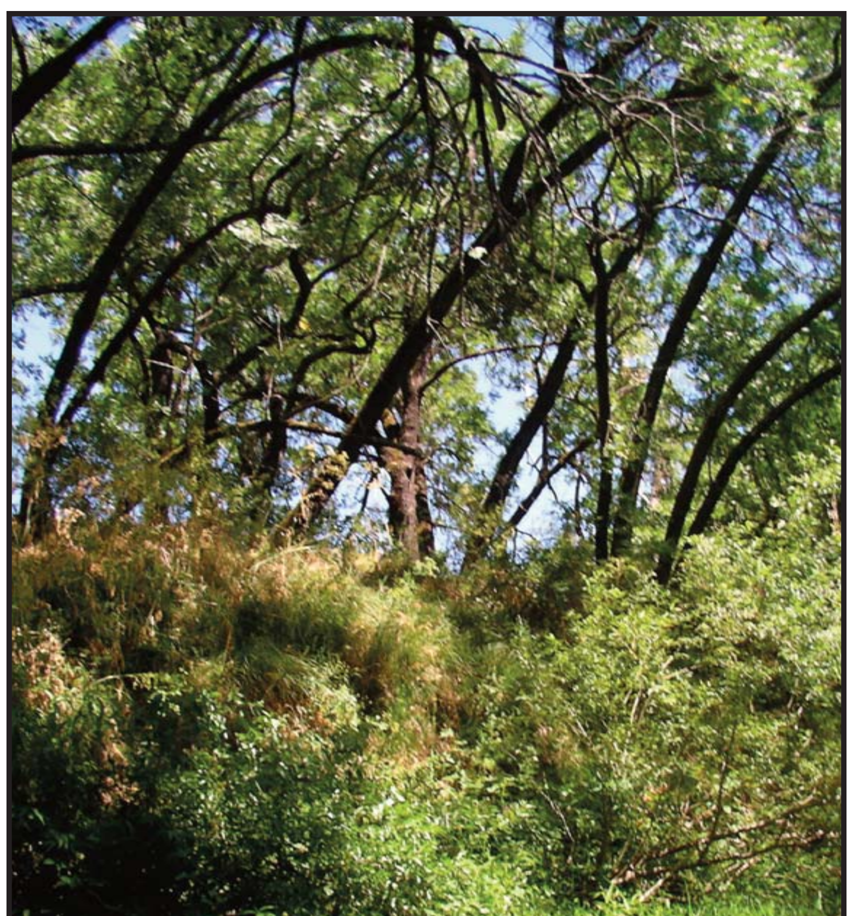
YOUNG WILLOW AND MATURE COTTONWOODS

This more varied riparian forest grades from the floodplain nearest to the channel out onto the valley floor. Larger floods coat the floodplain with a layer of fine silts and organic material creating a rich, fertile environment compared to the channel margin. Valley oak is a major component of the floodplain riparian forest. California buckeye, California bay laurel and coast live oak may also occur in this area. This floodplain forest is tall and diverse with trees reaching 100 feet in height often with over 20 different plant species in an area of a few thousand square feet. Valley oak, bay laurel, box elder, Ca. walnut, Oregon ash as well as large cottonwoods and willows and numerous vines and small herbs make up the mature riparian forest, also called gallery forest.

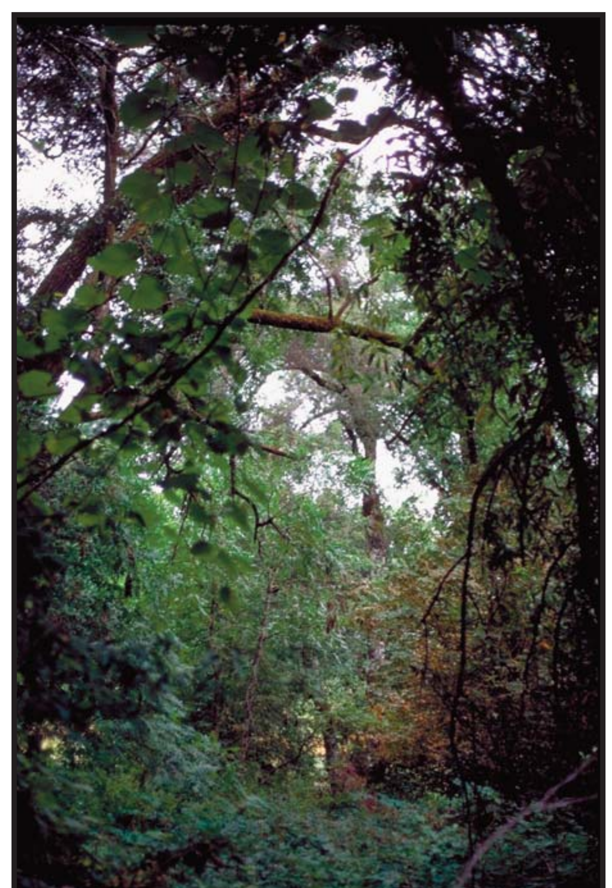
Just as the small seedlings of the forest are scoured out by the river, so is the mature gallery forest. As the river or creek channel meanders it erodes its outer banks and undercuts mature trees. A large flood can undercut and move numerous large trees down the river. Once eroded these mature trees rarely re-root like the willow. Instead these large, and now dead trees, become large wood or large woody debris, an essential component of aquatic habitat.

Ecological Succession

The process of change in the riparian ecosystem from pioneer species through mid-level habitat to gallery forest and finally to the woody debris stage is termed ecological succession and is controlled in timing and extent by the floods and geomorphic processes of the river system. During a major flood the river channel may scour and erode large patches of mature forest while simultaneously supplying new areas of alluvium for germination of seedling alder, willow and cottonwood. The flood cycle rejuvenates and resets the riparian ecosystem maintaining a diversity of growth stages and plant species.



YOUNG AND MATURE RIPARIAN VEGETATION



MATURE RIPARIAN FOREST

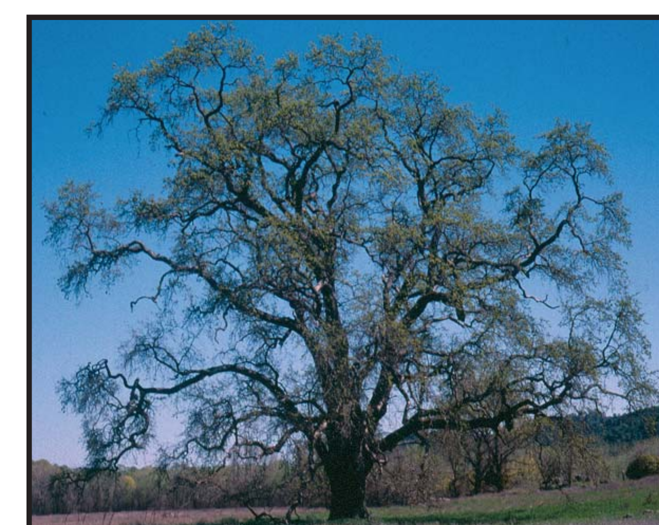
SNOWBERRY IS A NATIVE UNDERSTORY PLANT

BASKET SEDGE

DENSE NATIVE RIPARIAN UNDERSTORY

WESTERN SPICEBUSH

MATURE RIPARIAN TREE BECOMES LARGE WOOD

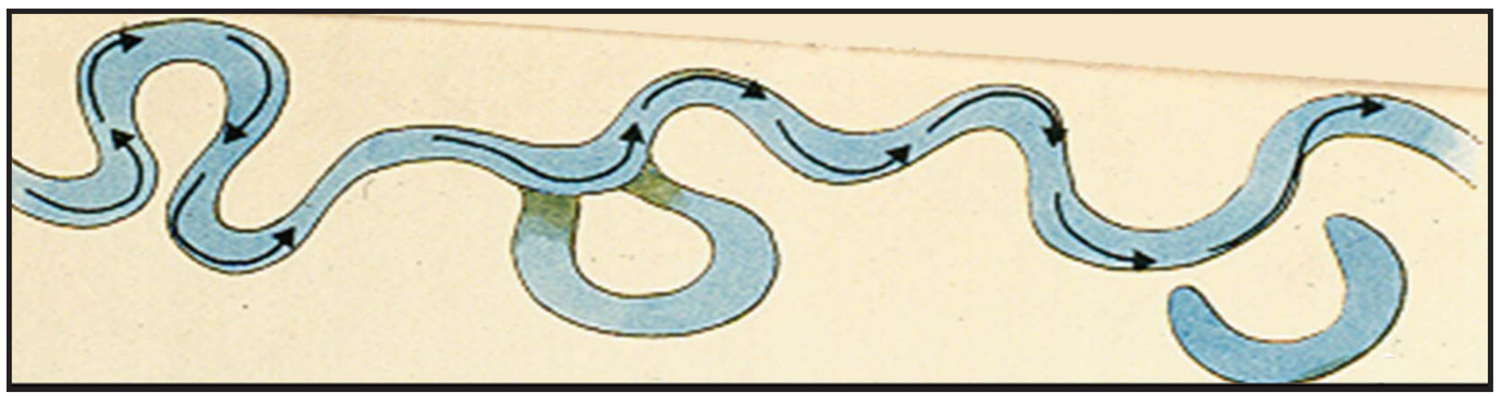


VALLEY OAK

The meandering river channel and the changes it creates in its floodplain produce cutoff meanders, abandoned river channels, sloughs and secondary channels. These former channels are usually deeper than the surrounding floodplain, fill with water and are lined with freshwater marsh plants such as cattails, sedges, bulrush and tules. These wetlands and ponds, interspersed over the floodplain amidst the riparian forest, increase habitat diversity.

Riparian habitat is sustained by the processes in the watershed and the sediment movement, flooding and meandering of the river channel. These processes are highly affected by human changes to the watershed, to the stream or river channel, and to the floodplain. For example, urban development typically involves eliminating all flooding of the floodplain. Floodwater is confined to the channel which may be bracketed between levees or cleared of riparian vegetation and lined with riprap. These changes create a river with an increased volume of stormwater moving at a higher velocity and high levels of channel scour.

The remaining riparian vegetation is likely to be scoured out. The processes that support regrowth of the riparian forest – channel meandering, formation of gravel bars with new alluvium, overbank flow, and adequate room for a varied and changing riparian corridor—are no longer part of the urbanized channel. To retain even a narrow riparian corridor under urban conditions will require continuous management including frequent replanting with riparian plants on the channel banks. It is not possible to retain a riparian ecosystem without the watershed and floodplain processes that regenerate and sustain the vegetation.



FLOODPLAIN WETLANDS ARE AN IMPORTANT ELEMENT OF THE RIPARIAN ECOSYSTEM

LEFT: REGENERATION OF WHITE ALDER WITH SEEDLINGS ON GRAVEL BAR NEXT TO THE CHANNEL AND MATURE TREES ON THE FLOODPLAIN

BELOW: CHANNEL INCISION ERODES OUT MATURE VEGETATION AND LIMITS REGENERATION

RIGHT AND BELOW: RESISTANT CLAY IN THE NAPA RIVER CHANNEL LIMITS THE REGENERATION OF SEEDLINGS AND THEIR GROWTH TO MATURE TREES

Riparian Wildlife

The patchwork of riparian and wetland areas creates numerous microhabitats for all types of wildlife. The lush, verdant summer growth of the riparian trees creates a ready food source of nuts, berries, seeds, leaves and insects. A patch of dense gallery forest may occur next to a mid-level forest with a wetland of tules set in-between. This mosaic contains a variety of structures: large trunks and branches of trees, dense bushy vegetation, wetlands with low growing plants and water weeds and hollow and standing dead trees. Each of these microhabitats can host different species, or provide for a certain habitat requirement such as nesting, feeding, resting, or cover from predators.

This smorgasbord of habitat types and feeding areas attracts wildlife from the drier hillslopes nearby and migrants from other areas. The tall trees of the gallery forest may provide all that a small nesting songbird, such as a warbler, really needs: nesting space, cover from predators, and an abundance of insects near the nest. This species may not need to move between the different types of habitat found on the floodplain. A red-tailed hawk may only use the riparian forest for a portion of its needs: to nest in the tall trees. The hawk's hunting is done on the nearby grassy hillslopes. Large mammals forage or hunt in the uplands, but visit the riparian forest for food sources in late summer or for water when creeks are dry.

Insect life is the most abundant component of the riparian forest and the most varied. Over half of the insect species found in the forest eat living plants; the other half subsists on dead leaves and logs, or is predacious or parasitic on other insects and animals. There are soil dwellers, flower sippers, leaf eaters and bark borers. Some butterflies and moths feed or lay their eggs on only one species of riparian plant.

Where there are insects there are animals that feed on them. Amphibians such as tree frogs and red-legged frogs live and breed in pools and wetlands in the shade of the riparian forest. In fact, about 80% of all amphibian species in California are dependent on riparian and stream habitats for some portion of their life cycle. Reptiles such as the aquatic garter snake and the western pond turtle, live in riparian and wetland areas. Mammals, including raccoon, mink, and river otter, are well known inhabitants of the riparian floodplain. Upland creatures such as deer need the riparian forest when food resources in the uplands are low. Nearly 40% of native mammals and reptile species depend on riparian habitat for at least one essential part of their life.

Birds are the most visible and vocal of the inhabitants of the riparian zone. There are few other habitat types in the state that support the diversity of birds found in the riparian forest. Nearly 120 species of birds breed during the spring and summer months in riparian habitats in Northern California.

For migrant songbird species the riparian forest is a second home. Some spend part of the year in the rainforest of Central and South America and return in the spring and summer to the riparian forest in California to nest. In the fall as cooler temperatures set in and the riparian trees lose their leaves, the birds fly back to the warmer southern and tropical climates. Other species nest in Alaska and Canada and fly to California to spend the winter feeding on berries, seeds, or insects in riparian and upland habitats.

Floodplain wetlands are where many types of waterfowl, mammals, fish and amphibians live. Wood ducks feed in the wetland and nest in the trunks of old trees along the borders of the marsh. Wading birds such as egrets and herons also frequent floodplain wetlands.

The river and its floodplain forest contain tall trees, short trees, dense vines and wetlands, river bars and flowing water. Each of the features provides different places for the animals to nest, hide, feed and carry out their lives.

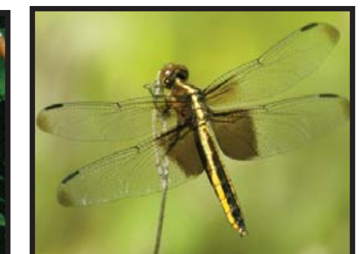

DIVERSE RIPARIAN HABITAT


BLACK PHOEBE


ACORN WOODPECKER


KINGFISHER


NESTING YELLOW WARBLER


DRAGONFLY


RED-WINGED BLACKBIRD


LITTLE BROWN BAT


PACIFIC TREE FROG


PIPEVINE SWALLOWTAIL BUTTERFLY AND CATERPILLAR ON NATIVE RIPARIAN PIPEVINE


STEELHEAD TROUT FRY


RACOON


RIVER OTTER

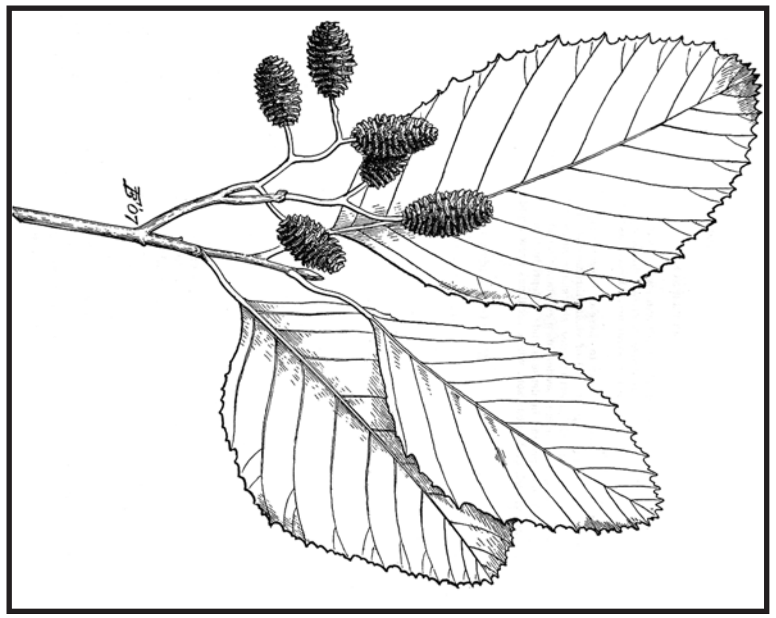

WESTERN POND TURTLE


DEER

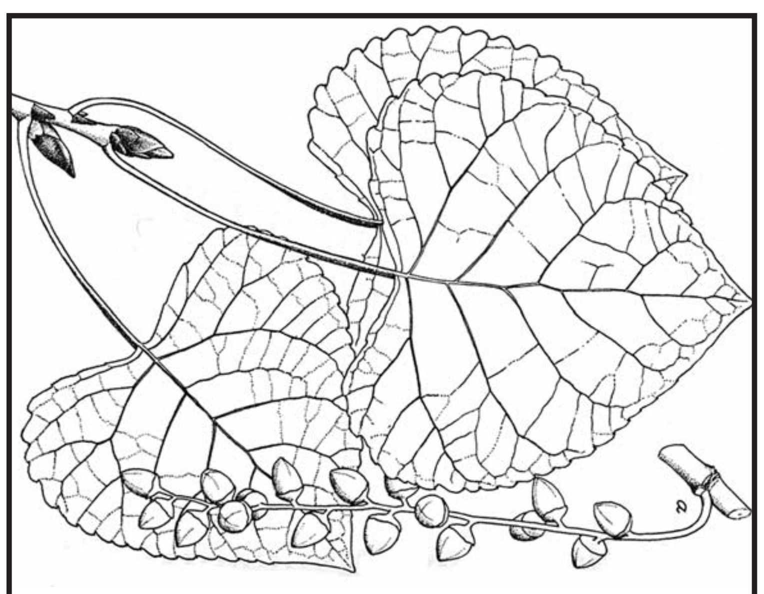
RIPARIAN TREE SPECIES

PIONEER SPECIES

Willow (*Salix spp.*)
Range: Interior and coastal northern California as well as the central valley and southern California.
Description: Willows have the unique ability to actively propagate in and around the bankfull channel. They are remarkably tenacious and can withstand the inundation and the high velocity of floodwaters. Their wood is soft, light and able to bend in high flows. Their deciduous leaves vary in form, but are frequently long and narrowly pointed.

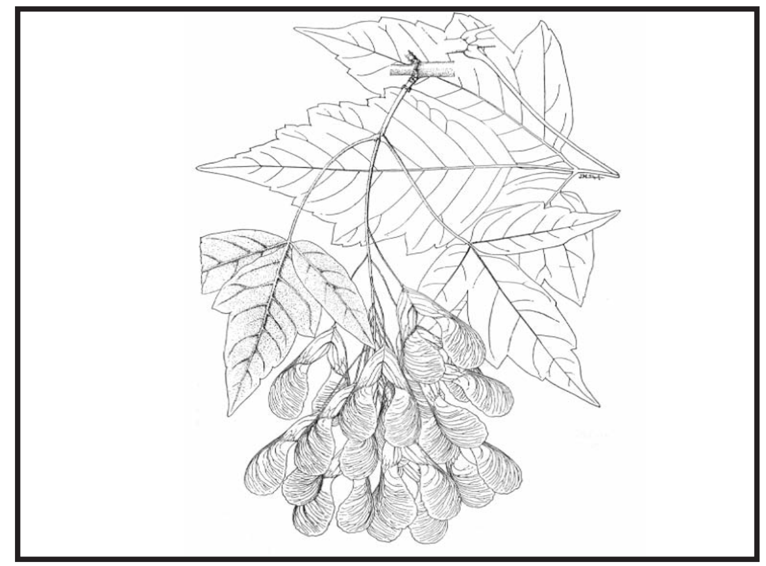


White Alder (*Alnus rhombifolia*)
Range: From northern Idaho southward through the California Coast Ranges and western slopes of the Sierra Nevada.
Description: White alder have mottled gray bark with flecked branches and shiny, dark green leaves. Leaves also tend to have a toothed border. They grow 30 to 40 feet high and 8 to 12 inches in diameter. Mature cones are shed in midwinter. White alder commonly grow adjacent to the low flow channel.

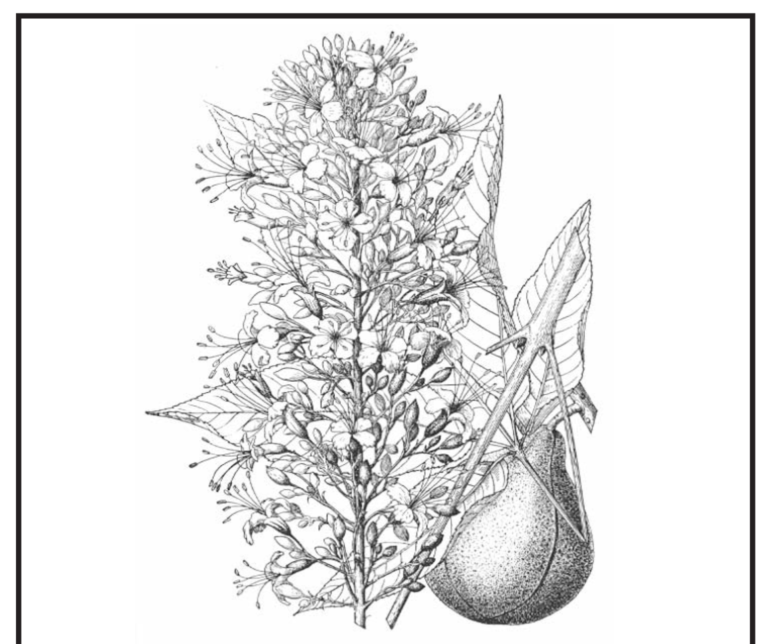


Fremont Cottonwood (*Populus fremontii*)
Range: Sacramento Valley and Coast Ranges in northern and southern California. Found on open gravel bars and mature riparian forests.
Description: Bark is thick, dark, deeply furrowed and boldly ridged. Winter buds are light green, hairless, and about ½ inch long. Leaves are 2 inches long. Cottonwoods grow up to 120 feet high and are in the same family as willows. Cottonwood is one of the colonizer species able to germinate next to the bankfull channel.

California Black Walnut (*Juglans californica var. hindsii*)
Range: The original distribution of California black walnut was limited to Walnut Creek, Atlas Peak and Gordon Valley in Napa County, and the lower Sacramento River. The native walnut was used extensively as a rootstock for English walnut orchards and has naturalized in many areas.
Description: Walnuts have compound leaves made up of 9-17 pointed leaflets. Walnuts grow very quickly as saplings and then much slower as mature trees. Black walnuts drop into creeks and rivers and are distributed to new growing areas.

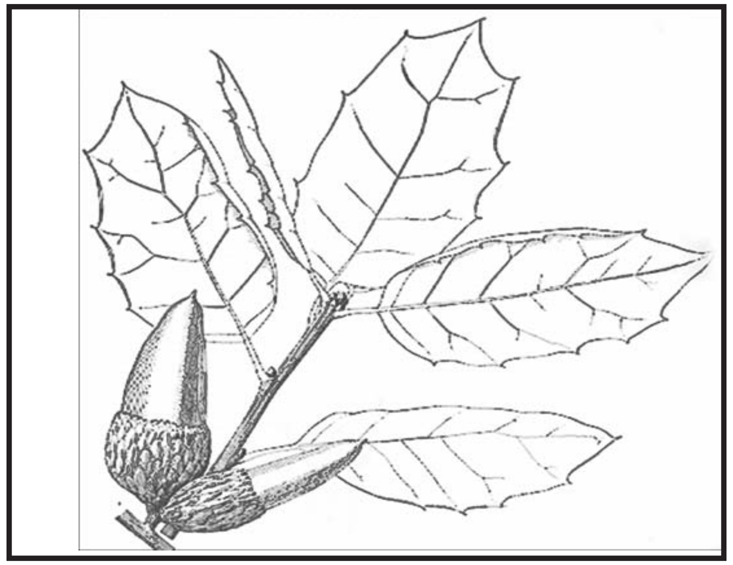


Box Elder (*Acer negundo*)
Range: Coast ranges from Sonoma to Santa Barbara Counties.
Description: Box elder is in the same family as the maple. These trees grow from 20 to 50 ft tall with separate male and female flowers and numerous seed pods produced on female trees. Box elder grows away from the active channel in areas of the riparian corridor less prone to scour and high water.

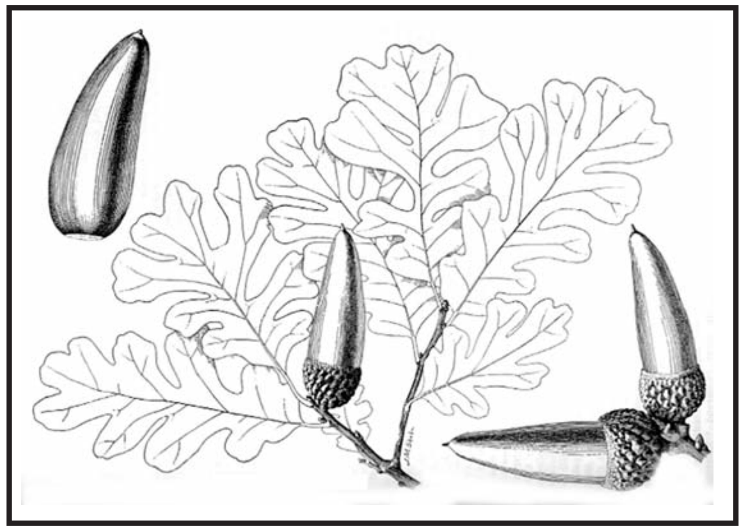


California Buckeye (*Aesculus californica*)
Range: Coast ranges from Mendocino County to San Luis Obispo County, Sierra foothills and parts of southern California.
Description: California buckeye has distinctive leaves with five leaflets. Buckeyes are one of the first of the deciduous trees to leaf out. Buckeye has numerous spikes of white flowers which produce leathery hulled fruits. Inside each fruit is a single shiny brown seed which gives the tree its name. This tree avoids the drought of summer by going dormant as early as July in very dry areas.

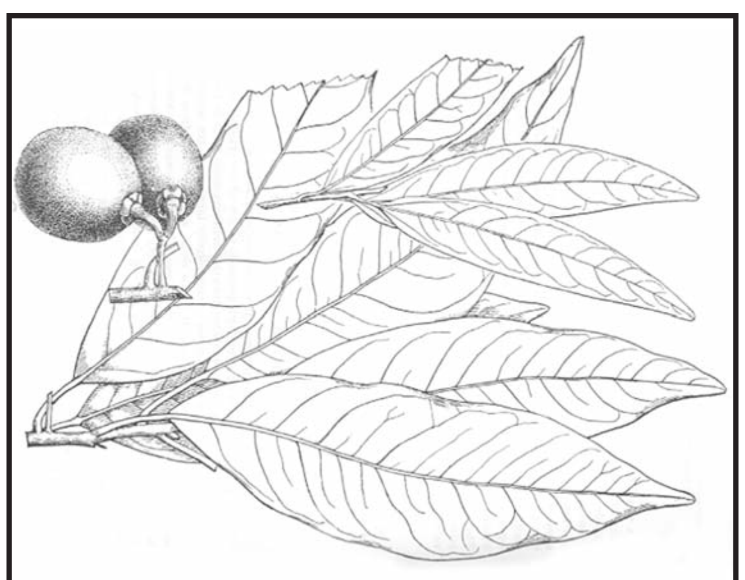
RIPARIAN TREE SPECIES



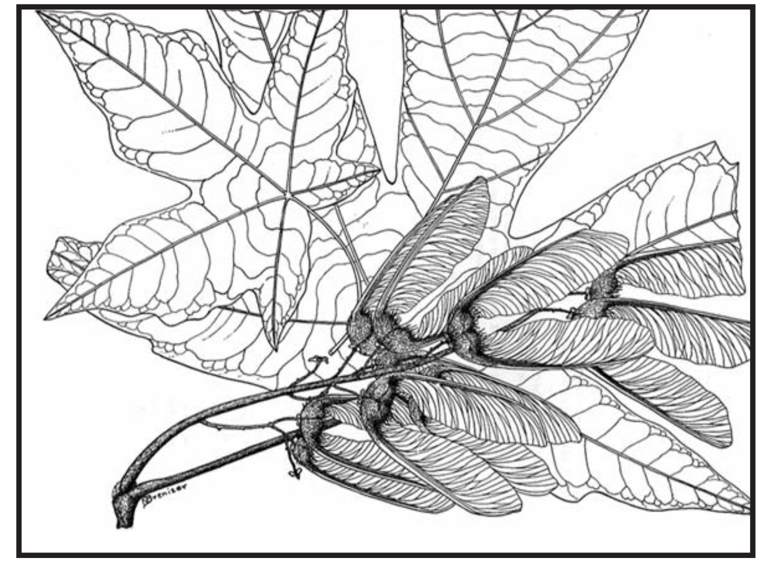
Coast Live Oak (*Quercus agrifolia*)
Range: From California Coast Ranges south down to Baja California, Mexico.
Description: The coast live oak (also known as the California live oak) is found in a variety of habitats, including well-established floodplains and mountains up to 4500 feet. The characteristically long and crooked limbs branch out from the short trunk. Its leaves are hard, waxy, convex in shape and generally a dark shiny green. Coast live oaks grow to 25-50 feet in height and 1-2 feet in diameter.



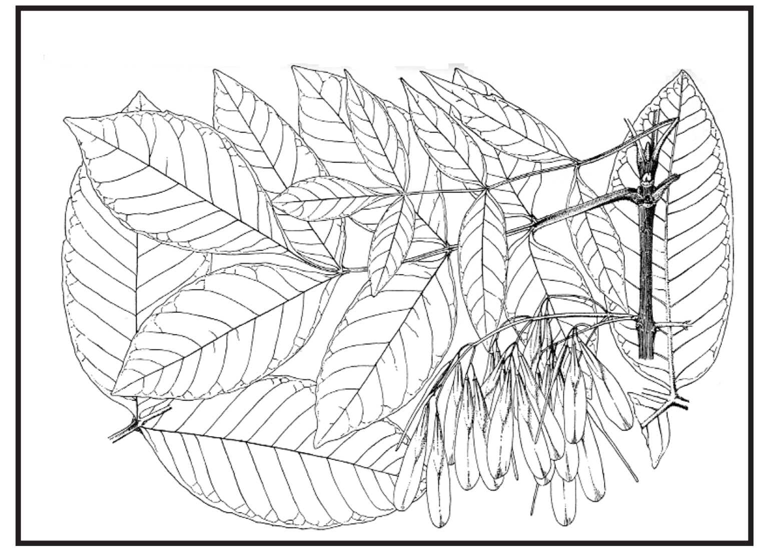
Valley Oak (*Quercus lobata*)
Range: Floodplains and valleys of the California Coast Ranges and western foothills of the Sierras extending south to Santa Monica, California.
Description: The valley oak is the largest of the western oaks ranging from 60-75+ feet in height with a diameter of 30 to 40+ inches. It loses its mature leaves in the fall and produces acorns in large quantities. Valley oak occupies the outermost portion of the riparian corridor and when eroded into the stream channel provides large wood for steelhead habitat.



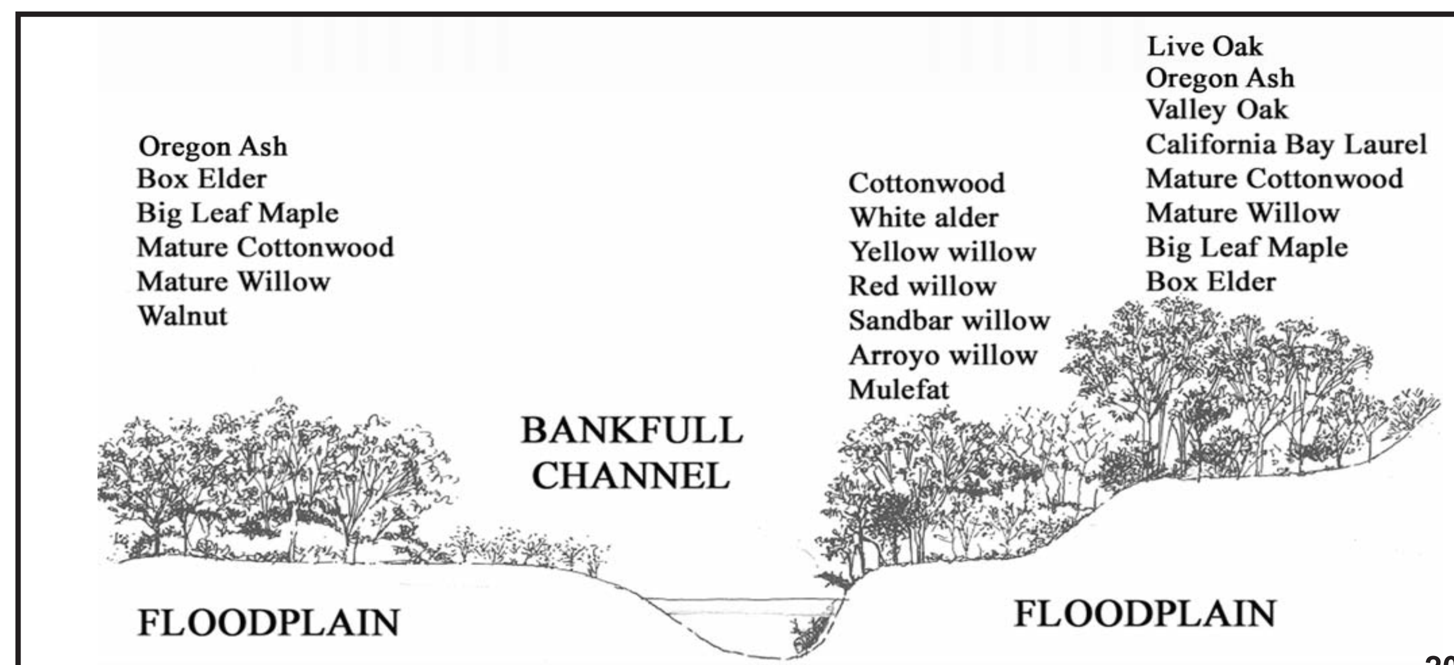
California Bay Laurel (*Umbellularia californica*)
Range: From southwestern Oregon down to the southern border of California.
Description: The bay laurel is an evergreen tree growing to heights of 120 feet and up to 4 feet in diameter. It occurs in floodplain riparian forests as well as mixed evergreen forests and other upland areas. It is a slow growing tree that lives for hundreds of years. Leaves have a pungent camphoric odor and seeds ripen in the fall.



Big Leaf Maple (*Acer macrophyllum*)
Range: From the coast ranges of British Columbia through Washington, Oregon down as far south as San Diego County, California.
Description: Bark of this deciduous tree is brown or bright reddish brown and deeply furrowed. Palmate leaves are 8-12 inches long, flowers bloom in drooping spikes 4-6 inches long. Fruit has distinctive two-wing structure, about 1½ inches long. These trees grow 30-50 feet in height and have been known to live 150 to 200 years or more. Maple can tolerate greater amounts of shade than many riparian species and lives in the midlevel and outer riparian corridor and floodplain.



Oregon Ash (*Fraxinus latifolia*)
Range: Coastal ranges of Washington, Oregon and northern California.
Description: This widespread tree is used as a hardwood for furniture. Oregon ash can grow to 75 ft. tall and live over 200 years. Oregon ash grows in moist streamside areas away from the active channel and prefers full sun. This ash produces large volumes of seed on female trees.



NAPA RIVER RIPARIAN CORRIDOR

On the Napa River the riparian ecosystem is limited to a corridor along the main river channel. The floodplain is used for intensive agriculture and urban uses. Many of the physical processes in the Napa River channel including flood velocities, scour, sediment deposition and channel meandering are highly altered from natural conditions.

There are several large municipal dams on tributaries to the Napa River as well as many small agricultural reservoirs. These reservoirs reduce the sediment supply to the river and induce the river to erode its bed and banks. Agricultural berms constructed on the channel edge confine floods to the channel for certain size flows, increasing the erosion and deepening of the channel. Over time the Napa River has entrenched and in most locations has very steep (>15 ft.) vertical banks. The floodplain or valley floor is now abandoned, left high and dry fifteen or more feet above the channel bottom. The riparian zone or area of frequent flooding along most of the Napa River does not include a large floodplain but consists of the bottom and banks of the channel.

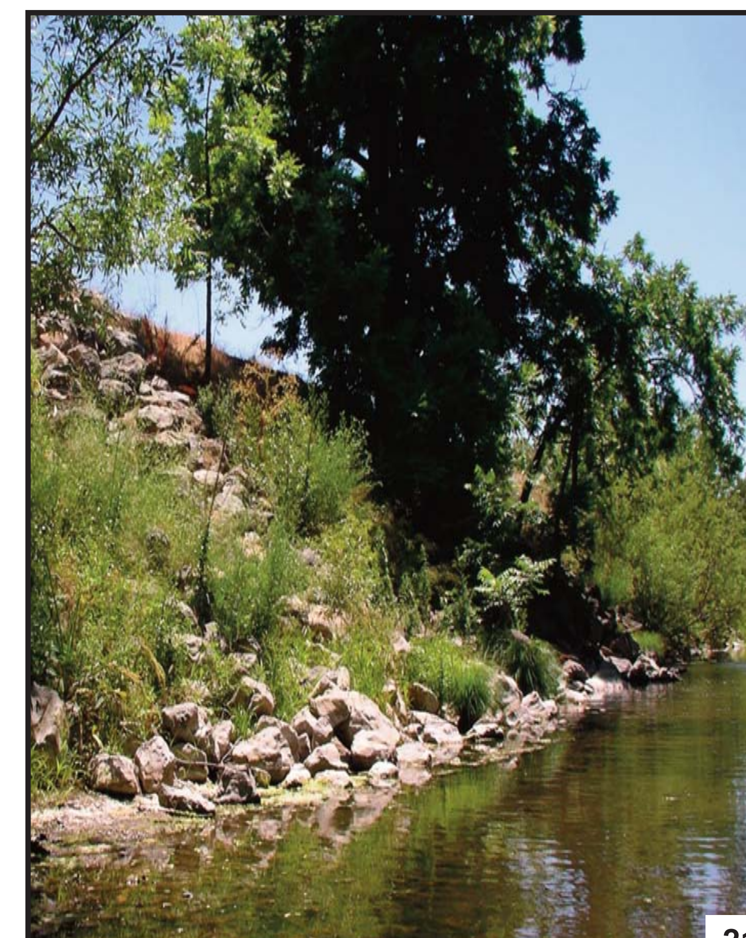
Due to the channel entrenchment, the velocity of flood flows is increased sometimes greater than the tolerance of riparian trees. In a few locations the river banks have eroded and failed, widening the channel and forming a new floodplain closer to the low-flow channel.

Additionally, landowners and managers have attempted to reduce bank erosion by dumping rock and planting willows along the bank. The top of the bank/berm areas next to the vineyards have often been cleared of invasive plants which host the Pierce's Disease bacteria, and native trees and understory plants are installed. Neither of these actions "restores" the riparian ecosystem as they do not create the physical conditions that support and sustain the system.

With a system as highly altered as the Napa River it is unclear how the riparian ecosystem is evolving and what actions are needed to make the riparian system healthy and self sustaining. Answering these questions and creating a detailed database on the riparian system is an essential first step in restoring the Napa River ecosystem.

The ecological questions addressed in the Napa River riparian study include:

1. Is there a reference reach in the project area representing undisturbed or target ecological conditions?
2. How do different reaches vary in vegetation density, and can these differences be related to physical parameters such as channel width and depth, or flow velocity?
3. How do different reaches vary in their biodiversity and successional status, and can these differences be related to physical parameters of channel width and depth or flow velocity? Are riparian tree species able to regenerate and undergo ecological succession with the altered physical dynamics of the current Napa River?
4. What is the relationship between invasive non-native plants and regeneration of native riparian species?
5. Where are existing large trees in danger of being undercut and lost along the entrenched channel
6. Where does rock riprap affect regeneration of riparian vegetation?
7. Where do areas of significant ecological value occur?

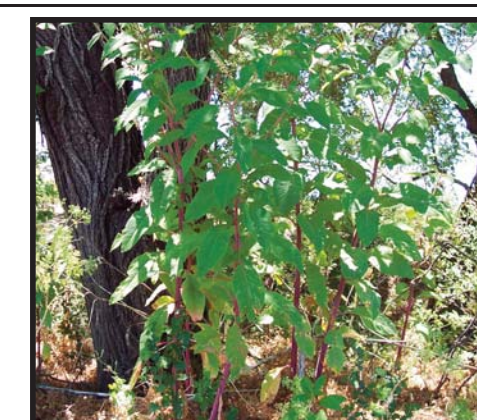


Napa River Riparian Corridor Plant Species

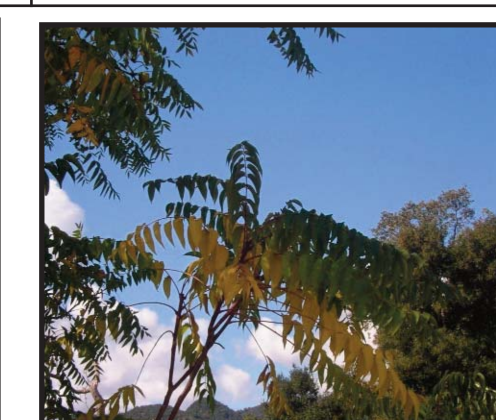
Common Name	Species Name	Status Native, Non-Native, Invasive
Native Trees		
Arroyo willow	Salix lasiolepis	Native
Big-leaf maple	Acer macrophyllum	Native
Blue elderberry	Sambucus nigra ssp. cerulea	Native
Box elder	Acer negundo	Native
California bay laurel	Umbellularia californica	Native
California buckeye	Aesculus californica	Native
California black walnut	Juglans californica var. hindsii	Native and hybrid with orchard tree
Coast live oak	Quercus agrifolia	Native
Fremont cottonwood	Populus fremontii	Native
Interior live oak	Quercus wislizenii	Native
Oregon ash	Fraxinus latifolia	Native
Red willow	Salix laevigata	Native
Sandbar willow	Salix lasiolepsis	Native
Arroyo willow	Salix sessilifolia	Native
Valley oak	Quercus lobata	Native
White alder	Alnus rhombifolia	Native
Non-native Trees		
Black locust	Robinia pseudoacacia	Non-native, invasive
Blue gum eucalyptus	Eucalyptus globulus	Non-native, invasive
Lombardy poplar	Populus nigra	Non-native; hybridizes with native cottonwood
Tree-of-heaven	Ailanthis altissima	Non-native, invasive
Acacia	Acacia decurrens	Non-native, invasive
Native Understory Species		
Basket sedge	Carex barbarae	Native
Beavertail cactus	Opuntia basilaris	Native; planted as food plant
California blackberry	Rubus ursinus	Native
California bulrush	Schoenoplectus californicus	Native
California honeysuckle	Lonicera hispidula	Native
California rose	Rosa californica	Native
California wild grape	Vitis californica	Native
Cocklebur	Xanthium sp	Native
Common knotweed	Polygonum sp.	Native
Common tule	Schoenoplectus acutus	Native
Coyote brush	Baccharis pilularis	Native
Dutchman’s pipe	Aristolochia californica	Native
Gooseberry	Ribes sp	Native
Horsetail	Equisetum sp.	Native
Mugwort	Artemisia douglasiana	Native
Mulefat	Baccharis salicifolia	Native
Poison oak	Toxicodendron diversilobum	Native
River sedge	Schoenoplectus fluviatilis	Native
Snowberry	Symphoricarpos albus	Native

Common Name	Species Name	Status Native, Non-Native, Invasive
Native Understory Species (cont.)		
Spicebush	Calycanthus occidentalis	Native
Stinging nettle	Urtica dioica	Native
Torrent sedge	Carex nudata	Native
Toyon	Heteromeles arbutifolia	Native
Umbrella sedge	Cyperus squarrosus	Native
Watercress	Rorippa nasturtium-aquaticum	Native
Wild cucumber	Marah fabaceus	Native
Non-native Understory Species		
Black mustard	Brassica nigra	Non-native, invasive
Blue periwinkle	Vinca major	Non-native, invasive
Bullthistle	Cirsium vulgare	Non-native, invasive
Curly dock	Rumex crispus	Non-native
Eggleaf spurge	Euphorbia oblongata	Non-native, invasive
English ivy	Hedera helix	Non-native, invasive
Fennel	Foeniculum vulgare	Non-native, invasive
Fullers teasel	Dipsacus fullonum	Non-native, invasive
Giant reed	Arundo donax	Non-native, invasive
Harding grass	Phalaris aquatic	Non-native, invasive
Himalayan blackberry	Rubus discolor	Non-native, invasive
Jimsonweed	Datura sp.	Non-native, invasive
Plum	Prunus sp	Non-native, invasive
Poison hemlock	Conium maculatum	Non-native, invasive
Pokeweed	Phytolacca americana	Non-native, invasive
Rattlebush	Sesbania punicea	Non-native, invasive
Six-petal water primrose	Ludwigia hexapetala	Non-native, invasive
Yellow nutsedge	Cyperus esculentus	Native but invasive
Yellow star thistle	Centaurea solstitialis	Non-native, invasive

INVASIVE ARUNDO DONAX



INVASIVE POKEWEED



INVASIVE TREE OF HEAVEN

Methods

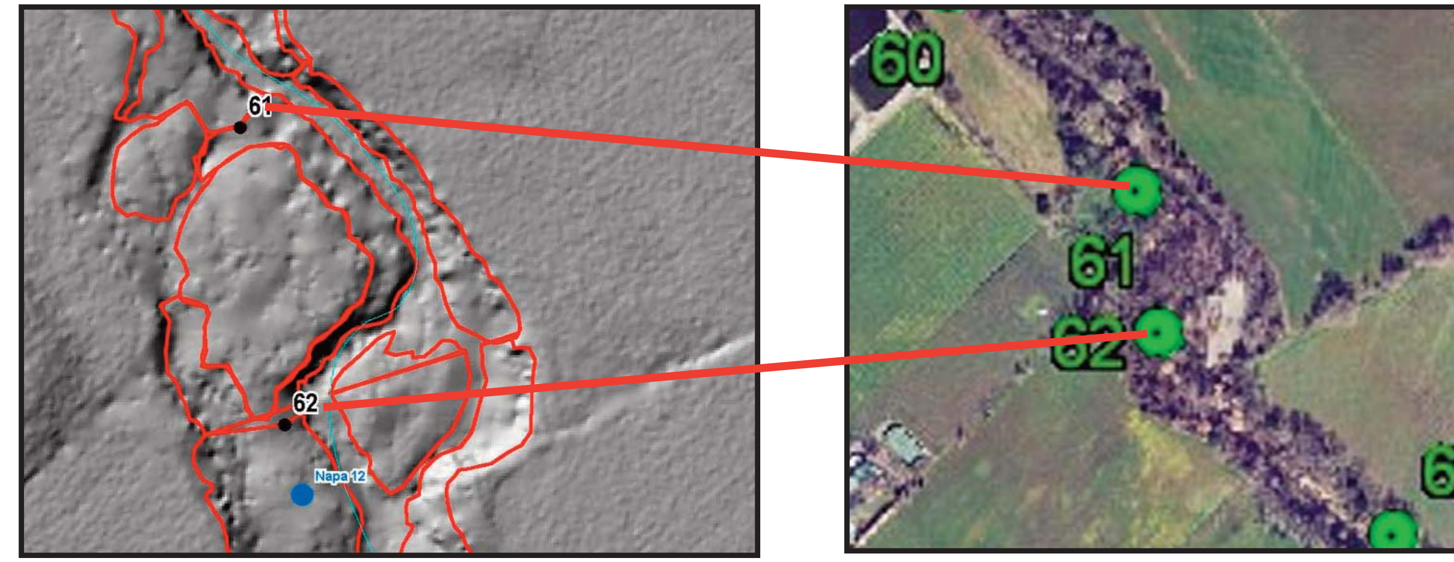
The riparian ecosystem of the Oakville to Oak Knoll reach of the Napa River was mapped and evaluated by the staff of the California Land Stewardship Institute. Laurel Marcus served as the principal scientist, Lisa Lackey led the GIS effort and Nelia White and Julie Beagle assisted in all aspects of the project. Darcie Luce and Danielle D'Amour assisted with report production. The field work was completed in September and early October 2007 when water levels were low and trees still retained their leaves. The field work required over 20 days total and all access was completed with landowner permission. A GIS was created for the project reach using the Napa County LIDAR set from 2003. The LIDAR shows topography at a very high resolution allowing for very detailed delineation of distinct topographic areas. A GIS specialist used the LIDAR set to delineate small topographic areas of the same elevations between the cross sections surveyed by the Napa RCD.

The topographic areas, or polygons, were classified by morphological area of the river corridor as: channel, right or left bank, right or left floodplain, secondary channel, side or tributary channel, berm (agricultural levee) or right or left outer bank. The channel occupies the lowest elevation and extended to where either a bank or distinct floodplain occurred. In many areas the bank extended from the edge of the low elevation channel to the former floodplain and upland edge of the riparian corridor. Much of the project area included the channel and right and left banks only. In some areas floodplains were delineated. The floodplains were relatively flat areas at a slightly higher elevation than the channel. A secondary channel typically occurred adjacent to a floodplain, and at a higher elevation than the main channel. Outer banks occurred adjacent to a floodplain or a secondary channel and on the outer edge of the corridor. The side channel is a tributary channel confluence with the river channel. Constructed earthen berms occurred on the outside of the corridor adjacent to agricultural lands. The boundaries and definition of each polygon was field checked and revised as needed.

Each polygon was given a unique number. The layer was loaded onto a Trimble GPS/GIS unit along with the aerial photography and LIDAR layer and used for the field mapping. A datasheet was developed for the field work for a detailed count of trees and understory in each polygon. Data was collected by teams of 2-3 staff members. Prior to field data collection on the Napa River, CLSI staff completed two weeks of field training in plant identification, and measuring DBH (Diameter at Breast Height) on trees. CLSI staff also learned how to estimate size class for vegetation which is based on DBH and height. One of four size classes was assigned to each tree.

Riparian Trees Size Class Definition		
Diameter at Breast Height (DBH)	Successional Status	Tree Size Class
<1"	Seedling	C1
1"-7"	Sapling	C2
7"-24"	Small/Medium Tree	C3
>24"	Large Tree	C4

Small/medium and large tree size classes (C3 and C4) are reproductive stages while seedlings (C1) represent newly germinated seeds from the year of the census. Saplings (C2) represent trees with several years of growth and vary in age by species. Seedlings and saplings are not reproductive stages. The relative number of the four size classes and distribution of size classes over different morphological areas in the corridor provide an indication of regeneration level and ecological successional processes.



LIDAR IMAGE ON LEFT WITH RED LINES MARKING POLYGONS USED FOR VEGETATION CENSUS. IMAGE ON RIGHT IS AERIAL SHOWING SAME AREA WITH NUMBERS INDICATING SURVEYED CROSS SECTIONS

C1 SIZE CLASS TREES OR SEEDLINGS

C2 SIZE CLASS TREES OR SAPLINGS

C3 SIZE CLASS TREES OR SMALL/MEDIUM TREES

C4 SIZE CLASS TREES OR LARGE TREES

For each polygon, the number of individual trees in each size class for each species was counted and recorded. Trees rooted upright but knocked over by floods with their main trunk growing horizontally were counted as one individual tree. Trees with multiple trunks arising below the level of breast height used in DBH measurements were counted as multiple individual trees. In some locations newly planted seedlings and saplings with irrigation were found. The counts of the newly planted trees with irrigation were segregated from the unplanted trees.

Understory plants were also identified and the species and density recorded. Location and extent of invasive giant reed (Arundo donax), black locust (Robinia pseudoacacia), Eucalyptus (Eucalyptus globulus), tree-of-heaven (Ailanthis altissima) as well as bank riprap were mapped in the field.

Using the Trimble GPS/GIS system the boundaries of each polygon were confirmed by one staff person and significant features digitized, as a separate staff person counted and recorded the number of individuals of each size class for each tree species and recorded the density and species of understory. All data sheets were filed in the CLSI office at the end of each field day.

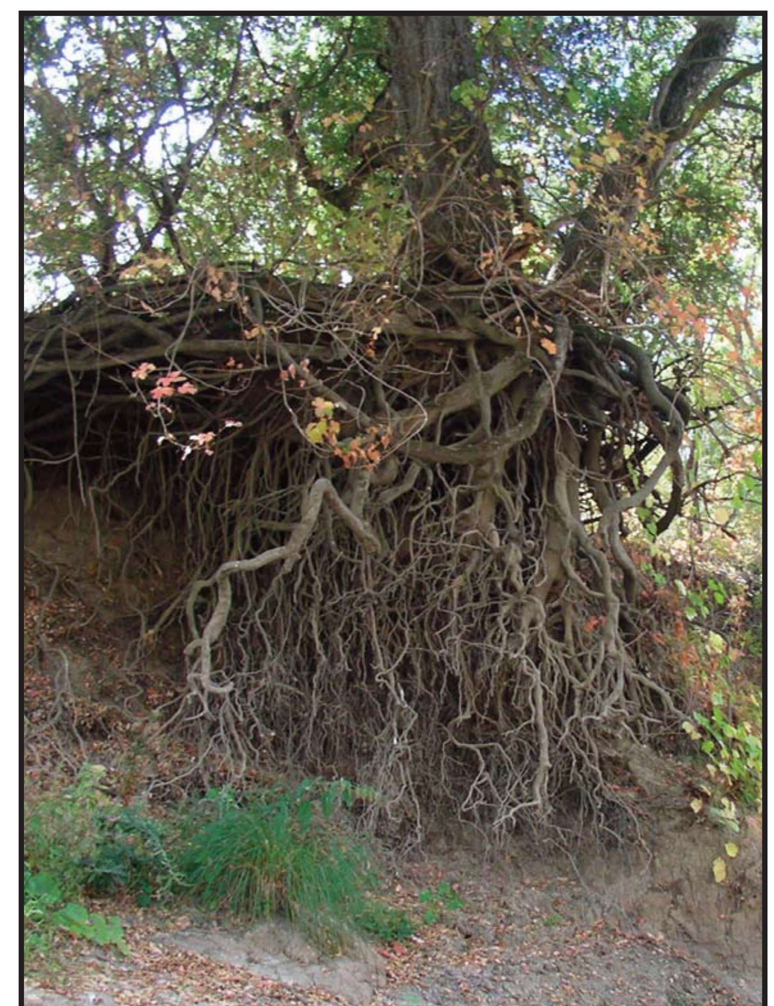
DATA ANALYSIS

Database Design

The database was designed using Microsoft Access. River mile, cross section, polygon ID number, river reach number, area of corridor, bank side, and other information were included as separate fields. Channel condition, bank condition, understory density and species, and general overstory description fields captured narrative information. Densities for the understory and overstory included fields for high, high-medium, medium, medium-low and low. The average height of the trees was generalized into 5 codes. Code 1 : <3', Code 2: 3'-15', Code 3: 16'-30; Code 4: 31'-65' and Code 5: >65'. A separate table was designed for data on size class (C1-C4) and the number of occurrences recorded in each polygon for each tree species by size class.

Data Entry

After the field data collection was complete, CLSI staff entered the data into the MS Access Database. Data was entered from the field datasheets by one CLSI staff member, and was cross-checked and proof-read by a second CLSI staff member in order to correct any errors in the data entry.



UPPER AND LOWER RIGHT: FIELD WORK IN REACH 8
MIDDLE: SPIDER TREE
LEFT: LARGE COTTONWOOD IN REACH 7

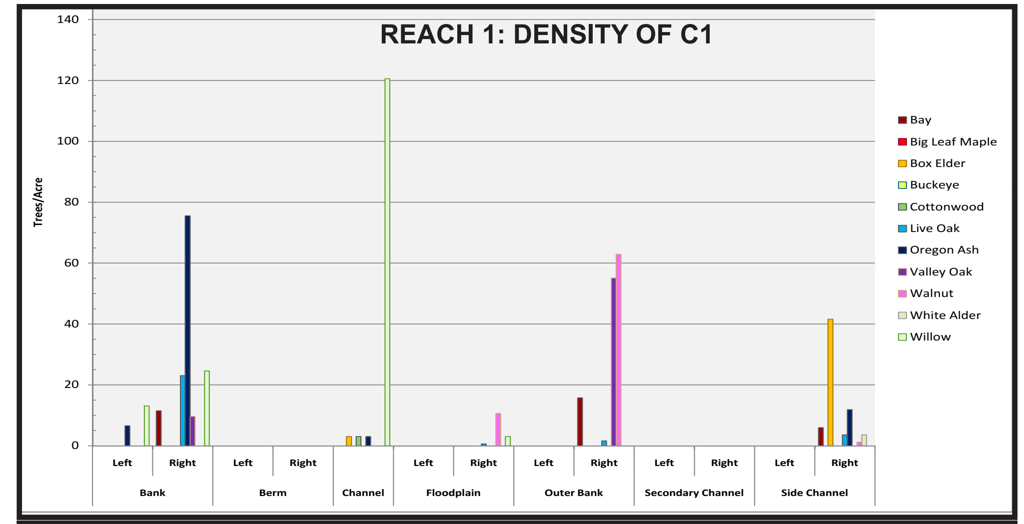
Analysis

After data entry was completed, several steps were taken to connect the GIS layers and the database. River mile markers and RCD cross-sections were used as boundaries in the field data collection. For analysis purposes the project area was divided into 11 reaches based on the geomorphologist's analysis. This was to assure that the organization of the data was consistent with all team members. The reach delineations were added to the GIS layers and the Access Database.

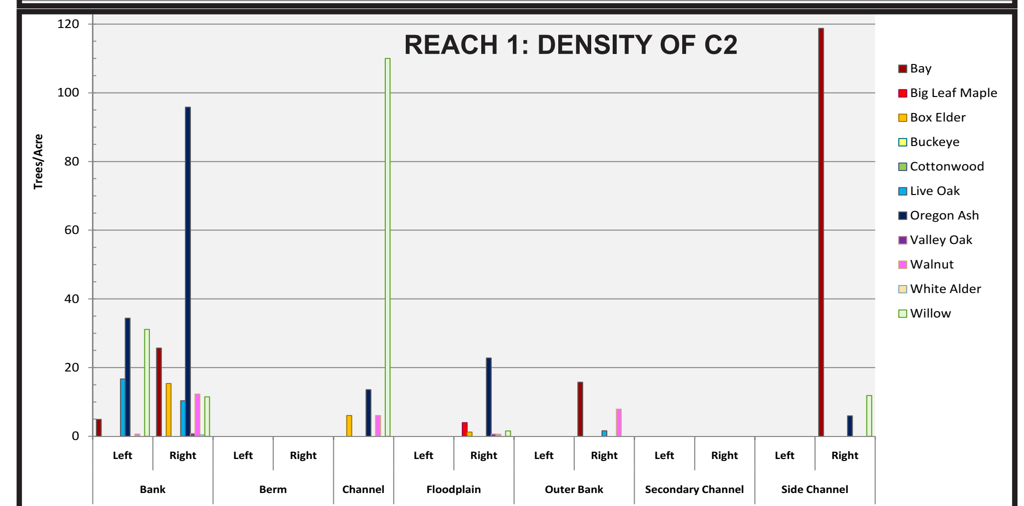
The original polygons for which the data was collected (termed "Cross section-Morphological Area-Side or XMS") were grouped into larger polygons defined by their morphology within a reach as opposed to between cross sections. These were referred to as "Reach-Morphological Area-Side or RMS". This conflation of the original cross sectional polygons (XMS) allows analysis of a larger yet still representative area of the channel. For example, 5-F-L refers to the left floodplain in reach 5, which is the sum of several of the original XMS floodplain polygons. It should be noted that the layers delineating the original XMS polygons were retained. ArcView/GIS was used to determine the acreage of each RMS.

The following analyses were charted using MS Access and MS Excel and information from the GIS:

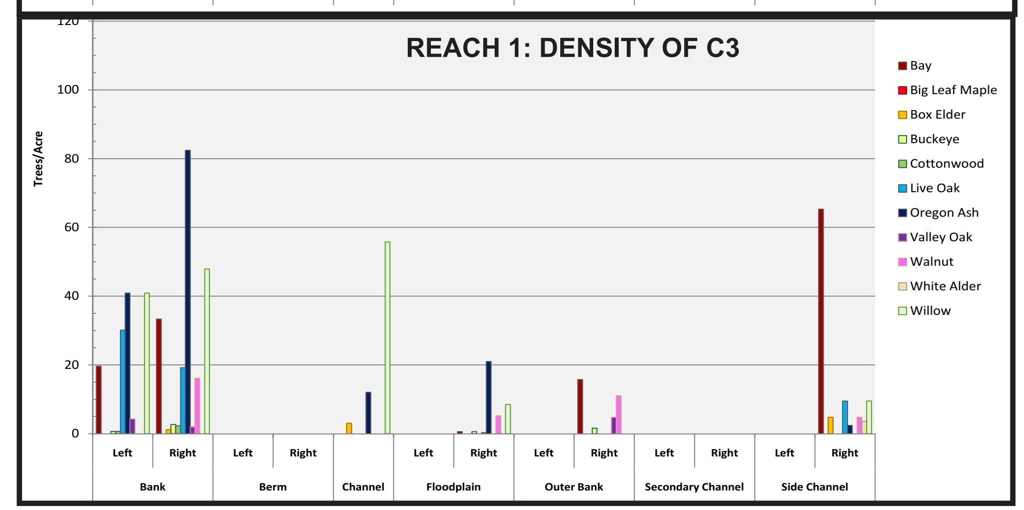
- Species diversity as described by the number of tree species in each morphological area by reach.
- The density of all species of native trees by size class within each morphological area by reach.
- The density of all sizes of all native trees irrespective of species, by morphological area by reach.
- Species dominance by morphological area, which was determined by calculating the total number of native trees of a certain species or size class (respectively) in a certain morphological area. If a species or size class represented at least 30% of the total and was 20% greater than the next closest dominant species or size, then it was considered dominant. If this situation didn't occur, the top two species/size classes were listed as co-dominants for a particular morphological area.
- The occurrence of spider trees, or trees with greater than half of their root mass exposed due to bank erosion were recorded as points in the field data. The number of spider tree occurrences /mile was calculated using ArcView GIS. The density of spider trees by morphological area and reach was calculated and charted.
- The extent of Arundo donax (giant reed) was mapped in the field. The density of Arundo was calculated by acreage and then charted by reach and by area of the channel.
- The density of invasive and non-native trees was calculated using the acreage of the morphological area, reported by species and morphological area within a reach. The non-native/invasive trees were also plotted against the density of C1 and C2 native trees within the same morphological area to determine whether a high occurrence of invasive plants could be correlated with low occurrences of native seedlings and saplings.
- The width of the riparian corridor was measured using high resolution imagery in GIS/ArcView at each RCD cross section. Cross-sections were measured from each edge of the canopy cover as seen on the aerial.. An average, minimum and maximum was recorded and plotted by reach. These measurements were evaluated for correlations with vegetative density and diversity.
- The extent of riprap on stream banks was also recorded in the field. It was recorded by linear feet by reach using the GIS/GPS unit and charted by reach.
- A number of other analyses were completed to determine if a clear relationship existed between the modeled 2-year, 5-year and 10-year flood event average flow velocities, and density of all trees and of just seedlings in the channel morphological area. The density of just seedlings as well as all trees was also compared to the width/depth ratio of the reach as well. The results of the vegetation mapping and analyses are presented by reach and summarized for the overall project reach.



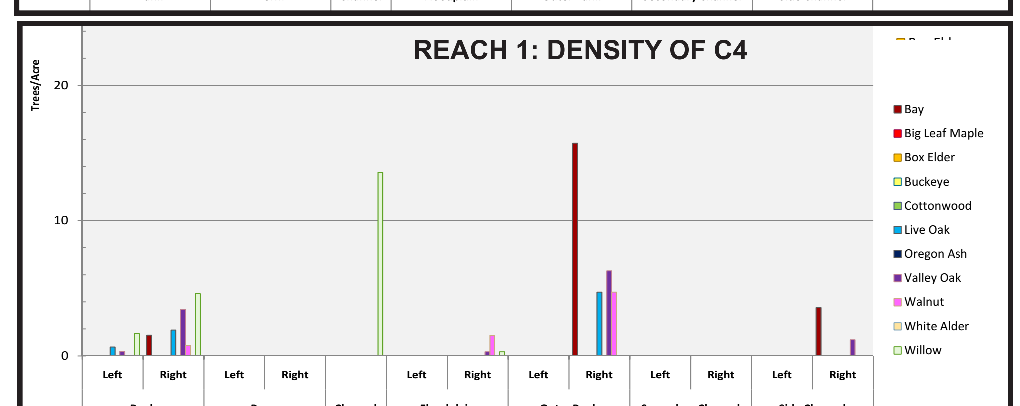
THIS GRAPH DEPICTS THE DENSITY OF C1 SIZE CLASS TREES (SEEDLINGS) OF ALL SPECIES IN REACH 1 PLOTTED BY MORPHOLOGICAL AREA



THIS GRAPH DEPICTS THE DENSITY OF C2 SIZE CLASS TREES (SAPLINGS) OF ALL SPECIES IN REACH 1 PLOTTED BY MORPHOLOGICAL AREA



THIS GRAPH DEPICTS THE DENSITY OF C3 SIZE CLASS TREES (SMALL/MEDIUM TREES) OF ALL SPECIES IN REACH 1 PLOTTED BY MORPHOLOGICAL AREA



THIS GRAPH DEPICTS THE DENSITY OF C4 SIZE CLASS TREES (LARGE TREES) OF ALL SPECIES IN REACH 1 PLOTTED BY MORPHOLOGICAL AREA

The Napa County Resource Conservation District (RCD) conducted a fisheries assessment for the Napa River between the Oakville Crossroad and Oak Knoll Avenue. This study assesses the quality and quantity of available aquatic habitat, specifically relating to salmonid life history requirements, and identify opportunities for restoration, habitat improvement, or preservation.

BACKGROUND

STEELHEAD TROUT (Oncorhynchus mykiss)

Steelhead and rainbow trout are the same species (Oncorhynchus mykiss). Rainbow trout remain in streams as resident fish while steelhead are anadromous migrating to and from the ocean. These two very different life histories occur within the same populations in the same stream. Steelhead are genetically identical to rainbow trout; their differing life history pattern represent an evolutionary adaptation to limited food and habitat resources available in streams. If access to the ocean is available, steelhead tend to dominate due to their larger size and increased egg production. However, if the stream contains barriers to upstream migration, steelhead will not return to reproduce, and the resident form of rainbow trout will become predominant in populations above the barrier.

Steelhead spend part of their life in freshwater and part in saltwater, and therefore face a complex set of environmental and physiological challenges. In the Napa River basin, adult steelhead spawning runs typically begin in January and extend through April, depending on early and late season stream flow patterns. Fish that make the upstream migration early in the season (December - January) have the advantage that their young emerge sooner and grow larger in the first year of life. However, these small fish, called fry, are more vulnerable to heavy winter storms, which can destroy redds or spawning nests and wash away developing fry. Steelhead that migrate later in the season (February – April) run the risk of being stranded by low spring and summer flows. Most populations contain a mix of early and late spawning fish, which improves the overall odds of success from year to year.

Steelhead grow rapidly in the ocean and reach sizes much larger than resident rainbow trout. After spending one to three years in the ocean, adult fish typically between 15 to 30 inches in length, return to their natal streams to spawn. Unlike pacific salmon, steelhead do not always die after spawning and are capable of spawning multiple times over a lifetime of five to seven years. The percentage of return spawning steelhead varies greatly from region to region but is generally fairly low, representing ten percent or less of the total population. In intermittent streams, low flows during the peak spawning months (February through April) can completely prevent steelhead from reproducing during a given season.

Steelhead spawn by constructing a redd in gravel substrates usually in pool riffle crests. The female scoops out a 6-10 inch depression with powerful movements of the tail and lays eggs in this redd pocket. An average female steelhead lays approximately 2,500 eggs. Accompanying males then fertilize the eggs, and the female quickly fills the redd back in with gravel. The egg development rate is temperature dependent and takes between one to two months. Eggs hatch in about 31 days at 50˚ F. Like other salmonids, steelhead hatch as alevins (with the yolk sac still attached) and spend their first two to four weeks in the gravel before emerging into the stream.

Juvenile steelhead spend one to four years in freshwater - two years is typical in the Napa River watershed. Juvenile steelhead feed primarily on aquatic insects and other invertebrates in riffles and grow

rapidly if food is abundant. When sufficient stream flows are sustained to support large aquatic insect populations throughout the year, juvenile steelhead can reach lengths adequate to out-migrate to the ocean (smolt) in one year. However, in streams with very low summer flows, steelhead grow very little during mid to late summer, and usually require two years or more to grow large enough to migrate to the ocean. Juvenile steelhead survival is directly related to body size, so larger steelhead smolts have a higher chance of surviving than smaller smolts.

Juvenile steelhead must have adequate year-round habitat. Hiding and escape cover provided by undercut banks, fallen trees, boulders and overhanging vegetation is an important part of rearing habitat for juvenile steelhead; especially for larger fish. Most forms of artificial bank protection including concrete walls, sackrete (stacked bags of concrete), and gabions (wire baskets filled with rocks) provide little or no cover for steelhead. Large boulders (2 foot or greater in diameter) can provide a limited amount of cover when placed in the streambed. However, smaller riprap, with small crevices between rocks, provides little hiding cover and often fills in with fine sediment and sand.

In streams with short or easy migrations adult steelhead tend to return at younger ages, but compensate for this by spawning in multiple years. In streams with longer more difficult migrations, the larger, stronger adults that do not return to the ocean tend to be most common. The “reproduce early and often” strategy has a distinct advantage in areas that experience severe seasonal variability with droughts that cut off flow and floods that destroy redds. A mixture of adult sizes provides the population with the greatest flexibility, and improves survivability over the long term.

CHINOOK SALMON (Oncorhynchus tshawytscha)

Fall-run Chinook salmon migrate up rivers from the ocean to spawn in their natal streams during the fall. In the Napa River, spawning typically occurs in November and December with the onset of winter rains. Chinook salmon spawn primarily in riffles at the downstream end of pools with appropriately sized gravel, sufficient depth, and nearby cover. Spawning gravel used by Chinook salmon ranges from ½ inch to 3 inches. Excessive amounts of fine sediment and sand in the streambed can reduce water flow through the gravels and limit egg survival and development.

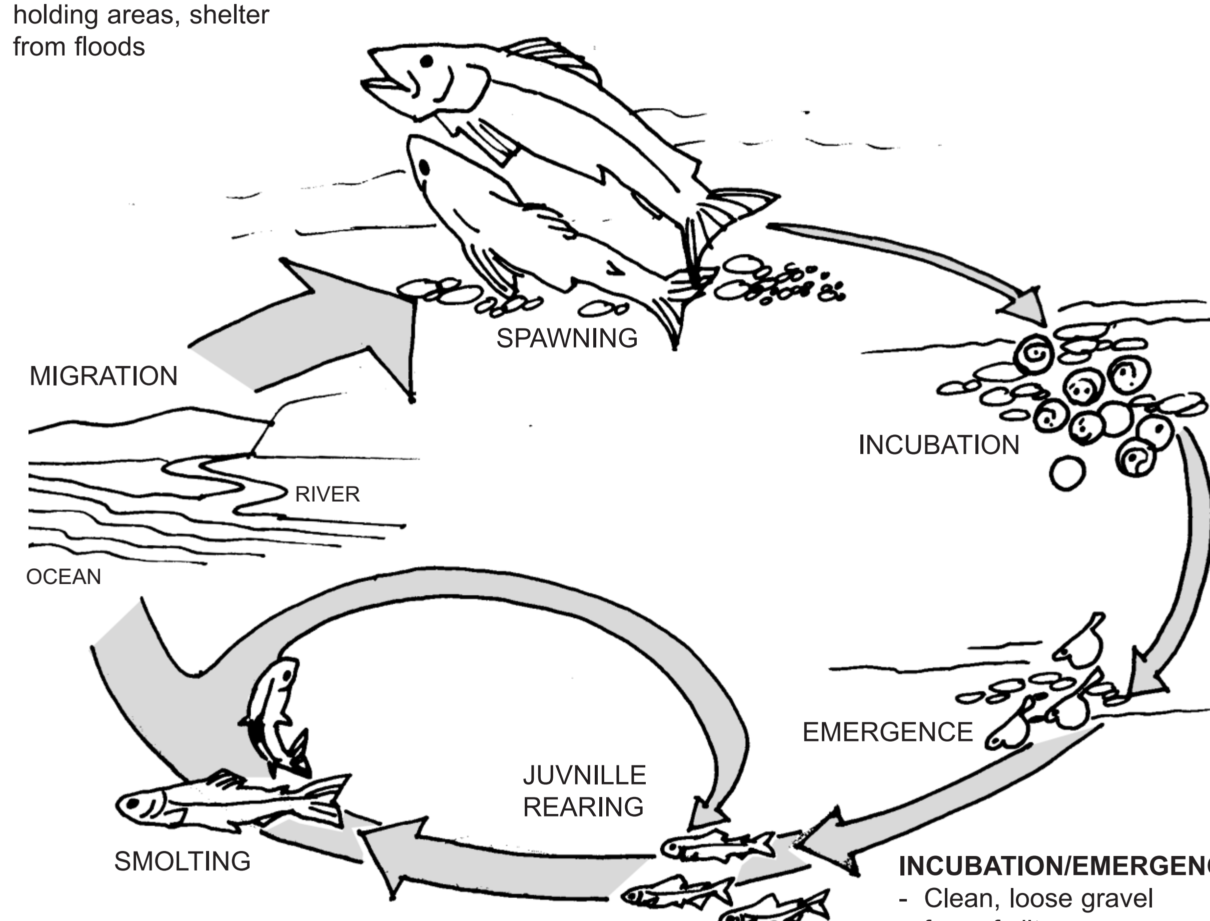
Before spawning, the female Chinook salmon excavates a redd, into the gravel and cobble substrate. After excavating the redd, she deposits eggs, which the male fertilizes and are then covers the redd with gravel. Chinook salmon redds are large, often exceeding 100 square feet in size. The female remains at the redd to defend the site from excavation by later-arriving salmon until she dies, usually within a few days after spawning. The fertilized eggs incubate in the gravel for a period of 6–13 weeks, depending on water temperature. The larvae that hatch from the eggs, called “alevins,” still have yolk sacs attached to provide nourishment. These larvae remain in the gravel until the yolk sac is absorbed, approximately two to three weeks, then swim up through the gravel substrate and begin rearing in open water. After emerging, the young fry disperse to protected stream margins and backwater habitats.

The period of fry emergence varies depending upon the timing of adult arrival and incubation temperature, but typically occurs from January through May. Some individuals disperse downstream as fry soon after emergence and do most of their growing in the lower river and estuary. However, most juvenile Chinook feed and grow near the area where they were born. Chinook salmon are especially well adapted to the Napa climate where high water temperatures and low flows during summer often are not suitable for salmon rearing. They avoid this period by migrating downstream (smolting) to the estuary by early summer. In this way, they are able to grow in the relative safety of the stream for several months and then move to suitable habitat downstream once the stream becomes inhospitable.

HABITAT REQUIREMENTS FOR CHINOOK SALMON AND STEELHEAD TROUT

ADULT MIGRATION
- Adequate cold water river flows
- Continuous migration corridor
- Normal turbidity/high water quality
- Complex habitat with holding areas, shelter from floods

SPAWNING
- Clean, medium-sized gravel
- Adequate streamflow
- Cold water temperatures
- High water quality/low turbidity
- Channel with complex habitat: pools, riffles, riparian trees, large logs
- Lack of siltation



SMOLTIFICATION/OUTMIGRATION
- Low number of predators
- Cold water temperatures
- Cover and complex habitat along river channel
- Lack of barriers in channel
- Adequate flow

JUVENILE REARING
- Adequate spring and summer cold water flows
- Swift water feeding habitats: riffles and runs
- Channel with complex habitat: pools, riffles, riparian trees, large logs
- Adequate territories for feeding and refuge
- High water quality
- Low predator numbers
- Complex habitat for flood refuge areas

INCUBATION/EMERGENCE
- Clean, loose gravel free of silt
- Cold water flows high in dissolved oxygen
- Lack of excessive channel scour and siltation
- Channel with complex habitat: pools, back water channels, alcoves
- Low predator populations

Water temperature is an important factor affecting Chinook incubation and juvenile rearing success. Temperature directly affects survival, growth rates, and smoltification. Temperature also indirectly affects vulnerability to disease and predation and further influences juvenile growth indirectly, through its impacts on food availability.

In addition to temperature, delivery of dissolved oxygen to the incubating eggs is a major factor affecting survival-to-emergence and is impacted by the deposition of fine sediment in the spawning substrate. Several studies have correlated reduced dissolved oxygen levels with mortality, impaired or abnormal development, delayed hatching and emergence, and reduced fry size at emergence in salmonids.

GENERAL SALMONID HABITAT REQUIREMENTS

Natural and manmade barriers to upstream migration are important factors in salmonid distribution and abundance. Barriers may prevent passage during all flow conditions or only during periods of low flow. Waterfalls, dry reaches, log jams, and other natural barriers exist to some degree in all streams. However, many man-made structures built within streams of the Napa River watershed including dams, culverts, road crossings, and seasonal diversions have severely limited the amount of habitat accessible to salmon and steelhead.

Excessive amounts of fine sediment can have a major impact on the early life stages of salmon and steelhead. Fine sediments from erosion smother incubating eggs by blocking water and oxygen flow through the gravel. Deposition of fine sediment onto the streambed reduces the amount of aquatic insect habitat, and it smothers algae and aquatic plants which make up the base of the food web. This in turn reduces the amount of food available to growing salmonids.

The amount of shade provided by streamside trees and vegetation affects rearing habitat in many ways. Shade from a dense riparian canopy blocks sunlight and keeps water temperatures cool during hot summer periods. However, too much shade prevents photosynthesis from occurring within the stream, thus reducing primary production at the base of the aquatic food web. Additionally, in streams with very dense canopies, the lack of sunlight may affect juvenile steelhead's ability to locate food. Canopy cover of 75% to 90% is desirable in most salmonid streams. Riparian trees are a valuable source of large woody debris, a major component of complex habitat. Fallen trees and limbs create cover and promote formation of deep pools through scouring. Tree leaves falling into a stream also provide a significant source of nutrients for aquatic insects that are the primary food source for young steelhead and salmon.

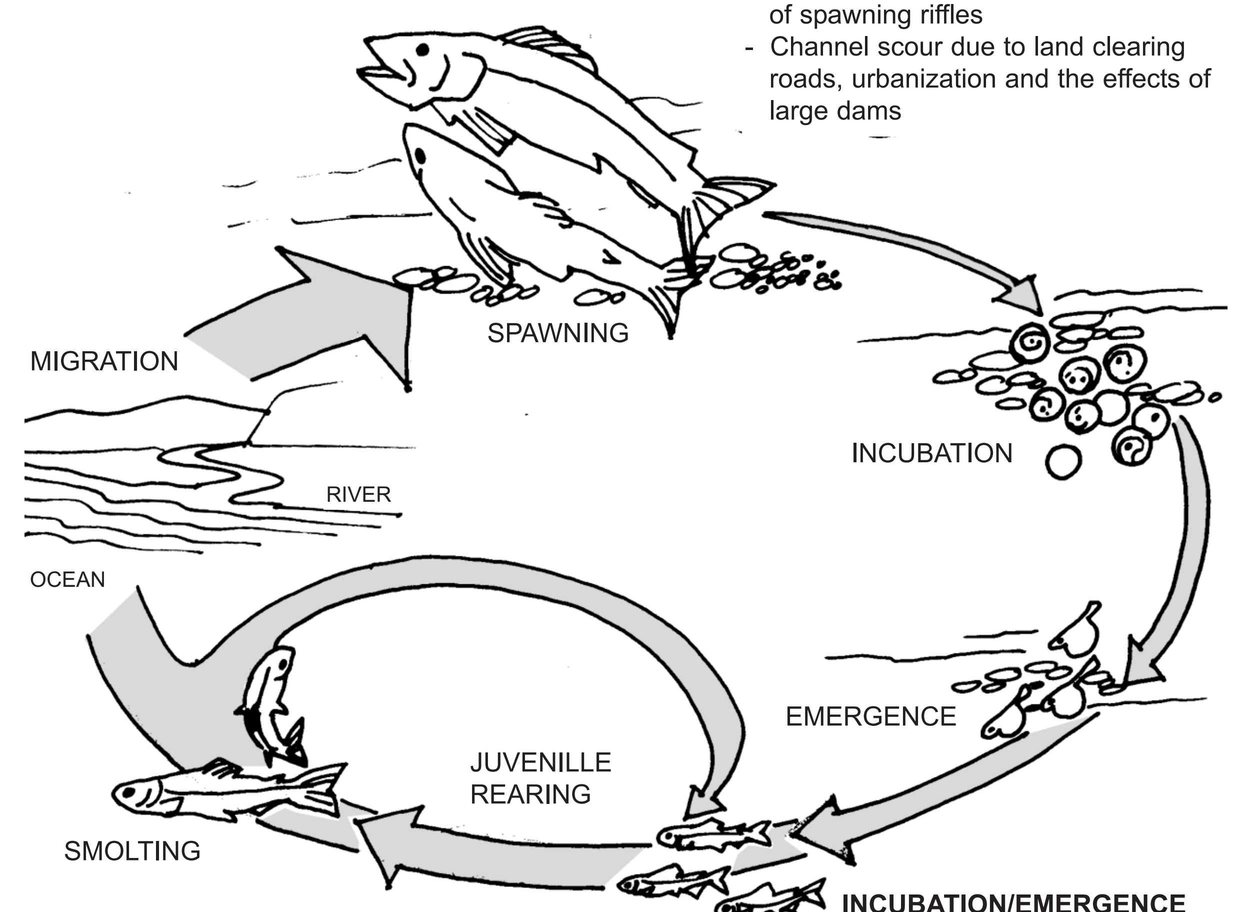
Channel features that provide refuge from high water velocities during winter storms is critical to young steelhead and salmon survival. This habitat is often in the form of deep pools with complexity from undercut banks, large woody debris, backwaters, calm eddies, and other refugia from high velocity water. Floodplain and side channel habitat that historically provided overwintering habitat during storm flows have been lost in much of the Napa River basin as a result of channel incision and levee construction during the past century.

Juvenile salmonids typically undergo the physiological changes needed to survive in saltwater in late March through May. This late migration allows them to feed longer during the most productive time of the year, growing to sizes which increase their chances for survival. This is also a period of rapidly declining stream flows in Napa, making the downstream journey over seasonal barriers, shallow riffles, and drying stream reaches somewhat risky.

FACTORS AFFECTING CHINOOK SALMON AND STEELHEAD TROUT HABITAT

ADULT MIGRATION - POTENTIAL PROBLEMS
- Low fall/winter flows
- Barriers - road culverts and crossings, temporary dams
- Channelization of creeks
- Water diversions
- Loss of complex habitat in creek and river

SPAWNING POTENTIAL PROBLEMS
- Soil erosion - siltation of creek
- Loss of channel form - channelization, removal of gravel, riparian forest and large wood
- Lack of gravel due to mining, channel incision, reservoirs and watershed changes
- Simplified channel from incision – loss of spawning riffles
- Channel scour due to land clearing roads, urbanization and the effects of large dams



OUTMIGRATION POTENTIAL PROBLEMS
- Predatory fish species
- Water diversions
- Loss of channel form and habitat
- Barriers - temporary dams, seasonally dry reaches
- Excessive water temperatures

JUVENILE REARING POTENTIAL PROBLEMS
- Excessive surface water/groundwater pumping, no screens on diversions
- Loss of channel form - channelization, removal of riparian forest, large wood
- Soil erosion - siltation of creek
- Excessive channel scour or fill
- Urban runoff, leaking septic systems - poor water quality
- Excessive water temperatures
- Low spring/summer flows

INCUBATION/EMERGENCE POTENTIAL PROBLEMS
- Soil erosion - creek siltation
- Unscreened water diversions
- Loss of channel form - removal of riparian forest, large wood, gravel
- Urban runoff, leaking septic systems
- poor water quality
- High velocity flows - urban areas and roads - channel scour
- Reservoir releases - channel scour
- Channelization of streams - loss of backwater and floodplain habitats
- Excessive water temperatures

NAPA RIVER FISHERY

The Napa River watershed covers an area of approximately 426 square miles and is contained by mountains to the north, west, and east. The watershed is typical of the California coastal range with northwest-southeast trending topography. The Napa River runs approximately through the center of the watershed on the valley floor. It drains 48 major tributaries and numerous smaller ephemeral streams on its 55 mile path from the headwaters of Mt. St. Helena in the Mayacamas Mountain range to the San Pablo Bay, the northern lobe of the San Francisco Estuary. Tidal influence extends upstream to around Trancas Avenue in the town of Napa.

There are 29 native and 22 non-native fish species that occur in freshwater and low brackish habitats of the Napa River basin (Koehler, 2007). Additionally, the Napa River historically supported thicktail chub (Gila crassicauda – now extinct), Sacramento perch (Archoplites interruptus – extirpated from the watershed), and coho salmon (Oncorhynchus kisutch – extirpated from the watershed). Juvenile chum salmon (Oncorhynchus keta) have recently been captured in the lower Napa River, although their status is unknown (Stillwater 2005). American shad (Alosa sapidissima) have been captured in the estuary occasionally, but they likely do not regularly occur in the river above the estuarine lower reaches. Brown trout (Salmo trutta) were captured in 1997 (Leidy) but have not been documented by any recent efforts and likely do not occur or are very uncommon within the basin.

A total of 14 native and 14 exotic fish species are known to occur in valley floor habitats, which includes the study reach of this project. Many of the non-native fish species have been documented only a few times in reaches upstream of Oak Knoll Avenue, as the river transitions from estuary to a low-gradient pool/riffle morphology. It is likely that most exotic fishes captured or documented in these upstream reaches are strays from irrigation ponds or have been intentionally released for fishing. Based on observations in the river during the past decade by RCD and others, it appears that no exotic fish species have established large, self-sustaining populations in the river, and the native fish assemblage is mostly intact. Steelhead are the most abundant and broadly distributed salmonid species within the Napa River watershed. Napa River steelhead populations have been greatly reduced from historical levels. It is estimated that the watershed historically supported a population of approximately 8,000 adult steelhead; however current population levels are unknown. Recent basin wide surveys estimate the population to be between 200 and 1,000 adult fish (Stillwater Sciences, 2002; EcoTrust, 2001). NOAA Fisheries listed steelhead as a federally threatened species in Napa County in August 1997 as part of the Central California Coast Distinct Population Segment (DPS). Despite reduced populations, the Napa River watershed is considered one of the most important anadromous fish streams within San Francisco Bay (Leidy et al., 2005). Steelhead spawning and rearing occurs primarily in coldwater tributary streams; very few steelhead appear to spawn in the mainstem Napa River in most years.

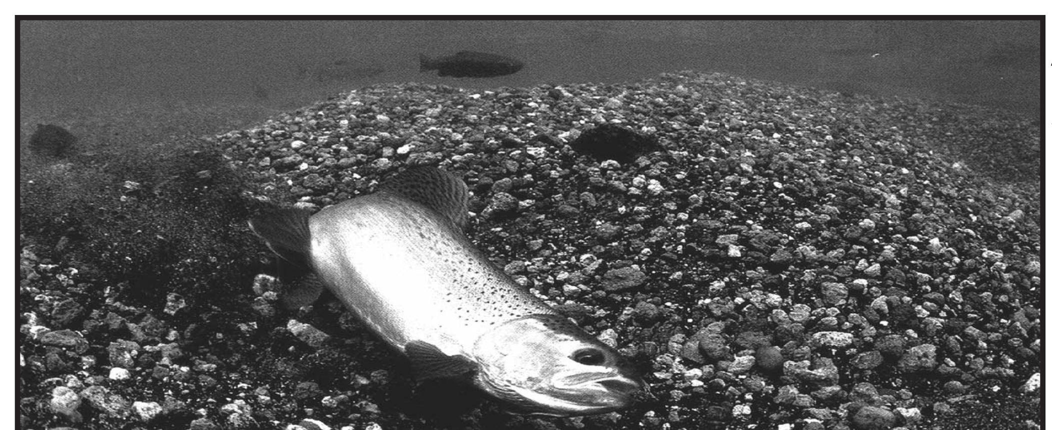
Beginning around 2001, an estimated run of 400-600 fall-run Chinook salmon (Oncorhynchus tshawytscha) have spawned annually in the mainstem Napa River (Koehler 2005; Koehler 2006). Although spawning has been documented in southern watershed tributaries, including Tulucay and Redwood Creek, most spawning has been documented upstream from Yountville to Calistoga. Capture of juvenile Chinook from the Napa River in each of the past four years (2004 - 2007) indicates successful reproduction has occurred in most years.

Very little is known about historical Chinook salmon abundance and distribution in Bay Area streams. In

Native Fish Species Currently or Historically Present in Streams of the Napa River Basin

	Common Name	Scientific Name	Origin	Family	Status
1	White Sturgeon	*Acipenser transmontanus*	Native	Acipenseridae	present
2	Sacramento Sucker	*Catostomus occidentalis*	Native	Catostomidae	present
3	Sacramento Perch	*Archoplites interruptus*	Native	Centrarchidae	extirpated
4	Pacific Herring	*Clupea pallasii*	Native	Clupeidae	present
5	Northern Anchovy	*Engraulis mordax*	Native	Clupeidae	present
6	Riffle Sculpin	*Cottus gulosus*	Native	Cottidae	present
7	Coastrange Sculpin	*Cottus aleuticus*	Native	Cottidae	present
8	Prickly Sculpin	*Cottus asper*	Native	Cottidae	present
9	Pacific Staghorn Sculpin	*Leptocottus armatus*	Native	Cottidae	present
10	Sacramento Pikeminnow	*Ptychocheilus grandis*	Native	Cyprinidae	present
11	Thicktail Chub	*Gila crassicauda*	Native	Cyprinidae	extinct
12	Hitch	*Lavinia exilicauda*	Native	Cyprinidae	present
13	Sacramento Blackfish	*Orthodon microlepidotus*	Native	Cyprinidae	present
14	California Roach	*Hesperoleucus symmetricus*	Native	Cyprinidae	present
15	Hardhead	*Mylopharodon conocephalus*	Native	Cyprinidae	present
16	Sacramento Splittail	*Pogonichthys macrolepidotus*	Native	Cyprinidae	present
17	Shiner Perch	*Cymatogaster aggregata*	Native	Embiotocidae	present?
18	Tule Perch	*Hysterocarpus traski*	Native	Embiotocidae	present
19	Three-spine Stickleback	*Gasterosteus aculeatus*	Native	Gasterosteidae	present
20	Bay Goby	*Lepidogobius lepidus*	Native	Gobiidae	present
21	Longjaw Mudsucker	*Gillichthys mirabili*	Native	Gobiidae	present
22	Tidewater Goby	*Eucyclogobius newberryi*	Native	Gobiidae	likely extirpated
23	Arrow Goby	*Clevelandia ios*	Native	Gobiidae	present
24	Delta Smelt	*Hypomesus transpacificus*	Native	Osmeridae	present
25	Jack Smelt	*Atherinopsis californiensis*	Native	Osmeridae	present
26	Longfin Smelt	*Spirinchus thaleichthys*	Native	Osmeridae	present
27	Pacific Lamprey	*Lampetra tridentata*	Native	Petromyzontidae	present
28	River Lamprey	*Lampetra ayresi*	Native	Petromyzontidae	present
29	Speckled Sanddab	*Citharichthys stigmaeus*	Native	Pleuronectidae	present
30	Starry Flounder	*Platichthys stellatus*	Native	Pleuronectidae	present
31	Steelhead / Rainbow Trout	*Oncorhynchus mykiss*	Native	Salmonidae	present
32	Chinook Salmon	*Oncorhynchus tshawytscha*	Native	Salmonidae	present
33	Coho Salmon	*Oncorhynchus kisutch*	Native	Salmonidae	extirpated
34	Chum Salmon	*Oncorhynchus keta*	Native	Salmonidae	status unknown

Compiled by J. Koehler (Napa County RCD) 2007 Sources: Stillwater Sciences 2002 Limiting Factors Analysis, Stillwater Sciences 2006 Napa River Fisheries Monitoring Program, information derived from CDFG surveys, J. Koehler personal experience, R. Leidy 1997, P. Moyle 2002.



A FEMALE SALMON FANNING GRAVEL TO BUILD A REDD TO SPAWN a recent review of existing fisheries information, no conclusive evidence of historical Chinook salmon populations could be found for the Napa River basin (Leidy et al., 2005). However, based on analysis of natural channel form, hydrology, and ecology, the Napa River likely supported a large, sustainable population of Chinook salmon under historical conditions (Stillwater Sciences, 2002). Additionally, the geographic location of the Napa River at the entrance to the Sacramento and San Joaquin River systems makes it likely that wild Chinook salmon would naturally stray into the Napa River during favorable periods.

During the past 150 years, a combination of factors including reduction in spawning habitat, channel and floodplain alterations, and the introduction of exotic predatory fishes have all reduced the river's potential to support a viable population of Chinook salmon. Today, there are approximately 25 miles of suitable Chinook spawning habitat in the mainstem Napa River and an additional 15 miles within low gradient reaches of several large tributaries.

METHODS

HABITAT TYPING

Habitat typing surveys were conducted in accordance with methodology presented in the California Salmonid Stream Habitat Restoration Manual (Flosi and Reynolds, 1994). The inventory uses a method that samples approximately 10% of the habitat units within the surveyed length. All habitat units included in the survey are classified according to habitat type and their lengths are measured. Habitat unit types encountered for the first time are further measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement. Since quantity and quality of pool habitat has been identified as a critical factor affecting salmonid populations in California streams, every third pool encountered was fully measured.

SNORKEL SURVEY

To determine fish assemblage composition, distribution, and habitat associations a snorkel survey was completed in May 2007. A two person crew conducted a continuous downstream observational swim of the entire study reach during the course of two days. Approximate target species densities were calculated for randomly selected pools by estimating pool area and counting the number of individuals observed. Habitat associations were noted, and key observations were documented with GPS coordinates. Water temperature was continuously monitored with handheld thermometers throughout the survey. Streamflow was recorded at the USGS streamgage at Oak Knoll Avenue.

SALMON SPAWNER SURVEYS

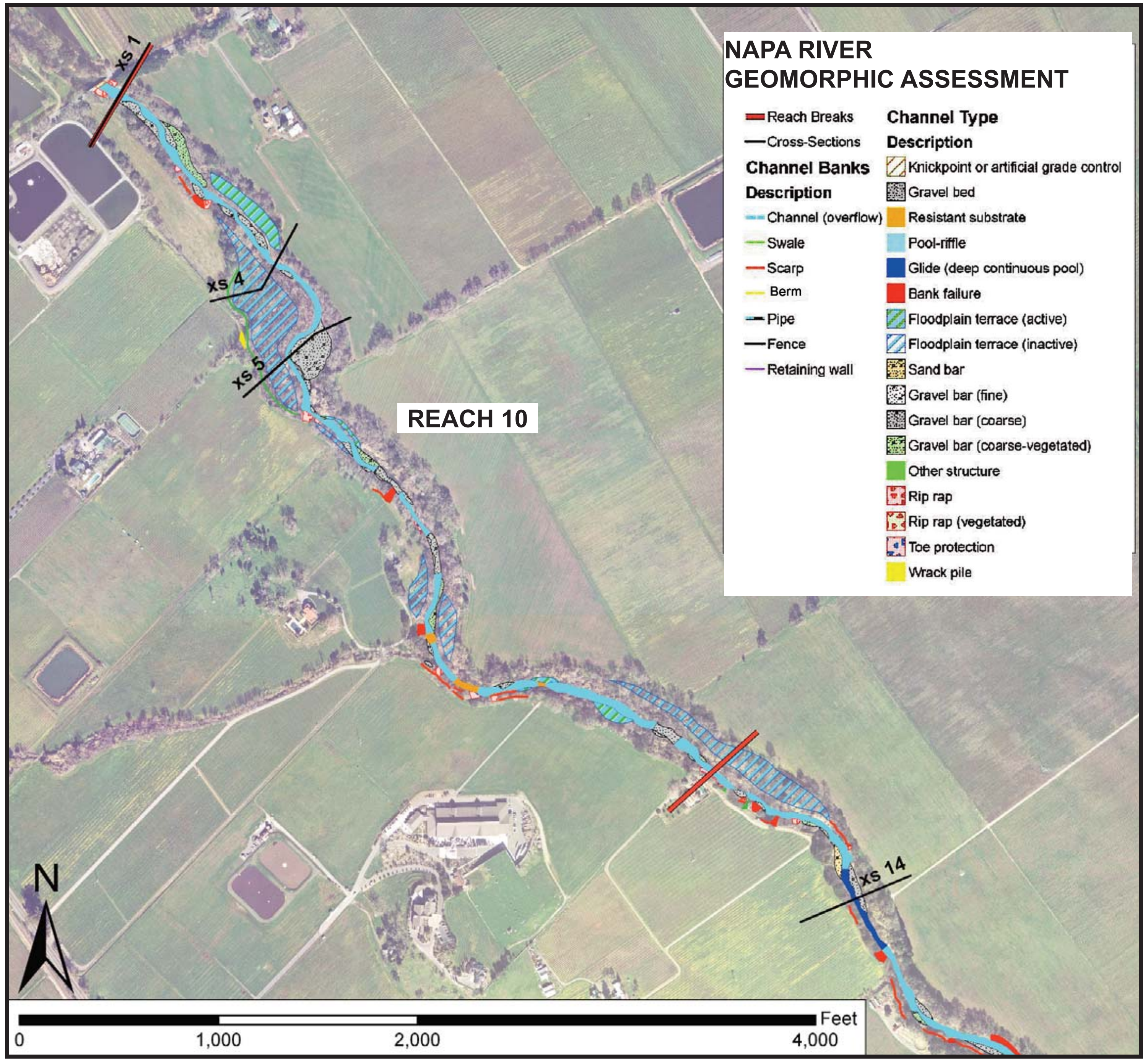
Surveys were conducted following California Department of Fish & Game protocols as described in the California Salmonid Stream Habitat Restoration Manual (Appendix A). Two person crews waded the reach in three days to count salmon carcasses and live fish, map redd locations and characteristics, and identify key habitat features during spawning flow conditions. All carcasses encountered were examined for marks or tags, and a tissue sample was collected for genetic analysis. Surveys covered approximately 2.5 miles (4 km) per day and consisted of the following sub-reach designations: Reach 1-3 (South), Reach 5-7 (Central), and Reach 8-10 (North). Surveys were conducted only when flows were sufficiently low to safely wade and provide good water clarity.

Two surveys were conducted in the Central Reach in December 2006. One survey was conducted in all three reaches in December 2007.

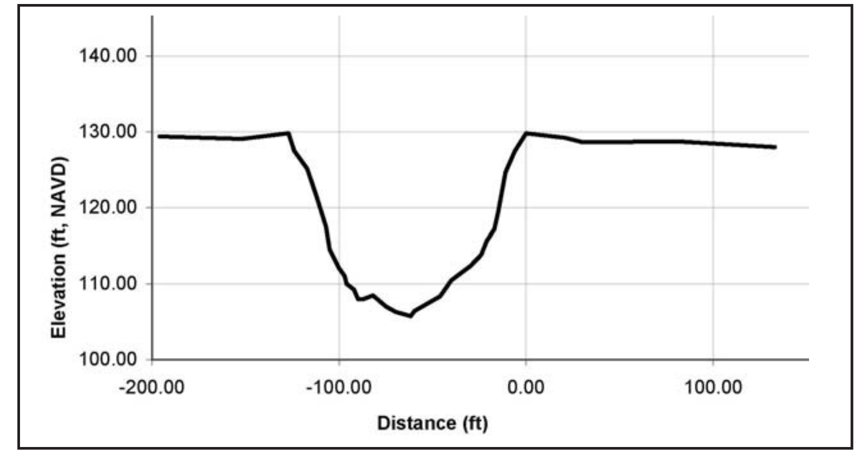
Exotic Fish Species Currently or Historically Present in Streams of the Napa River Basin.

1	Inland Silverside	*Menidia beryllina*	Exotic	Atherinidae	present
2	Smallmouth Bass	*Micropterus dolomieui*	Exotic	Centrarchidae	present
3	Bluegill	*Lepomis macrochirus*	Exotic	Centrarchidae	present
4	Redear Sunfish	*Lepomis microlophus*	Exotic	Centrarchidae	present
5	Green Sunfish	*Lepomis cyanellus*	Exotic	Centrarchidae	present
6	Largemouth Bass	*Micropterus salmoides*	Exotic	Centrarchidae	present
7	Black Crappie	*Pomoxis nigromaculatus*	Exotic	Centrarchidae	present
8	White Crappie	*Pomoxis annularis*	Exotic	Centrarchidae	present
9	Threadfin Shad	*Dorosoma petenense*	Exotic	Clupeidae	present
10	American Shad*	*Alosa sapidissima*	Exotic	Clupeidae	status unknown
11	Common Carp	*Cyprinus carpio*	Exotic	Cyprinidae	present
12	Goldfish	*Carassius auratus*	Exotic	Cyprinidae	present
13	Golden Shiner	*Notemigonus crysoleucas*	Exotic	Cyprinidae	present
14	Rainwater Killifish	*Lucania parva*	Exotic	Fundulidae	present
15	Shimofuri Goby	*Tridentiger bifasciatus*	Exotic	Gobiidae	present
16	Yellowfin Goby	*Acanthogobius flavimanus*	Exotic	Gobiidae	present
17	Brown Bullhead	*Ameiurus nebulosus*	Exotic	Ictaluridae	present
18	Black Bullhead	*Ameiurus melas*	Exotic	Ictaluridae	present
19	White Catfish	*Ameiurus catus*	Exotic	Ictaluridae	present
20	Channel Catfish	*Ictalurus punctatus*	Exotic	Ictaluridae	present
21	Wakasagi	*Hypomesus nipponensis*	Exotic	Osmeridae	present
22	Striped Bass	*Morone saxatilis*	Exotic	Percichthyidae	present
23	Western Mosquitofish	*Gambusia affinis*	Exotic	Poeciliidae	present
24	Brown Trout	*Salmo trutta*	Exotic	Salmonidae	status unknown

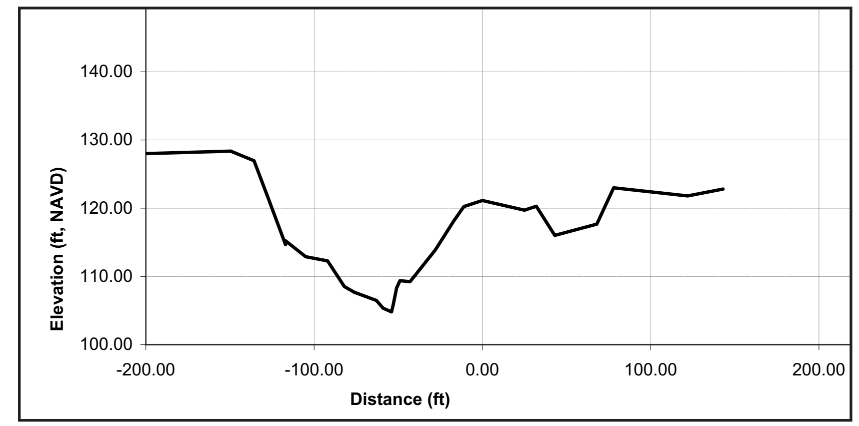
Compiled by J. Koehler (Napa County RCD) 2007 Sources: Stillwater Sciences 2002 Limiting Factors Analysis, Stillwater Sciences 2006 Napa River Fisheries Monitoring Program, information derived from CDFG surveys, J. Koehler personal experience, R. Leidy 1997, P. Moyle 2002.



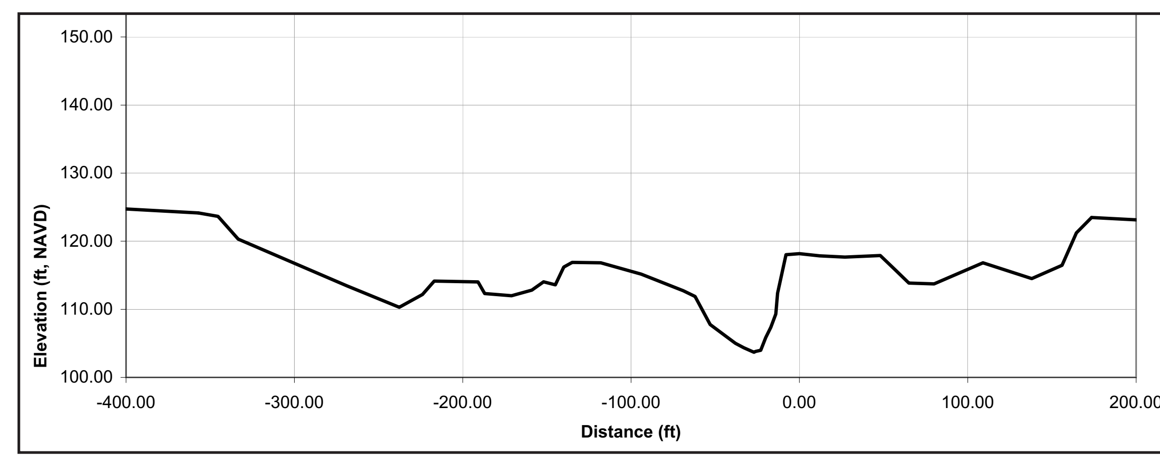
Representative Cross Sections



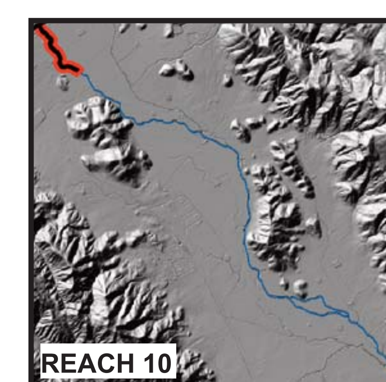
XS 1
W:D = 5.3
Most entrenched condition



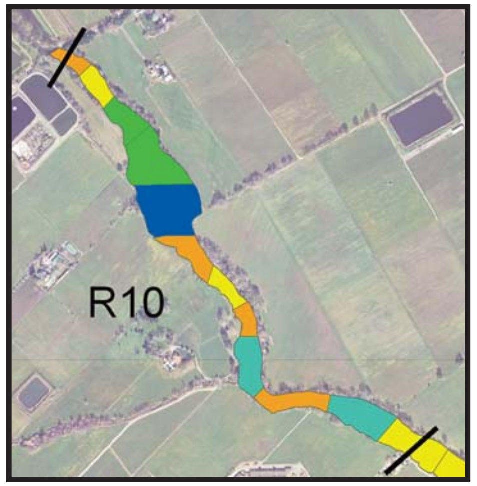
XS 4
W:D = 11.3
Typical conditions

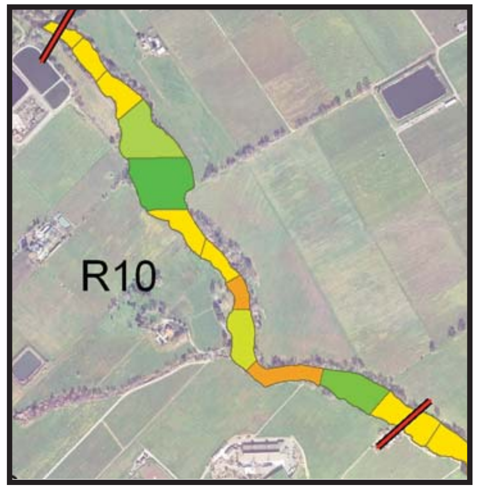


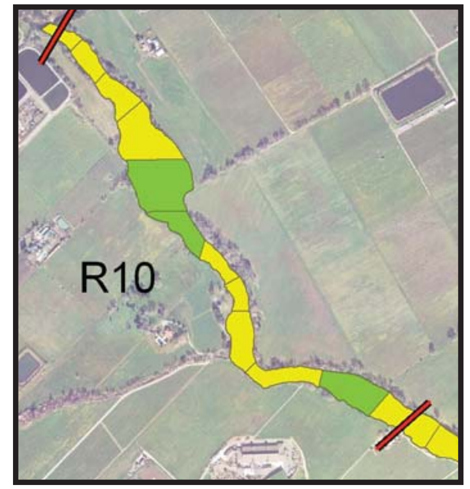
XS 5
W:D = 26.2
Widest condition



Physical Characteristics of Reach 10







Confinement

Width To Depth Ratio

- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide

10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

2-Year Discharge - Existing

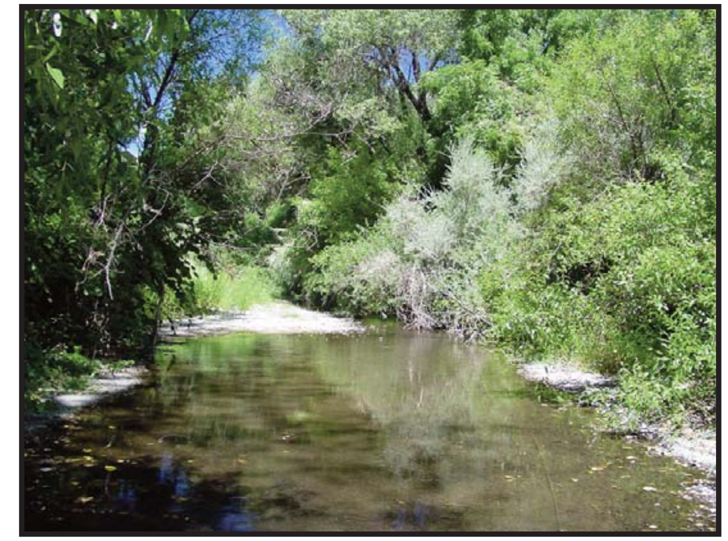
Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Reach 10 is the widest and most physically diverse reach of the project area, and contains the largest area of naturally-functioning geomorphic conditions. With an average bank top width of 214 feet and depth of 21 feet, almost half the reach has w:d ratios that support natural geomorphic functions such as meandering, point bar and riffle-pool formation, and this manifests itself in abundant spawning gravels. However these gravels are of variable quality due to infilling from fine sediment in some locations.

The Shield's stress analysis shows some areas with selective scour where a thin layer of spawning gravel or weaker unvegatated bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds. Other sections of this reach have Shields stress indicating partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.

This reach contains the largest areas of floodplain terrace in the project area, though much of this terrace is inactive. Inactive terraces are former floodplain now left high on the banks by channel incision and therefore not inundated as frequently as active terraces. The active terrace areas and some secondary channels provide refuges for juvenile fish during winter floods, as do large woody debris features in this reach.



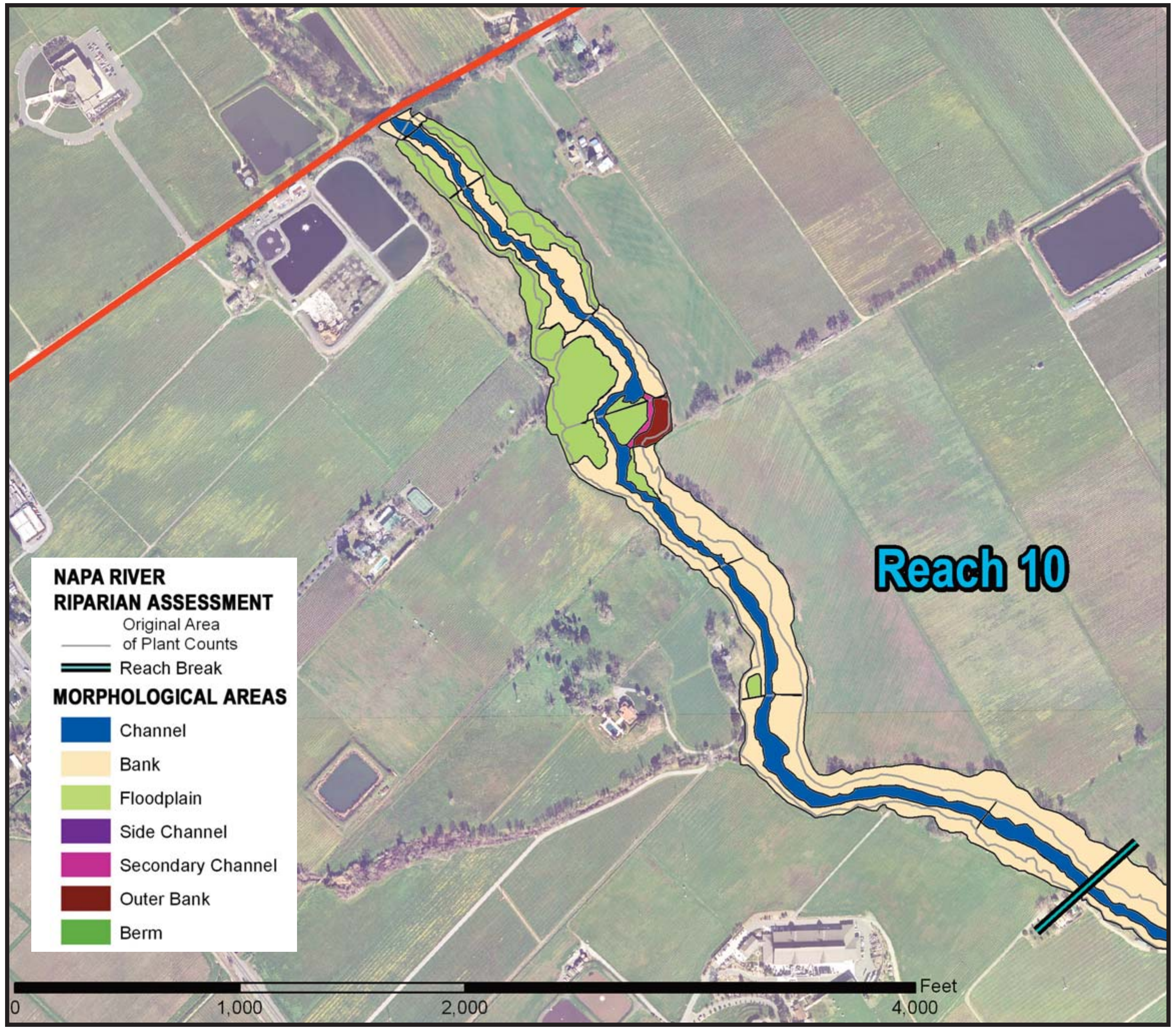
These images show the relatively abundant gravel bar and secondary channel features in Reach 10, alongside some of the steep banks typical of outside bends.

Reach 10 has changed the most in the last 50 years. Historic aerial photos show that the two main bends in the reach have avulsed to the east, locally doubling the width of the riparian corridor. This reach has historically incised by an estimated 10 feet, and has widened to an average 214 feet, close to equilibrium width. Under a "no-action alternative" we would expect narrower reaches to widen through bank erosion until a width of approximately 200-240 feet is reached including a median predicted widening of 25 feet. We would expect to see some continued channel migration on outside bends such as the predicted high velocities on eastward bend midway down the reach. Because the channel is close to stability we would not expect to see significant negative effects on the channel cross section from bank stabilization.

Flood characteristics:

Reach 10 is the least flood-prone reach in the project area, with a capacity mostly between the 5 and 10-year event.

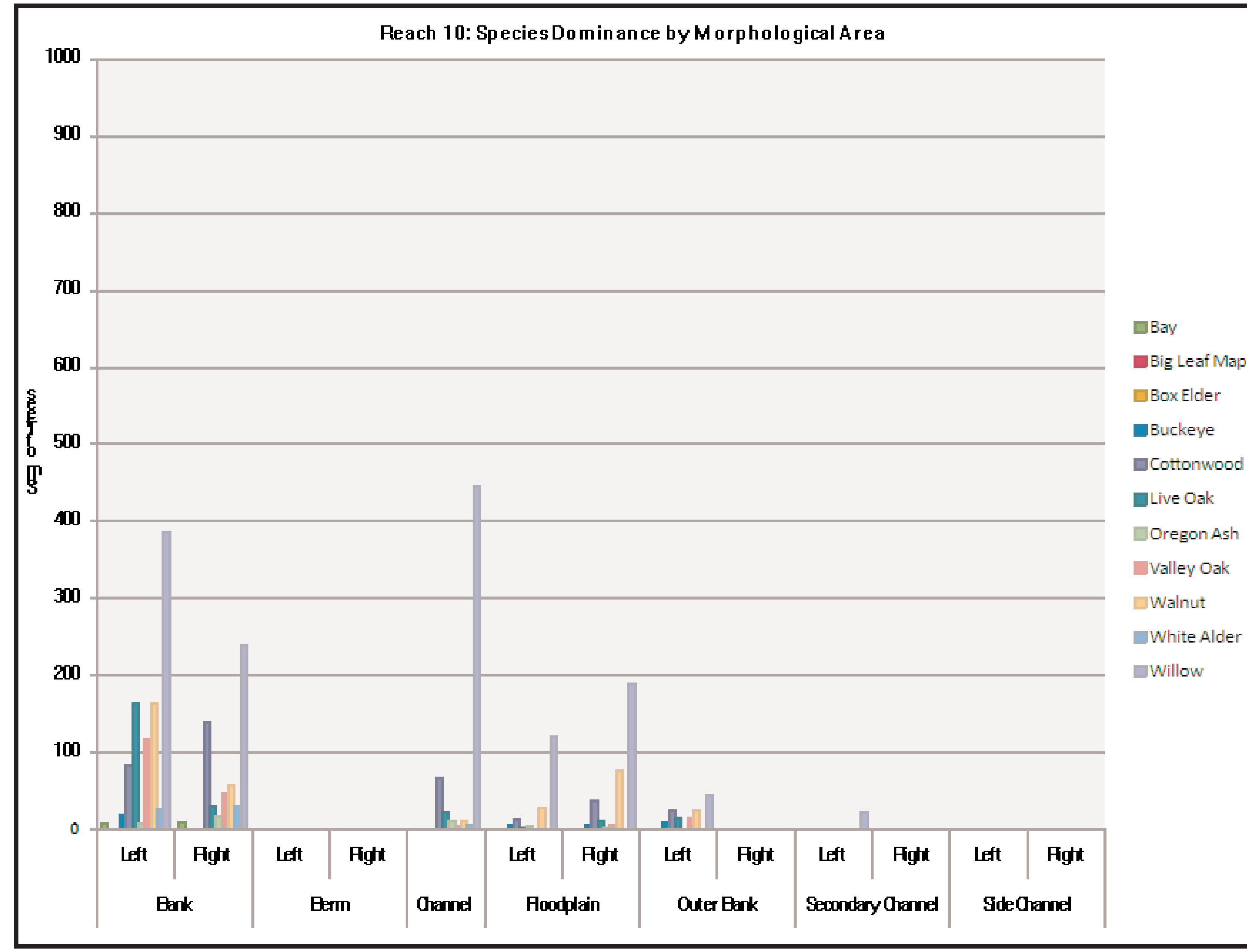
Average velocity during the ten-year flood is 3-9 feet per second.



Reach 10: Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre*
Channel	5.5	103
Bank-left	6.1	159
Bank-right	5.7	113
Floodplain-left	1.8	93
Floodplain-right	2.8	92
Secondary channel	0.14	23
Outer bank-left	0.34	141

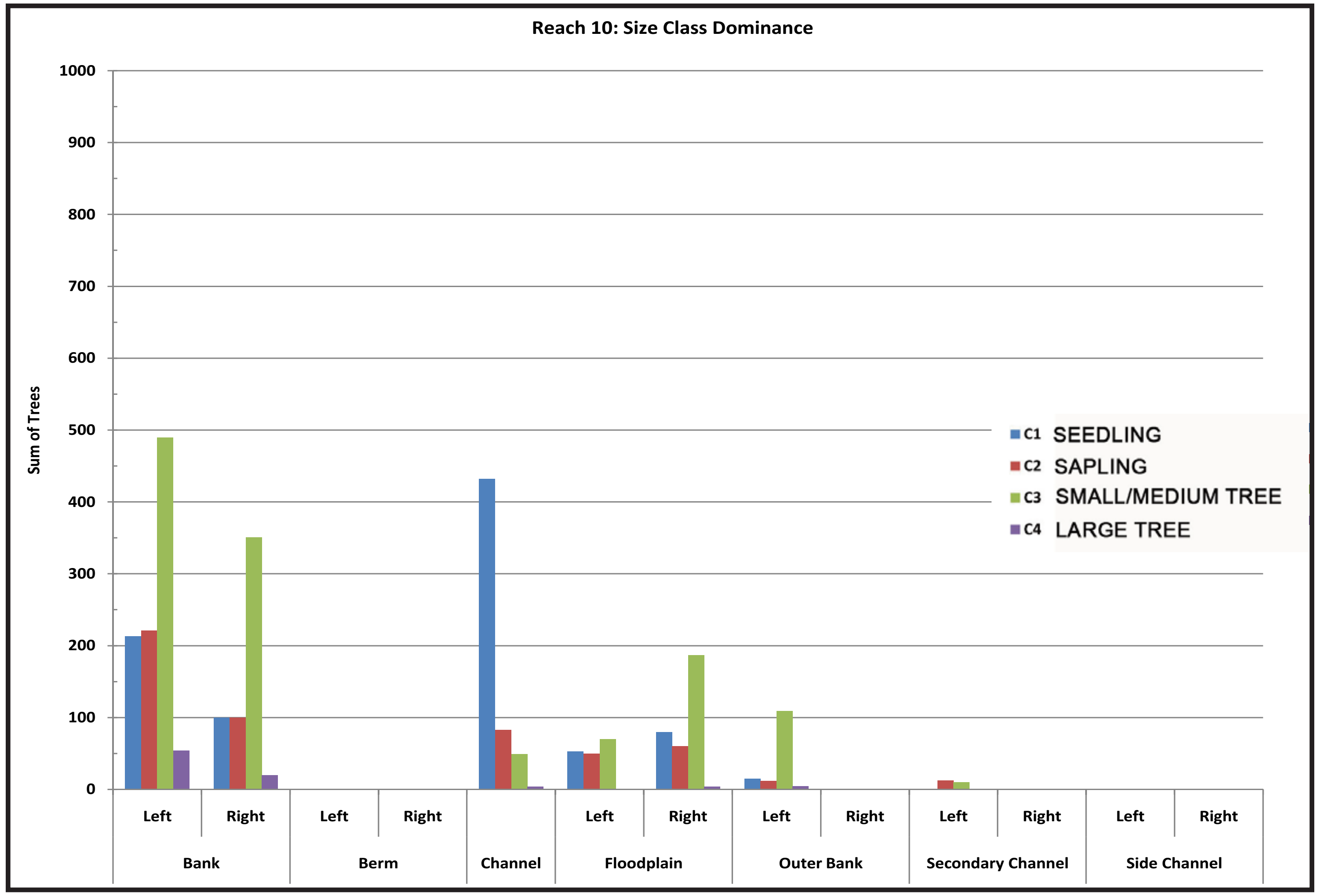
*For morphological areas of less than one acre, the actual tree count is listed

Description: Reach 10 extends from the Oakville Cross Road Bridge for 0.98 miles downstream and includes 22.6 acres of riparian corridor and channel area. Reach 10 includes the widest area of the Napa River project area with a maximum riparian corridor width of 531 ft. and minimum width of 181 ft. The average corridor width is 279 ft. in Reach 10. One of the landowners in this reach described a flood event which rapidly widened the river channel through bank failures. The upstream section of Reach 10 is complex with a right and left floodplain, a secondary channel, and outer bank area, while the downstream section has only channel and bank areas.



Species Diversity

Willow is the dominant tree species on both banks, in the channel, on the floodplain areas, in the secondary channel and on the outer bank. Both banks have a high level of biodiversity with nine tree species represented. Large numbers of Ca. walnut, live oak, Fremont cottonwood, and valley oak occur on both banks and the outer bank. Ca. bay laurel, Ca. buckeye, Oregon ash, and white alder occur on the banks in lower numbers.



Size Class Dominance

In Reach 10, C3 size trees (small-medium trees) are the dominant size class on both banks, the floodplains, and the outer bank. C1 (seedlings) and C2 (saplings) size trees occur at low, but approximately equal densities in the bank, floodplain and outer bank areas. The channel is the only area dominated by seedlings. Large trees (C4) are primarily found on the banks.

Distribution of Size Classes and Species: Willow are the primary species of seedling in all morphological areas. However, the channel area also has Fremont cottonwood, Oregon ash, Ca. walnut and white alder seedlings in low numbers. The banks have six species of seedlings while the floodplains only have Ca. walnut in addition to willow. Willow saplings (C2) dominate the channel but in much lower numbers than seedlings. The left bank has a diversity of saplings while willow saplings dominate all other areas of the corridor. Willow small-medium trees (C3) dominate all areas of the corridor but are in very low numbers in the channel. The banks have a diverse assemblage of C3 trees. Large trees (C4) primarily occur on the banks and include size tree species.

Invasive Species: Reach 10 has a high density of *Arundo donax* at 9% of the corridor area or 2.09 acres. The Arundo is primarily located on both banks with a smaller area on the floodplains and a small area in the channel. Eucalyptus trees were also recorded in Reach 10, mostly on the outer bank, with some in the channel. The outer bank area has a high level of species diversity; it appears the eucalyptus is not affecting the growth of the native trees in this area.

Spider Trees: Reach 10 has the lowest number of spider trees/river mile in the project area. The majority of these spider trees are located on the banks and include eight different species

Understory: Understory species recorded in Reach 10 include non-native Himalayan blackberry and blue periwinkle in very dense stands, along with wild grape, Ca. rose, snowberry, mugwort, fennel, and grasses on the bank and floodplain areas. The channel area has torrent sedge, river sedge, bulrush, watercress, curly dock, cattails, yellow nutsedge, grasses, and small herbaceous plants.

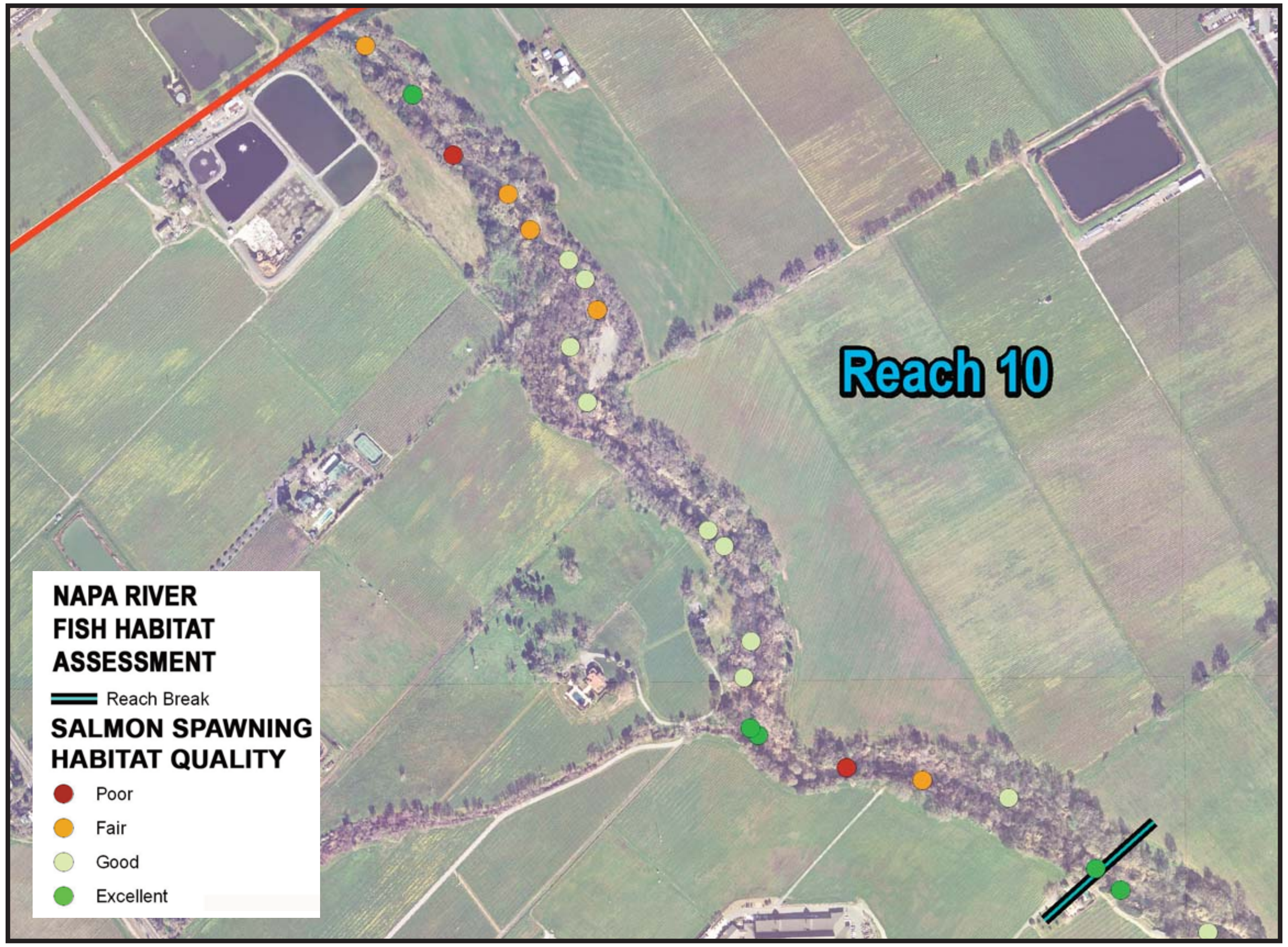
Riprap: Reach 10 has a very low level of riprap with less than 25 linear feet on each bank.

Ecological Trends: Reach 10 has complex morphology allowing for a large degree of ecological processes including succession of plant species and regeneration. Seedlings of all three pioneer species (willow, white alder, Fremont cottonwood) occur in the channel with willow germinating in high numbers. However, survival of these seedlings is limited in the channel where sapling and small/mediem tree numbers are very low and almost entirely willow with a few Fremont cottonwood. The floodplain areas, adjacent to the channel, are largely unvegetated gravel bars with some C1, C2 and C3 willow. The higher, less frequently inundated, floodplains are covered with a denser, more diverse flora of willow, Ca. walnut and Fremont cottonwood. Unlike the channel where seedlings are numerous and saplings and small/medium trees are scarce, the floodplains have more numerous small/medium trees and fewer seedlings and saplings. This indicates a higher survival rate for trees on the floodplain areas rather than in the channel.

On both banks, biodiversity is high with willow, white alder, Ca. walnut, valley oak, Oregon ash, live oak, Fremont cottonwood, Ca. buckeye and Ca. bay laurel. Small/medium trees far outnumber seedlings and sapling trees, but most of the tree species are regenerating in low numbers. *Arundo donax* is densest on the banks and likely interferes with seedling survival for most of these species. Overall, tree density is low in Reach 10 compared to other reaches.

Large trees of six species occur in Reach 10 primarily on the banks and outer banks. The dominance of small/medium trees on the banks, outer bank and floodplain areas indicates conditions which may support growth to the C4 stage. Additionally, Reach 10 has a very low level of spider trees and riprap, indicating low bank erosion and loss of trees.

LARGELY UNVEGETATED FLOODPLAIN

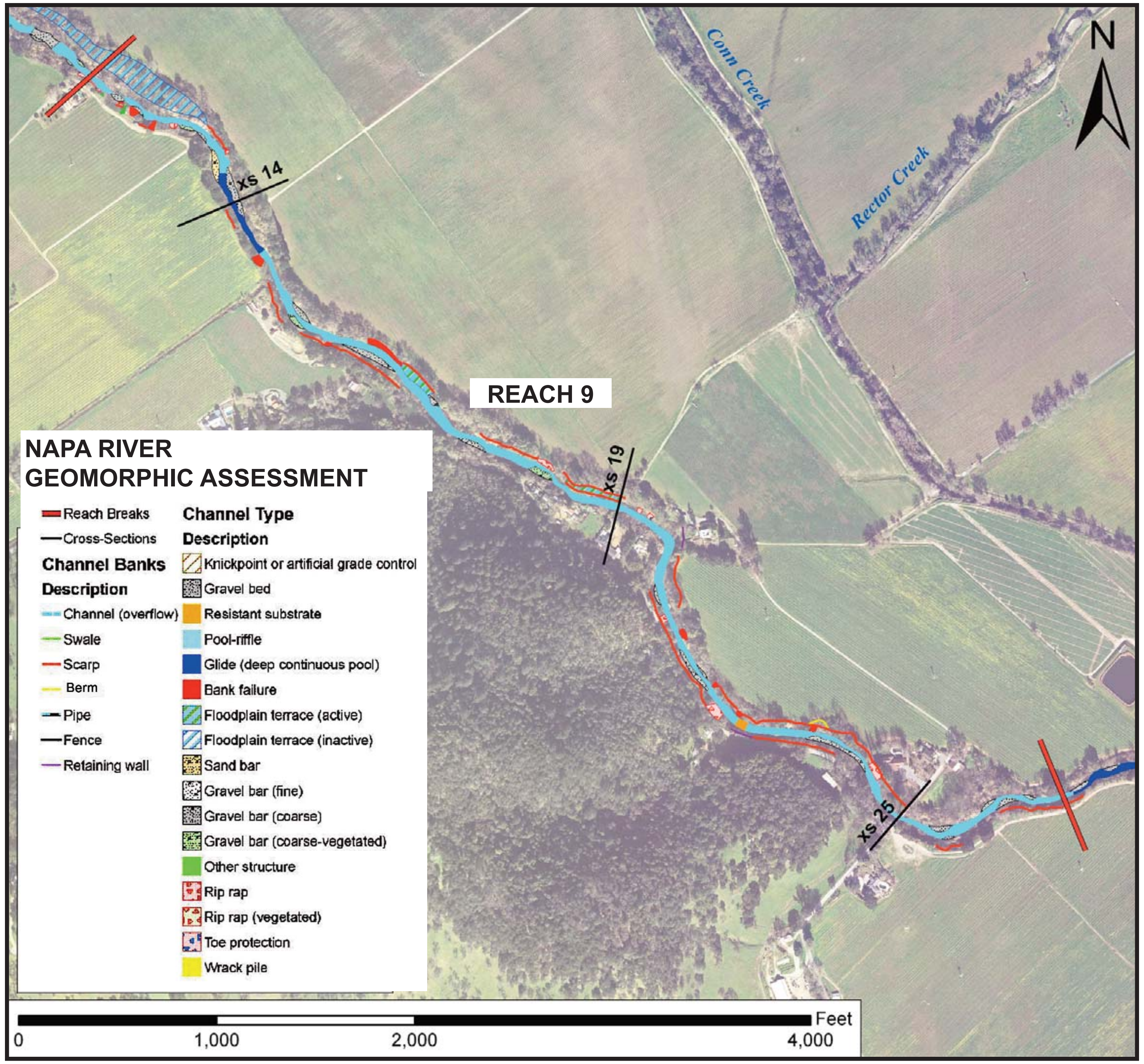


Reach 10 contains a favorable diversity of habitats, especially in the upstream area near the Oakville Crossroad. The channel in the upper reach was noticeably wider than most of the rest of the project area and contains large gravel bars. Spawning riffles were abundant in this reach; however, there was a mix of high and low quality sites. The quality of several potential spawning patches was reduced by the presence of fine sediment and the overall lack of topographic definition.

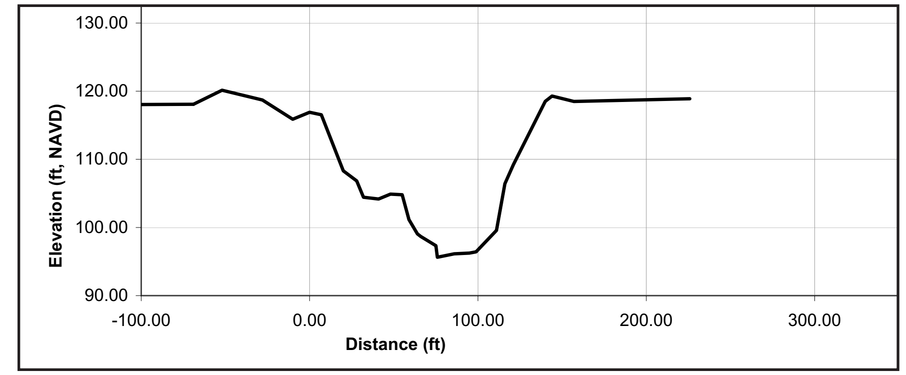
A total of two high quality backwater and side-channel pools were observed in Reach 10. During our May 2007 snorkel survey, we observed abundant Chinook salmon parr using these habitats.

Similar to most other reaches, several sections of Reach 10 had very low canopy densities and thick mats of filamentous green algae in the channel, primarily in shallow glide habitats. Overall the average canopy density over the main river channel was 58%, which is below the 80% canopy target for salmonid rearing streams (Ca. Dept of Fish and Game 1998). It may be difficult to achieve a high canopy density in the upper areas of this reach where the channel is dominated by broad gravel bars.

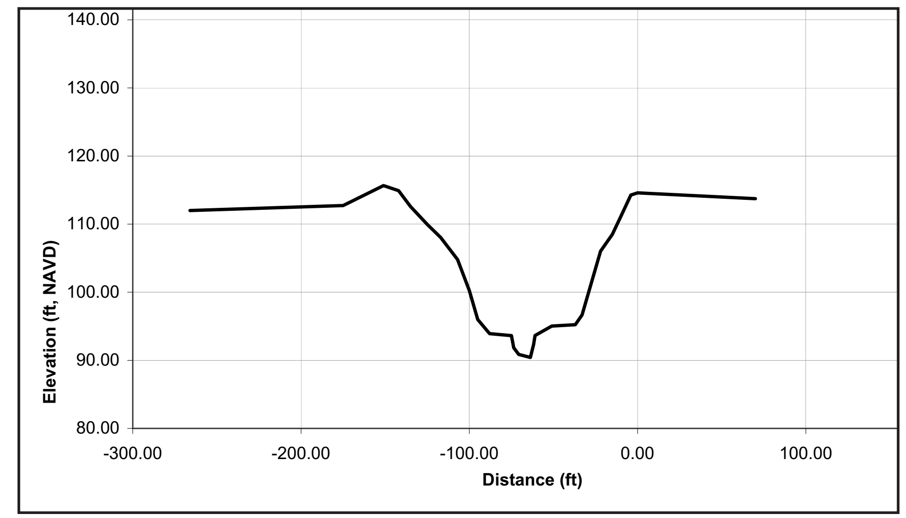
THIS PHOTO SHOWS A SIDE CHANNEL WITH AN ALCOVE OF HIGH HABITAT QUALITY FOR YOUNG SALMON.



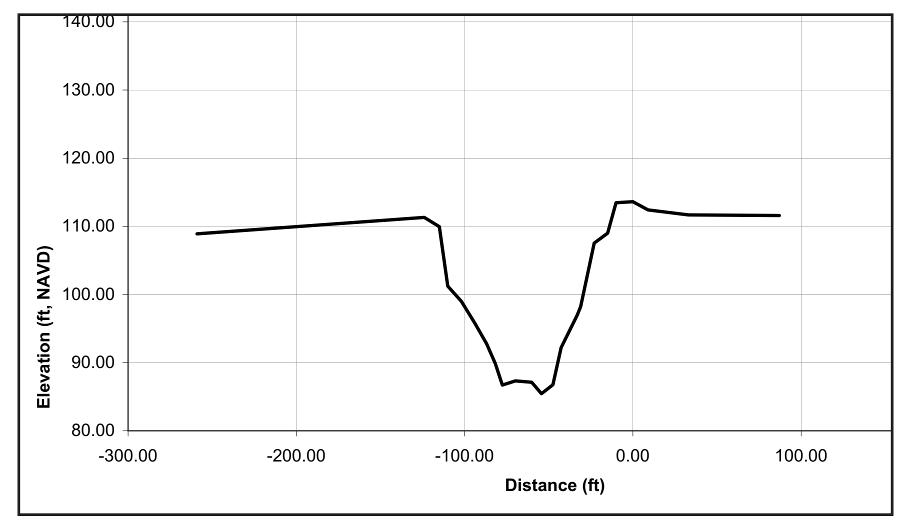
Representative Cross Sections



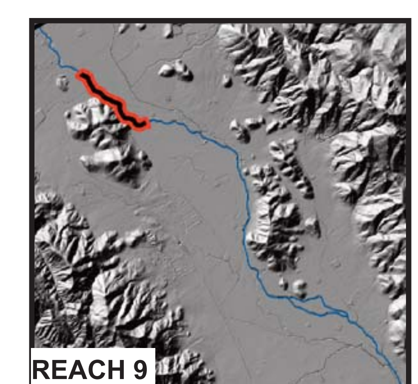
XS 14
W:D = 8.3
Least entrenched condition



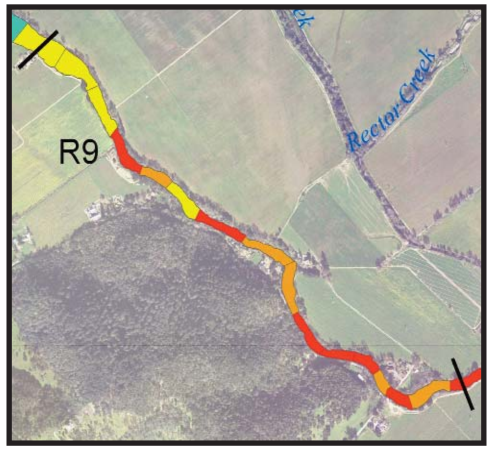
XS 19
W:D = 5.8
Typical conditions



XS 25
W:D = 4.4
Most entrenched condition



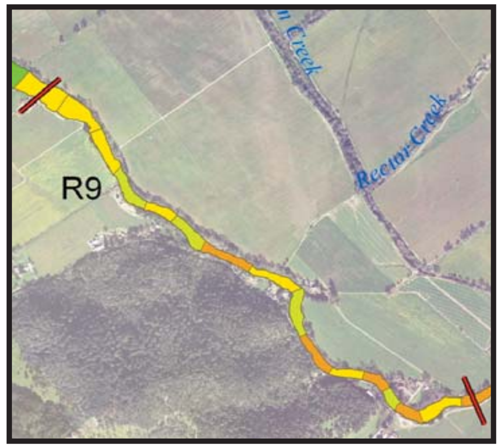
Physical Characteristics of Reach 9



Confinement

Width To Depth Ratio

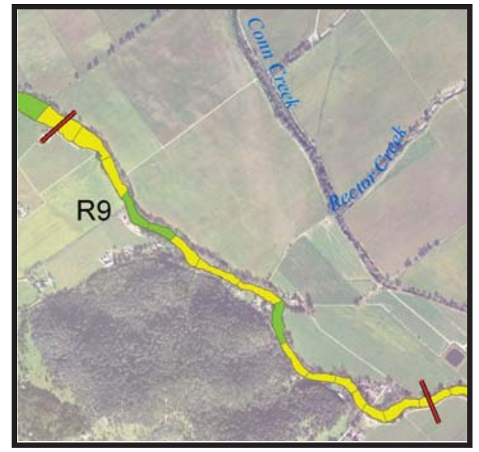
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

2
3
4
5
6
7
8
9
10
11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Reach 9 is deeper and much more entrenched that the upstream Reach 10, but less so than downstream Reach 8. It is more diverse and has better quality physical conditions than average for the project area, with numerous small gravel point bars and riffles. Some potential spawning gravels are somewhat infilled with fine sediment. Two thirds of the reach is either entrenched or deeply entrenched, with one third approaching functional width. Most of the channel is actively widening through erosion and bank slumps, which are more widespread in this reach than any other in the project area. Bank instability is increased by the proximity of the channel to the neighboring hillslope along the downstream west bank. As a consequence, there are several areas of rip rap and hard bank protection.

The Shield's stress for this reach shows selective scour where a thin layer of spawning gravel or weaker unvegetated bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds**.** Other sections of this reach have Shields stress indicating partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.

Over 1,000 feet of Reach 9's riparian corridor has widened by almost 100 feet to the east since the 1940s, seemingly from colonization by trees of an abandoned terrace that was formerly farmed.

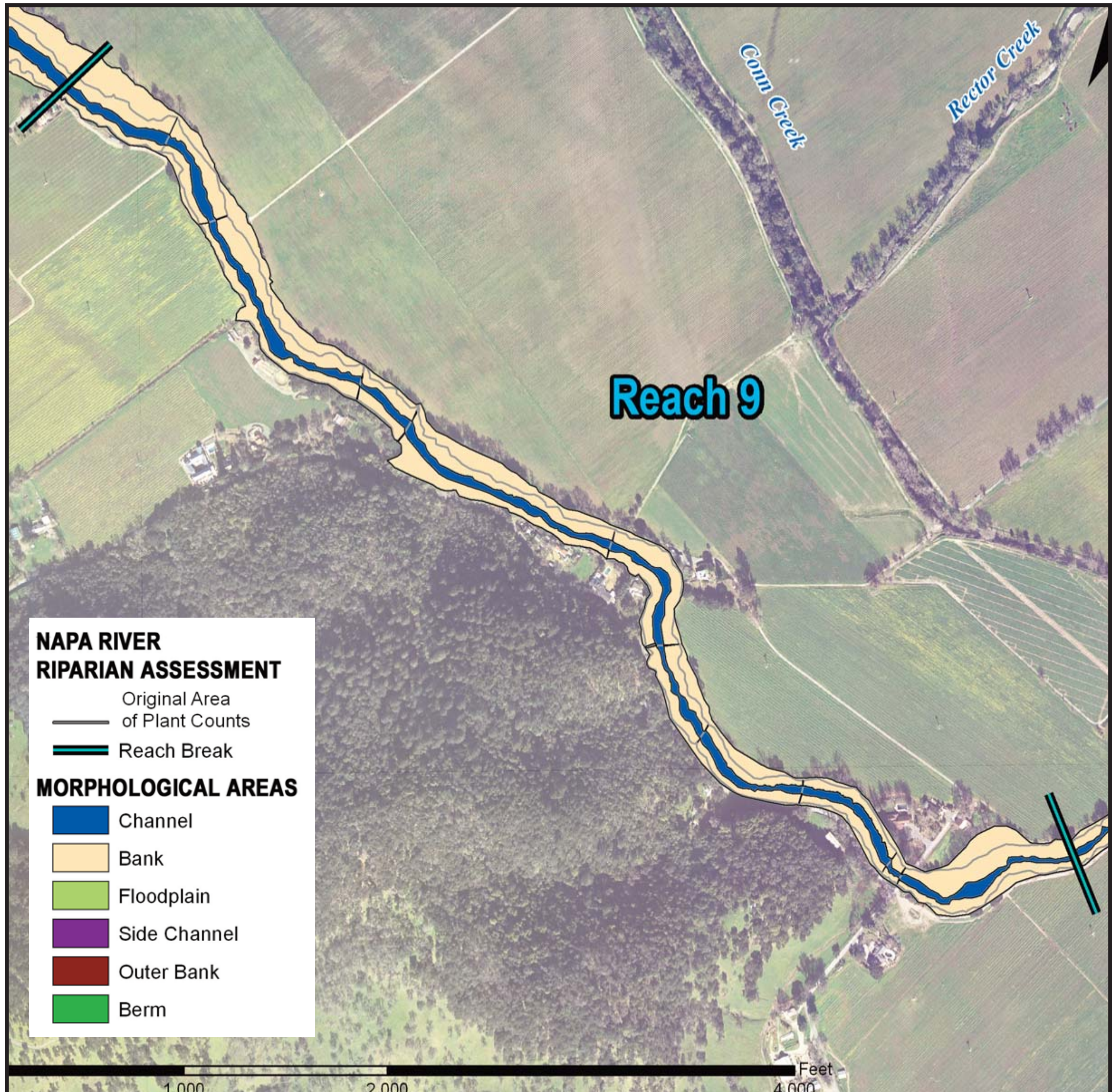
These images of Reach 9 capture the combination of deep, entrenched conditions with unstable banks (upper) interspersed with pockets that contain spawning gravel bars and small floodplains (lower).

It is unclear from aerial photos whether the channel itself, or merely the riparian corridor has widening in this reach. This corridor widening process has provided a buffer for natural channel recovery in a significant portion of the reach.Historically Reach 9 has incised by approximately 15 feet, and has widened to on average 143 feet. Under a "no-action alternative" we might eventually expect an average of 100 feet of widening in this reach through bank erosion until a width of approximately 240 feet is reached. Because much of the reach is quite a long way from an equilibrium width there is a high risk that extensive bank stabilization in narrower sub-reaches could lead to downcutting as the channel expands its cross section area.

<u>Flood characteristics:</u>

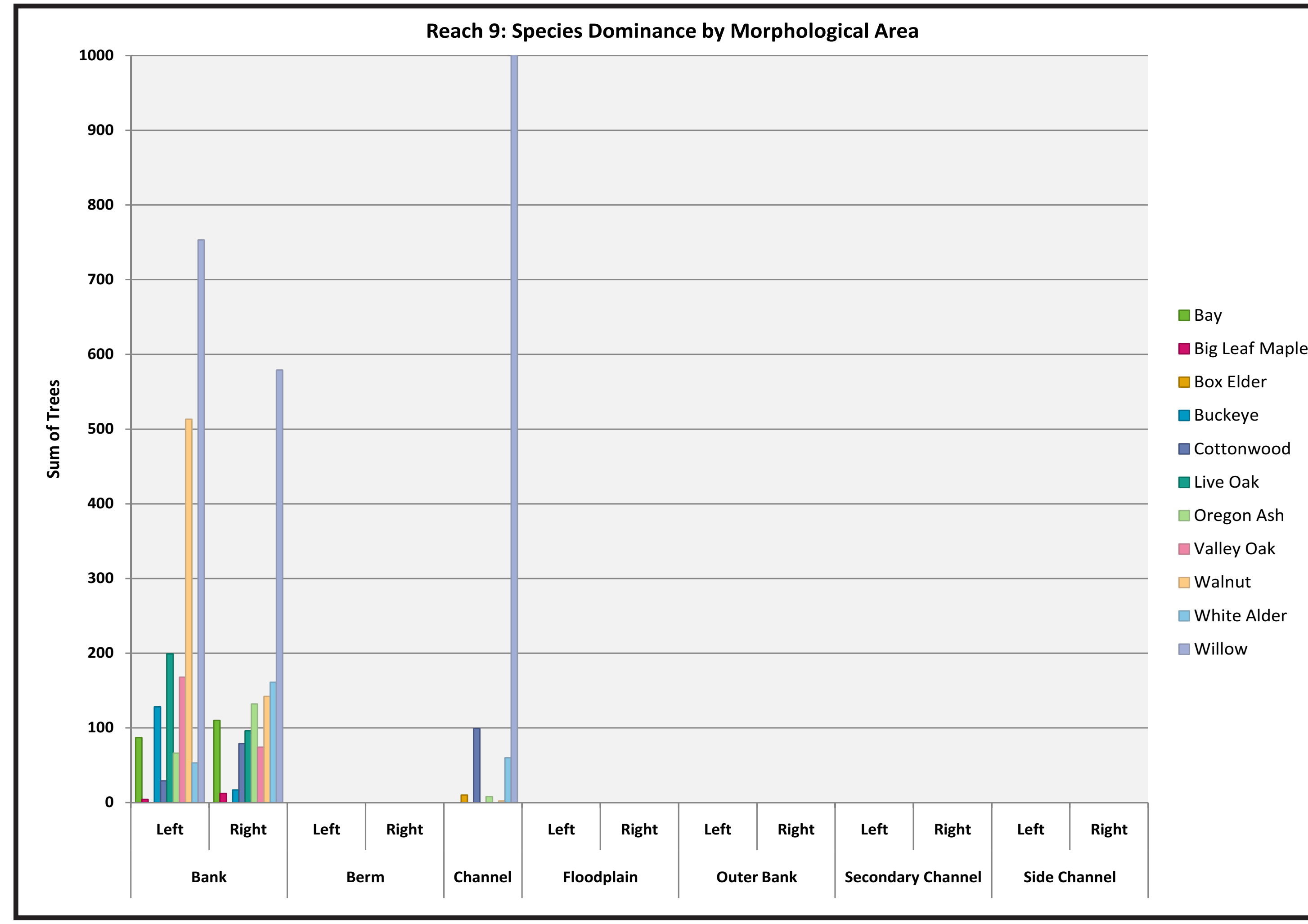
Reach 9 mostly experiences out of bank flows during events between the 5 and 10-year flood, with a few sections flooding below the 5-year flood.

The average velocity during a ten-year flood is 6-9 feet per second.



Reach 9: Vegetation Density		
Morphological Area	**Acres**	**Vegetation Density in Trees/Acre**
Channel	**5.8**	**287**
Bank-left	**8.5**	**246**
Bank-right	**7.07**	**203**

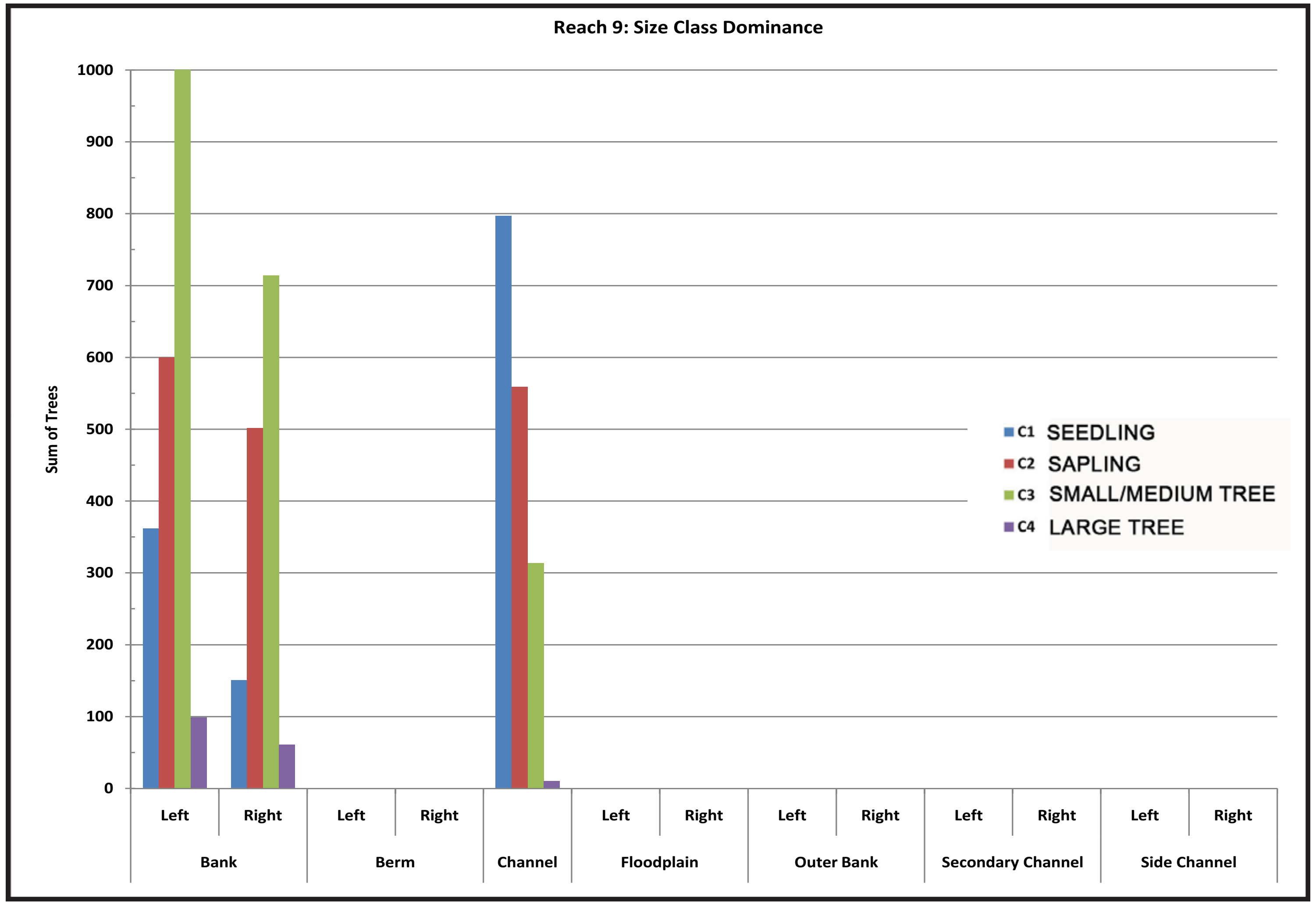
Description: Reach 9 is 1.31 river miles in length and includes 21.5 acres of riparian corridor and channel area. The riparian corridor varies from a maximum width of 200 ft. to a minimum of 115 ft. in Reach 9. The average corridor width is 159 ft. in this reach. Reach 9 contains channel, left and right bank morphological areas.



Species Diversity

Willow is the dominant species in the channel and bank areas. The banks support nine other species.

BANK EROSION IN REACH 9



Size Class Dominance

In the channel area, seedling (C1) trees are the most abundant size class. Significant numbers of sapling (C2) trees are also present with about half as many small and medium (C3) trees. On both the right and left banks, C3 trees dominate. The number of C2 trees is about half as many as the total C3 trees on each bank.

Distribution of Size Classes and Species: Willow seedlings are the most abundant in all three morphological areas. The banks also have live oak, Ca. walnut, and valley oak seedlings. Willow saplings are the most abundant C2 size class tree in the channel. The banks have a diversity of saplings of eight species including Ca. walnut, valley oak, and Fremont cottonwood. Willow is the most abundant C3 size class tree species in all three morphological areas. There are also a few white alder C3 trees in the channel area. On both banks many of the same species that occur as C2 size class trees are also found as C3 trees including willow, Ca. walnut, live oak, Ca. bay laurel, and valley oak. There are a few large willow and white alder trees in the channel area while the banks have eight species of C4 size class trees.

Invasive Species: Reach 9 has the highest density of *Arundo donax* in the project area at 11% of Reach 9 at 2.39 acres. The majority of the Arundo is on the banks. The banks have a relatively low abundance of seedlings which could be due to competition with the Arundo. Other non-native, non-riparian trees recorded include black locust, pine, Eucalyptus, and London planetree on the banks, and black locust, tree-of-heaven, and London planetree in the channel.

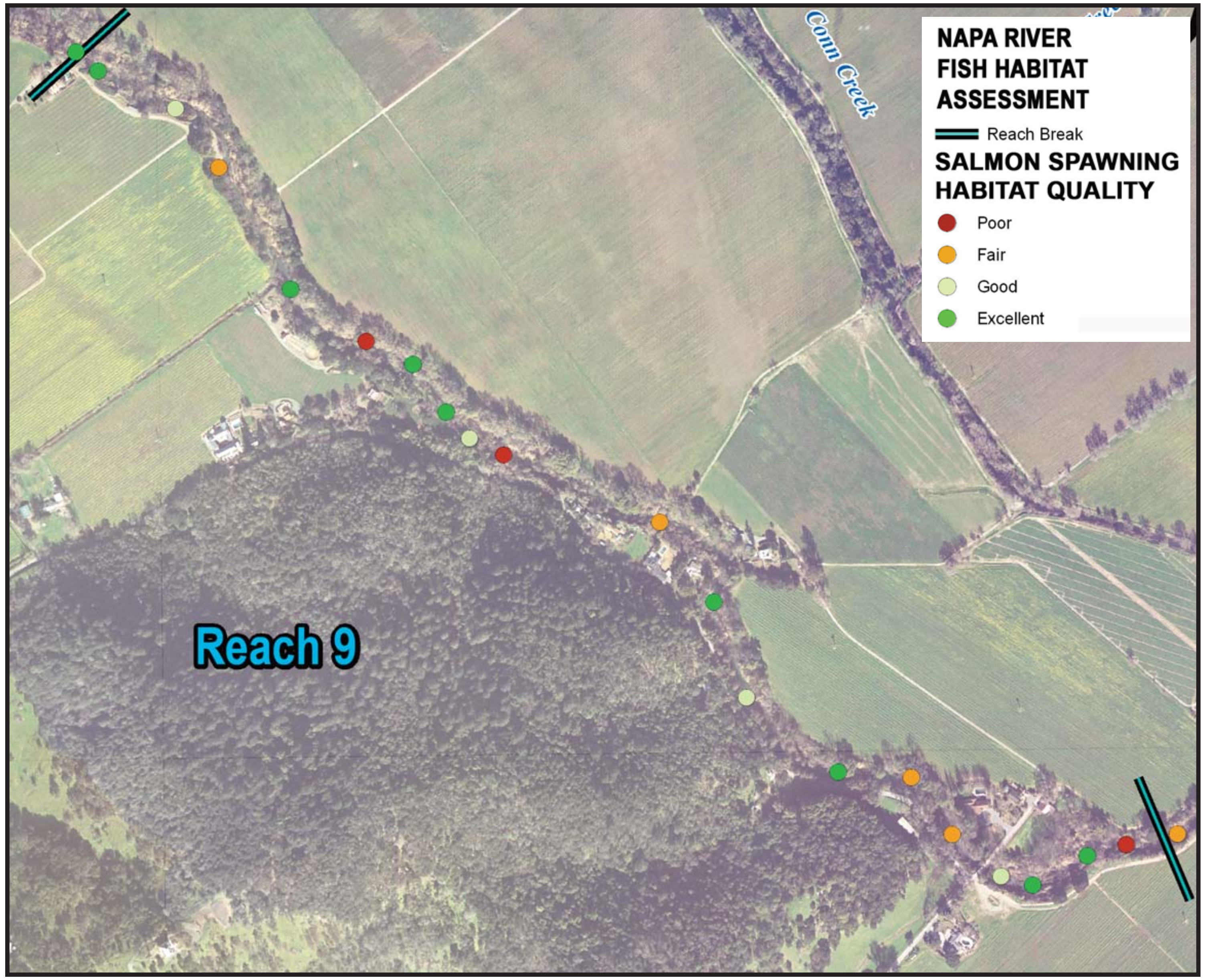
Spider Trees: Reach 9 has a relatively low occurrence of spider trees. Ca. bay laurel was the most abundant spider tree on the banks, with large live oak, Ca. walnut, Ca. buckeye, and valley oak also undercut on the banks.

Understory: Species recorded in the bank areas include Himalayan blackberry, blue periwinkle, Ca. wild grape, basket sedge, toyon, snowberry, gooseberry, mugwort, blue elderberry, and various grasses and herbs. The channel area has torrent sedge, river sedge, Ca. tule, cattails, yellow nutsedge and various grasses and ornamentals.

Riprap: Reach 9 has a high level of rock riprap on both banks in the downstream portion, where there are a number of residences. There are 732 linear feet of riprap on the right bank, 158 linear feet on the left bank, and 5 linear feet in the channel.

Ecological Trends: Reach 9 exhibits a number of ecological trends. The channel shows a dominance of willow in all four size classes, with some white alder and Fremont cottonwood, the other "pioneer" species. As would be expected, the abundance of willow in the channel area shows a decrease from the C1 to C4 size class. Willows are undergoing regeneration and growth to mature stage trees. The bank areas demonstrate species diversity in all size class stages. Willow, Ca. walnut, valley oak, live oak, and Ca. bay laurel show regeneration in low numbers. There is a high level of Arundo and rock riprap on the banks, which may reduce seedling germination and survival. There are several locations in Reach 9 where a resistant clay layer dominates the channel bed and base of the banks and severely limits vegetation growth. Tree density is relatively medium to high throughout the entire reach in comparison to other reaches.

REACH 9



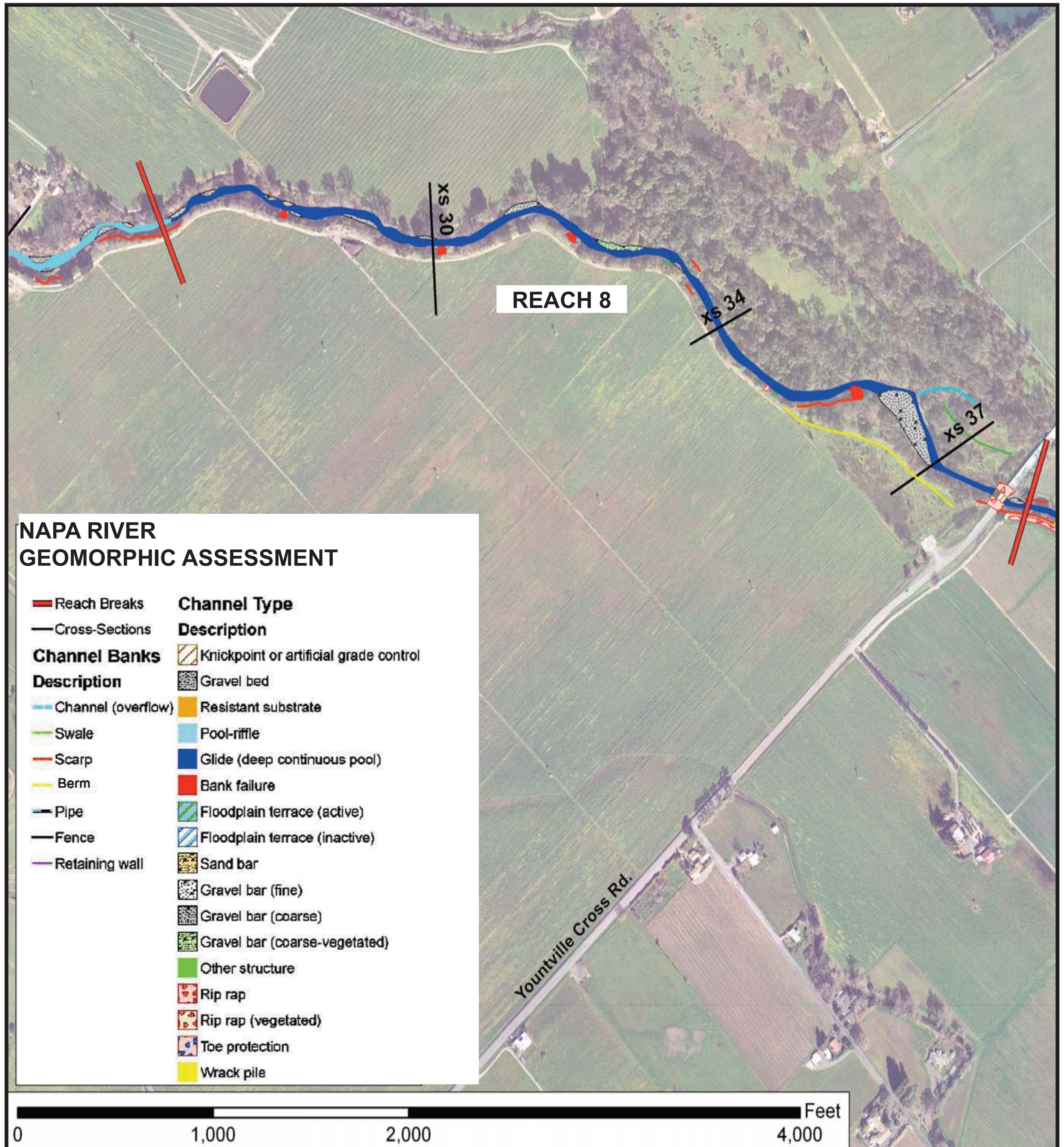
Reach 9 is the longest reach of the survey and contained a fairly balanced mix of pools, riffles, and flat-water when compared with other reaches. With approximately 12.3 habitat units per 1,000 feet of channel, Reach 9 provided a relatively high diversity of habitats throughout its length. Pools in this reach were relatively deep with an average maximum residual depth of 3.7 feet. These deep pools contained favorable amounts of cover from large woody debris (LWD) and overhanging vegetation.

Spawning habitat was generally well distributed throughout the reach, and was typically associated with well defined pools formed by LWD or corner scour. Spawning was documented at a few of these high quality sites in December 2007, but the low number of salmon in the river made it difficult to discern habitat preference patterns. In higher salmon abundance years, this reach would be expected to support approximately 20 spawning pairs in its current condition.

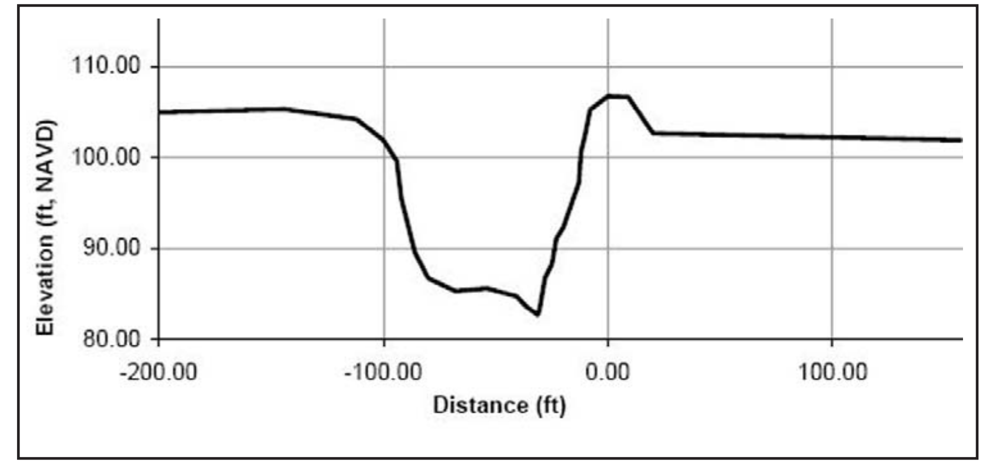
A total of four high quality backwater pools and side channel habitats were seen in Reach 9. These features promote rapid growth of juvenile salmon and provide shelter from predators and high stream velocities. Due to the loss of these important rearing habitats re-creating such features wherever feasible should be considered a high priority for improving fish habitat. The four examples of these habitat types in Reach 9 may be a useful guide for planning future restoration efforts.

BURIED LARGE WOOD CREATES SCOUR AND UNDERCUT BANK - A HIGH QUALITY HABITAT.

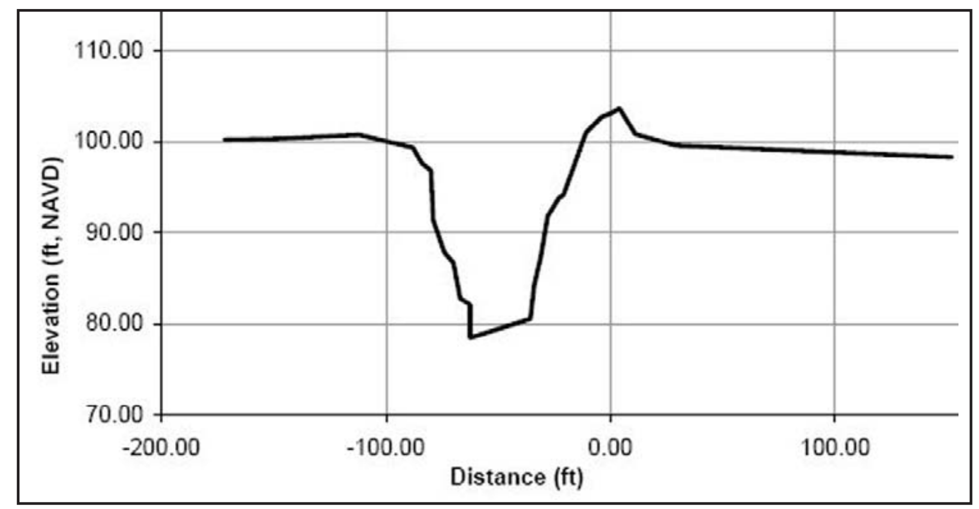
REACH DESCRIPTIONS: GEOMORPHOLOGY — REACH 8



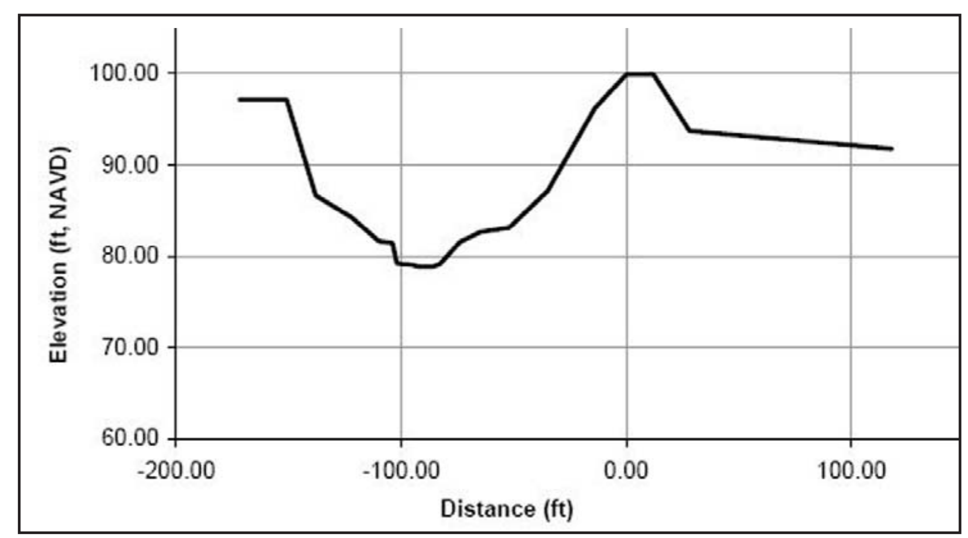
Representative Cross Sections



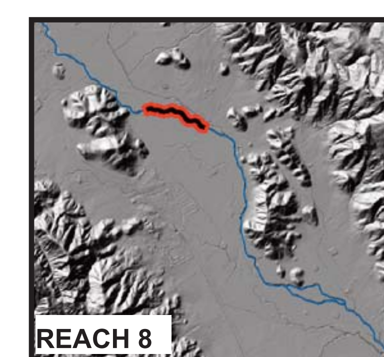
XS 30
W:D = 6.0
Average condition



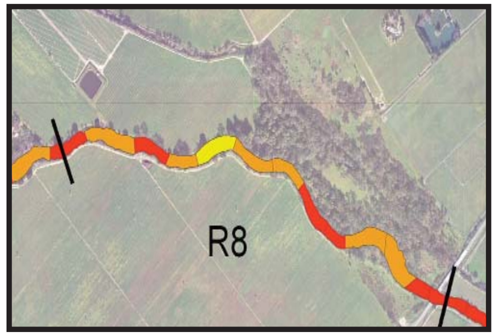
XS 34
W:D = 3.4
Most entrenched condition



XS 37
W:D = 7.5
Least entrenched condition



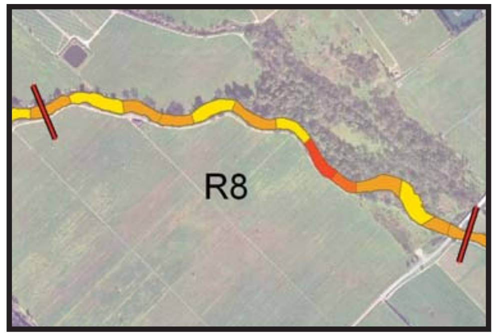
Physical Characteristics of Reach 8



Confinement

Width To Depth Ratio

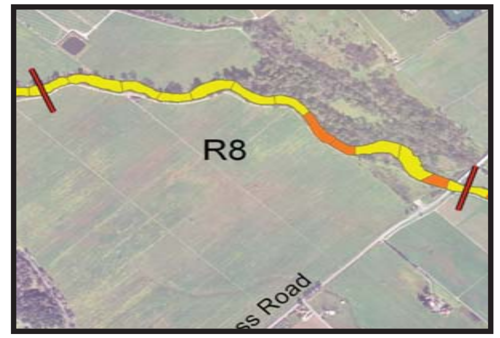
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Upstream Reach 8 is deeply entrenched with failing banks and long, continuous pools (upper images and lower left image). Downstream the channel widens and the banks become lower in the Napa River Ecological Reserve in Yountville, (lower right image).

Reach 8 is less deep but slightly more entrenched than Reach 9 due to its very narrow condition (average width 115 feet). Width:depth ratio is 5.5:1, which is approximately average for the project area overall. The upstream three quarters of the reach are effectively one long pool, with almost no gravel bars and very homogenous channel conditions. The very steep banks are contributing to poor riparian conditions with many failing trees and poor prospects for revegetation. The downstream quarter enters the Napa River Ecological Reserve in Yountville, initially as an entrenched channel, becoming wider and less entrenched where it joins Conn Creek. At the confluence there is abundant gravel and some more diverse riffle-pool conditions.

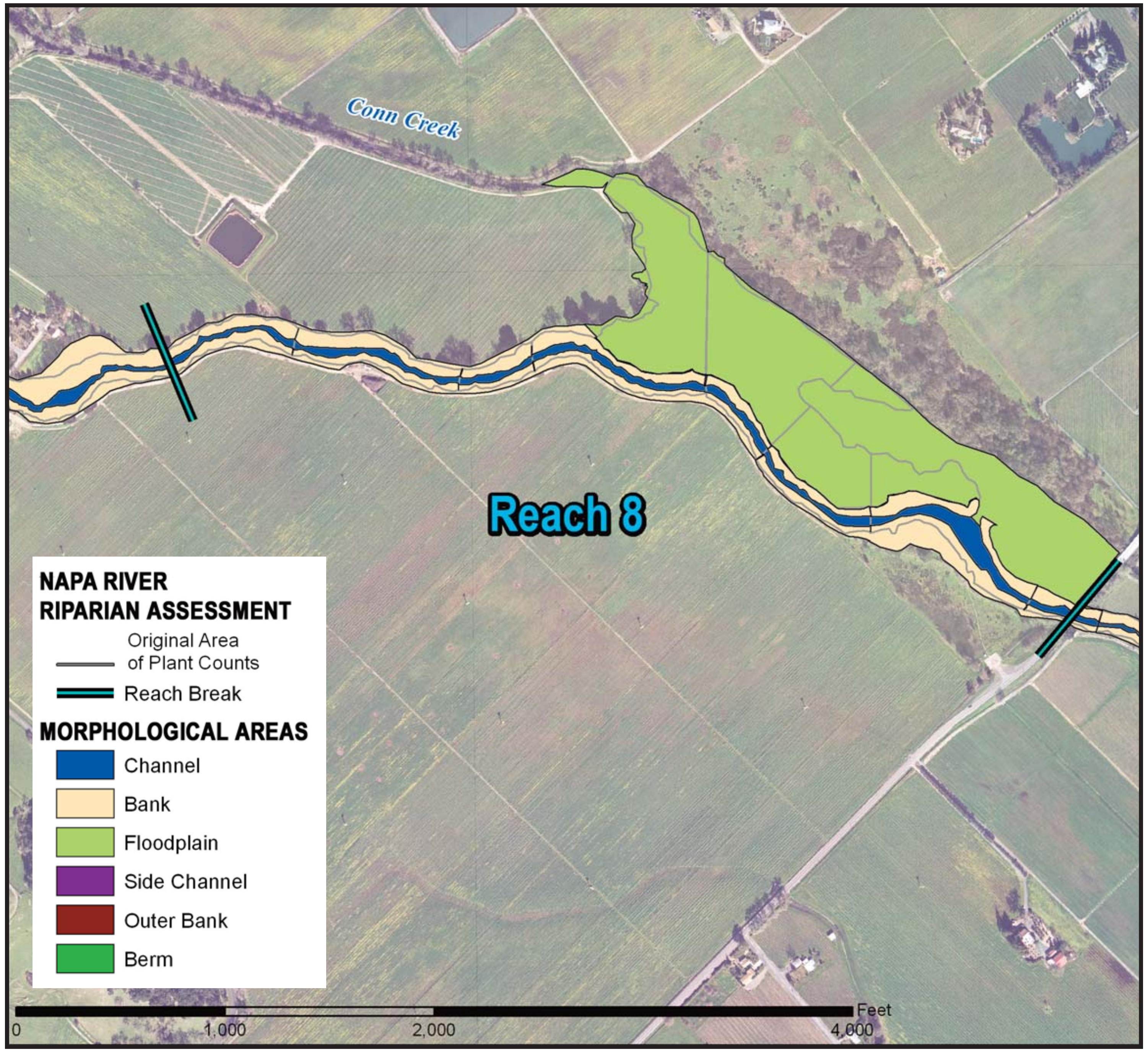
Shields stress analysis shows most of this reach has partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs. Several areas show full scour where the gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features.

This reach has historically incised by approximately 10 feet, and has not yet widened much beyond its original width (assumed to be around 100 feet), except in the Preserve area. We anticipate significant bank instability problems in future as the channel widens in response to incision. Under a “no-action alternative” we might eventually expect an average of 100 feet of widening in this reach through bank erosion until a width of approximately 215 feet is reached. Because most of the reach is quite a long way from an equilibrium width there is a high risk that extensive bank stabilization in narrower sub-reaches could lead to downcutting as the channel expands its cross section area.

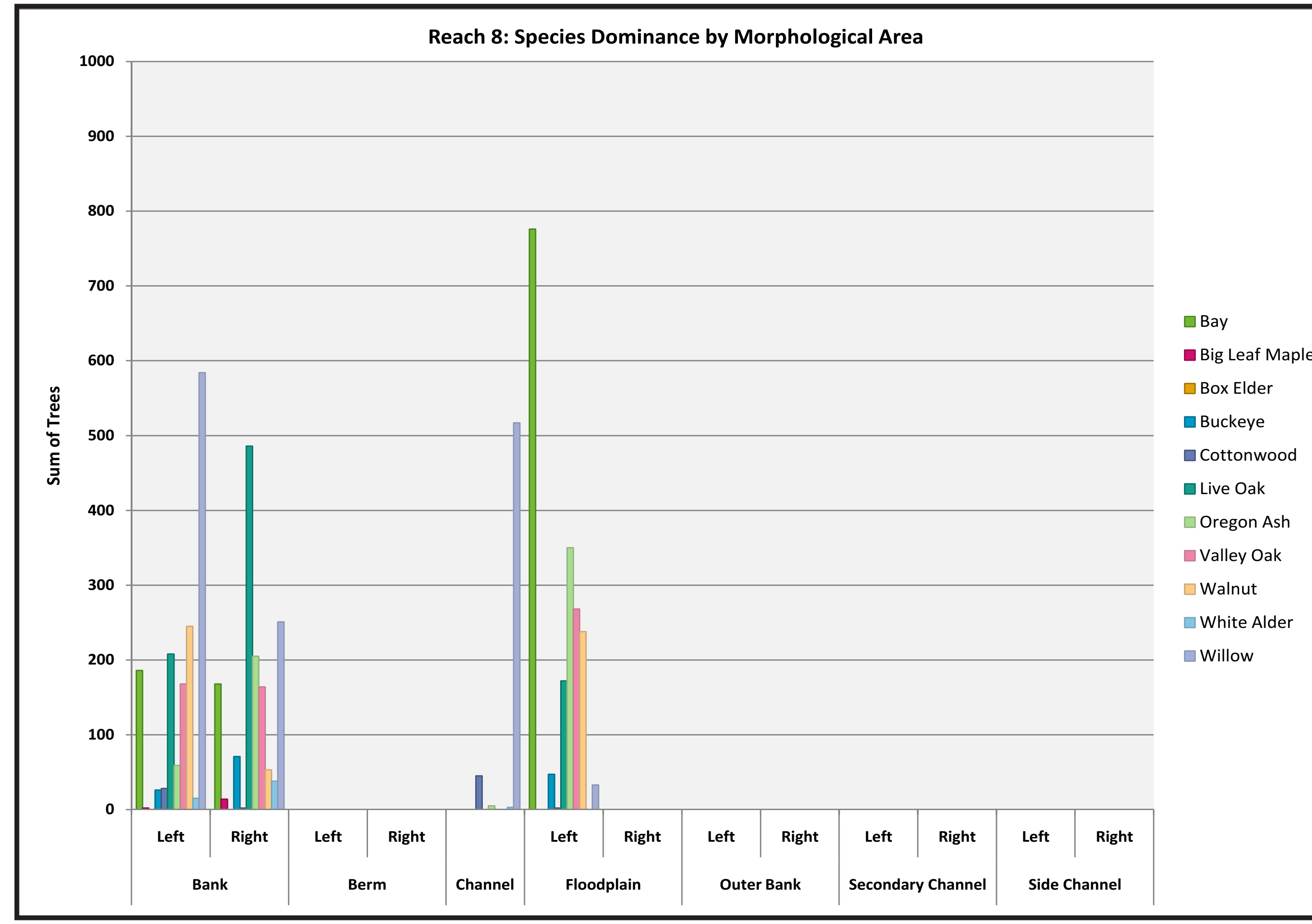
Flood characteristics:

The Reach 8 channel can not contain the 5-year flood event.

Average velocity during the ten-year flood is 6-10 feet per second.



Description: Reach 8 includes 0.97 river miles and 34 acres of riparian corridor and channel area. The riparian corridor in Reach 8 varies from 490 ft. to 124 ft. in width, and averages 229 ft. Reach 8 has channel, right and left bank areas, and a large floodplain between the Napa River and Conn Creek channels.

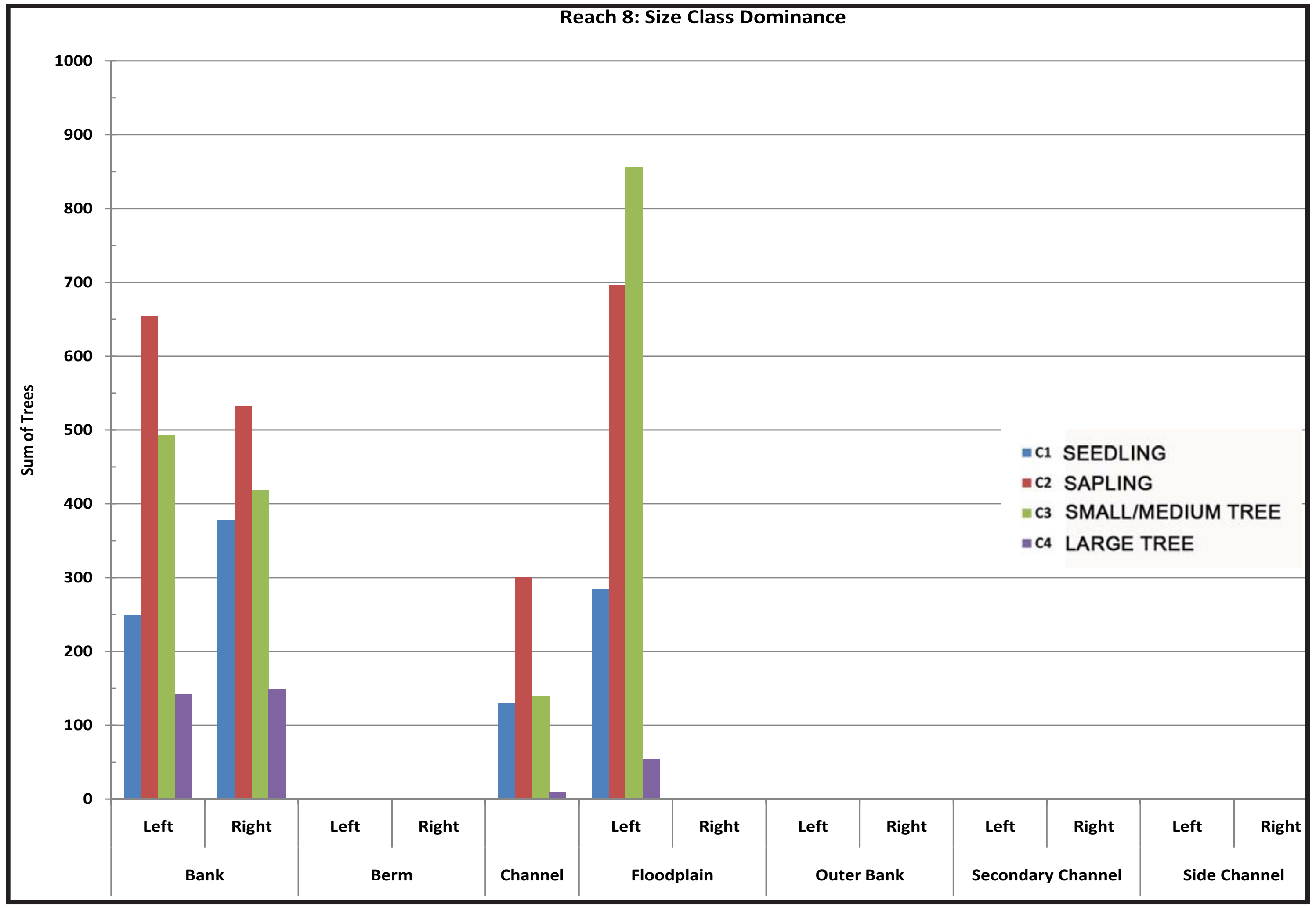


Species Diversity

Ca. bay laurel, live oak and willow dominate the channel and banks of Reach 8. Oregon ash, valley oak and Ca. walnut dominate the floodplain.

Reach 8: Vegetation Density

Morphological Area	Acres	Vegetation Density in Trees/Acre
Channel	4.1	139
Bank-left	5.7	268
Bank-right	3.7	391
Floodplain-left	20.2	94



Size Class Dominance

C2 and C3 size class trees are co-dominants on both banks. C4 trees occur on both the left and right banks in relatively high numbers. Saplings (C2) dominate the channel with C1 and C3 size class trees occurring in nearly equal numbers. The floodplain area is dominated by C3 size class trees and also has an abundance of C2 size trees. Both C1 and C4 size trees occur in low numbers.

Distribution of Size Classes and Species: The channel has low densities of willow and cottonwood seedlings. C2 willows dominate the channel area with few other saplings. The channel area primarily has willow in the C3 size class.

The banks have a total of eight species of seedlings. On the left bank, six species of seedlings occur at low densities, with valley oak the most numerous. On the right bank, live oak seedlings are numerous with low numbers of five other species. On the left bank, willows are the most numerous C2 trees with large numbers of live oak and Ca. walnut. On the right bank, valley oak and live oak are the primary sapling size trees. On the banks, willows are also the primary C3 size trees, but there are seven other species present. Ca. bay laurel in the C3 size class dominates the floodplain area. C4 size trees are numerous in this reach on the banks. C4 size Ca. bay laurel and valley oak occur at densities of 15-20 trees/acre. Large C4 live oak, Ca. walnut, and willow also occur on the banks.

The floodplain area has very low numbers of five species of C1 trees. Saplings occur in low numbers, with Ca. bay laurel and valley oak the primary species. The floodplain area has a few C4 Ca. bay laurel and valley oak but high numbers of C3 size class Ca bay laurel.

Invasive Species: Reach 8 has a low level (0.007% of reach area) of *Arundo donax* totaling 0.26 acres, with nearly all of it located on the banks. Other non-native species in Reach 8 include black locust, Lombardy poplar, and blue gum eucalyptus. These invasive and non-native plants appear to be competing with native seedlings. The Lombardy poplar, an ornamental species, was planted as part of a bank revegetation project.

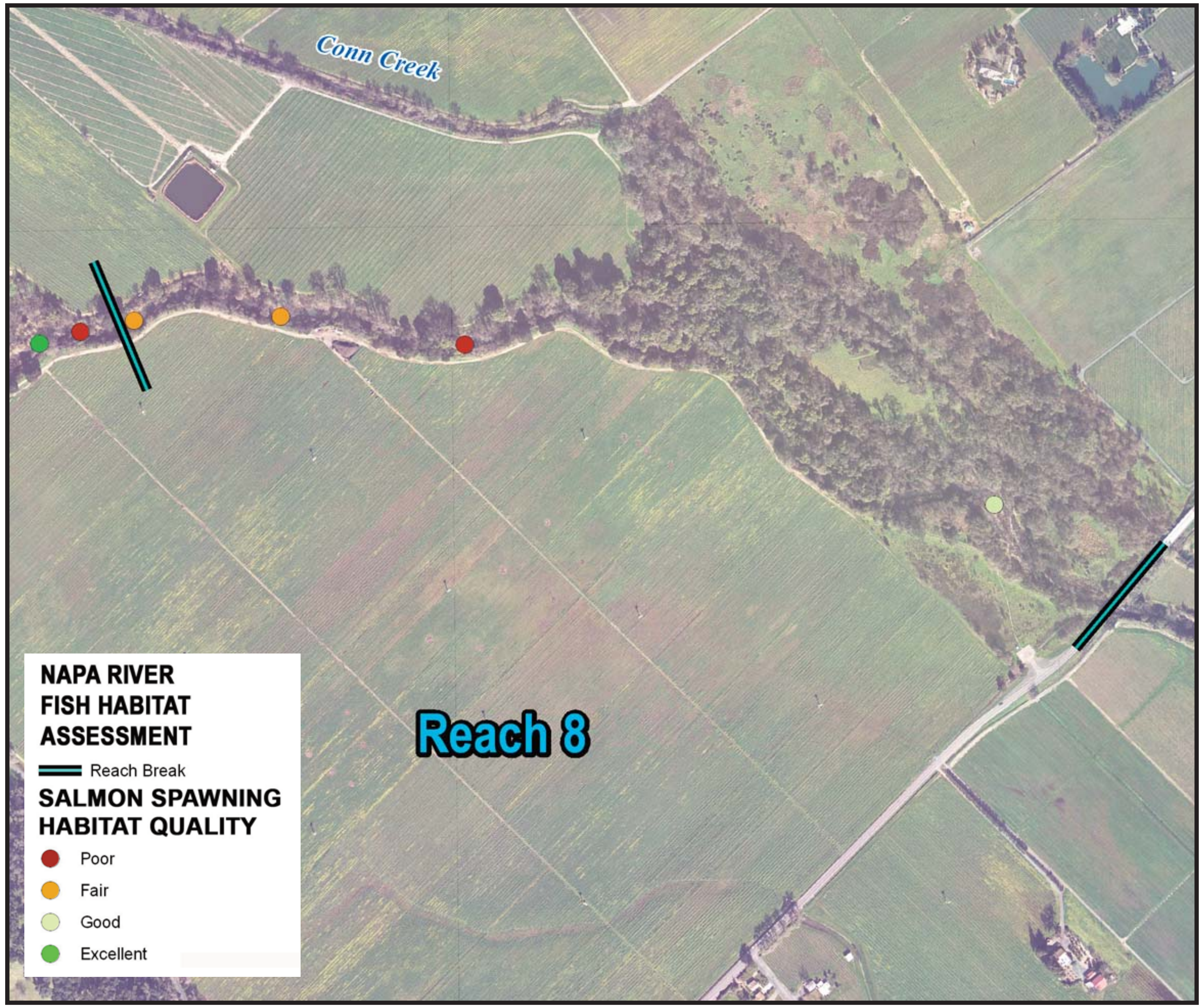
Spider Trees: Reach 8 has a high number of spider trees on the banks and in the floodplain. Fifty-five large Ca. bay laurel trees, over thirty large valley oak and twenty large live oak were recorded as being undercut and at risk of failure.

Understory: The understory vegetation in Reach 8 is low in density and consists of Himalayan blackberry, blue periwinkle, Ca. wild grape, basket sedge, snowberry, mugwort, and poison oak. Torrent sedge, horsetail, river sedge, and yellow nutsedge occur along the channel.

Riprap: Reach 8 has a moderate amount of riprap on the banks, with 85 linear feet on the left bank and 35 linear feet on the right bank.

Ecological Trends; Reach 8 differs from the other reaches by having an old growth forest of Ca. bay laurel, valley oak, and live oak on the banks and a large floodplain with numerous small/medium and large trees. Regeneration in these areas is occurring with valley and live oaks the most abundant seedlings. This old growth forest provides ample shade and other riparian species may have difficulty germinating and maturing. Many of these large trees are being undercut from bank erosion. Along the channel, sapling willows are the primary trees. Over time, the current trend of channel widening will remove this old growth, mature riparian habitat, allowing early stage riparian willow forest to grow. The Napa River has a small amount of old growth riparian forest. Reach 8 is a unique area in need of a reduction in erosion to reduce ecological loss. There is a resistant clay layer in many locations in the channel in Reach 8. overall tree density id medium in comparison to other reaches.

REACH 8 HAS NUMEROUS LARGE OLD GROWTH TREES. MANY OF THESE TREES ARE BEING UNDERCUT BY BANK EROSION. A WILLOW REVETMENT WAS CONSTRUCTED AROUND THE TREES IN THE PHOTO TO REDUCE EROSION BUT NEVER GREW.



Reach 8 extends through the Napa River Ecological Reserve to the Yountville Crossroad. The channel through the Reserve offers relatively high quality spawning and rearing habitat, especially near the confluence with Conn Creek. Near this confluence the channel is fairly wide with abundant, well-sorted gravel and side channels. This short section of the river may serve as reference conditions and help to guide restoration efforts in the river.

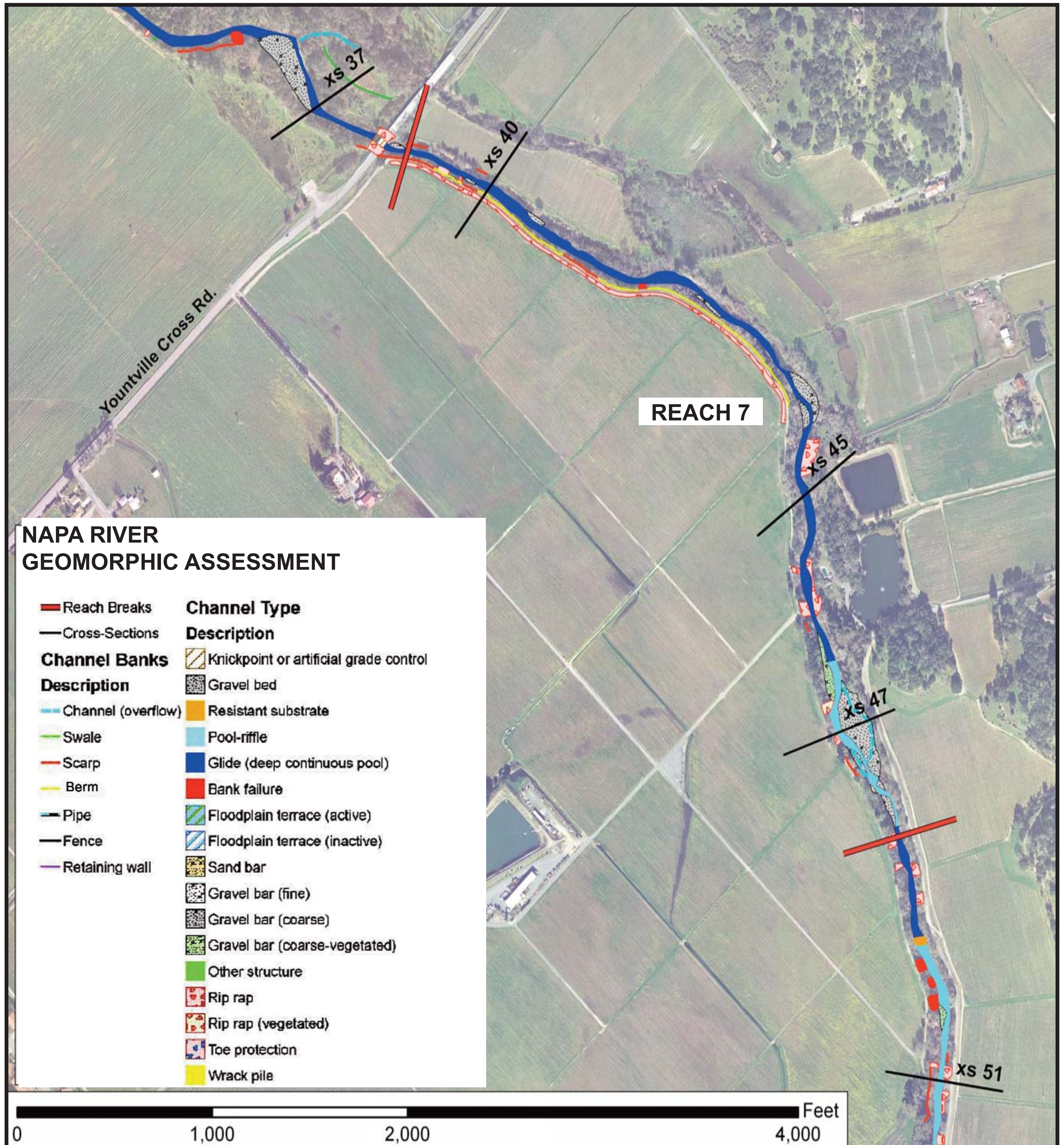
Immediately upstream of the Reserve, the river is dominated by long pools and glides. This section extends approximately 3,667 feet with only one short riffle. This long pool/glide sequence was nearly void of fish during our survey in May 2007 and was characterized by mud/silt substrate and generally very homogenous channel topography.

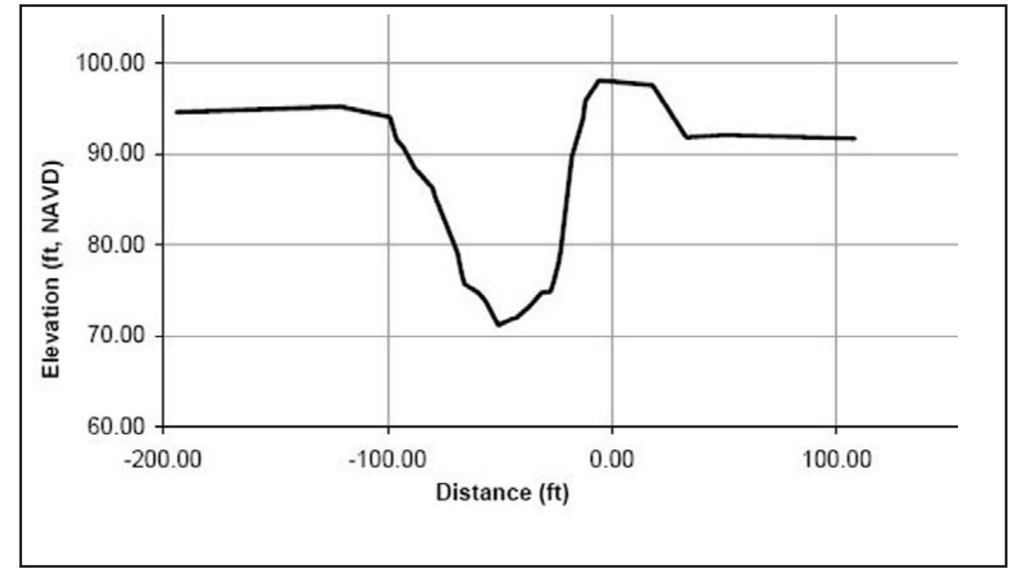
Reach 8 contains very little salmon spawning habitat; only four potential sites were identified and all but one was considered low quality. Spawning patches in this reach lacked topographic definition and contained substrate that was generally too small for successful incubation.

Habitat quality increased in the upper end of this reach as the channel transitioned to Reach 9. Pools at the upper end of the reach had more definition, contained more LWD and other cover, and provided a variety of microhabitats for juvenile salmonid rearing. These pools contained abundant Chinook salmon parr in May 2007, as well as other less common natives, including tule perch and hardhead.

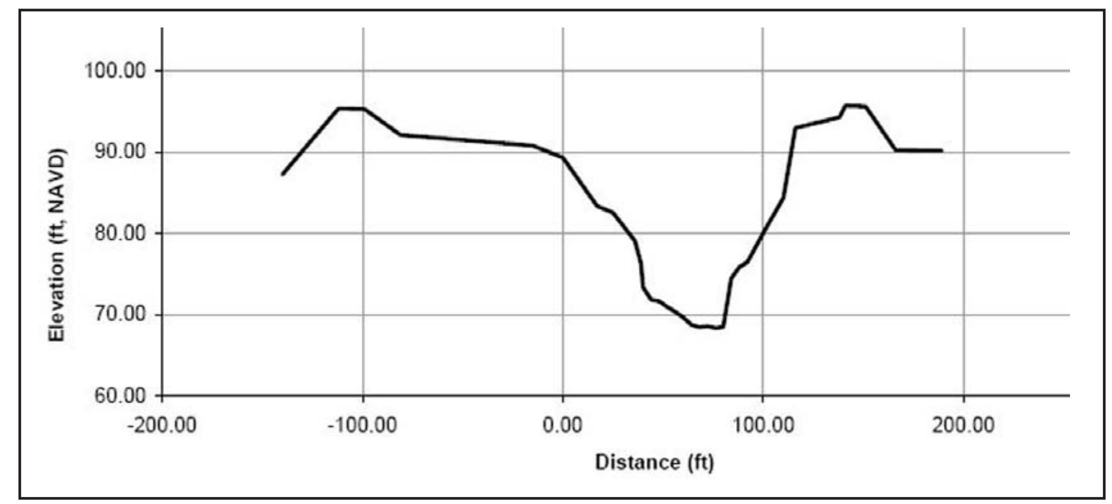
A LONG DEEP POOL UPSTREAM OF THE NAPA RIVER ECOLOGICAL RESERVE.
THIS AREA HAS A LOW HABITAT VALUE FOR SALMON.

Representative Cross Sections

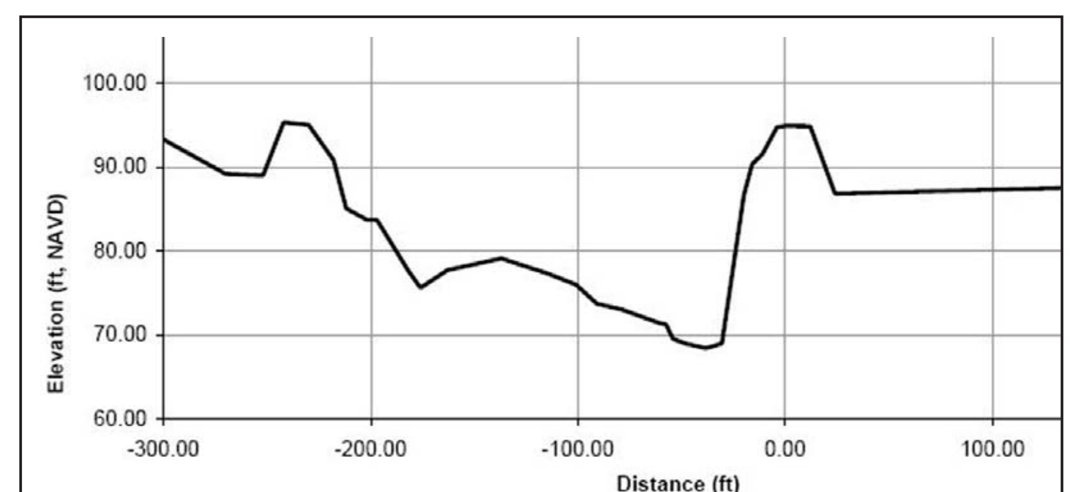




XS 40
W:D = 3.8
Most entrenched condition

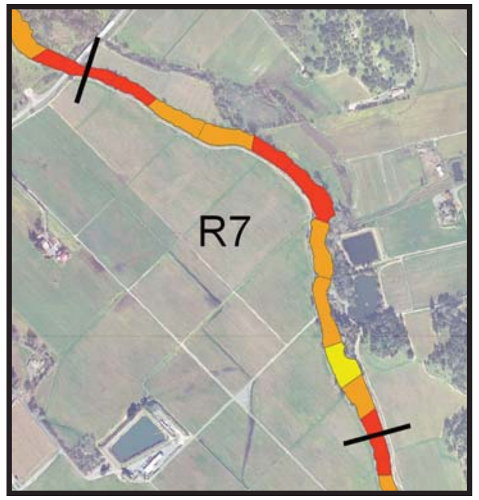


XS 45
W:D = 5.8
Average condition



XS 47
W:D = 8.6
Least entrenched condition

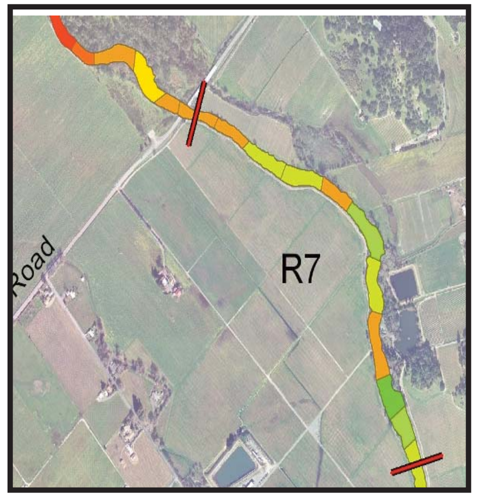
Physical Characteristics of Reach 7



Confinement

Width To Depth Ratio

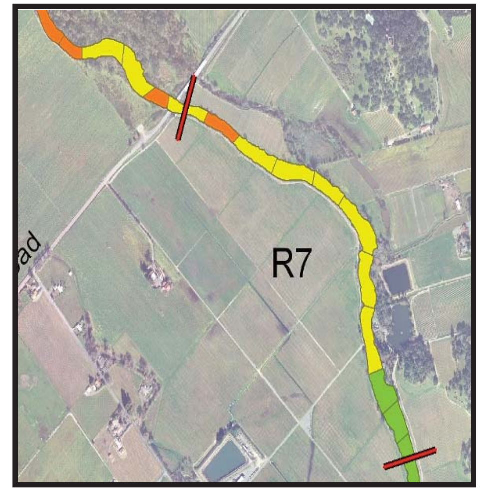
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Reach 7 is characterized by confined upper sections with deep glides and eroding banks, with pockets of gravel and floodplain increasing downstream. Many of the banks are armored with riprap.

Reach 7 has similar characteristics to upstream Reach 8, with most of the channel being deeply entrenched but some pockets of more natural geomorphic function, especially downstream where there are several large gravel bars in wider reaches.

The upstream half of the reach is deeply entrenched and dominated by a very steep west bank topped by a levee, with slightly less steep conditions on the east bank. In places the channel has incised down to a cohesive, resistant substrate. The west bank levee has experienced erosion problems from overtopping in several recent flood events. The channel is dominated by a single long pool with little channel diversity.

The downstream half of the reach is wider and has more natural geomorphic function, with several significant gravel bars. The channel has a riffle-pool form in the most downstream section.

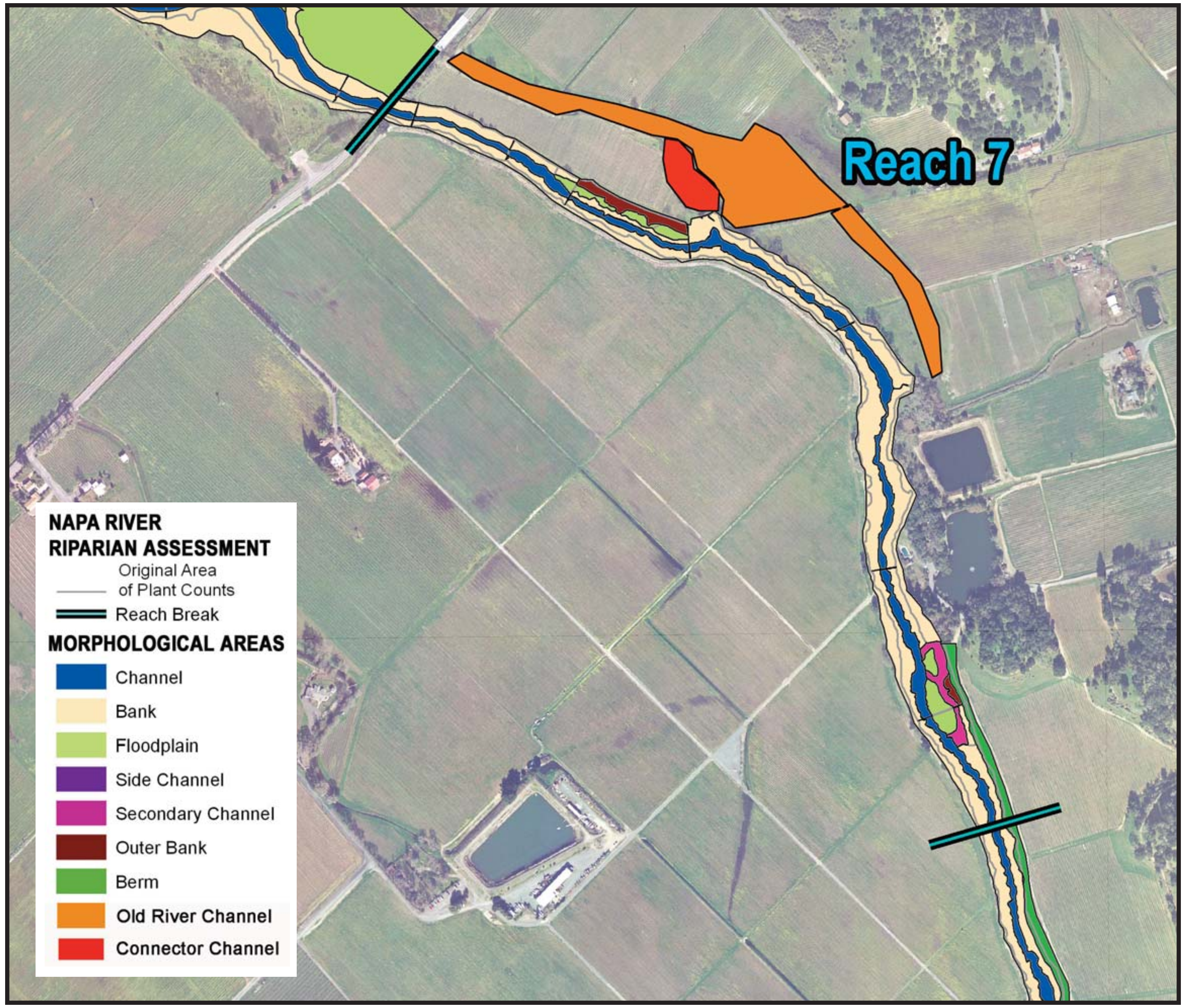
The Shield's stress analysis shows areas with selective scour where a thin layer of spawning gravel or weaker unvegetated bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds. Partial scour areas are the most common where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs. One area has full scour where gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features.

This reach has historically incised by approximately 15 feet, and remains overly narrow for its depth (average width 137 feet, average depth 25 feet). We anticipate significant bank instability problems in future as the channel widens in response to incision. Under a "no-action alternative" we might eventually expect an average of 115 feet of widening in this reach through bank erosion until a width of approximately 250 feet is reached.

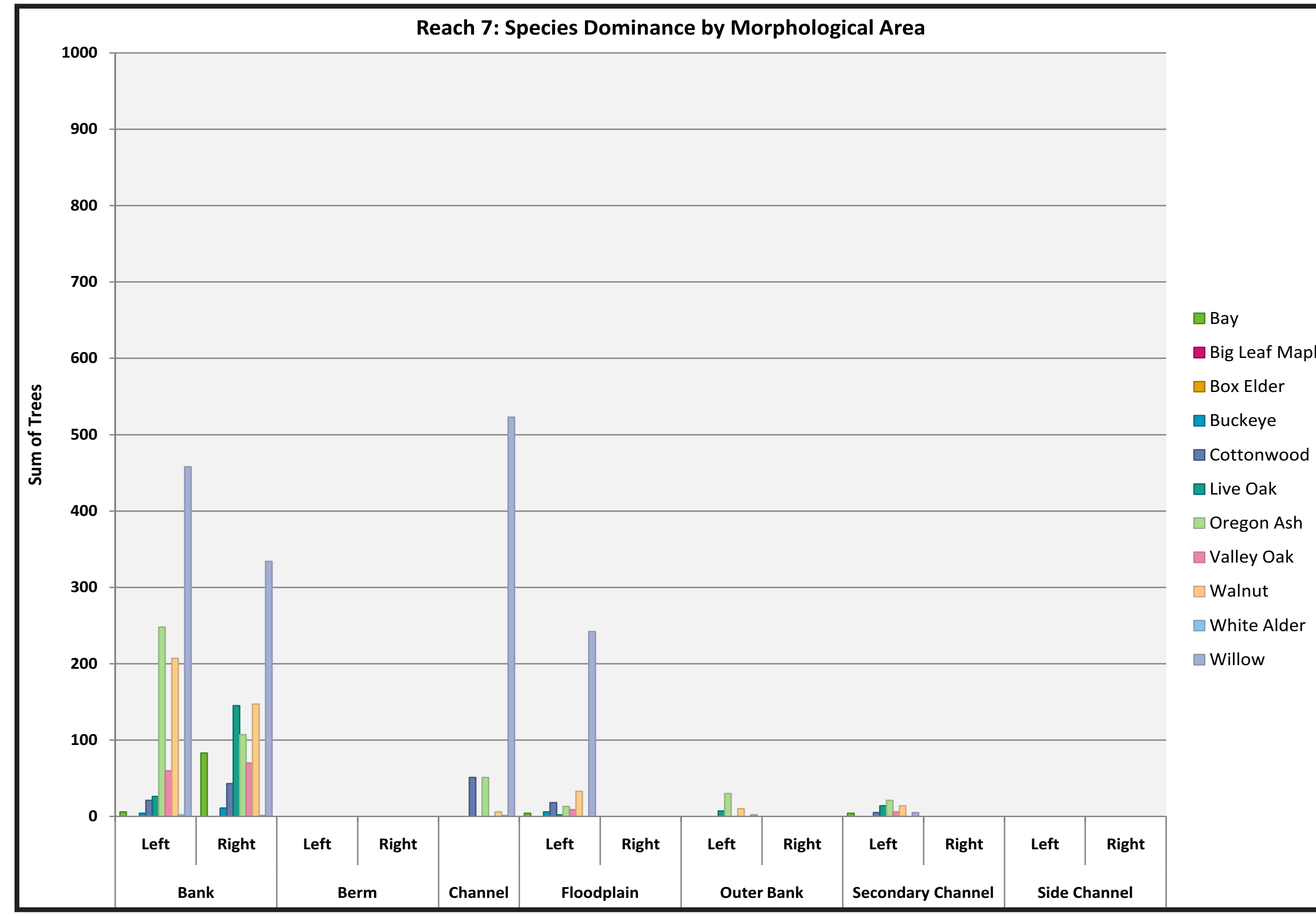
<u>Flood characteristics:</u>

The Reach 7 channel can not contain the 5-year flood event.

Average velocity during the ten-year flood is 4 -8 feet per second.



Description: Reach 7 extends for 0.86 miles and encompasses 14.38 acres of riparian corridor and channel area. The width of the riparian corridor varies from a maximum of 230 ft. to a minimum of 93 ft. and an average of 131 ft. Reach 7 is one of the narrowest reaches, and includes channel, right and left banks, left berm, left floodplain, secondary channel, and outer bank morphological areas. A separate channel to the east parallels the main river and has been turned into a series of reservoirs along its downstream area. A connector channel now carries flood flows back into the river.

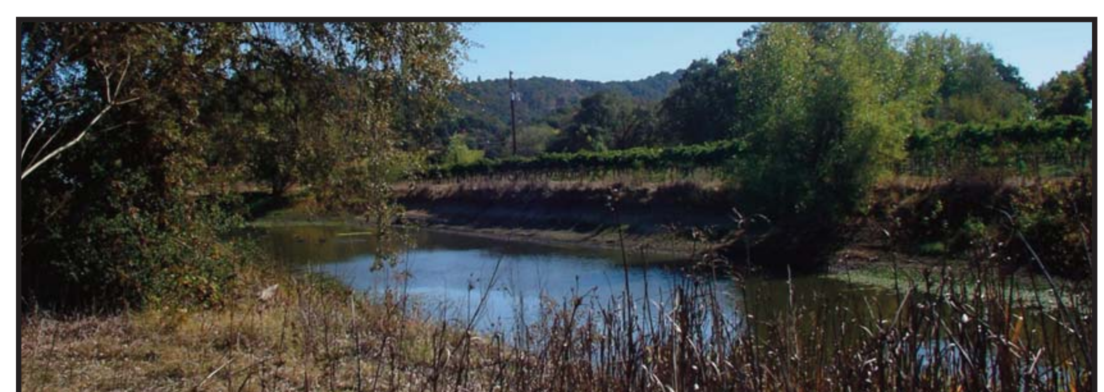


Reach 7: Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre*
Channel	3.4	183
Bank-left	3.9	271
Bank-right	4.1	263
Floodplain-left	0.98	330
Secondary channel-left	0.50	70
Outer bank-left	0.58	49
Berm-left	0.76	0

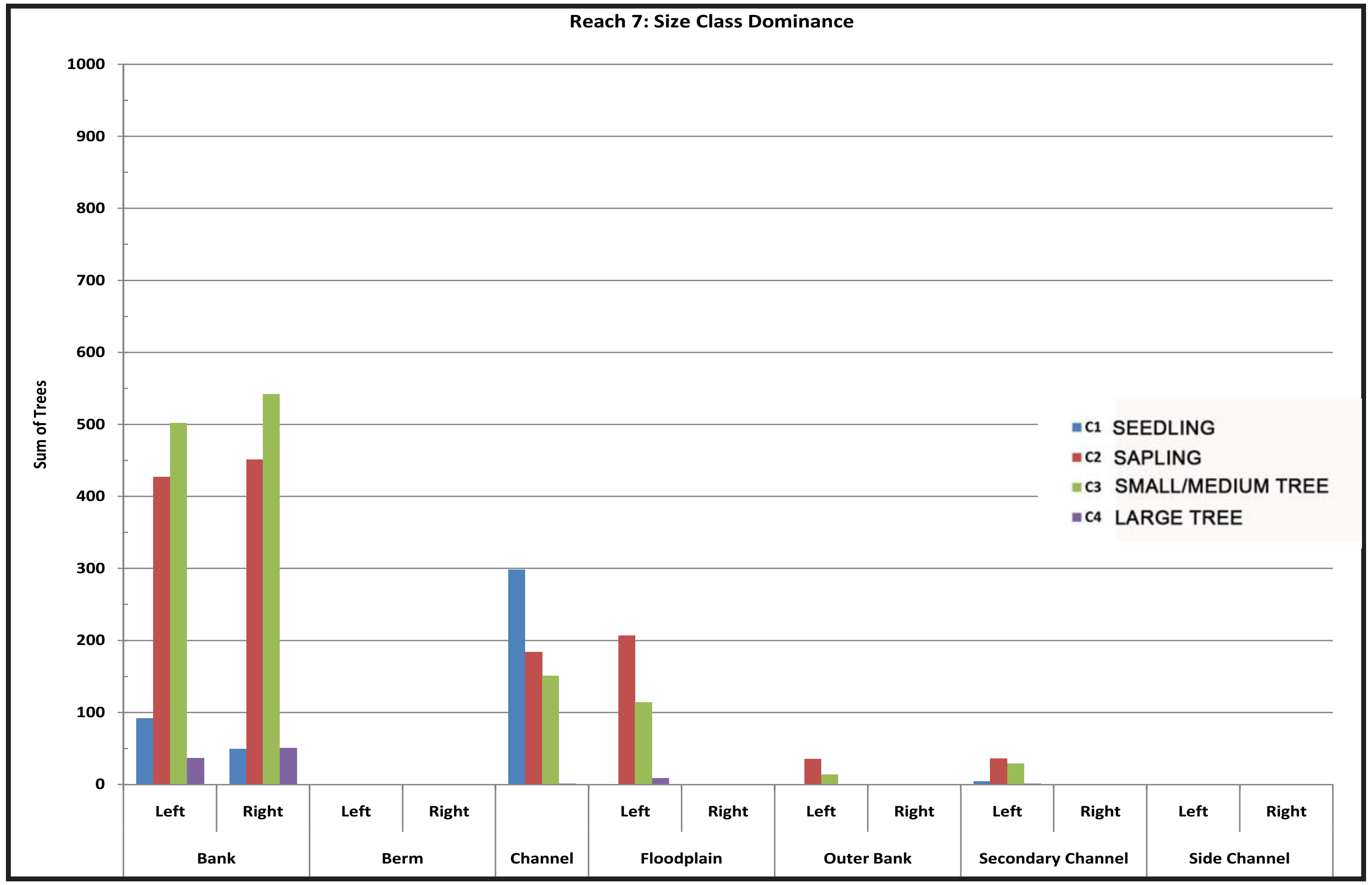
*For morphological areas of less than one acre, the actual tree count is listed

Species Diversity

Willow is the dominant species in the channel and on the banks and floodplain. The banks also support seven other tree species.



THE OLD RIVER CHANNEL THAT PARALLELS REACH 7 WAS CHANGED INTO A SERIES OF RESERVOIRS IN ITS DOWNSTREAM AREA.



Size Class Dominance

Seedlings (C1) are the most numerous size class trees in the channel and were scarce on the flood-plain, outer bank and secondary channel. Sapling trees (C2) dominate the floodplain and outer bank areas. Small/medium trees (C3) and saplings are co-dominants on both banks and in the secondary channel. Large trees are limited to the banks and floodplain.

Distribution of Size Classes and Species: Willow is the primary species of seedling in the channel, with small numbers of Oregon ash and Fremont cottonwood. Seedling density on the banks is low and made up of Oregon ash, live oak, Ca. walnut, and valley oak. There are almost no seedlings on the floodplain, outer bank or secondary channel. Willow saplings dominate both banks, the channel, and floodplain area with Ca. walnut, Oregon ash, and less numerous valley oak, live oak, Fremont cotton-wood, and Ca. bay laurel. The channel has only willow C3 size class trees. The banks have eight species of C3 size class trees with willow most numerous and Ca. walnut, Oregon ash, live oak, and Ca. bay lau-rel in large numbers and valley oak, Fremont cottonwood, and Ca. buckeye in low numbers. Seven species of C3 trees grow on the floodplain; willow is the most numerous. Six tree species grow in the secondary channel, with live oak the most abundant. Live oak and Ca. walnut are the primary C3 species on the outer bank. There are no C4 size class trees in the channel or outer bank areas. The banks have a few C4 trees of five different species. The floodplain has C4 cottonwood trees along with a few Ca. buckeye, valley oak, and willow. The secondary channel has a few C4 Oregon ash.

Invasive Species: Reach 7 has a medium level of *Arundo donax* growth, which encompasses 0.17 acres or 0.01% of the total corridor acreage. Arundo primarily grows on the banks. Black locust is abun-dant on the right bank and eucalyptus and black locust occur in low densities on the left bank. Eucalyptus also occurs in the channel and in the secondary channel.

Spider Trees: Reach 7 has a high level of spider trees on both banks.

Understory: Understory plants recorded included basket sedge, Himalayan blackberry, Ca. wild grape, pokeweed, blue periwinkle, snowberry, and grasses. Along the channel cattails, torrent sedge, river sedge, Ca. wild grape, pokeweed, and yellow nutsedge were recorded.

Riprap: Reach 7 has a very high amount of riprap on the right bank, with 2,330 linear feet.

Ecological Trends: Reach 7 is relatively narrow with a great deal of riprap on the banks and a large number of spider trees. Additionally, a resistant clay layer covers a large part of the channel. The chan-nel supports willow seedlings, but only a proportion are surviving to the C3 size class. The banks have very low numbers of seedlings and the floodplain, outer bank and secondary channel have almost no seedlings. The C3 and C4 trees along the banks are being undercut due to bank erosion. The riparian forest is not regenerating in most areas of Reach 7. The resistant clay layer limits vegetative growth and bank erosion is removing mature vegetation. In addition, large stands of black locust, an invasive non-native species, may also be reducing survival of native tree seedlings. Overall tree density is medium in comparison to other reaches.

In Reach 7, there is a parallel channel to the main Napa River which fills with flood water from the river on a 2 to 5 year frequency storm. This second channel is relatively natural in its most upstream section, but has been changed into a series of reservoirs in its downstream area. A small channel connects this upstream area to the river. The natural upstream section is shallow and wide with freshwater marsh and willow groves. The connection channel to the river is severely incised and its banks have a large infestation of pokeweed. Many of the reservoirs are surrounded with willow and wetland plants.

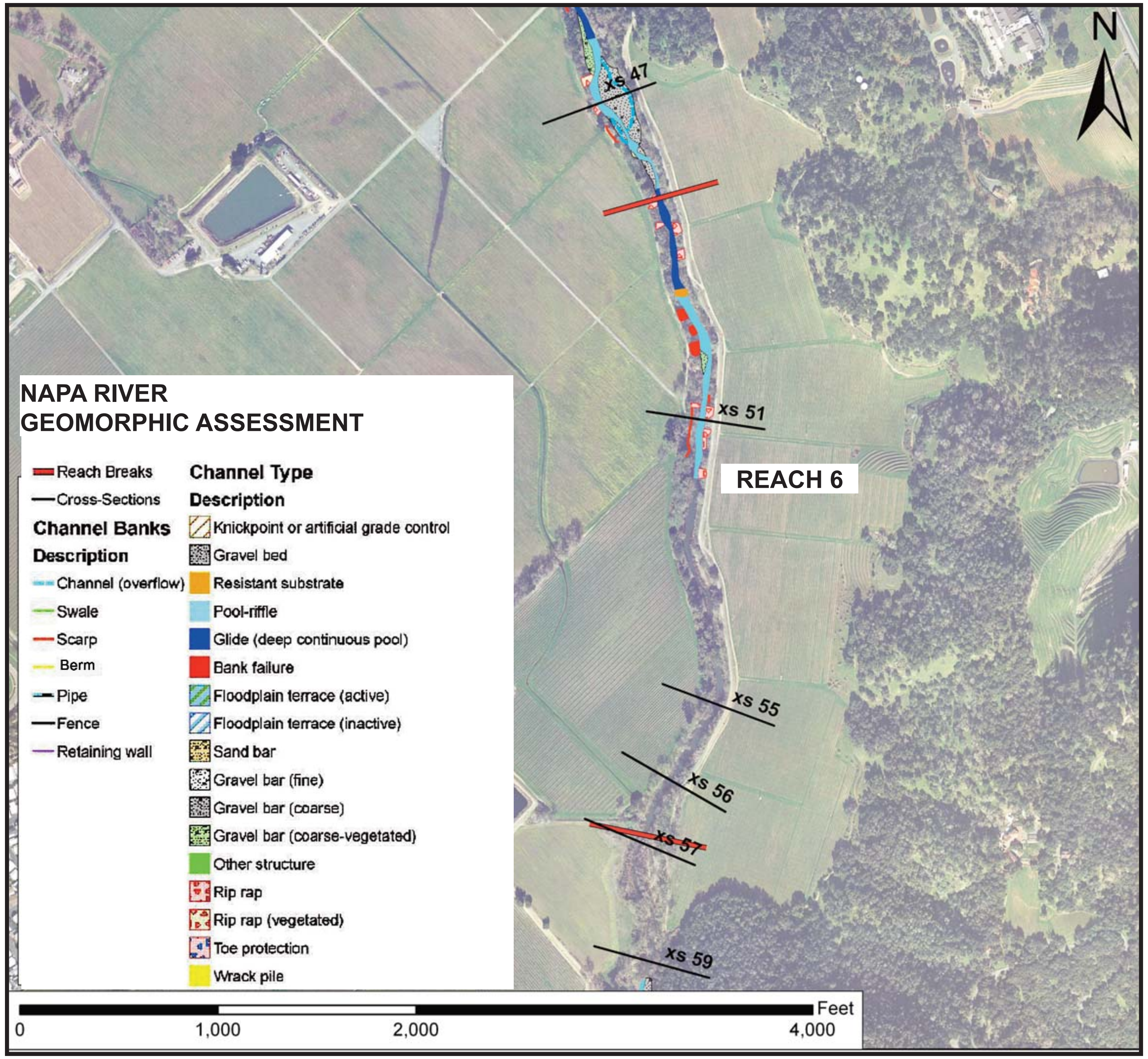
ARUNDO DONAX IN REACH 7

Reach 7 contains a moderate amount of high quality salmon spawning habitat. This habitat was fully utilized in 2006 when we observed 17 redds in only 12 potential sites – the remaining five redds were constructed in other habitats, such as glides. It is likely that the Yountville Crossroad is a low flow barrier for early migrating salmon, and many of the fish that spawned in Reach 7 were unable to pass, eventually giving up and spawning in marginal habitats. The low number of salmon counted in 2007 did not allow us to verify this theory.

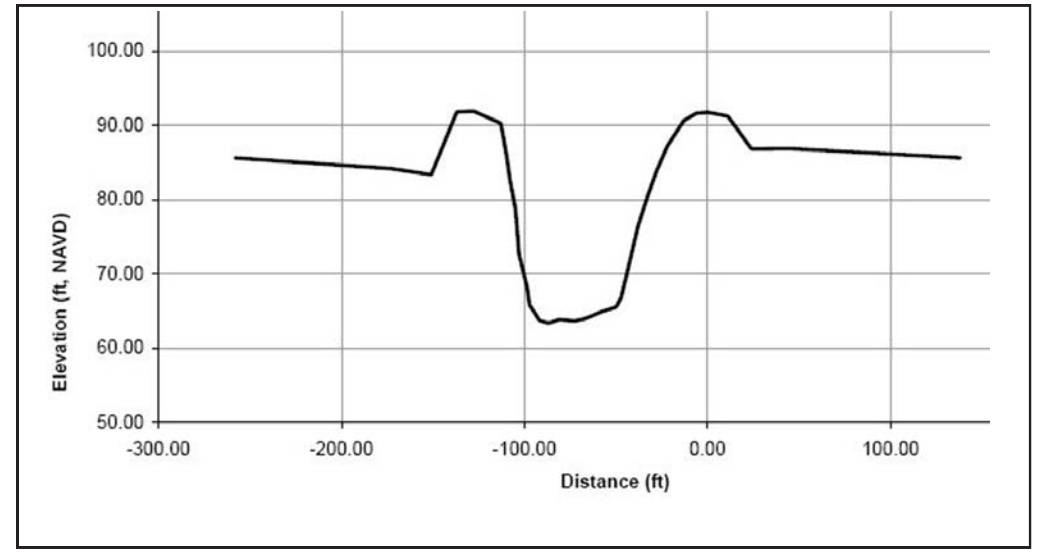
Pools in Reach 7 were generally very deep with an average maximum residual depth of 3.8 feet. Pool shelter in these pools however was quite low with an average value of 70. These deep pools contained large schools of Sacramento pike minnow and Sacramento suckers, and were generally void of juvenile salmon.

Reach 7 contains one high quality backwater pool, a very rare features throughout the survey. Back-water pools promote rapid growth of juvenile salmon and provide shelter from predators and high stream velocities.

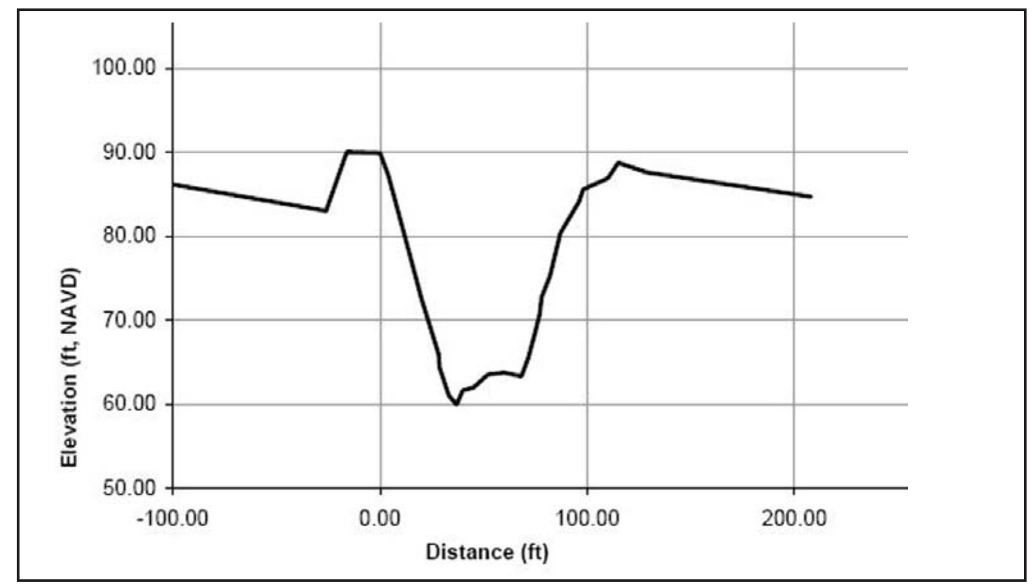
HIGH QUALITY SPAWNING RIFFLE IN REACH 7.



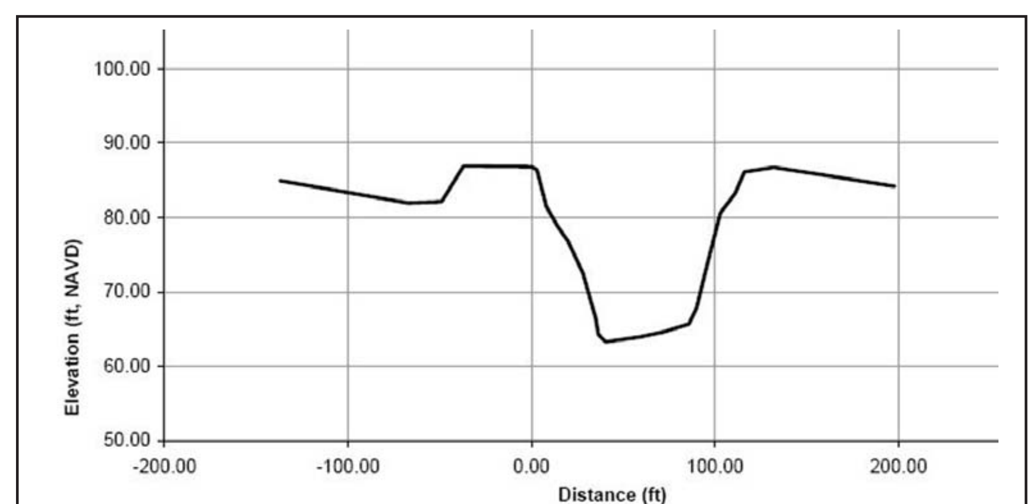
Representative Cross Sections



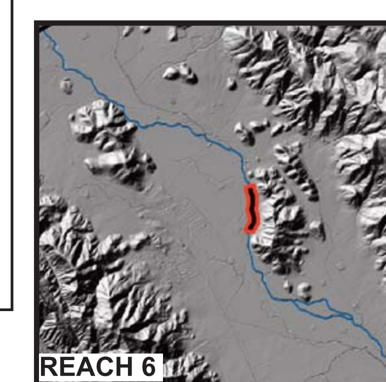
XS 51
W:D = 4.2



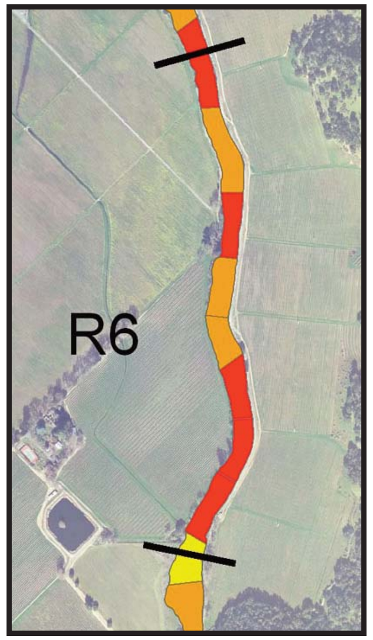
XS 55
W:D = 4.0
Most entrenched condition



XS 56
W:D = 4.9
Average condition



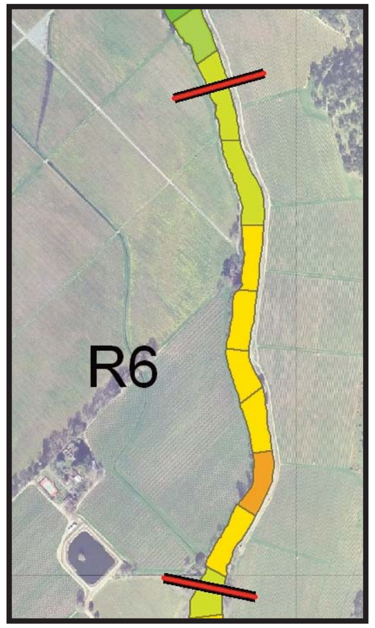
Physical Characteristics of Reach 6



Confinement

Width To Depth Ratio

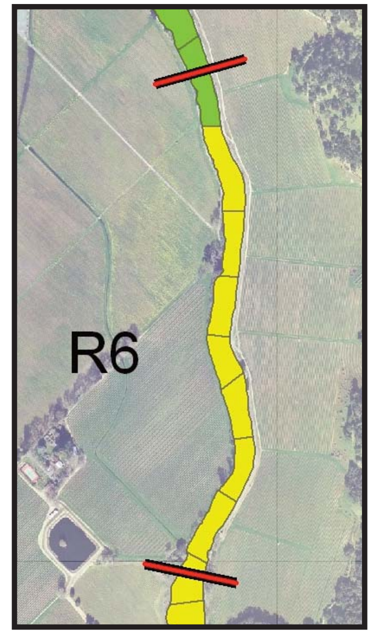
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Reach 6 is one of the most confined reaches in the project area, with relatively homogeneous conditions and few geomorphic features that support good salmonid habitat (e.g. gravel bars, secondary channels, floodplain sections). The reach is bounded on the east bank and parts of the west bank by a levee at the top of a steep bank. The bank is actively eroding in many areas, and has been protected by rip rap in others. Most of the reach is a series of long pools with little riffle-pool habitat. In several areas the channel has eroded down to a layer of resistant cohesive substrate.

The Shields stress analysis shows partial scour for most of this reach where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.

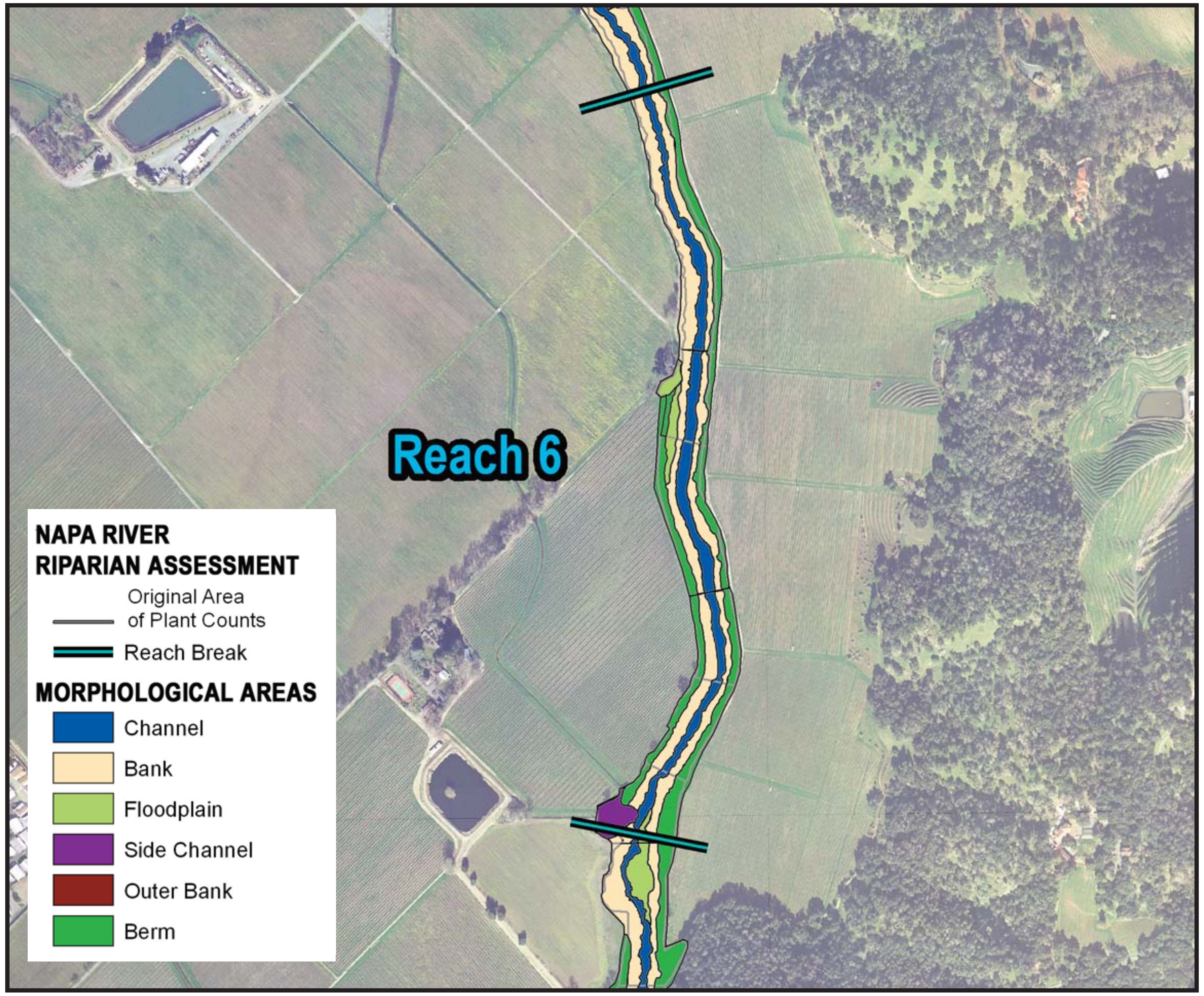
Continuous glides, steep eroding banks and hard bank protection are common in Reach 6.

At almost 27 feet deep on average, this reach has incised by approximately 15 feet, and remains overly narrow with an average depth of 136 feet. We anticipate significant bank instability problems in future as the channel widens in response to incision. Under a "no-action alternative" we might eventually expect an average of 130 feet of widening in this reach through bank erosion until a width of approximately 270 feet is reached.

<u>Flood characteristics:</u>

The Reach 6 channel can not contain the 5-year flood event.

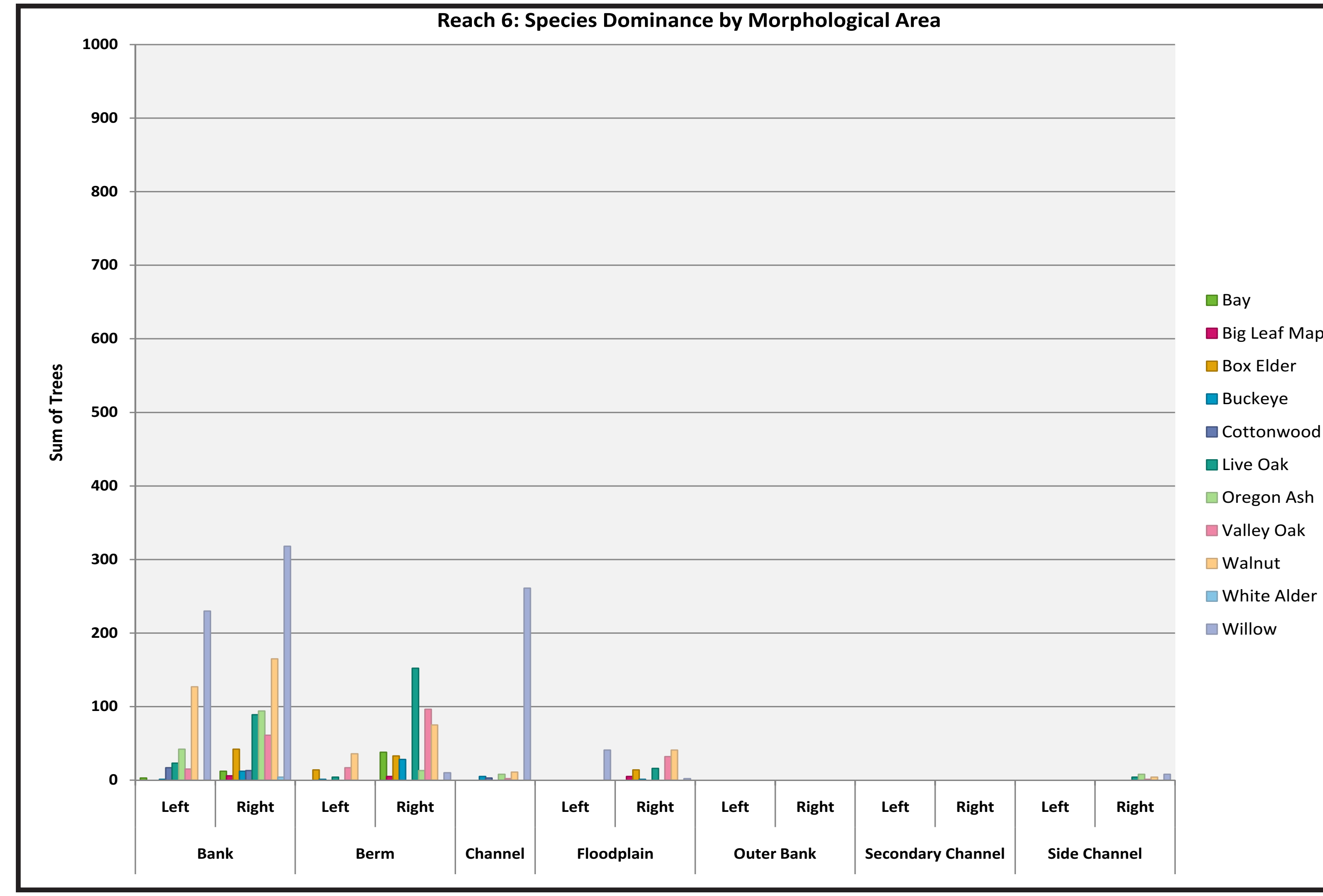
Average velocity during the ten-year flood is 6-8 feet per second.



Reach 6 Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre*
Channel	2.9	99
Bank-left	2.6	178
Bank-right	3.3	288
Berm-left	2.8	31
Berm-right	1.3	153
Floodplain-left	0.06	41
Floodplain-right	0.49	121
Side channel-right	0.46	25

*For morphological areas of less than one acre, the actual tree count is listed

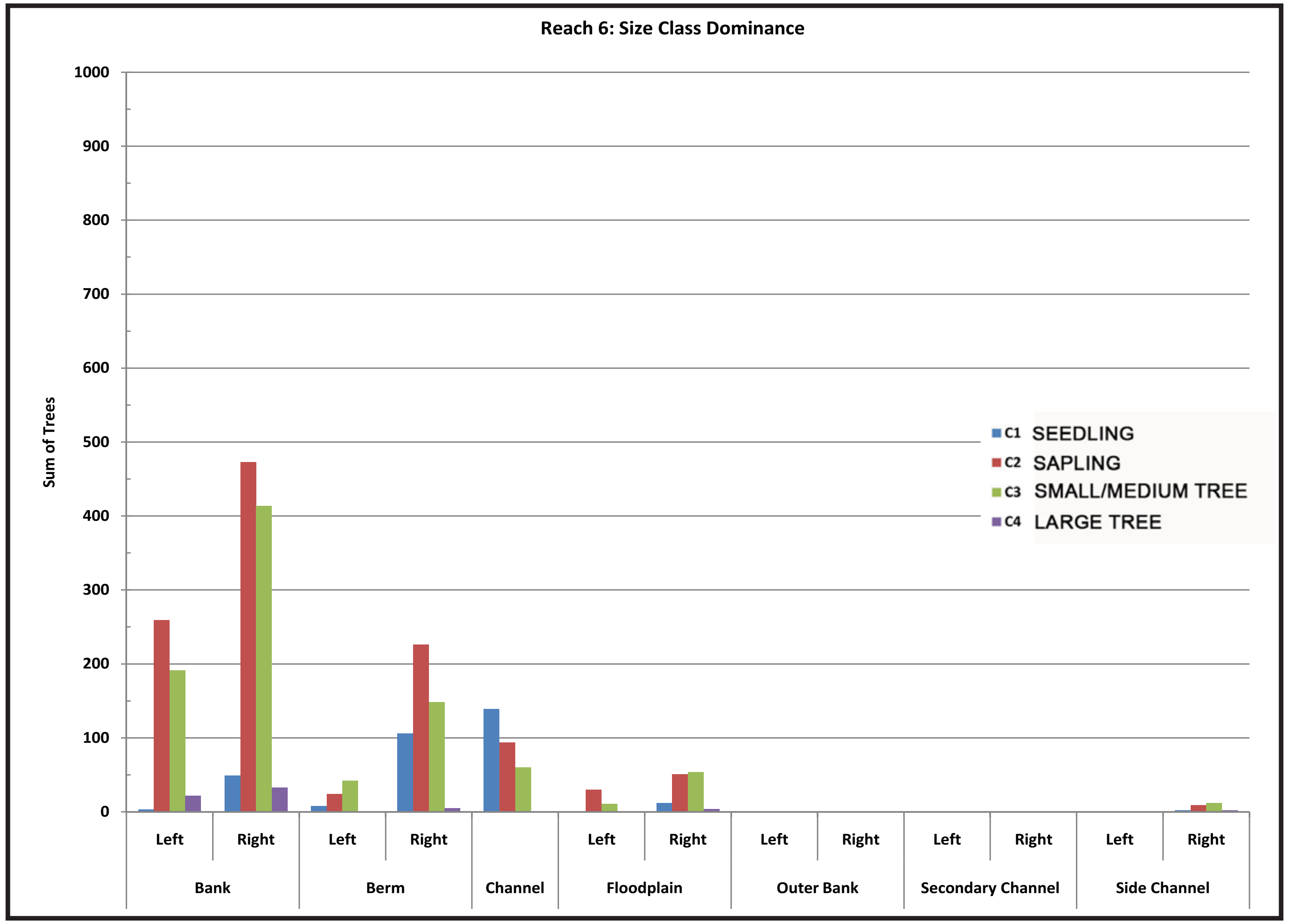
Description: Reach 6 extends for 0.65 miles and has 13.83 acres of riparian corridor and channel area. The riparian corridor varies from a maximum of 250 ft. to a minimum of 121 ft. with an average width of 152 ft. Reach 6 includes the channel, right and left banks, right and left berms, right and left floodplains, and a side tributary channel area.



Species Diversity

Willow is the primary species in the channel and on the banks. An additional 11 tree species occur on the banks. The right floodplain and right berm also support a diversity of tree species.

BIG LEAF MAPLE WITH PAIRED WINGED SAMARA (SEEDS).



Size Class Dominance

Sapling size trees (C2) and small/medium trees (C3) are co-dominants on both the right and left banks, the side channel, and the floodplain areas. Seedlings (C1) and saplings (C2) are co-dominant in the channel area. Very low numbers of C4 trees occur in many of the morphological areas.

Distribution of Size Classes and Species: Seedlings are the most numerous in the channel and are made up entirely of willow. On the banks and side channel, live oak seedlings dominate the C1 size class. On the berms, box elder, valley and live oak seedlings are numerous.

Sapling willow dominates the channel. The banks have ten species of sapling trees with willow the most abundant. Ca. walnut, valley oak, Oregon ash, and live oak saplings are also common. The right berm has nine species of C2 trees with live oak the most common. The right floodplain has seven species of saplings with valley oak and box elder the most common.

The highest density of C3 size class trees occurs on the floodplain. The banks have eight species of C3 trees with Ca. walnut and willow most common and also with box elder, valley oak, live oak, Oregon ash, and Ca. buckeye. On the right berm, live oak, valley oak, and Ca. walnut are the main C3 size trees.

Large trees occur in low numbers on the banks, right berm, right floodplain, and side channel, and are made up of Ca. walnut, live oak, Oregon ash, and willow.

Invasive Species: *Arundo donax* occurs in low density on the bank and floodplain areas, covering 0.18 acres or 0.01% of the Reach 6 corridor area. Other non-native species in Reach 6 include Eucalyptus that grows on both banks and on the right berm. Lombardy poplar, planted as part of a revegetation project, was also found on the banks in Reach 6.

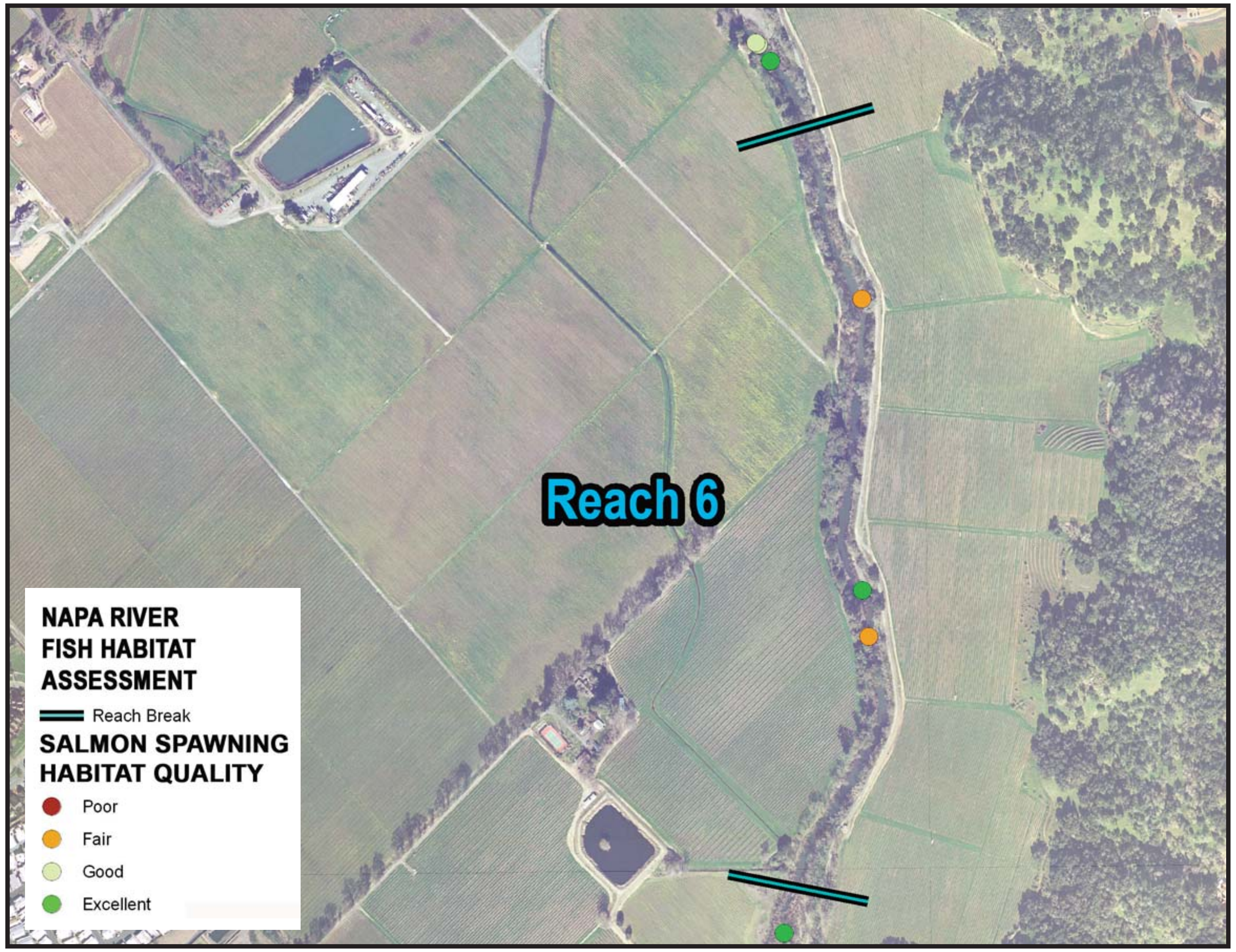
Spider Trees: Spider trees occur on both banks and on the side channel at medium levels. Ca. walnut is the primary species along with Fremont cottonwood, Ca. bay laurel, live oak, and Oregon ash.

Understory: Understory species recorded on the banks include Himalayan blackberry, snowberry, pokeweed, Ca. wild rose, coyote brush, basket sedge, mugwort, poison hemlock, and annual grasses. Understory plants along the channel include yellow nutsedge, cattail, torrent sedge, pondweed, cocklebur, and various herbaceous plants.

Riprap: Reach 6 has a high level of riprap on the banks, with 585 linear feet on the left bank and 326 linear feet on the right bank.

Ecological Trends: The channel shows a high proportion of C1 trees which are almost entirely willow. The banks have mostly saplings and small/medium (C3) trees, but very few seedlings. Outside of the channel, there is very little regeneration occurring in this reach and the channel area shows low survival. A resistant clay layer occurs over most of the channel in Reach 6 and limits vegetation growth. There is a high level of riprap and many of the larger trees are being undercut by bank erosion. Overall tree density is low to medium in comparison to other reaches.

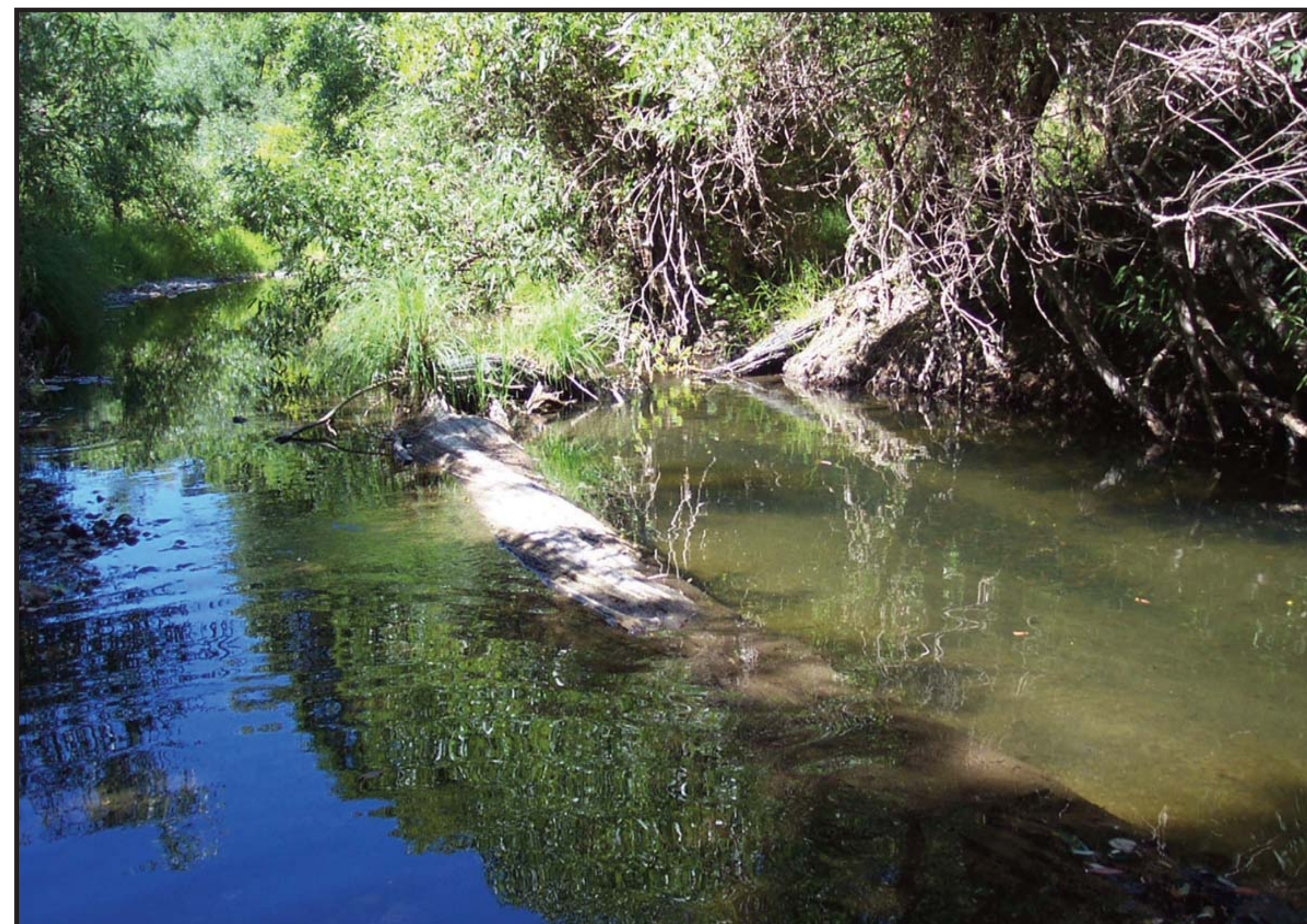
REACH 6



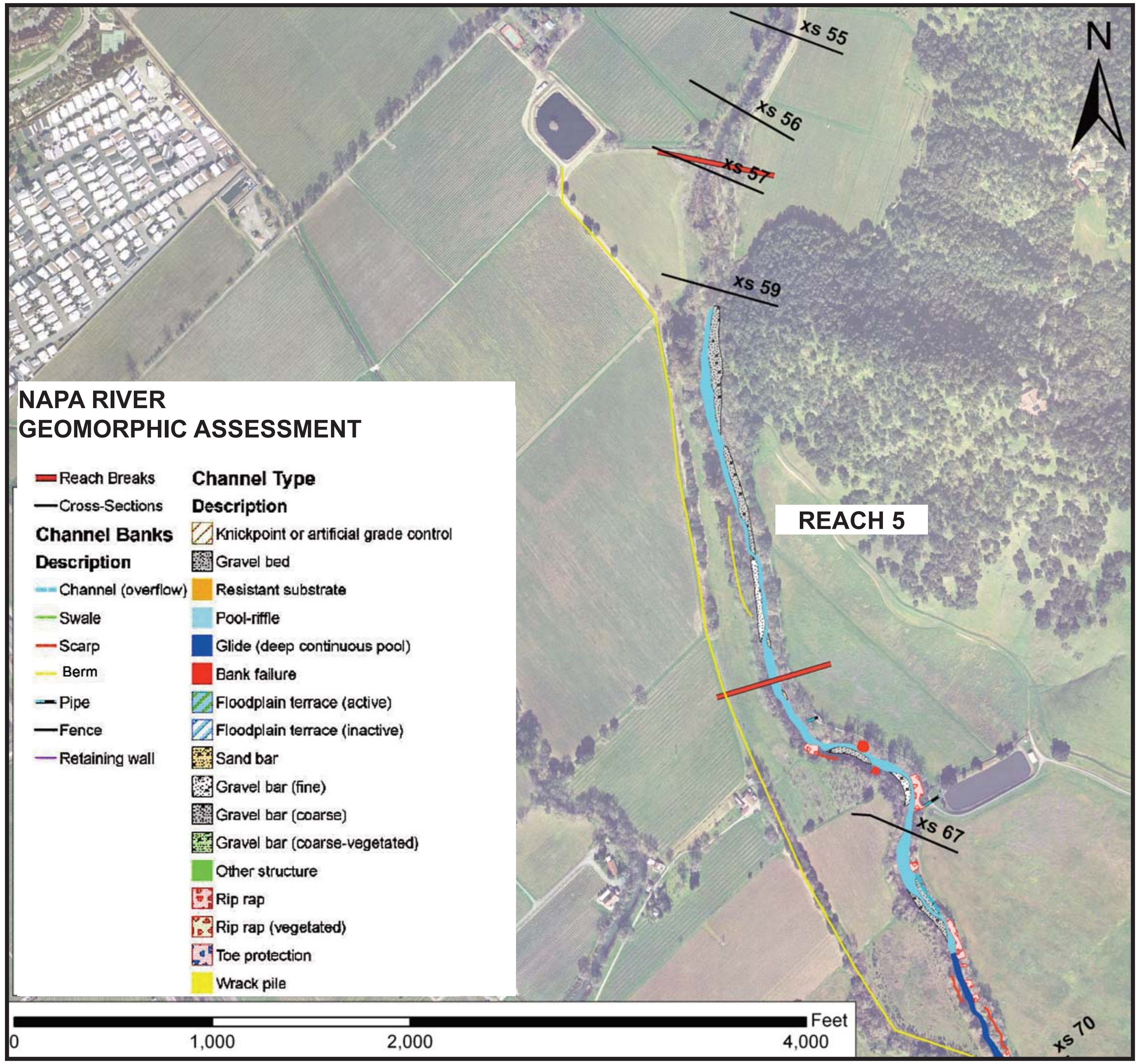
Overall, Reach 6 contained a small amount of high quality spawning and rearing habitat interspersed with generally degraded sections. The reach contained a high proportion of glides (42%) that were typically associated with straight rip-rap lined sections with sparse canopy, algae mats, and eroding banks. These low quality habitats contained no juvenile salmonids during our spring surveys, and were generally void of fish. Breaking up these long shallow glide habitats into smaller more hydraulically distinct units would provide additional instream habitat for salmon rearing and other native fishes. Restoration projects that target these nested disturbance sites to reconnect otherwise discontiguous patches of high quality patches upstream and downstream could be an efficient way of re-creating habitat.

Much of Reach 6 had low canopy densities and thick mats of filamentous green algae in the channel, primarily in shallow glide habitats. Overall the average canopy density for the reach was only 59%, which is well below the 80% canopy target DFG uses for salmonid rearing streams.

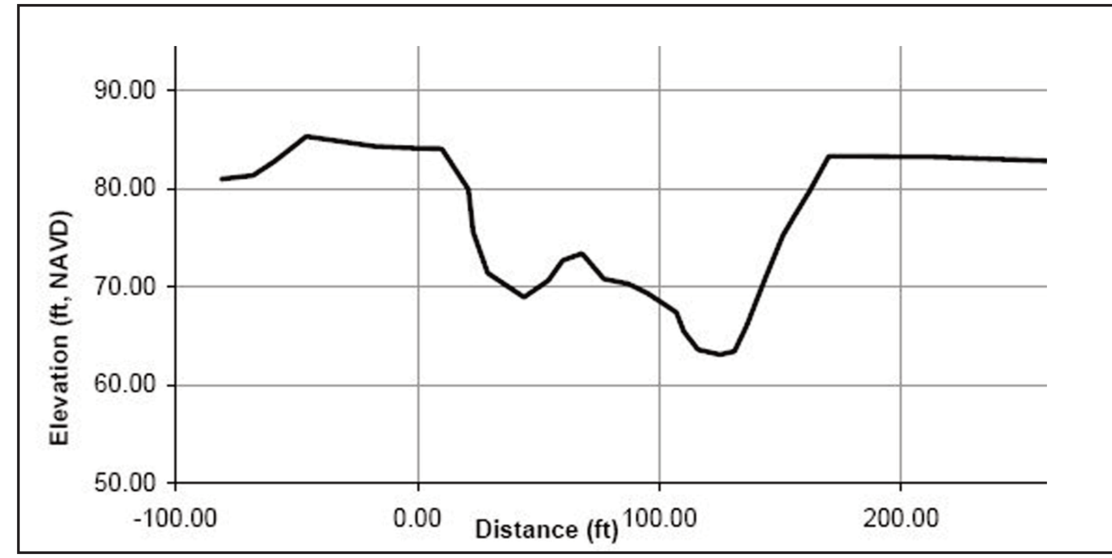
Salmon spawning habitat was very sparse in Reach 6 with only three potential sites in the entire reach, comprising only 5% of the reach length. In 2006, we observed either live salmon spawning or constructed redds at all three potential sites, suggesting that there is demand for additional spawning habitat in this reach.



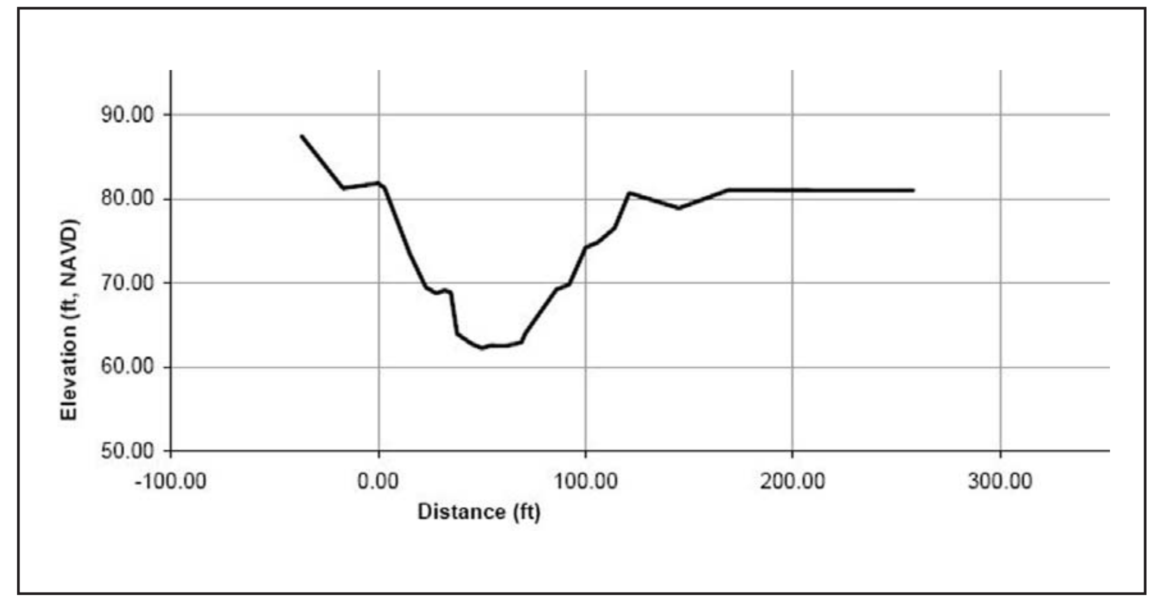
A HIGH QUALITY SIDE CHANNEL POOL WITH LARGE WOOD IN THE UPSTREAM AREA OF REACH 6.



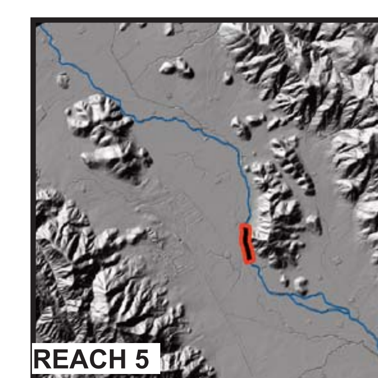
Representative Cross Sections



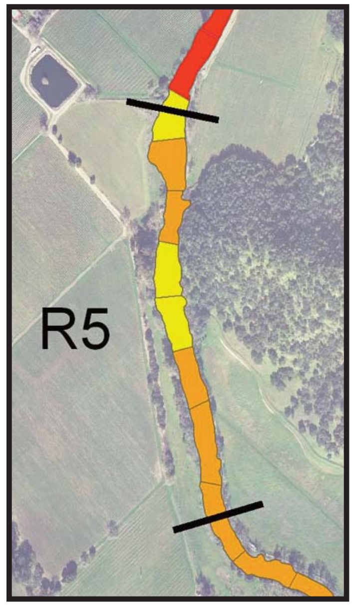
XS 57
W:D = 7.9
Less entrenched than average



XS 59
W:D = 6.6
More entrenched than average"



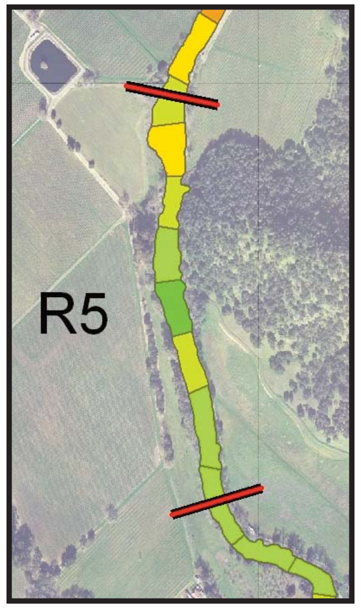
Physical Characteristics of Reach 5



Confinement

Width To Depth Ratio

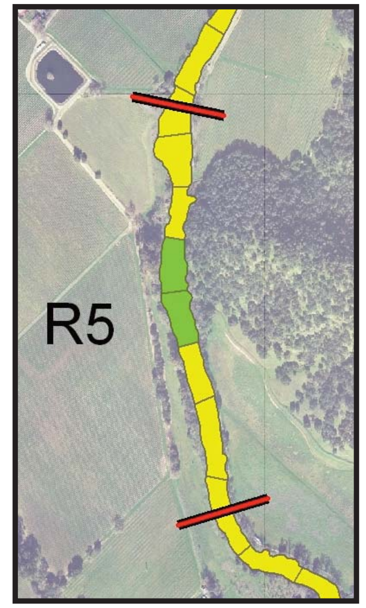
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Reach 5 has several areas of vertical, eroding banks with riprap.

Reach 5 is the second least entrenched reach in the project area, with a series of long gravel bars that help create riffle-pool habitat. There are some features within the bank top corridor that create refuges for fish during high flows.

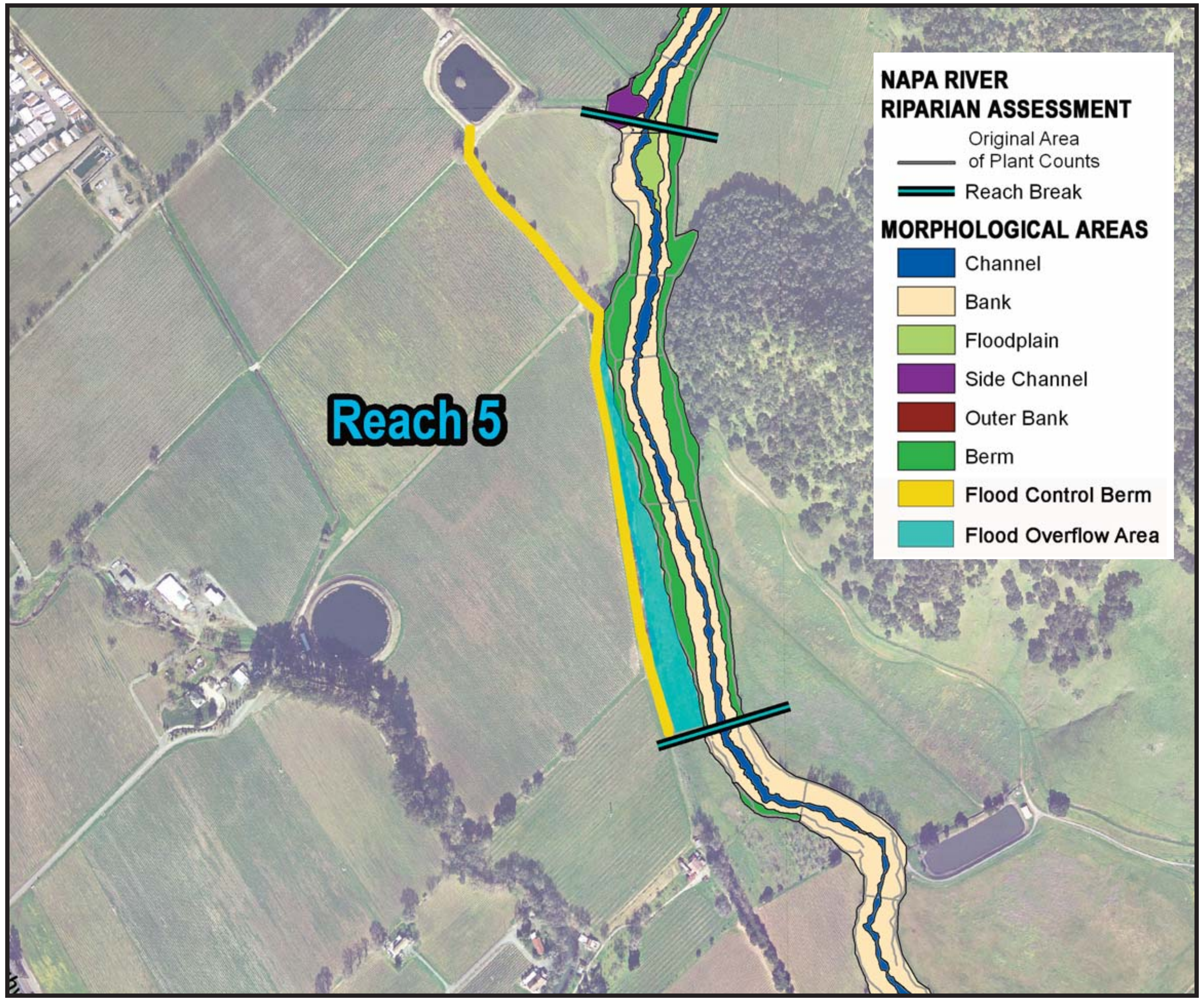
The Shields stress analysis shows partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs. One area shows selective scour where a thin layer of spawning gravel or weaker unvegetated bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redd.

With an average depth of 21 feet this reach has incised by approximately 10 feet, while its average width of 150 feet is amongst the widest for the project area. Under a “no-action alternative” we might eventually expect an average of 100 feet of widening in this reach through bank erosion until a width of approximately 250 feet is reached.

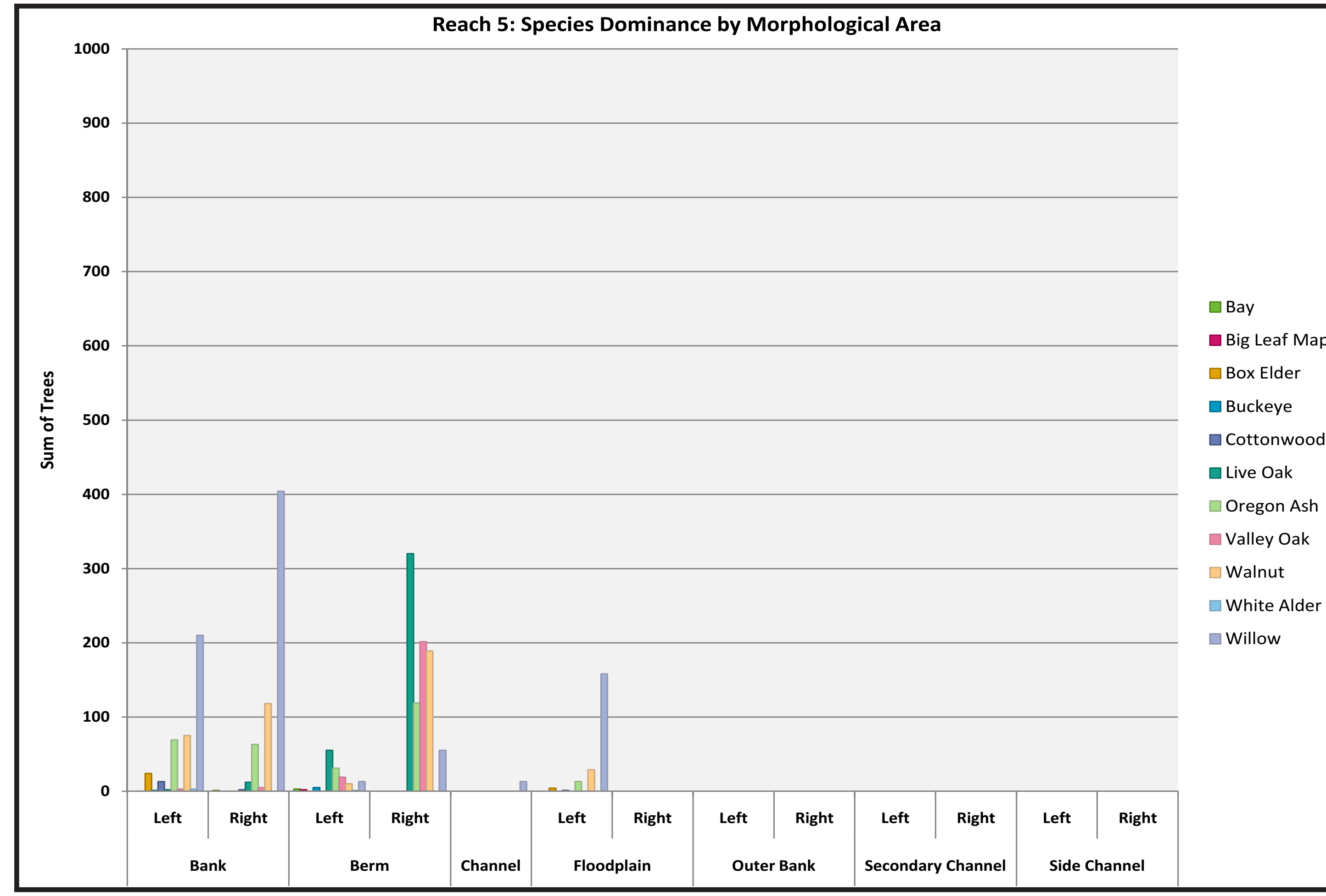
Flood characteristics:

Some parts of Reach 5 experience out of bank flows during the 2-year flow, with others flooding during the 5-year flow, making it one of the most flood-prone reaches.

Average velocity during a ten year flood is 3-7 feet per second.



Description: Reach 5 extends for 0.5 miles and encompasses 15.0 acres of riparian corridor and channel area. The riparian corridor varies from a maximum of 288 ft. to a minimum of 170 ft. with an average of 229 ft. Reach 5 includes channel, right and left banks, left floodplain and left and right berm morphological areas. A flood control berm and flood overflow area borders the rivers' right bank.



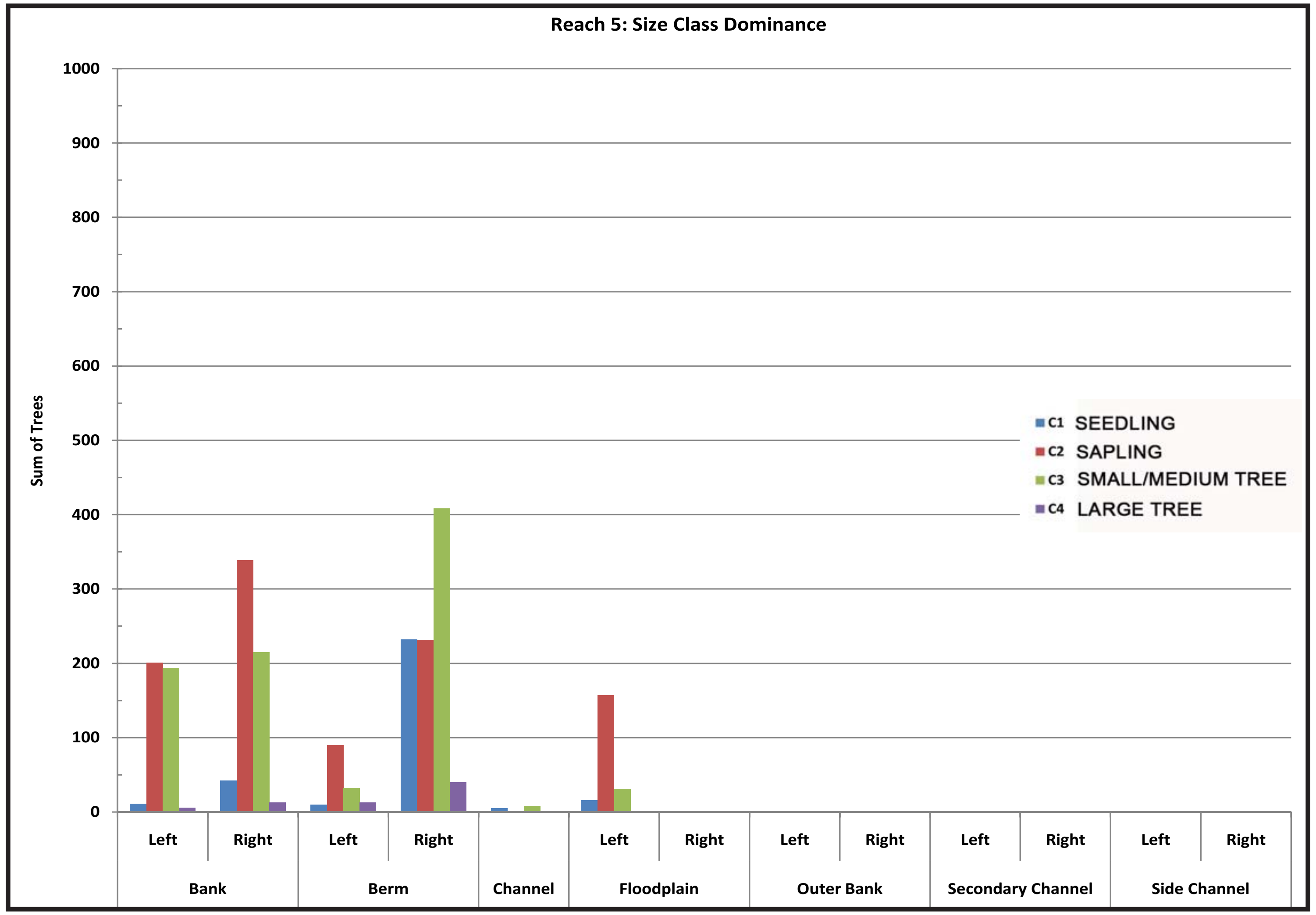
Species Diversity

The channel has very little vegetation, primarily willow. Willow also occurs on the floodplain and banks which have 3-4 other tree species as well.

Reach 5: Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre**
Channel	1.6	8
Bank-left	2.99	136
Bank-right	3.3	183
Floodplain-left*	0.54	205
Berm-left	2.4	45
Berm-right*	2.0	68

*Irrigated plantings were removed from density count
**For morphological areas of less than one acre, the actual tree count is listed

THE FLOOD CONTROL BERM IS ON THE RIGHT AND THE OVERFLOW AREA ON THE LEFT IN THIS PHOTO WITH THE RIVER CHANNEL TO THE FAR LEFT.



Size Class Dominance

The channel has almost no vegetation, with less than 10 trees. The banks have mostly C2 and C3 trees and a low number of C1 and C4 size class trees. The left berm is dominated by C2 trees. The right berm has the most C4 trees in this reach as well as a high number of C3 trees. C2 size class trees dominate the floodplain area.

Distribution of Size Classes and Species: There are very few naturally occurring seedlings in Reach 5, especially in the channel. There are numerous planted C1 live and valley oaks on the right berm.

There are few saplings in the channel area. Willow saplings are the most abundant C2 trees on both banks. The banks also have Ca. walnut, box elder, Oregon ash, and Fremont cottonwood saplings. Live oak saplings are numerous on both berms. Willow saplings are numerous on the floodplain along with Ca. walnut, valley oak, and box elder.

There are few C3 trees in the channel. Small/medium willows dominate both banks and the floodplain. Other C3 trees on the banks and floodplain are Ca. walnut and Oregon ash. The left berm has very few C3 trees, while the right berm has a large number of C3 trees dominated by live oak, with Ca. walnut, valley oak, willow, and Oregon ash.

There are very few C4 trees. Ca. walnut, Fremont cottonwood, live oak, and valley oak make up most of the C4 trees on both banks and both berms with C4 willows in the floodplain area.

Invasive Species: *Arundo donax* is not common in Reach 5, covering 0.2 acres or 0.01% of the reach acreage, and occurs on the banks and berms. Other invasive species include Eucalyptus on the right berm and both banks, and tree of heaven on the left berm and both banks.

Spider Trees: Spider trees occur on both banks in low numbers. Oregon ash, Ca. walnut, willow, valley oak, big-leaf maple, and live oak spider trees were recorded.

Understory: A low density understory of Himalayan blackberry, Ca. blackberry, blue periwinkle, pokeweed, snowberry, wild grape, and mugwort occurs on the banks and berm. On the channel, river sedge, yellow nutsedge, tules, cattails, and pondweed occur.

Riprap: Reach 5 has a medium level of riprap on the banks, with 64 linear feet on the left bank and 33 linear feet on the right bank.

Ecological Trends: Reach 5 has a simplified morphology with minimal vegetation and little to no regeneration. Neither the left nor right bank has many C1 or C4 trees; both banks have low density vegetation. A resistant clay layer dominates the channel area which is nearly unvegetated. The berms also have few naturally occurring seedlings and few C4 trees. The large trees remaining in Reach 5 are being undercut and eroded out. Overall tree density is low to very low in comparison to other reaches.

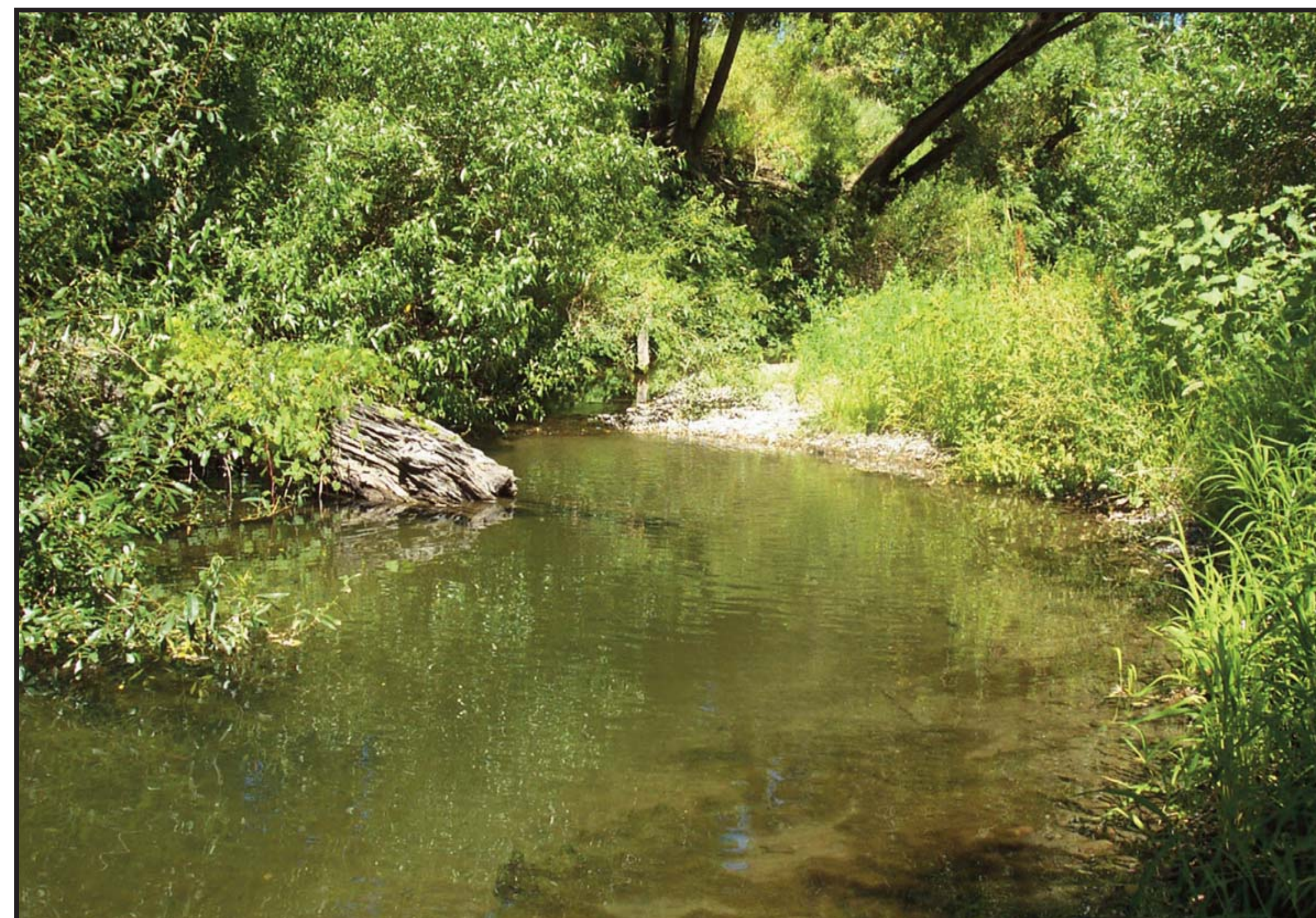
A RESISTANT CLAY LAYER IN THE CHANNEL OF REACH 5 DOES NOT SUPPORT VEGETATIVE GROWTH.

Reach 5 is characterized by a relatively tightly spaced pool/riffle morphology with abundant spawning habitat. This reach contained a high diversity of habitats averaging 13.6 habitat units per 1,000 feet of channel. Habitat quality increases with diversity, indicating that this reach contains some of the highest quality habitat in the surveyed area. Much of the habitat diversity in this reach appeared to be associated with LWD that has created topographically defined scour pools and provided instream cover.

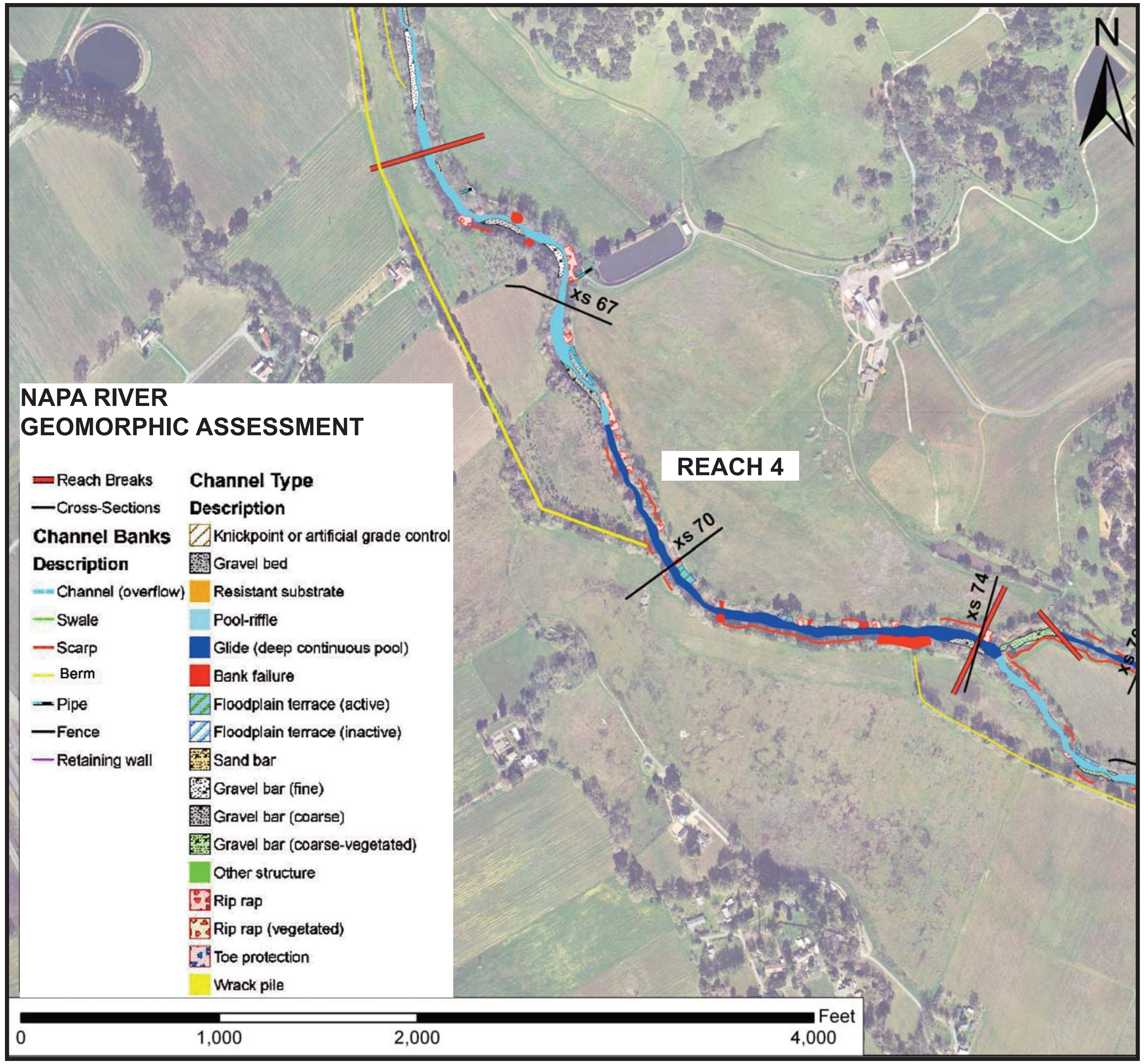
Chinook salmon spawning was observed throughout this reach in 2006 with limited spawning in 2007. In 2006, salmon were documented at six out of nine (67%) potential spawning sites in the reach, which suggests that spawning habitat is slightly underutilized by the current population of salmon in Napa.

Reach 5 contained one high quality backwater pool and a small adjacent flood terrace, both very rare features throughout the survey. Backwater pools promote rapid growth of juvenile salmon and provide shelter from predators and high stream velocities.

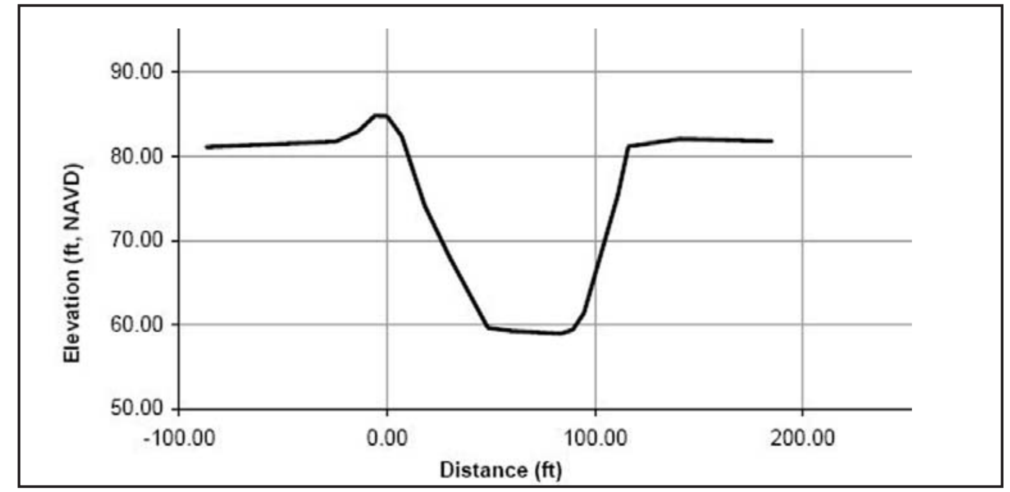
Several sections of Reach 5 have very low canopy densities and thick mats of filamentous green algae in the channel, primarily in shallow glide habitats. Overall the average canopy density for the reach was 64%, which is below the 80% canopy target for salmonid rearing streams.



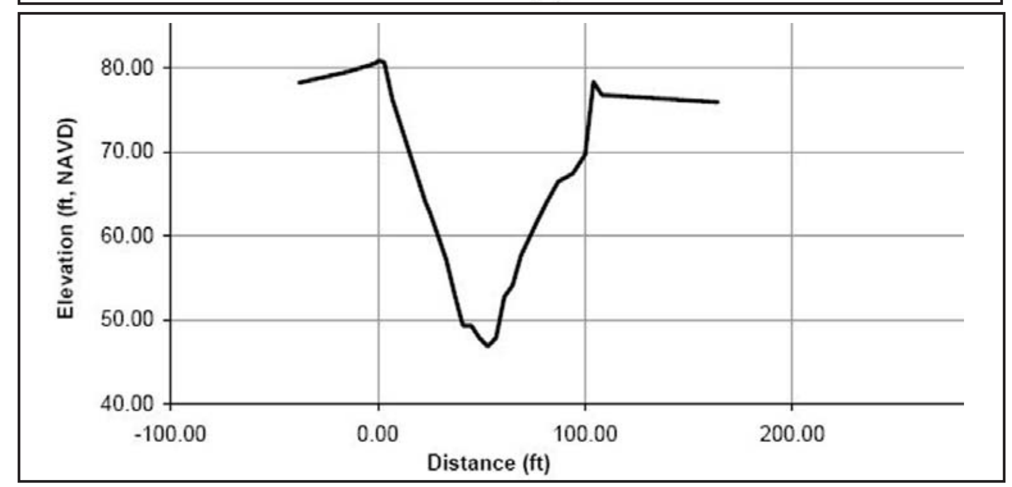
A HIGH QUALITY SCOUR POOL FORMED BY LARGE WOOD IN REACH 5.



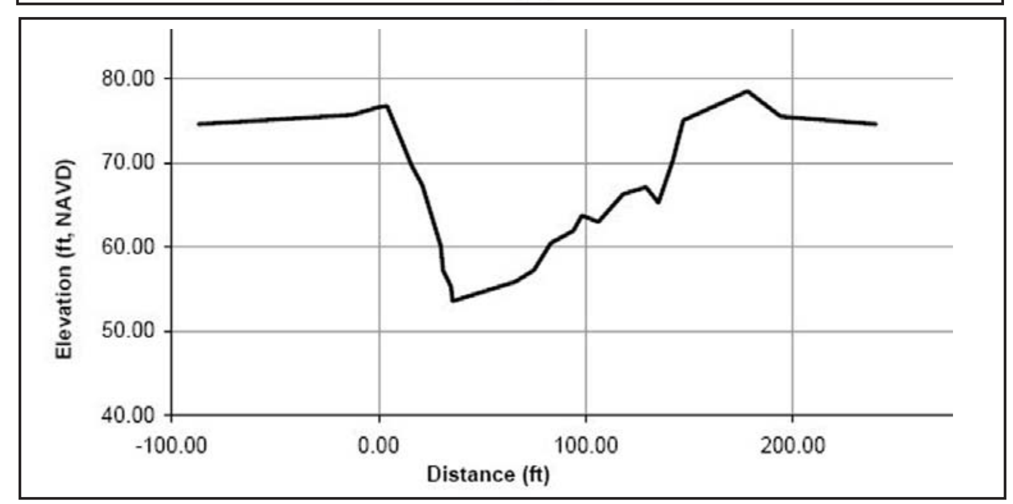
Representative Cross Sections



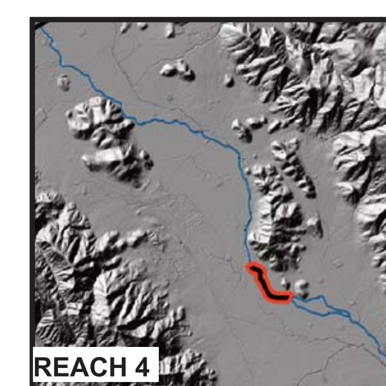
XS 67
W:D = 4.9
Average conditions



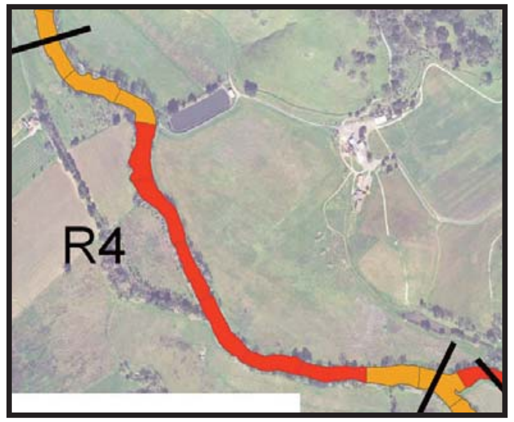
XS 70
W:D = 3.2
Most entrenched section



XS 74
W:D = 6.2
Least entrenched section



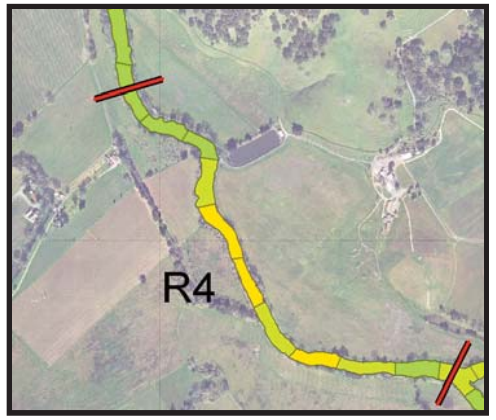
Physical Characteristics of Reach 4



Confinement

Width To Depth Ratio

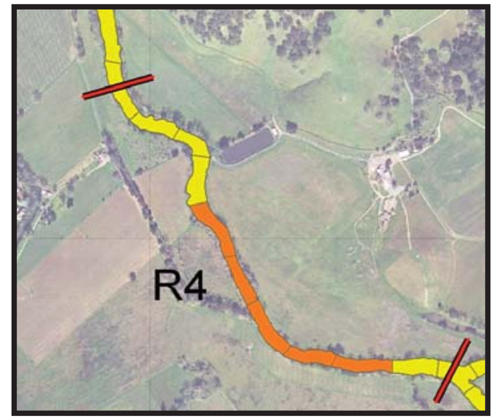
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Images show wider conditions at the upper and lower ends of the reach, with upper right and lower left images typical of the more entrenched and eroding middle section.

Reach 4 is the most entrenched reach in the project area with an average w:d of 4.9. Most of the reach is one single pool, though there is a small area of riffle-pool habitat at the upstream end. Incision has exposed a resistant, cohesive substrate in many sections.

The Shields stress analysis shows full scour for much of the reach where gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features. One area has partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.

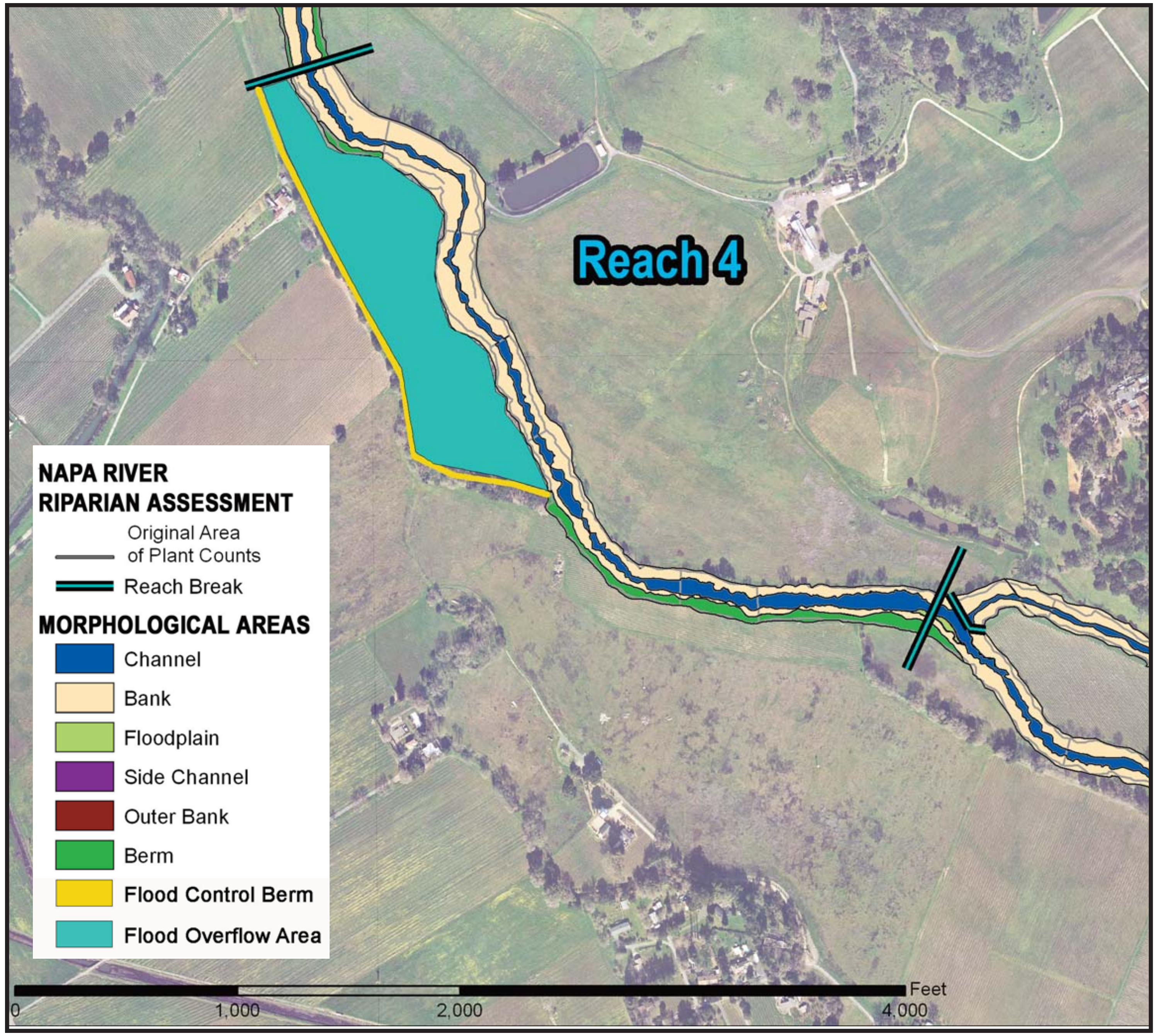
This reach has the second greatest percentage of actively eroding or hardened banks in the project area.

With an average depth of 26 feet this reach has incised by approximately 15 feet, while its average width of 125 feet is amongst the widest for the project area. Under a “no-action alternative” we might eventually expect an average of 135 feet of widening in this reach through bank erosion until a width of approximately 260 feet is reached.

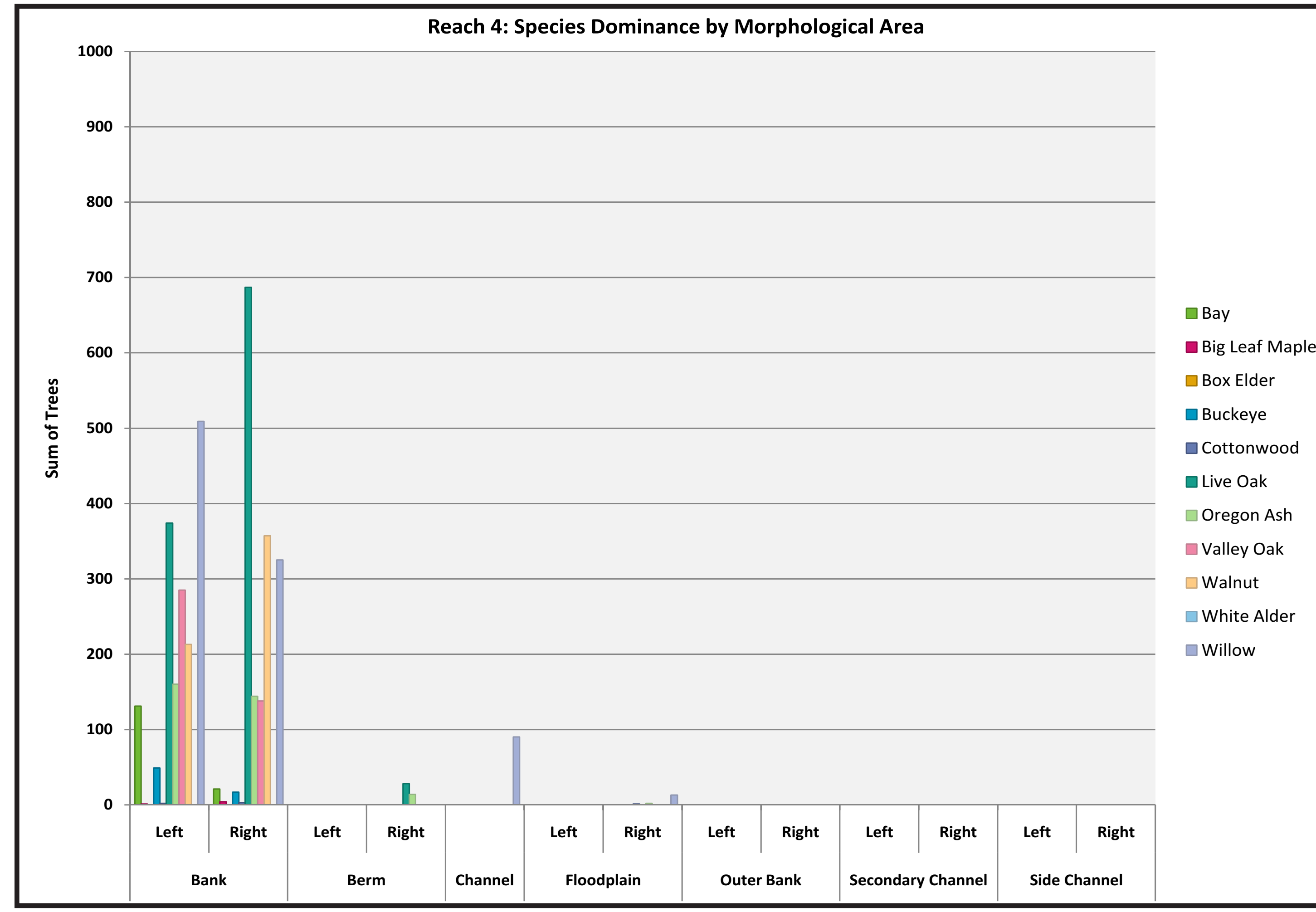
<u>Flood characteristics:</u>

Some parts of Reach 4 experience out of bank flows during the 2-year flow, with others flooding during the 5-year flow, making it one of the most flood-prone reaches.

Average velocity during a ten year flood is 5-7 feet per second.



Description: Reach 4 extends for 0.81 river miles and encompasses 14.93 acres of riparian corridor and channel area. The riparian corridor is narrow in Reach 4 with a maximum width of 185 ft., a minimum width of 120 ft., and an average width of 156 ft. Reach 4 has channel, right and left bank, right berm, and right floodplain morphological areas. The southern area of the flood control berm and flood overflow area border the right bank of Reach 4.



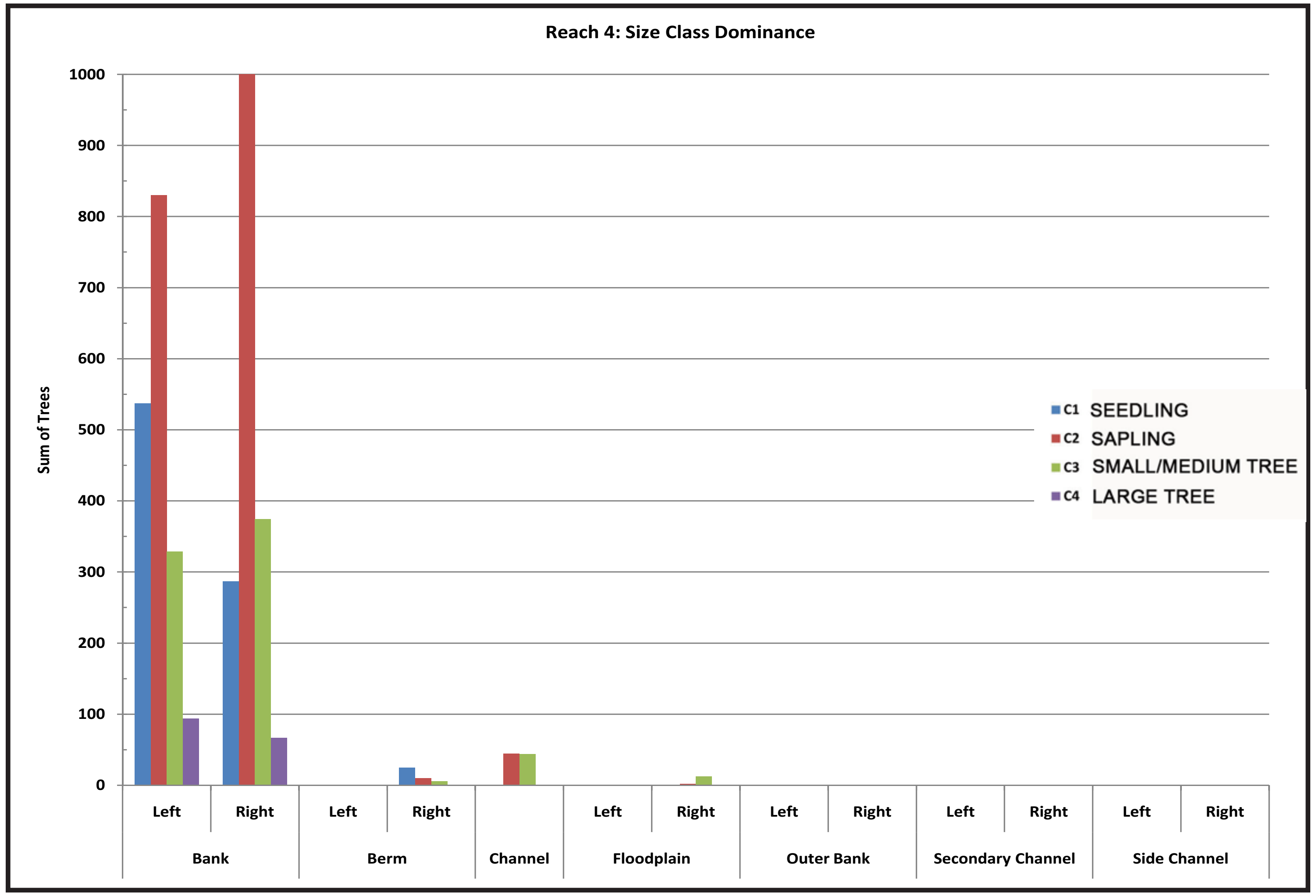
Reach 4: Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre*
Channel	3.7	24
Bank-left	5.2	200
Bank-right	4.1	423
Berm-right	1.7	24
Floodplain-right	0.03	16

*For morphological areas of less than one acre, the actual tree count is listed

Species Diversity

The channel has only willow. The banks have eight tree species with live oak dominant on the right bank and willow and live oak co-dominant on the left. The berm and floodplain have little vegetation.

THE FLOOD OVERFLOW AREA ADJACENT TO REACH 4.



Size Class Dominance

C2 and C3 trees are co-dominants in the channel area. On the right bank, C2 trees are dominant, while C1 and C2 size class trees are co-dominant on the left bank. C1 trees dominate the right berm.

Distribution of Size Classes and Species: There are no seedlings in the channel or floodplain areas. Live oak seedlings are the most abundant and dominate the bank and berm areas. Low numbers of Ca. walnut, valley oak, Oregon ash, and Ca. bay laurel seedlings occur on the banks.

The channel has a few willow saplings. Live oak saplings are numerous on the right and left banks. Ca. walnut, willow, and valley oak saplings are common on the right bank. Oregon ash is the only sapling on the floodplain and berm and is abundant on the banks.

C3 trees are not very numerous on the berm or banks or in the channel. Willow, Ca. walnut, valley oak, live oak, Ca. bay laurel, Ca. buckeye, and Oregon ash occur in low numbers on the banks.

Large C4 valley oak, Ca. walnut, Fremont cottonwood, willow, white alder, live oak, and Ca. bay laurel occur in low numbers on the banks and very low numbers on the floodplain and channel.

Invasive Species: Reach 4 has a relatively low level of *Arundo donax* in the channel and bank areas with 0.17 acres or 0.01% of the Reach 4 area. Other non-native species present on the banks are low densities of tree-of-heaven, Eucalyptus, and black locust. The low densities of invasive plants likely do not limit the growth of native seedlings and saplings.

Spider Trees: Reach 4 has the largest number of spider trees per river mile in the project area. Ca. walnut and Ca. bay laurel are the most numerous spider trees, with significant numbers of undercut valley oak, willow, Oregon ash, Ca. buckeye, and live oak as well.

Understory: Understory species recorded on the banks and berm were low to medium density and include Himalayan blackberry, snowberry, basket sedge, mugwort, pokeweed, Ca. rose, blue periwinkle, poison oak, coyote brush, Ca. blackberry, nettles, and grasses. Understory species in the channel area included torrent sedge, yellow nutsedge, wild grape, and grasses.

Riprap: Reach 4 has a high level of riprap on both banks. The left bank has 649 linear feet and the right bank has 177 linear feet of riprap.

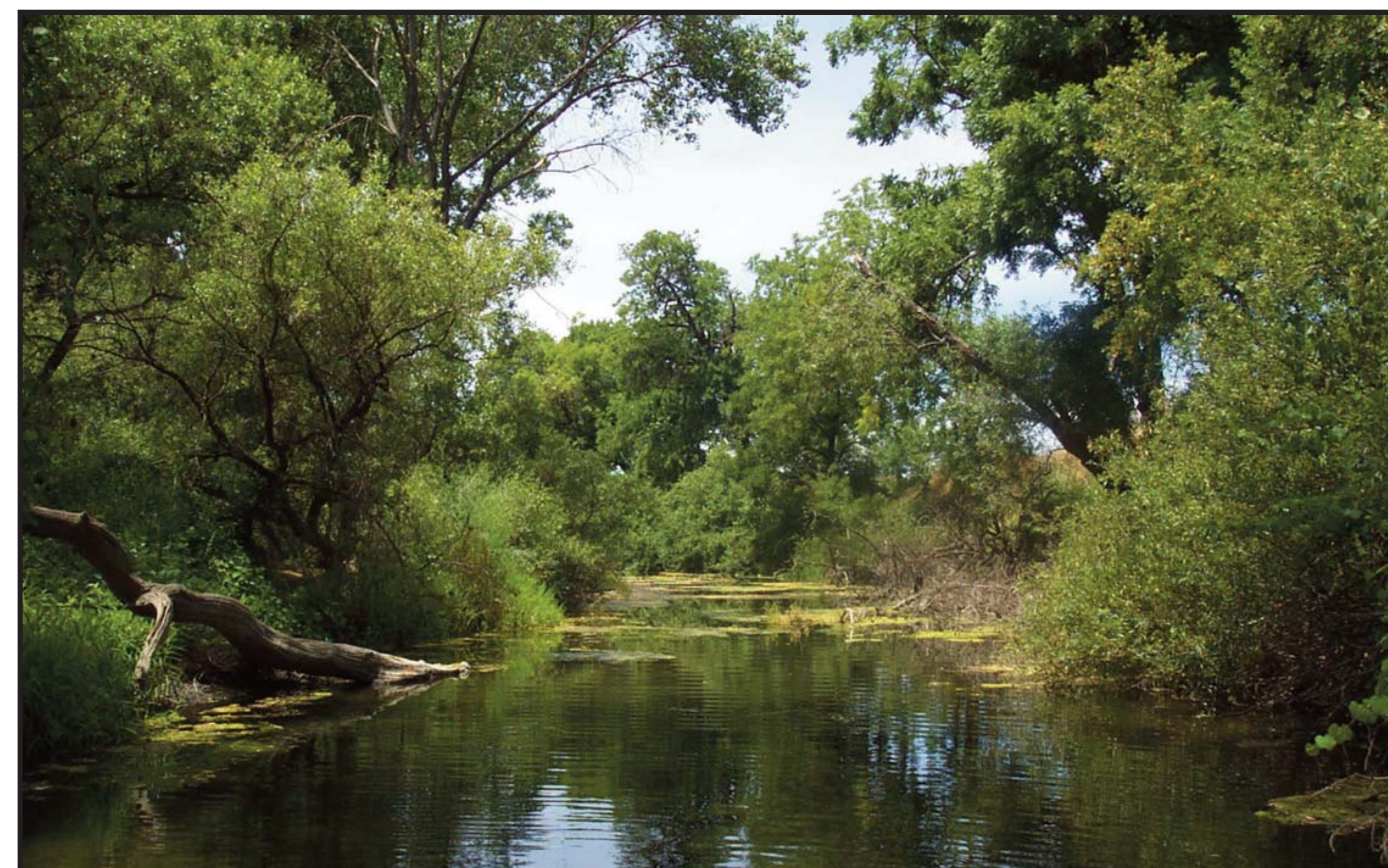
Ecological Trends: Vegetative density is very low in the channel and floodplains of Reach 4 with few seedlings growing in the channel and no regeneration. Live oak is the only species which exhibits all four growth stages on the banks. A resistant clay layer dominates the channel. Invasive species are not numerous in Reach 4 and do not appear to interfere with native regeneration. Most of the large trees are being undercut and there is a large amount of riprap on the banks. Overall tree density is low in comparison to other reaches.

REACH 4 HAS FEW SEEDLINGS IN THE CHANNEL AND LITTLE REGENERATION.
RIPRAP IS COMMON ON THE BANKS AS ARE UNDERCUT LARGE TREES.

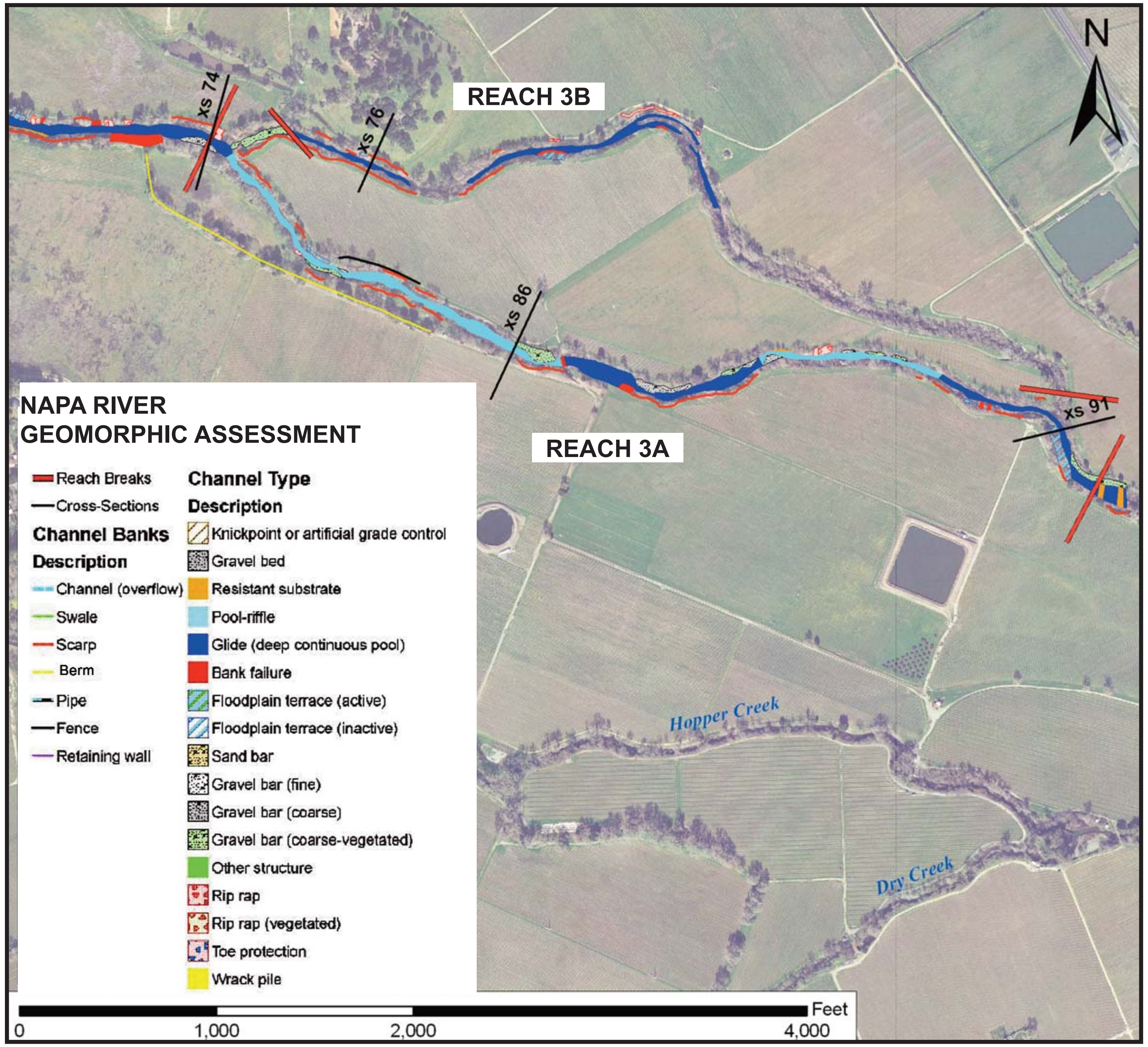
Approximately 85% of Reach 4 is a single deep pool/glide sequence that spans approximately 3,150 feet of channel without a hydraulic break. Long pool/glide sequences such as this favor native and exotic predatory fishes such as pike minnow and bass that feed on outmigrating salmon and steelhead. These lake-like habitats offer few feeding opportunities for juvenile salmonids, and generally do not provide a diversity of microhabitats that young salmon can use. However pools such as this one do provide adult salmon with good holding habitat and might contain year-round cold water at depth for juvenile steelhead holding over through summer.

At the upstream end of the reach, the channel returns to a pool/riffle morphology and contains several high-quality spawning riffles. Substrate in these riffles is at the small range of suitable spawning sizes for Chinook salmon, and as a result might be expected to mobilize easily and cause redd scour. The amount of spawning habitat in Reach 4 was overall very low largely due to the long pool/glide sequence in the lower area of the reach.

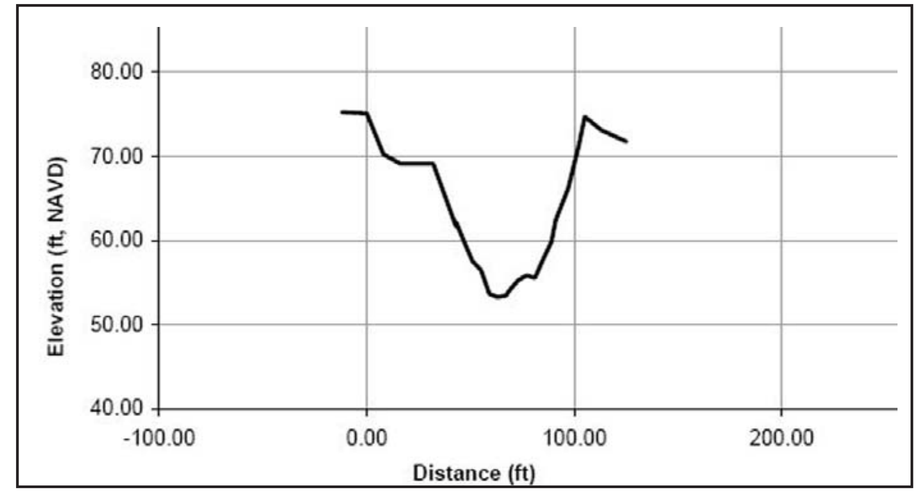
Sections of Reach 4 had very low canopy densities and thick mats of filamentous green algae in the channel, primarily in shallow glide habitats in the upstream area of the reach. Bullfrog tadpoles were abundant in these areas. Abundant algal growth indicates a lack of riparian shading.



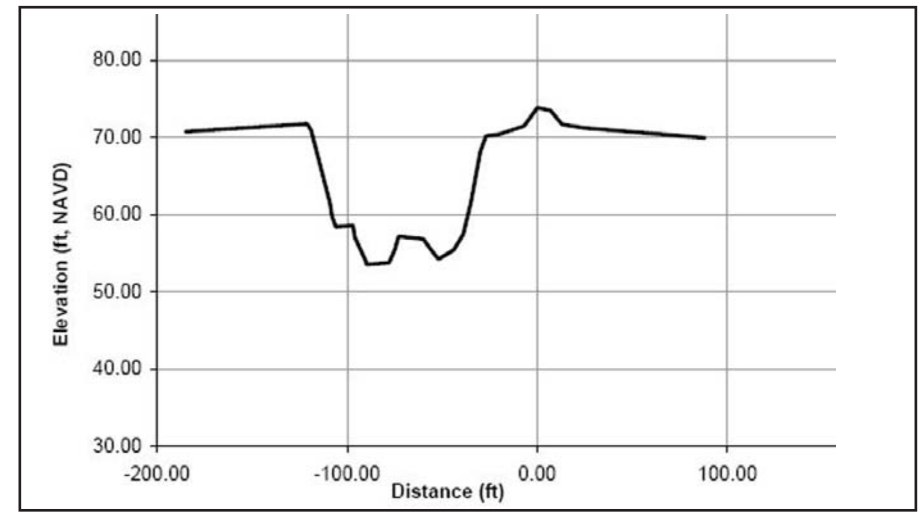
MOST OF REACH 4 IS A LONG POOL/GLIDE SEQUENCE OF LIMITED VALUE TO SALMON.



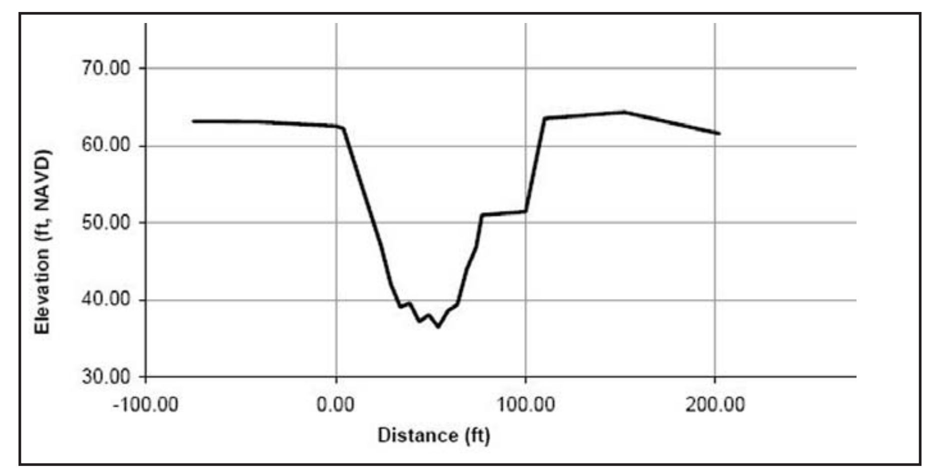
Representative Cross Sections



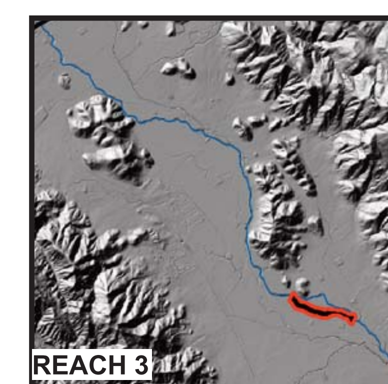
XS 76
W:D = 4.9
Average conditions



XS 86
W:D = 7.0
Least entrenched section



XS 91
W:D = 4.1
Entrenched section

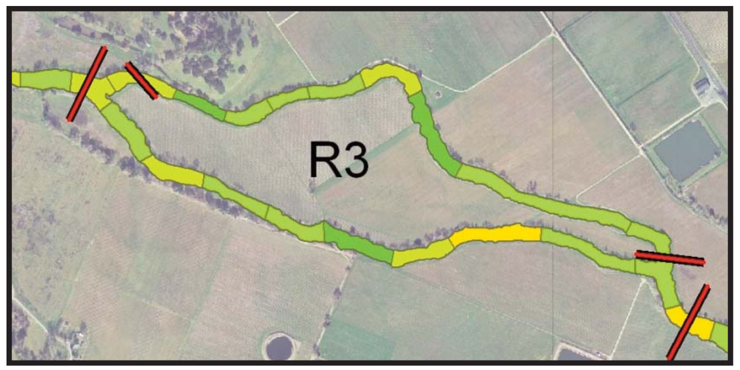


Physical Characteristics of Reach 3A and B

Confinement

Width To Depth Ratio

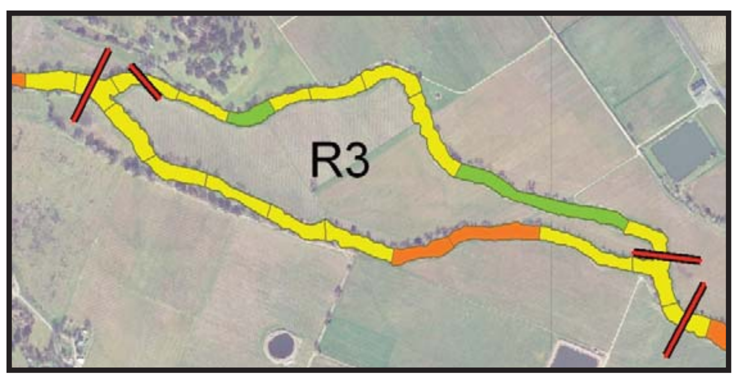
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Note: Because Reach 3 is split into two channels, w:d ratio is of less use as a measure of entrenchment than for single channel reaches.

Reach 3 is a split channel segment that provides an example of what much of the Napa River used to look like before the secondary channels were cut off. The west branch (3A) is currently dominant and the east branch (3B) functions as a high flow secondary channel, thought there is evidence that in the 1950s the roles were reversed, and future reversals are possible. The main channel is the most physically diverse of any reach in the project area, with mostly riffle-pool habitat, several linear gravel bars and some potentially high quality spawning habitat that is somewhat spoiled by fine sediment infilling the gravels. The reach has a low w:d ratio and a high degree of channel erosion. Though w:d ratio is a less helpful metric in split channels, this reach is still somewhat over narrowed for its depth. Historic aerial photos show that this reach formerly had numerous additional side channels and wetlands that have now been filled in and isolated by levees.

The Shields stress analysis shows partial scour in this reach where the upper few inches of spawning

These images show the combination of steep, eroding banks with relatively good in-channel gravel and vegetation cover that is typical of Reach 3

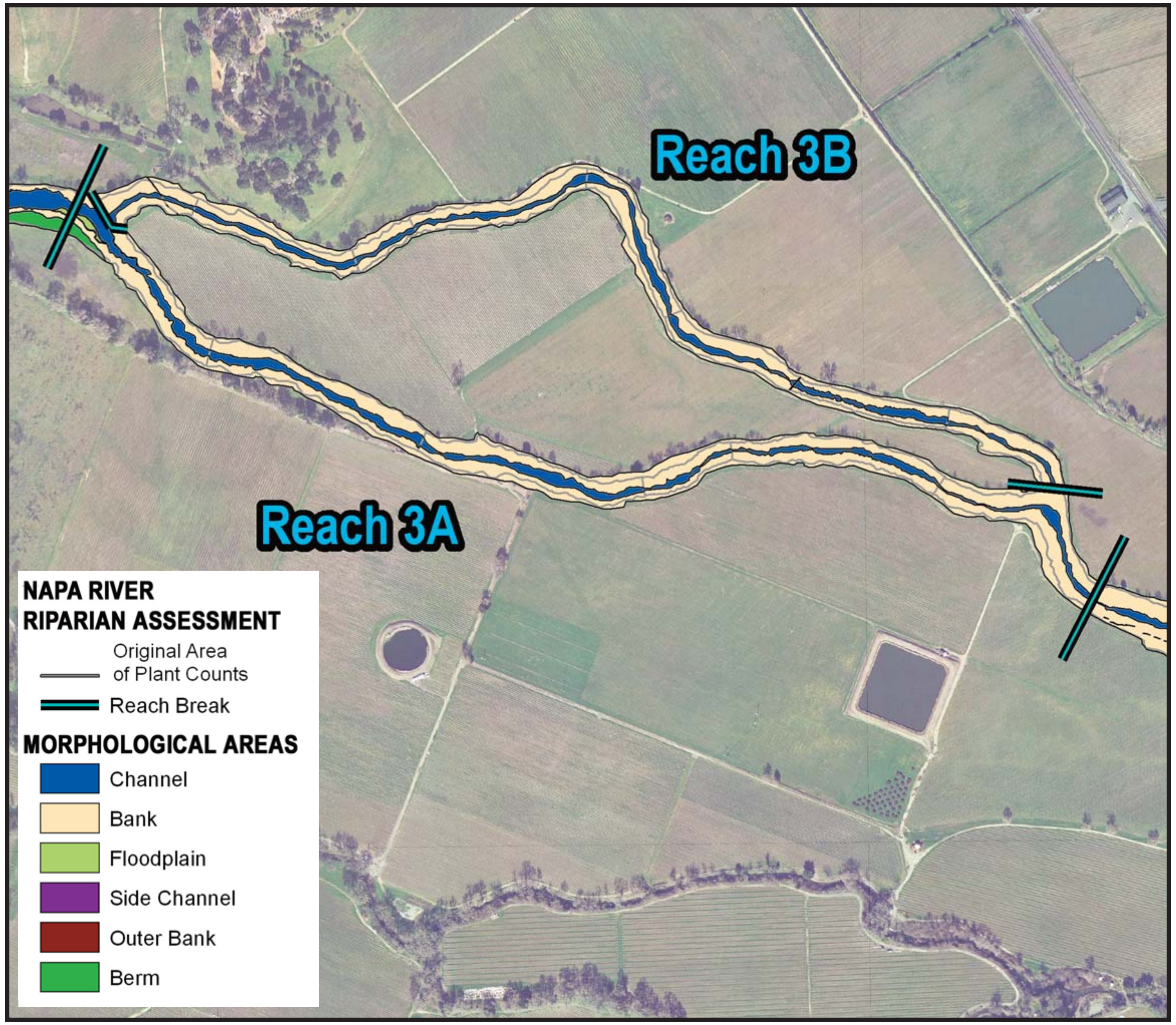
gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs**.** One area shows full scour where gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features. Another area shows selective scour where a thin layer of spawning gravel or weaker unvegetated bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds

With an average width of 95 feet and depth of 20 feet we would expect to see some additional widening in this reach, though the amount is less predictable than for other reaches.

<u>Flood characteristics:</u>

Reach 3 is the most flood-prone reach in the project area, with the 2-year flow overtopping the banks in all areas.

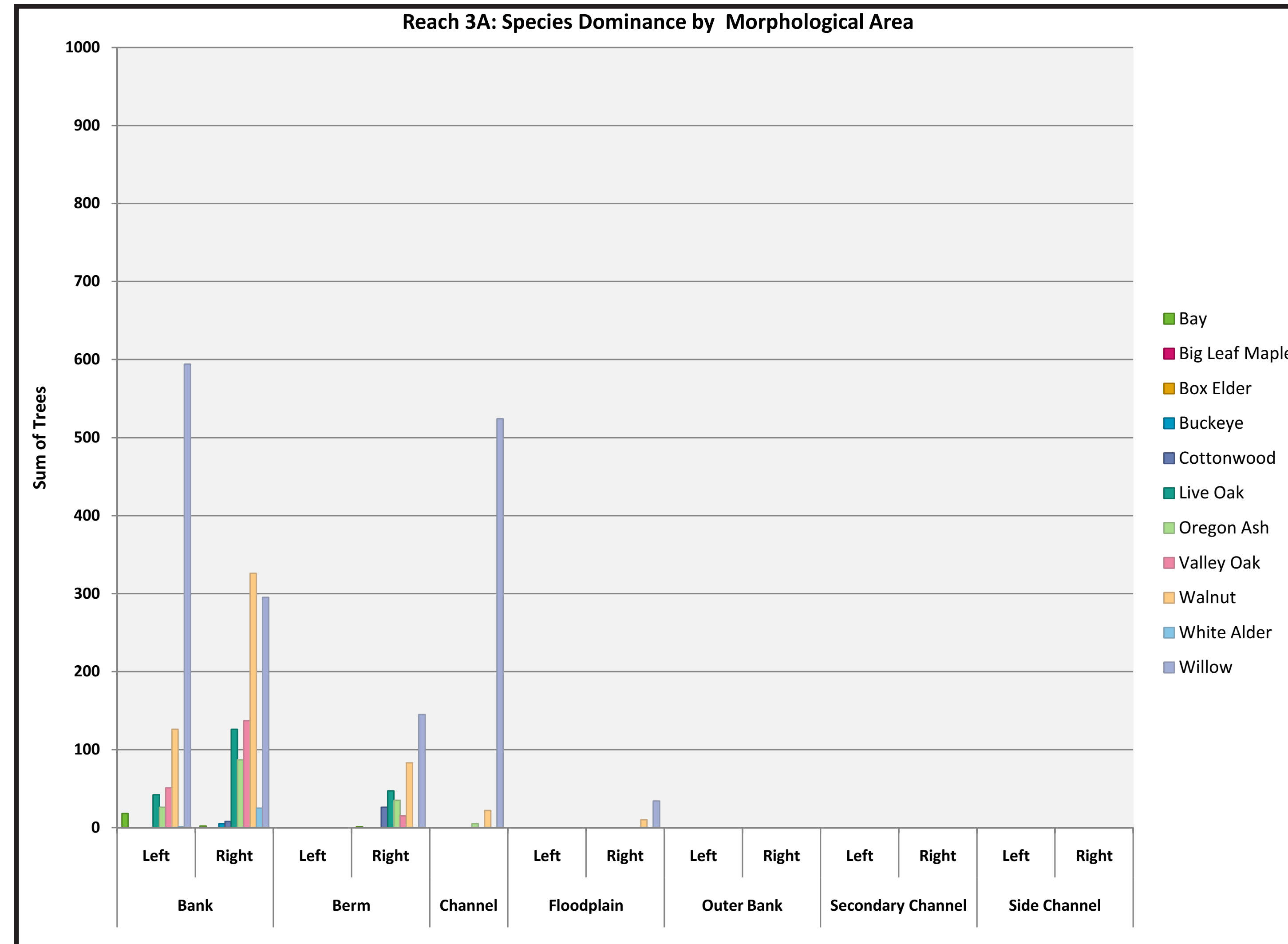
Average velocity during the ten-year flow however is 3-7 feet per second.



Reach 3: Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre
Reach 3A:		
Channel	3.3	166
Bank-left	5.4	161
Bank-right	4.5	306
Floodplain-right	0.08	44
Reach 3B:		
Channel	2.5	63
Bank-left	4.4	243
Bank-right	3.2	298

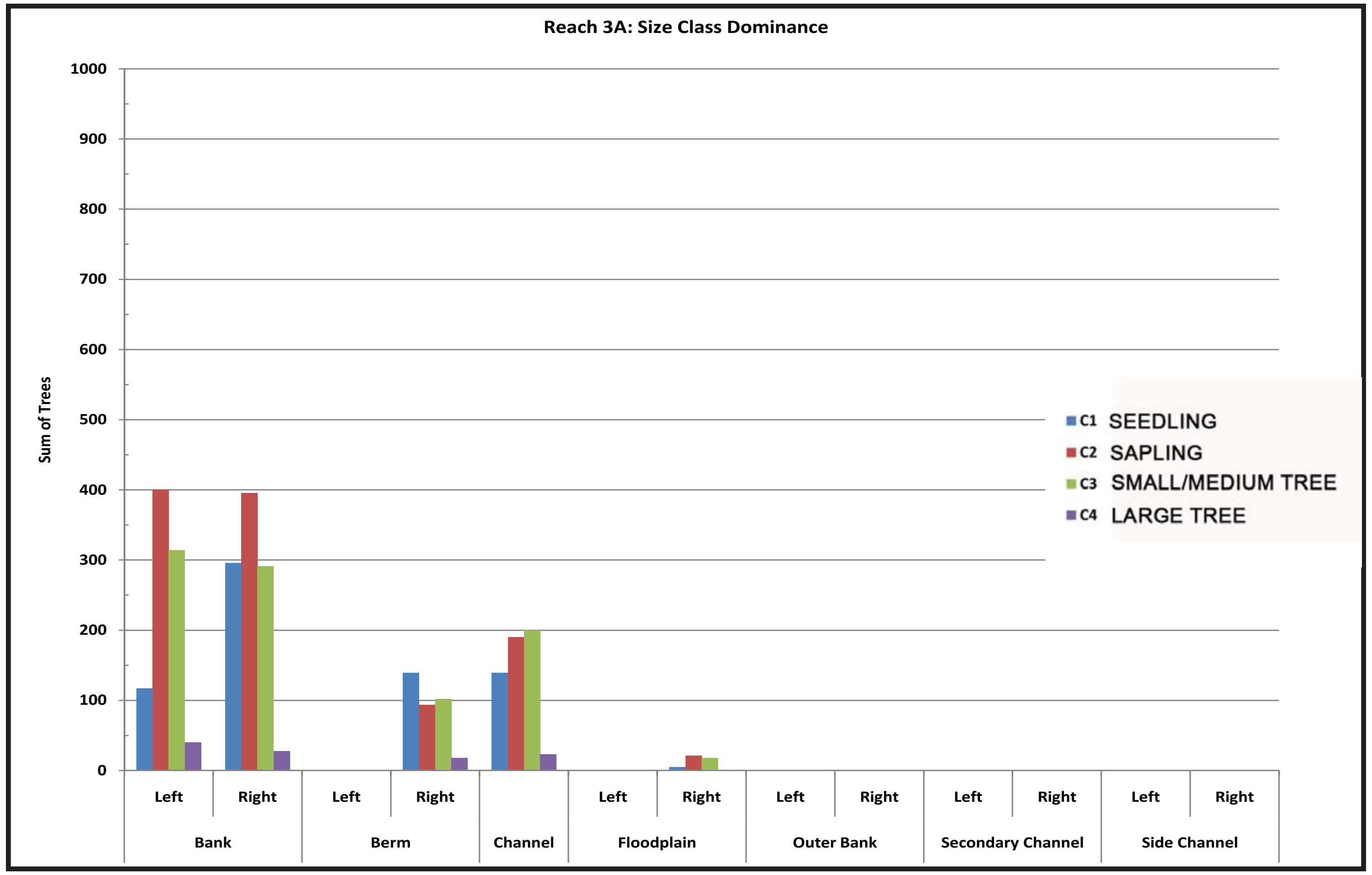
*For morphological areas of less than one acre, the actual tree count is listed

Description: Reach 3 consists of two river channels separated by a vineyard. We have designated these areas as Reach 3A (south channel) and 3B (north channel). Reach 3A is 1.0 river miles long and encompasses 13.4 acres of riparian corridor and channel area. Reach 3B is 0.98 river miles and encompasses 10.29 acres of riparian corridor and channel area. Reach 3A includes channel, right and left banks, right berm, and right floodplain morphological areas. Reach 3B has channel and right and left banks morphological areas. The Reach 3A riparian corridor is a maximum of 162 ft. with a minimum of 86 ft. and an average of 115 ft. The riparian corridor of Reach 3B is 200 ft. at the maximum, 85 ft. at the minimum and averages 112 ft.



Species Diversity Reach 3A

Willow is the dominant species in the channel and on the floodplain and left bank. Willow and Ca. walnut are co-dominant species on the right bank.



Size Class Dominance Reach 3A

Size class C2 and C3 trees are dominant in the channel, on the left and right banks, and in the floodplain area. Seedlings and large trees also occur in the channel and left and right bank areas.

Distribution of Size Classes and Species Reach 3A: There are moderate numbers of willow seedlings in the channel. The banks have a low density of seedlings including Ca. walnut, willow, valley oak, Oregon ash, and live oak. A few Ca. walnut seedlings occur on the floodplain.

The channel has primarily willow saplings with a few Ca. walnut and Oregon ash. The right bank has nine different species of sapling; willow and Ca. walnut are the most numerous. The left bank has seven different species of saplings, with willow the most abundant.

The channel has primarily C3 willow. Willow C3 size class trees are abundant in the floodplain. The right bank has nine species of C3 trees, and the left bank has six species. Willow is the dominant species on both banks. The right berm has seven species of C3 trees.

There are a few large willow trees in the channel. On the banks there are six different species of C4 trees with valley oak and willow the most numerous. There are C4 valley oak, Ca. walnut, and willow on the right berm.

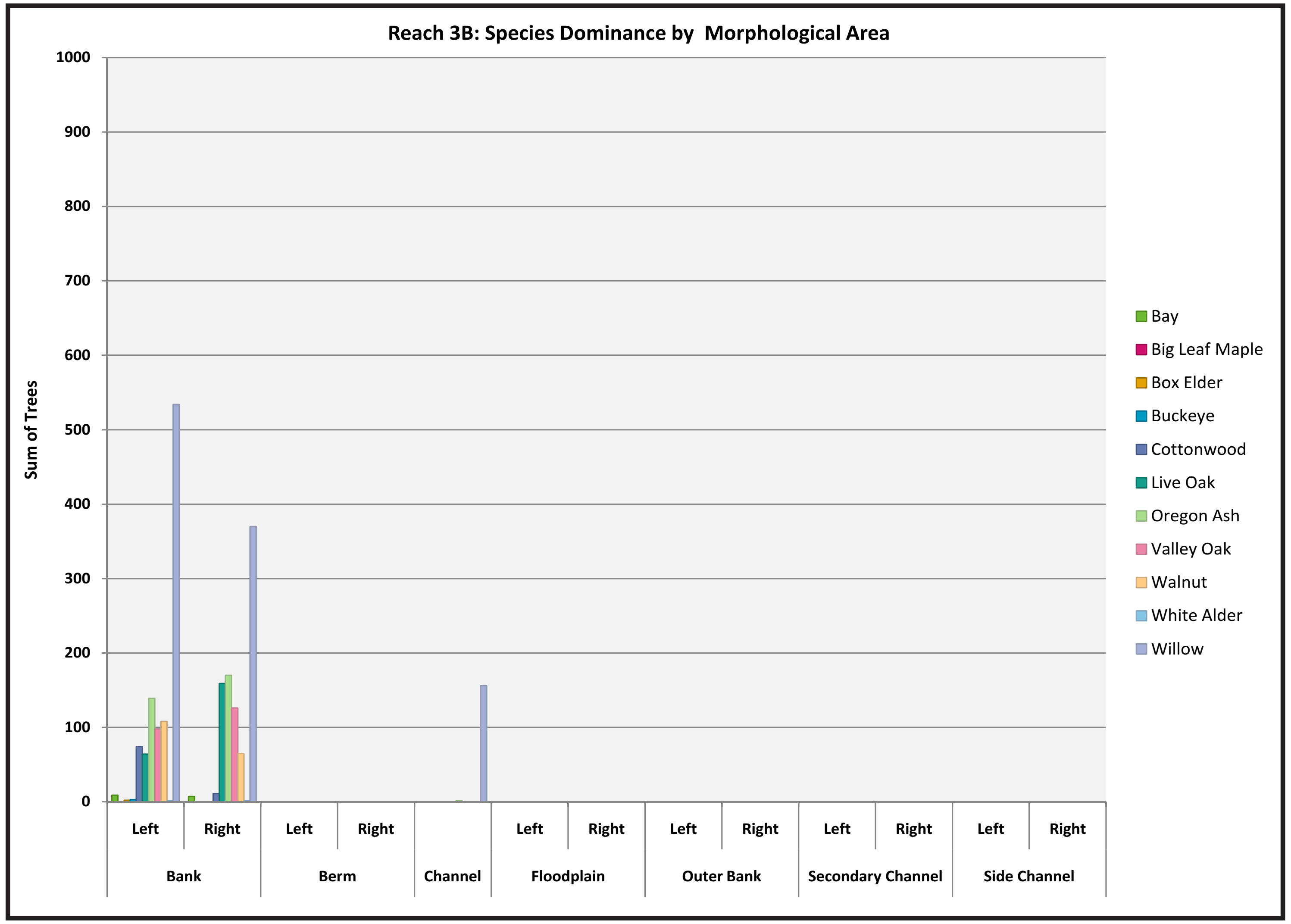
Invasive Species Reach 3A: *Arundo donax* is rare in this reach, covering 0.06 acres or 0.004% of the total reach area. Other non-native invasive plants recorded include tree-of-heaven, plum, and Eucalyptus. Invasive densities are too low to affect native plant growth.

Spider Trees Reach 3A: This reach has a medium level of spider trees all located on the banks. Seven different species of spider trees occur with Ca. walnut, valley oak, live oak, and willow the most abundant.

Understory Reach 3A: Understory plants recorded include blue periwinkle, Himalayan blackberry, snowberry, pokeweed, poison oak, wild grape, mugwort, horsetail, coyote brush, and fennel. In the channel, cattails, river sedge, torrent sedge, tules, and Himalayan blackberry dominate.

Riprap Reach 3A: There is a medium level of riprap with 89 linear feet on the left bank and 74 linear feet on the right bank.

Ecological Trends Reach 3A: In all areas of the channel, C2 and C3 size class trees are more numerous than seedlings. Seedlings of willow and Ca. walnut occur on the right bank along with saplings and small/medium trees, demonstrating a low level of regeneration of these species. Vegetative density is relatively low within the reach. C4 trees occur on both banks and in the channel and many are being undercut. Overall tree density is medium in comparison to other reaches.



Species Diversity Reach 3B

Willow dominates all three morphological areas: channel and left and right banks. A total of nine tree species occur on the banks.

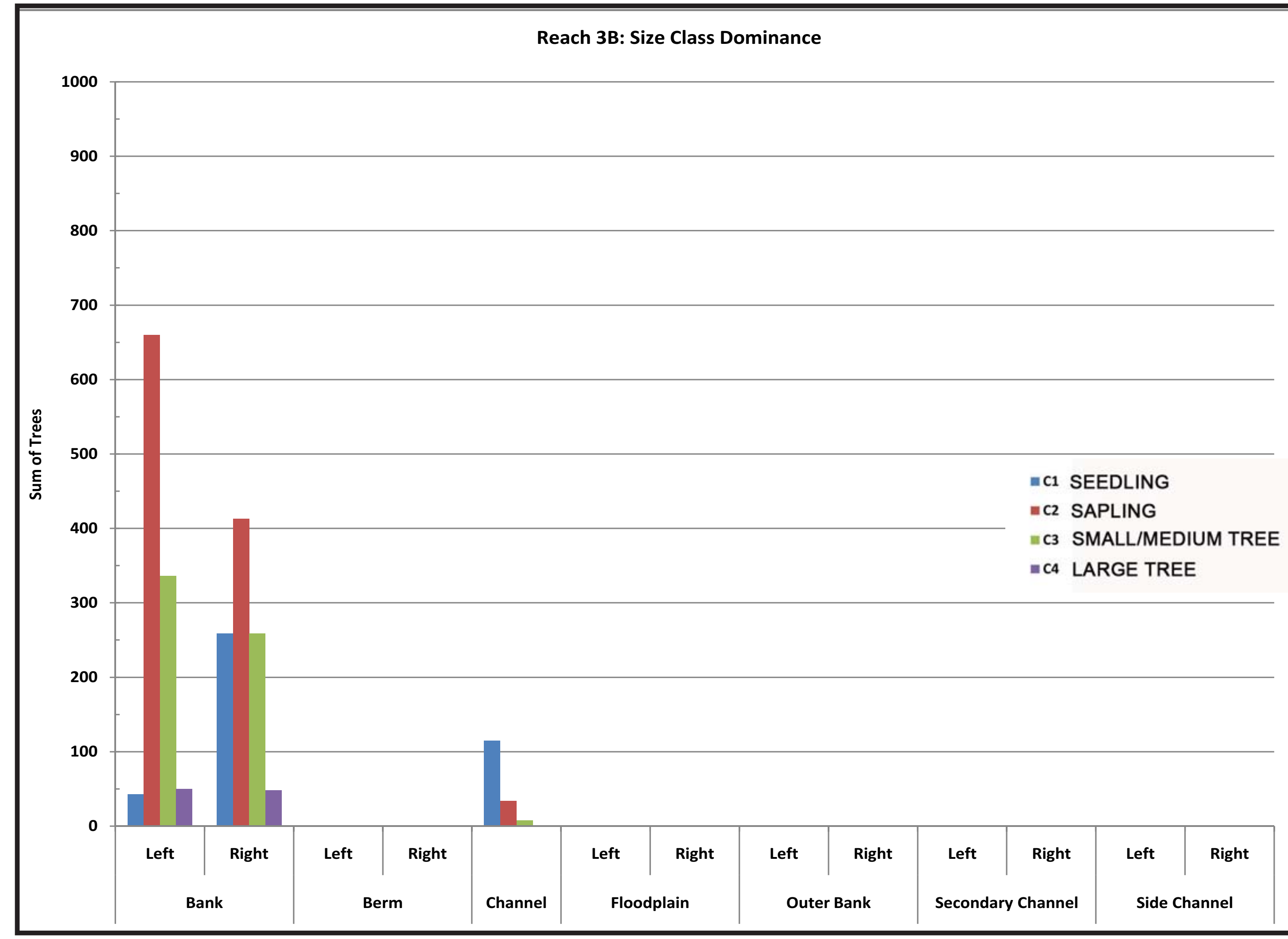
Distribution of Size Classes and Species Reach 3B: The channel has low numbers of willow seedlings. Willow and Oregon ash seedlings occur on the right bank with a few Ca. walnut and live oak C1 trees. There are very low numbers of seedlings on the left bank, made up mostly of Oregon ash and valley oak.

There are only willow saplings in the channel. There are seven species of saplings on both banks with willow the most numerous and Oregon ash, live oak, and Ca. walnut also common.

There are few C3 trees in the channel. There are moderate numbers of eight species of C3 size class trees on the banks. Willow, valley oak, and live oak are the most abundant.

There are no large trees in the channel. There are moderate numbers of large trees on the banks, with valley oak and live oak the most numerous.

Invasive Species Reach 3B: *Arundo donax* does not occur in this reach. Eucalyptus and plum were recorded on both banks in low numbers. It is unlikely that the low numbers of invasive plants impact native plant growth significantly.



Size Class Dominance Reach 3B

Seedlings (C1) are the dominant size class in the channel. Saplings dominate the left bank, whereas C1, C2, and C3 size classes are co-dominants on the right bank.

Spider Trees Reach 3B: Reach 3B has a medium level of spider trees all located on the banks. Six different species occur with valley oak, live oak, Ca. walnut, and Oregon ash most abundant.

Understory Reach 3B: Understory species recorded include Himalayan blackberry, coyote brush, Ca. rose, wild grape, Ca. blackberry, poison hemlock, mugwort, and grasses. The channel area has river sedge and wild grape.

Riprap Reach 3B: There is a medium level of riprap with 35 linear feet on the left bank and 89 linear feet on the right bank.

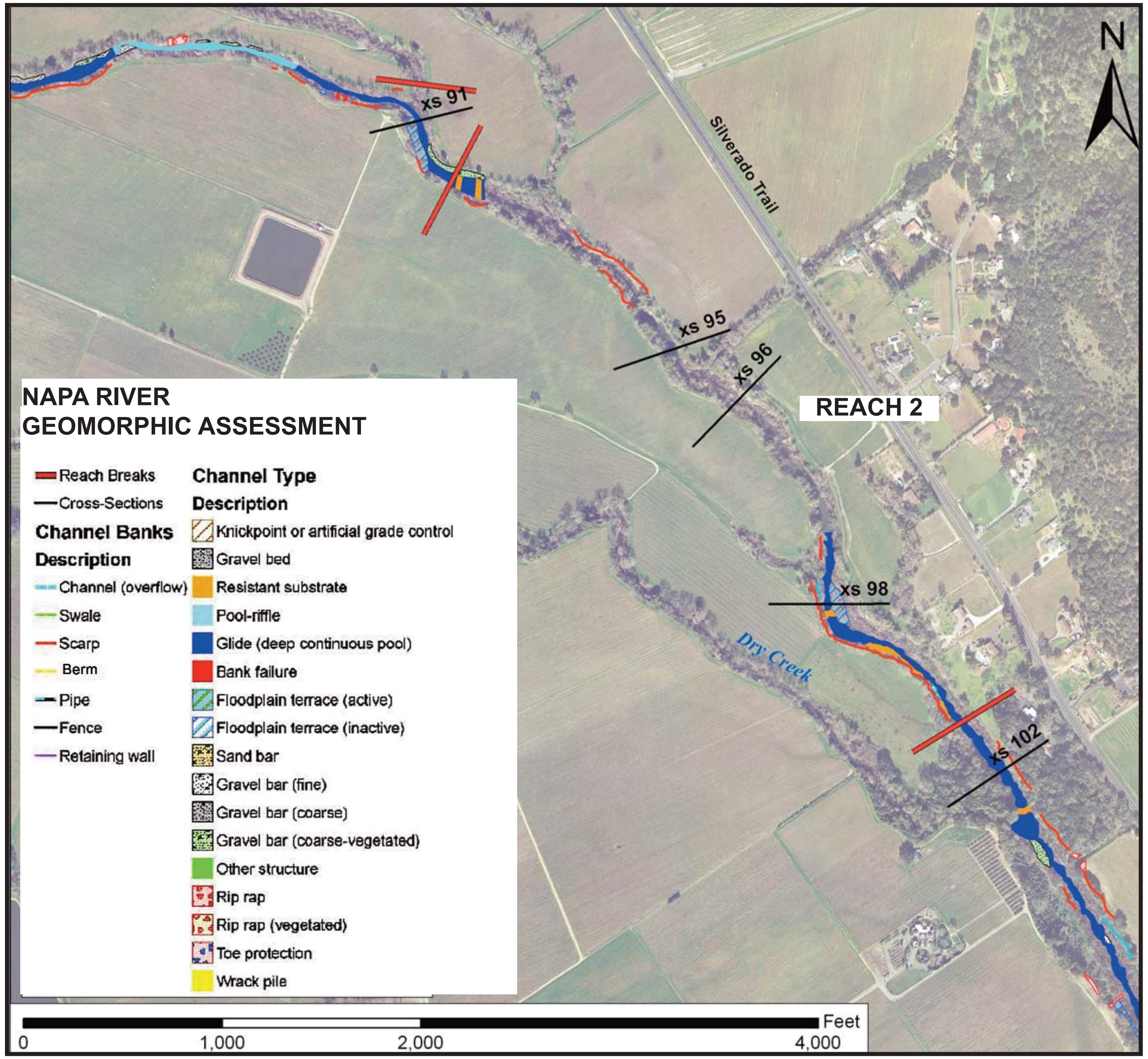
Ecological Trends Reach 3B: The channel area has low numbers of seedlings and regeneration is very low. Both banks have a moderate number of C3 trees. There are a few large trees which are being undercut by channel erosion. Overall tree density is low in comparison to other reaches.

Reach 3A is the primary channel for this split reach, and it contained water during both our summer habitat survey and our winter salmon surveys, while Reach 3B was dry in the summer. This reach was quite narrow and had more tightly spaced riffle pool morphology than other reaches, as it carries only about half of the Napa River's flow during a storm event. This reach had the highest habitat diversity with a value of 14.2 units per 1,000 feet of channel. Habitat quality increases with diversity, so this high score indicates this reach contains some of the highest quality habitat of the entire survey. However, this high quality habitat was distributed in small patches throughout the reach, and was intermixed with areas of severe bank failure, little riparian canopy, and other generally degraded conditions.

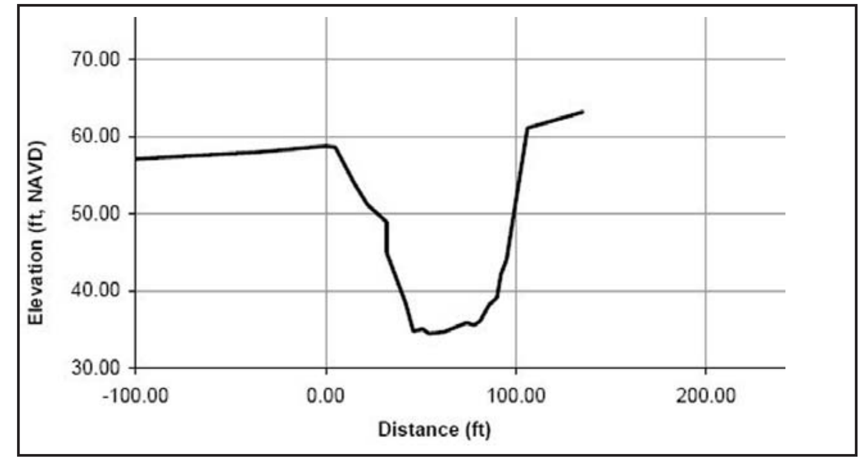
This reach contains a relatively high percentage of riffles (14% total length) compared with other reaches. Spawning riffle quality was best in the center of the reach and deteriorated toward the top of the reach due to shallow conditions and fine substrate. Despite the high number of potential spawning sites in this reach, no evidence of spawning was observed in 2007. Salmon, and potentially steelhead, would be expected to use the abundant high quality spawning habitat in this reach in years with higher population numbers.

Pool shelter was fairly high with an average pool shelter rating of 91, primarily from overhanging aquatic vegetation and LWD. Several pools in this reach were associated with LWD jams in deeply entrenched sections of the river with near vertical banks. These pools contained schools of large Sacramento pike minnow during our spring 2007 survey, and were generally void of juvenile salmon.

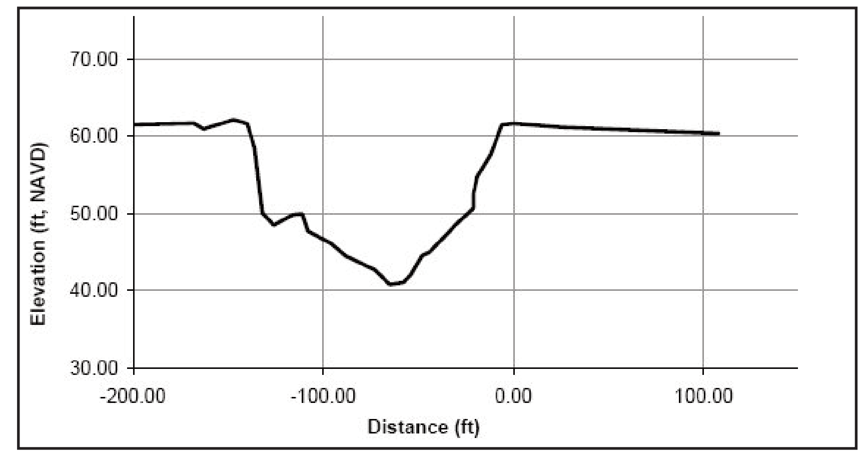
HIGH QUALITY SPAWNING RIFFLES WERE MORE ABUNDANT IN REACH 3A THAN OTHER REACHES.



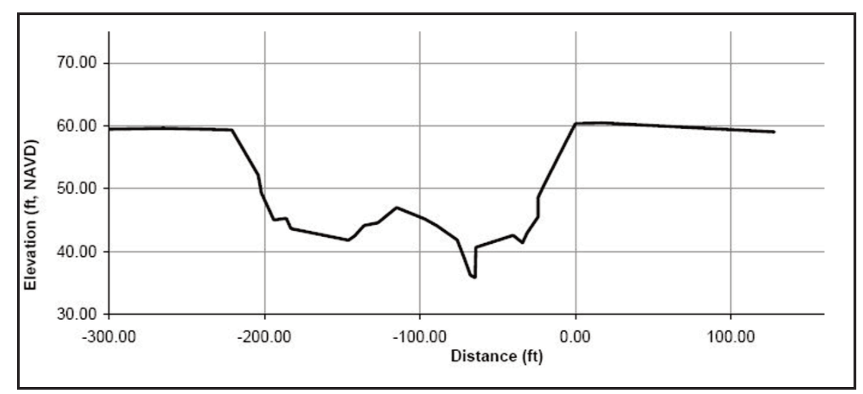
Representative Cross Sections



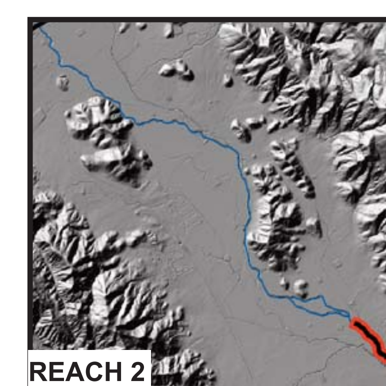
XS 95
W:D = 4.2
Most entrenched conditions



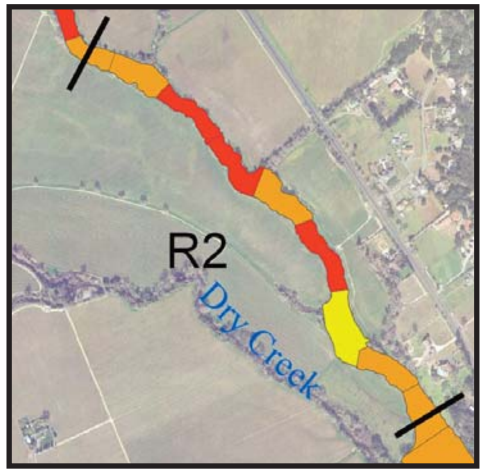
XS 96
W:D = 7.1
Average section



XS 98
W:D = 9.4
Least entrenched section



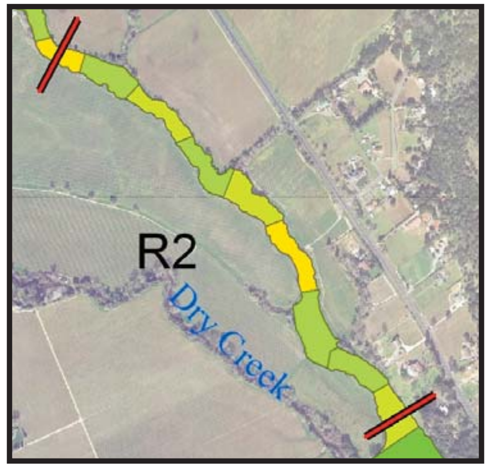
Physical Characteristics of Reach 2



Confinement

Width To Depth Ratio

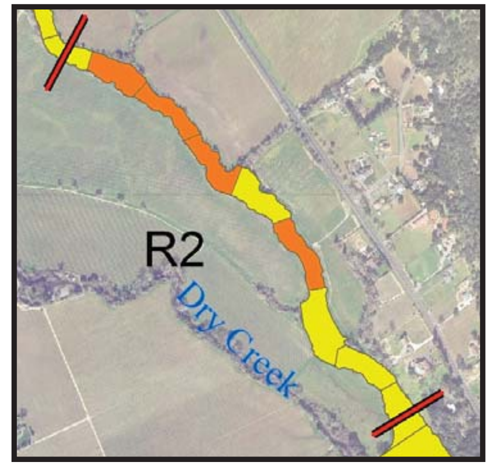
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

Reach 2 is dominated by resistant channel bed materials made up of cohesive clays and indurated sediments. This resistant clay forms a poor substrate for channel geomorphic processes such as riffle and pool formation, and biological processes such as spawning gravels and rearing pools, and riparian vegetation. The reach is dominated by long pools and flatwater, with no side channels or backwater areas and few terraces to provide high flow refugia for fish. Interestingly this reach is approximately average for the project area in terms of entrenchment (average w:d ratio of 6.5), suggesting that the cohesive sediment is more of a control on channel conditions than simple channel entrenchment. With an average width of 143 feet and a depth of 21 feet the channel appears closer to equilibrium width than many other reaches but is clearly not functioning well at present. Under a “no action” alternative, the channel would be expected to widen approximately 80 feet.

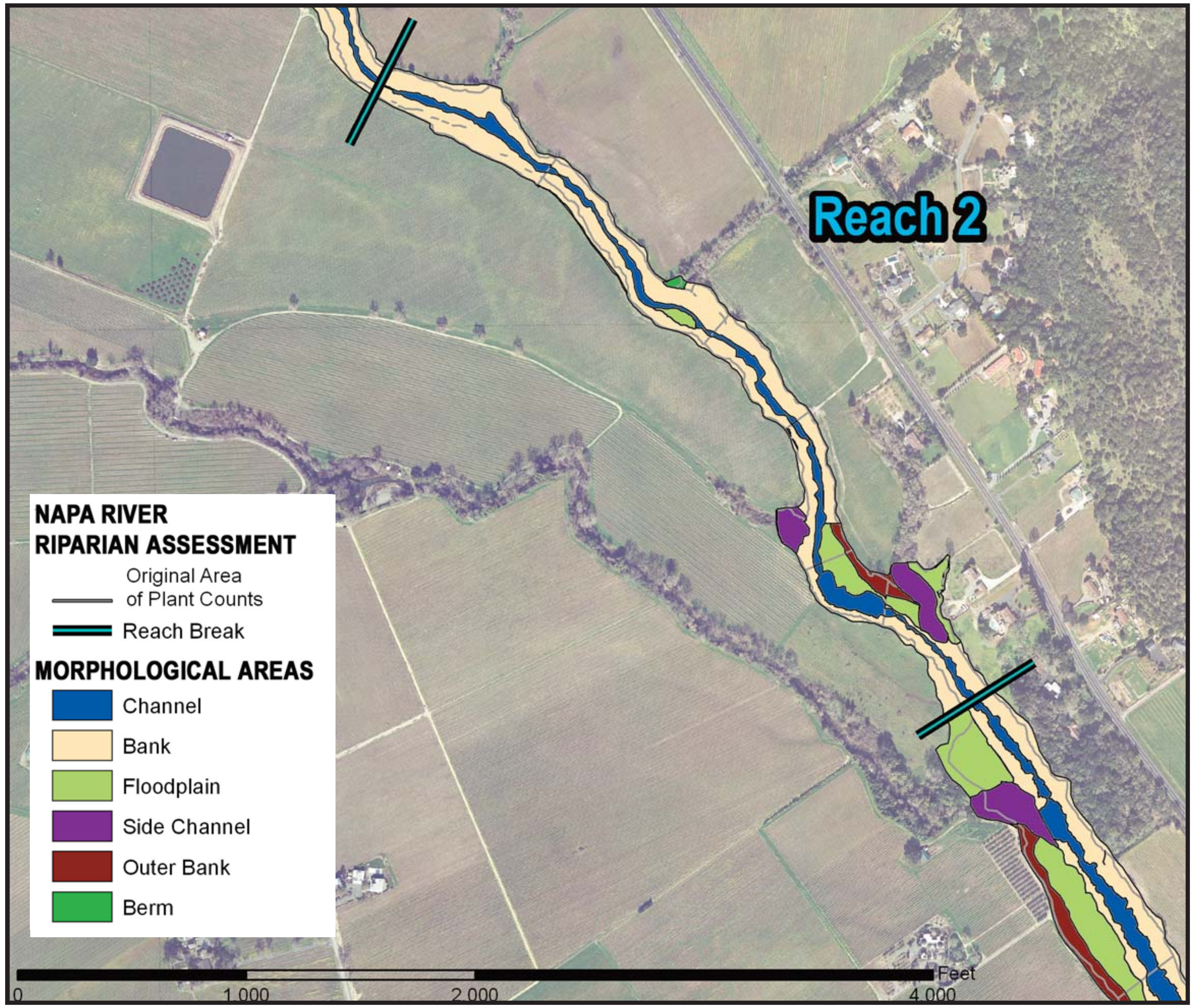
The Shields stress analysis shows full scour for this reach where gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features. Several areas have partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.

These images show the steep banks and relatively sparse riparian corridor typical of Reach 2.

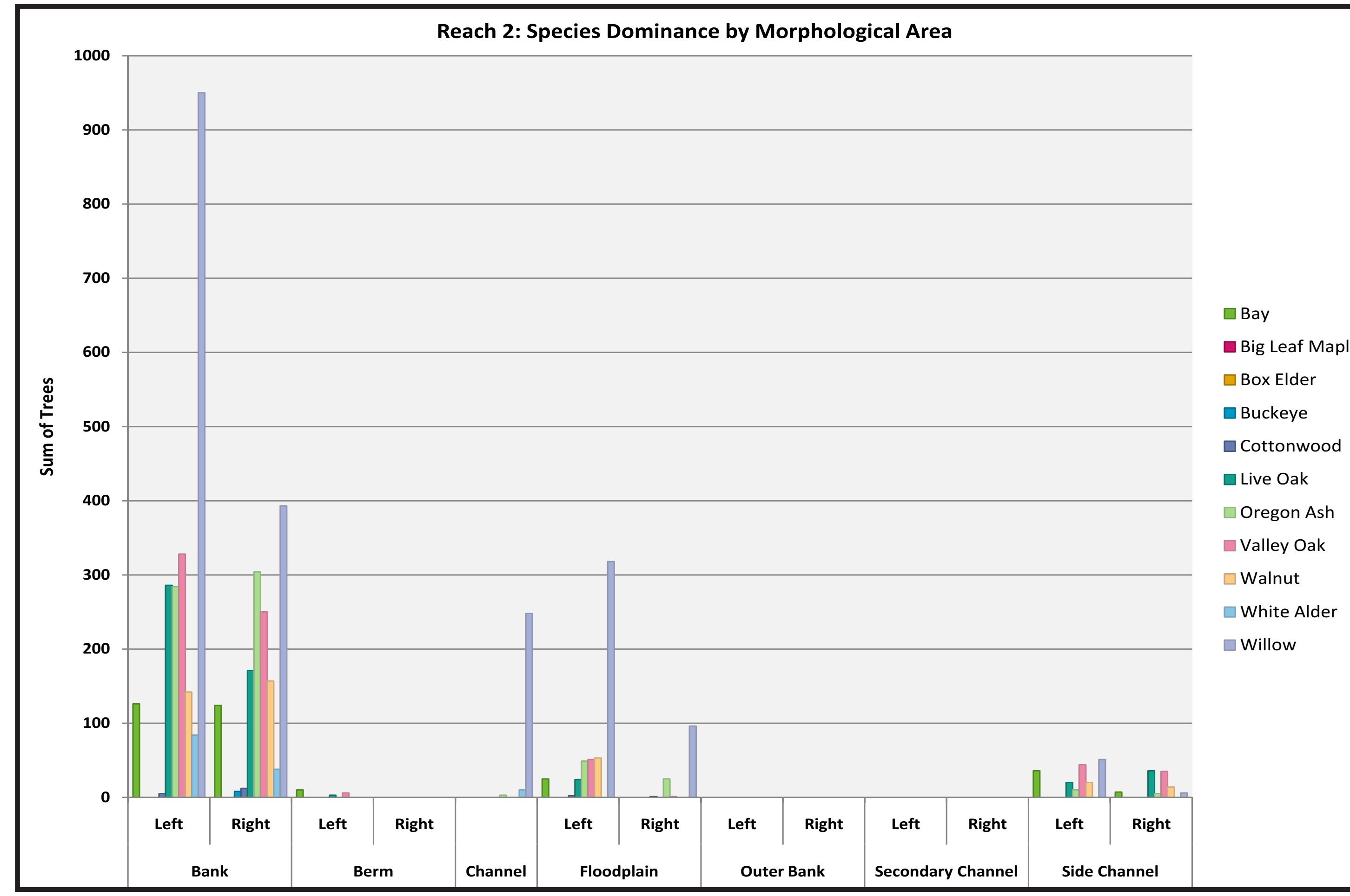
Flood characteristics:

Most of Reach 2 experiences out of bank flows during the 5-year flow, with one section flooding during the 2-year flow.

Average velocity during a ten year flood is 4-7 feet per second.



Description: Reach 2 extends for 0.76 river miles and encompasses 15.78 acres of channel and riparian corridor. The Reach 2 riparian corridor has a maximum width of 270 ft., a minimum width of 124 ft., and an average width of 186 ft. Reach 2 includes the channel, right and left banks, a small left berm, right and left floodplains, left outer bank, and right and left side channel morphological areas.



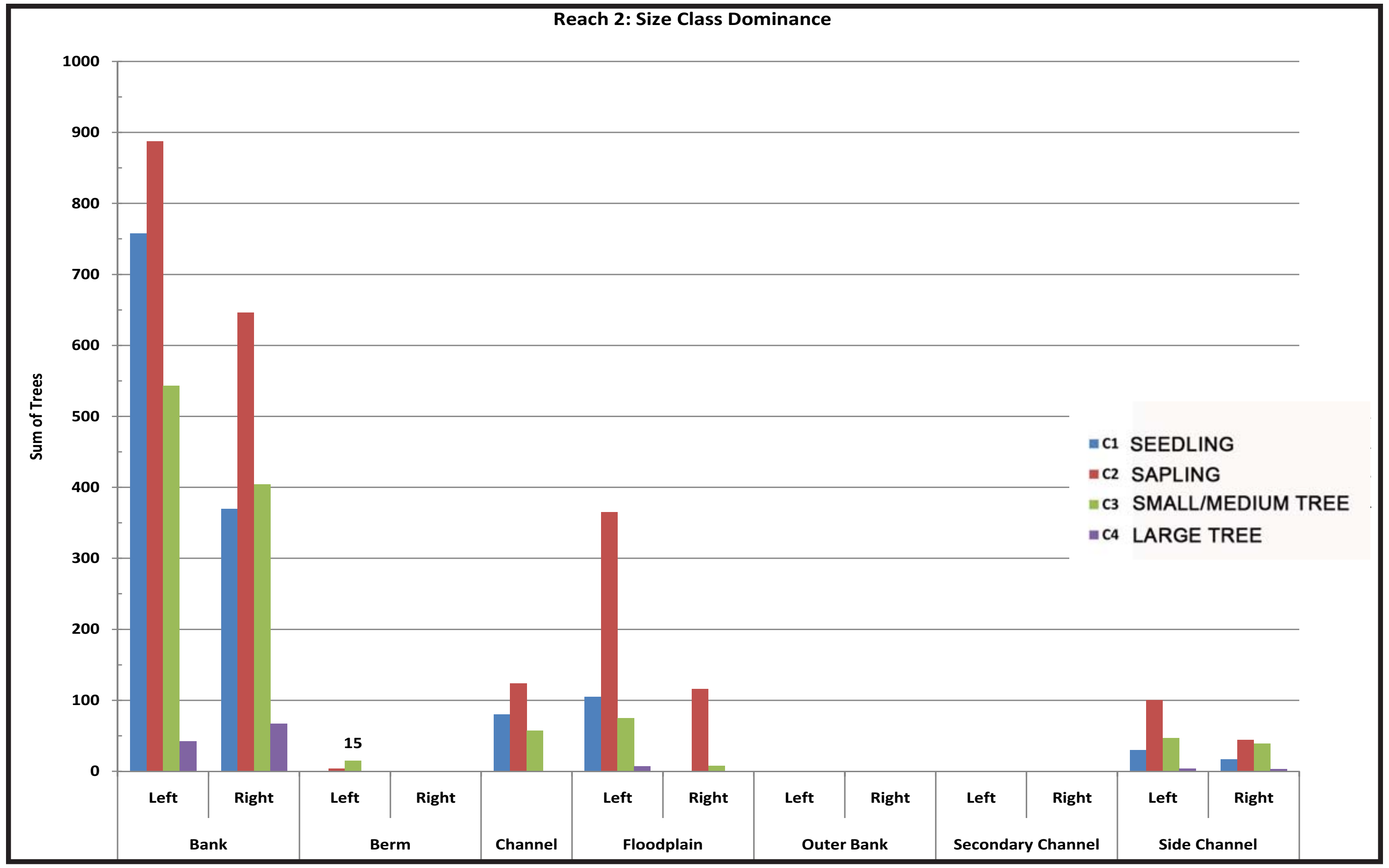
Reach 2: Vegetation Density		
Morphological Area	Acres	Vegetation Density in Trees/Acre*
Channel	2.79	93
Bank-left	4.94	451
Bank-right	4.81	332
Floodplain-left	1.38	399
Floodplain-right	0.16	66
Outer bank-left	0.43	99
Berm-left	0.05	19
Side channel-left	0.77	181
Side channel-right	0.40	103

*For morphological areas of less than one acre, the actual tree count is listed

Species Diversity

Willow is the dominant or co-dominant species in all areas of the channel except for the tributary side channels and berms. The banks support nine species of trees.

SEEDLING WILLOWS HAVE LIMITED GROWTH IN RESISTANT CLAY LAYER.



Size Class Dominance

Sapling trees are the most numerous in all areas of the corridor and are the dominant size class in the floodplain and side channel. Seedlings occur in relatively high numbers in the channel and moderate numbers in all other areas of the corridor. Large trees occur on the banks and in the floodplain.

Distribution of Size Classes and Species: The channel primarily has willow seedlings with a few white alder seedlings. On the left bank, willow seedlings are abundant with valley oak, Oregon ash, and live oak also numerous. On the right bank, Oregon ash seedlings are abundant with live oak and valley oak numerous. Willow and valley oak are the primary seedlings in the floodplain areas. The two side channel areas have valley oak and live oak seedlings.

Willow saplings are very abundant in Reach 2 and are the main C2 size class trees in the channel. The banks have eight species of saplings with willow the most abundant on both banks. Both floodplain areas have very high densities of willow saplings. The right floodplain also has abundant Oregon ash C2 trees. The left floodplain has numerous Oregon ash and Ca. walnut saplings. The left side channel has mostly willow saplings. The right side channel has saplings of Ca. walnut, live oak, valley oak, and Oregon ash but no willow saplings.

C3 size class trees in the channel are willows. The banks both have mostly willow C3 trees but also have less numerous Ca. bay laurel, valley oak, Ca. walnut. Both side channels have a diverse assemblage of C3 trees with valley oak, Ca. bay laurel, live oak, willow, and Ca. walnut present. The left and right floodplains have primarily C3 willow with low numbers of Fremont cottonwood on the right floodplain and Ca. bay laurel, live oak, valley oak, and Ca. walnut on the left floodplain.

Large trees occur on both banks, the floodplain, and the side channel areas. Valley oak is the primary species, with Ca. bay laurel, Oregon ash, Ca. walnut, willow, live oak, and Fremont cottonwood.

Invasive Species: Reach 2 has a very low density of *Arundo donax* at 0.02 acres or 0.001% of the total area of Reach 2. Other invasive species recorded in Reach 2 include Eucalyptus in both floodplain areas and on the banks, tree-of-heaven on the right bank, and black locust on the left bank. These invasive tree species do not appear to be reducing C1 and C2 density.

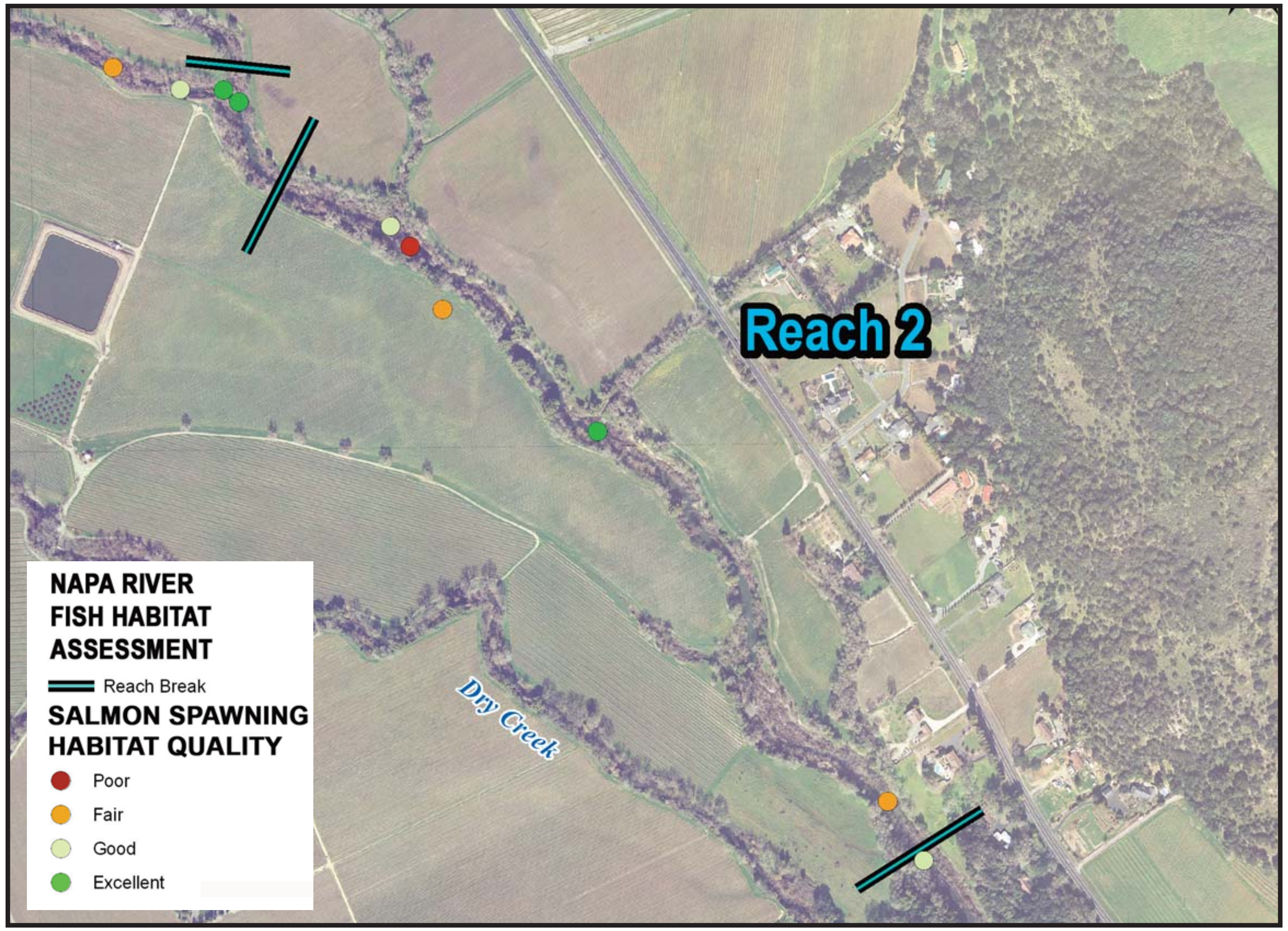
Spider Trees: Reach 2 has a high level of spider trees. Most are located on the banks, but the left berm, channel, and left side channel also have spider trees. Valley oak and Ca. bay laurel are the most common species of spider tree with Oregon ash, live oak, and Ca. buckeye also numerous.

Understory: Understory plants recorded in the corridor include Ca. rose, snowberry, Ca. wild grape, Himalayan blackberry, Harding grass, coyote bush, poison oak, pokeweed, black mustard, mugwort, fennel, and grasses. Along the channel cattails, torrent sedge, and tules were recorded.

Riprap: Reach 2 has a moderate amount of riprap with 39 linear feet along the left bank.

Ecological Trends: This reach has a high number of saplings. Willow is the dominant species in the channel and on the banks. This may indicate that conditions are conducive to the vegetative spread of willow. There are few C3 trees in the channel. The banks have a variety of species in all four size classes. It appears that live oak, Ca. bay laurel, and valley oak are regenerating along the upper area of the bank, while willow is regenerating along the base of the bank and in the channel. Oregon ash also appears to be regenerating on the banks. However, the large trees on the banks are being undercut. A resistant clay layer dominates sections of the channel in Reach 2, restricting seedling germination and vegetative growth. Overall tree density is low in the channel and high in other areas in comparison to other reaches

A RESISTANT CLAY LAYER DOMINATES THE CHANNEL IN REACH 2 AND ELIMINATES SEEDLING GERMINATION.

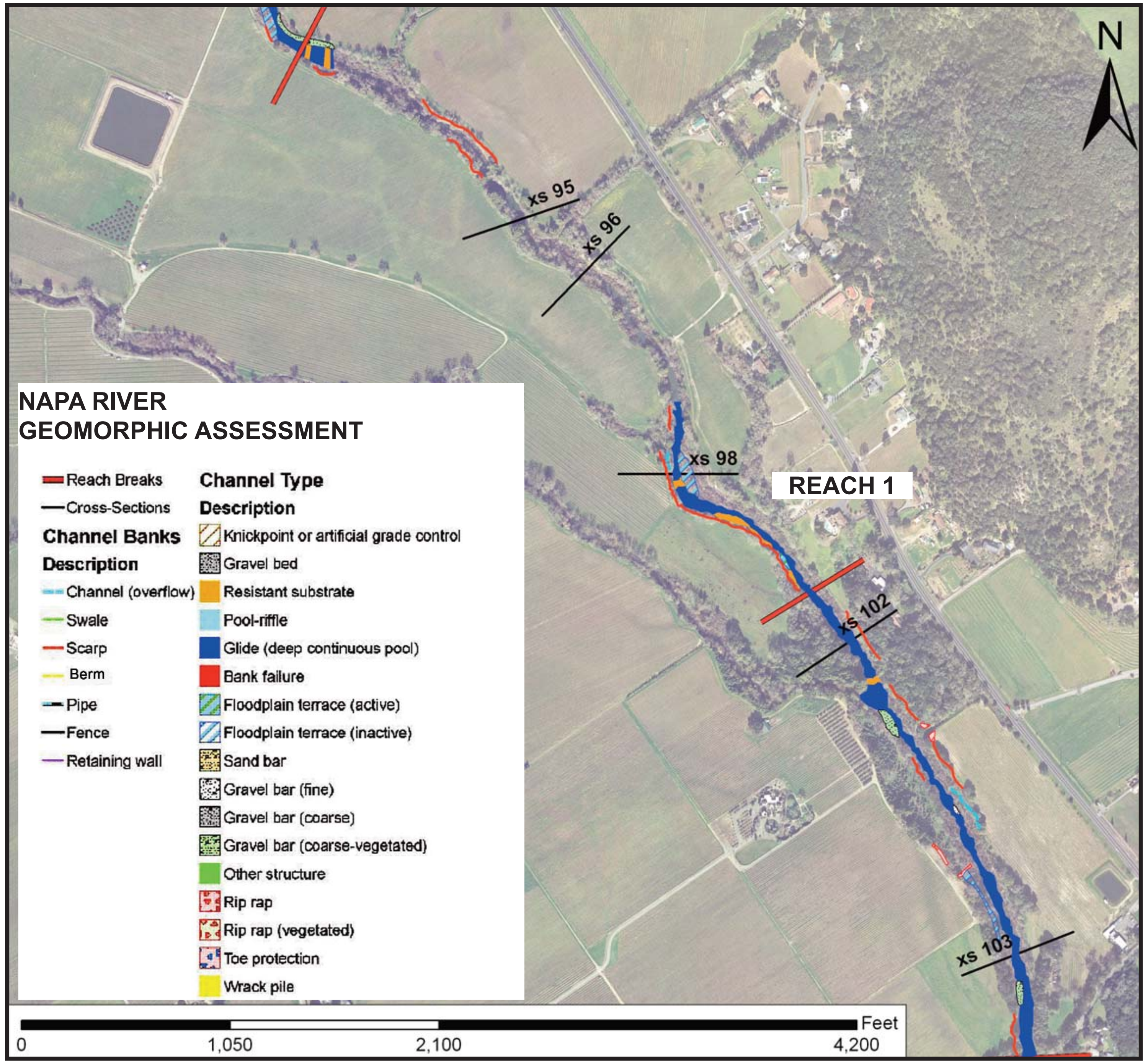


Reach 2 is characterized by a hardpan clay formation in the bed and banks throughout much of its length. This reach was dominated by pools and flatwater, which comprised 91% of this reach's length. Flatwater habitats in this reach were primarily long shallow glides and relatively short deep runs through bedrock or other confined sections of the river. The run habitats were full of juvenile Chinook salmon parr during our May 2007 snorkel survey, and several schools of 40+ fish were observed actively feeding in the high velocity lanes at the tops of each run unit throughout this reach.

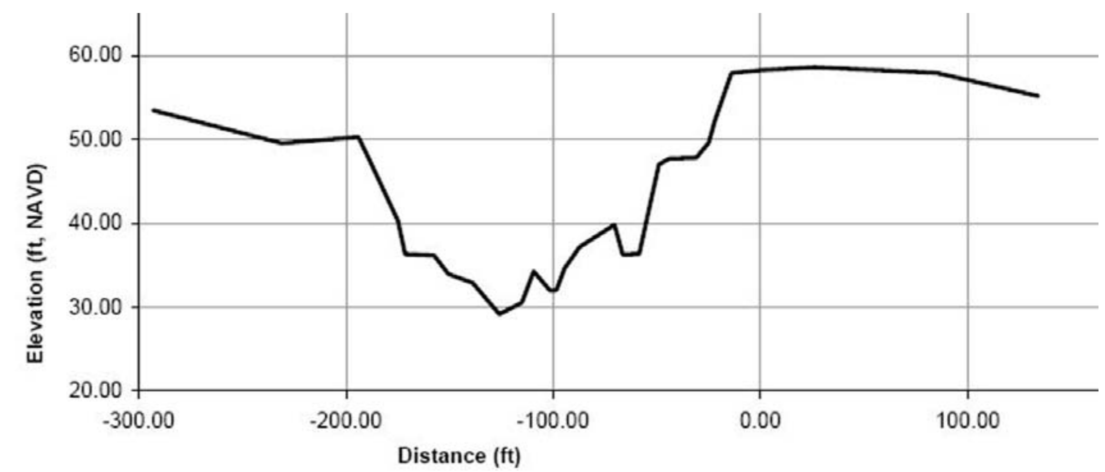
Salmon spawning habitat was relatively sparse in Reach 2 and many hydraulically appropriate sites were deemed unsuitable due to bedrock substrate. No evidence of spawning was observed in 2007, but as with Reach 1, fish would be expected to spawn at potential sites in this reach in higher abundance years.

There were no side-channel habitats or backwater pool units in this reach to provide juvenile salmon feeding opportunities or velocity shelters. Cover in pools was generally high with an average shelter rating of 125. Pool cover in this reach consisted almost entirely of overhanging terrestrial vegetation, and several areas were very heavily overgrown with wild grape and willow in the active channel.

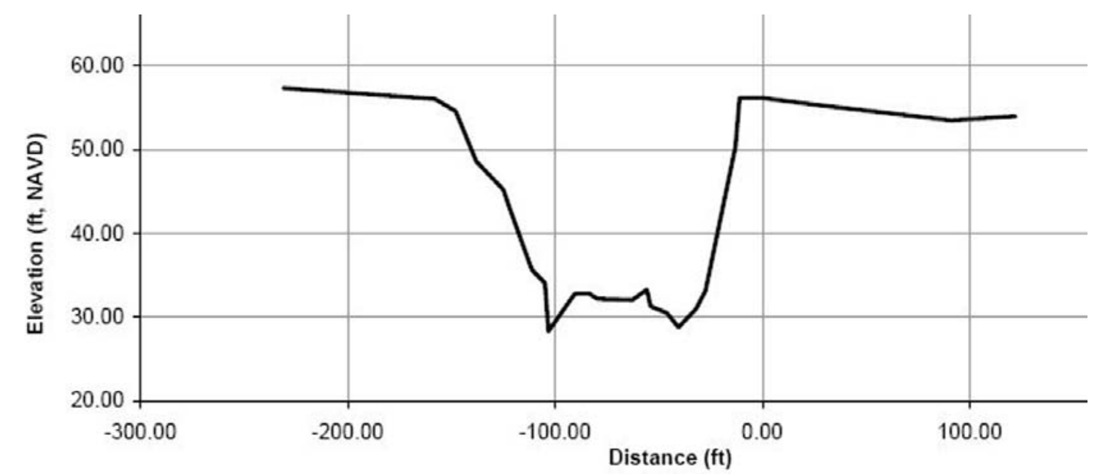
REACH 2 IS DOMINATED BY A RESISTANT CLAY ON THE CHANNEL AND BANKS REDUCING SPAWNING AREAS.



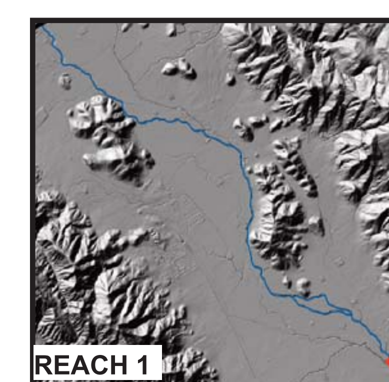
Representative Cross Sections



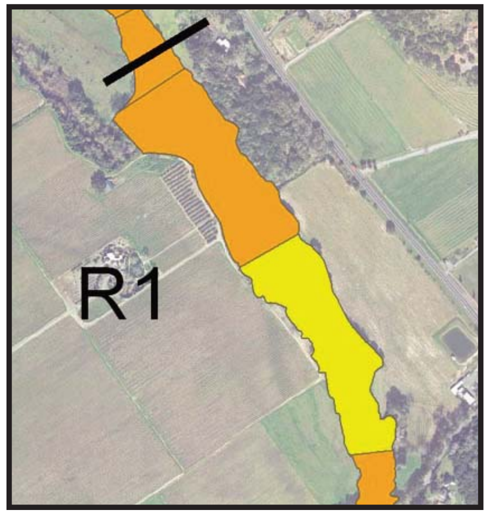
XS 102
W:D = 8.0
Least entrenched conditions



XS 103
W:D = 5.3
Most entrenched section



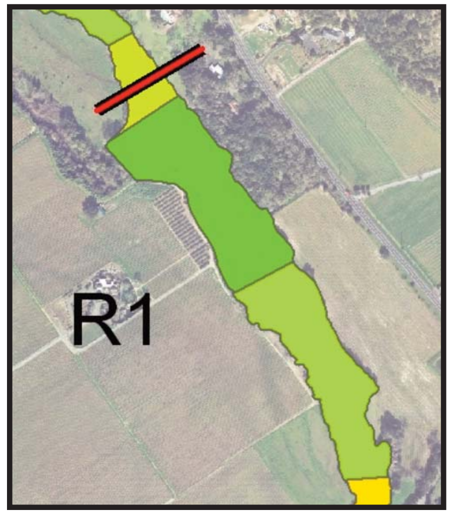
Physical Characteristics of Reach 1



Confinement

Width To Depth Ratio

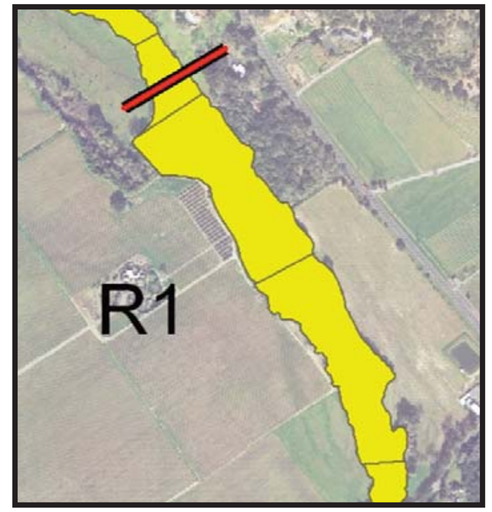
- 2.5 - 5 Deeply Entrenched
- 5 - 7.5 Entrenched
- 7.5 - 10 Approaching Functional Width
- 10 - 12.5 Functional Width
- 12.5-15 Wide
- > 12.5 Very Wide



10-year Discharge - Existing

Average Velocity (ft/s)

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11



2-Year Discharge - Existing

Shields Stress (Regime)

- 0.0 - 0.01 (None)
- 0.01 - 0.03 (Selective)
- 0.03 - 0.06 (Partial)
- 0.06 - 0.10 (Full)
- > 0.1 (Channel Altering)

These images convey the relatively ‘trench-like’ character of Reach 1, with straight glides and steep banks.

Reach 1 is dominated by resistant channel bed materials of cohesive clays and indurated sediments. This resistant clay layer forms a poor substrate for both channel processes such as riffle and pool formation and biological processessuch as spawning gravels and rearing pools, and riparian vegetation. The reach is dominated by long pools and flatwater, with no side channels or backwater areas and few terraces to provide high flow refugia for fish.

Reach 1 is strongly influenced by the confluence with Dry Creek, which enters from the west side with a large delta that provides the best habitat in this reach.

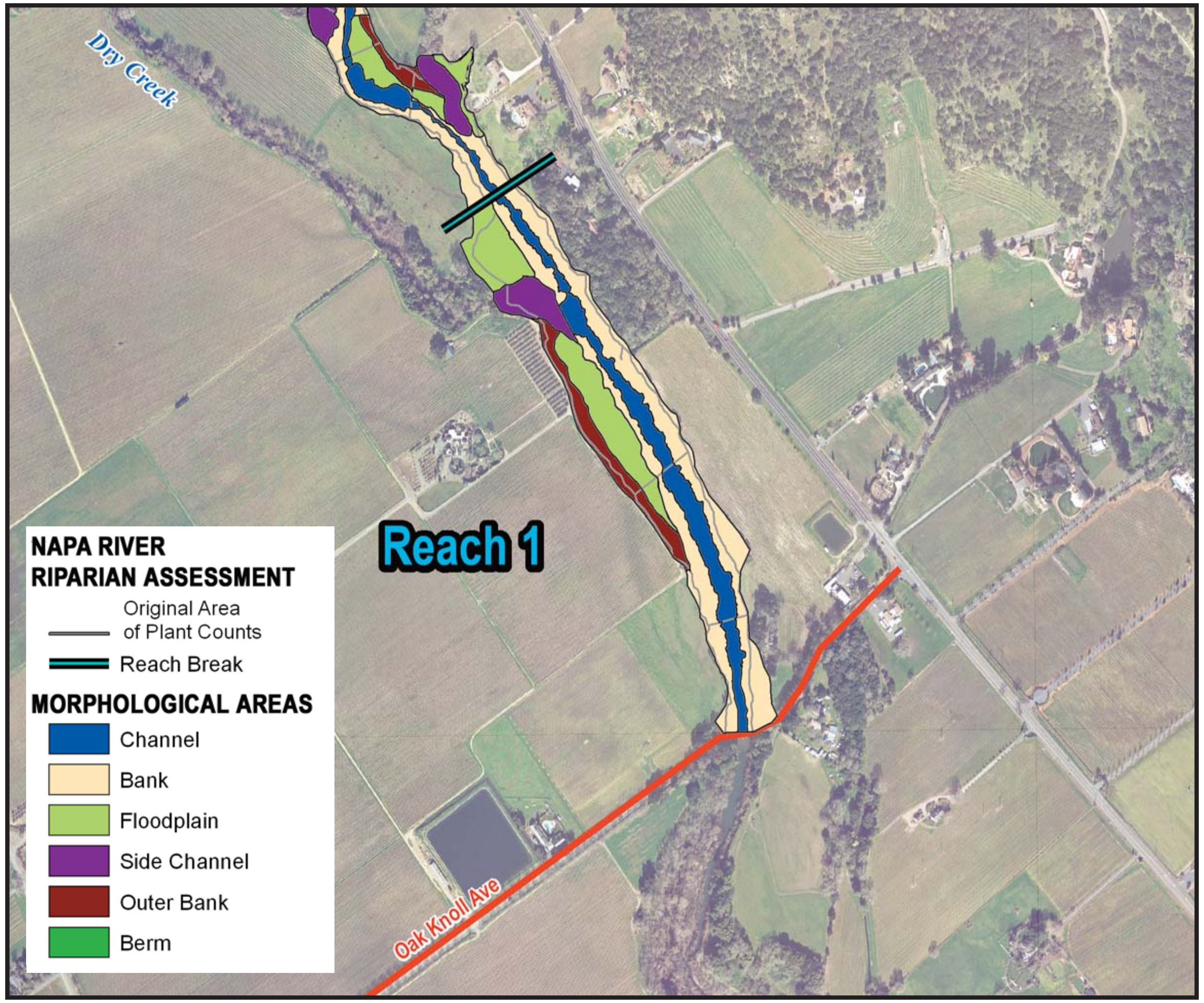
Interestingly this reach is better than average for the project area in terms of entrenchment (average w:d ratio of 6.8), suggesting that the cohesive sediment is more of a control on channel conditions than simple channel entrenchment. With an average width of 159 feet and a depth of 24 feet the channel appears closer to equilibrium width (estimated at 240 feet) than many other reaches and involving approximately 80 feet of widening under a “no action” alternative.

The Shields stress analysis shows this reach has partial scour where the upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.

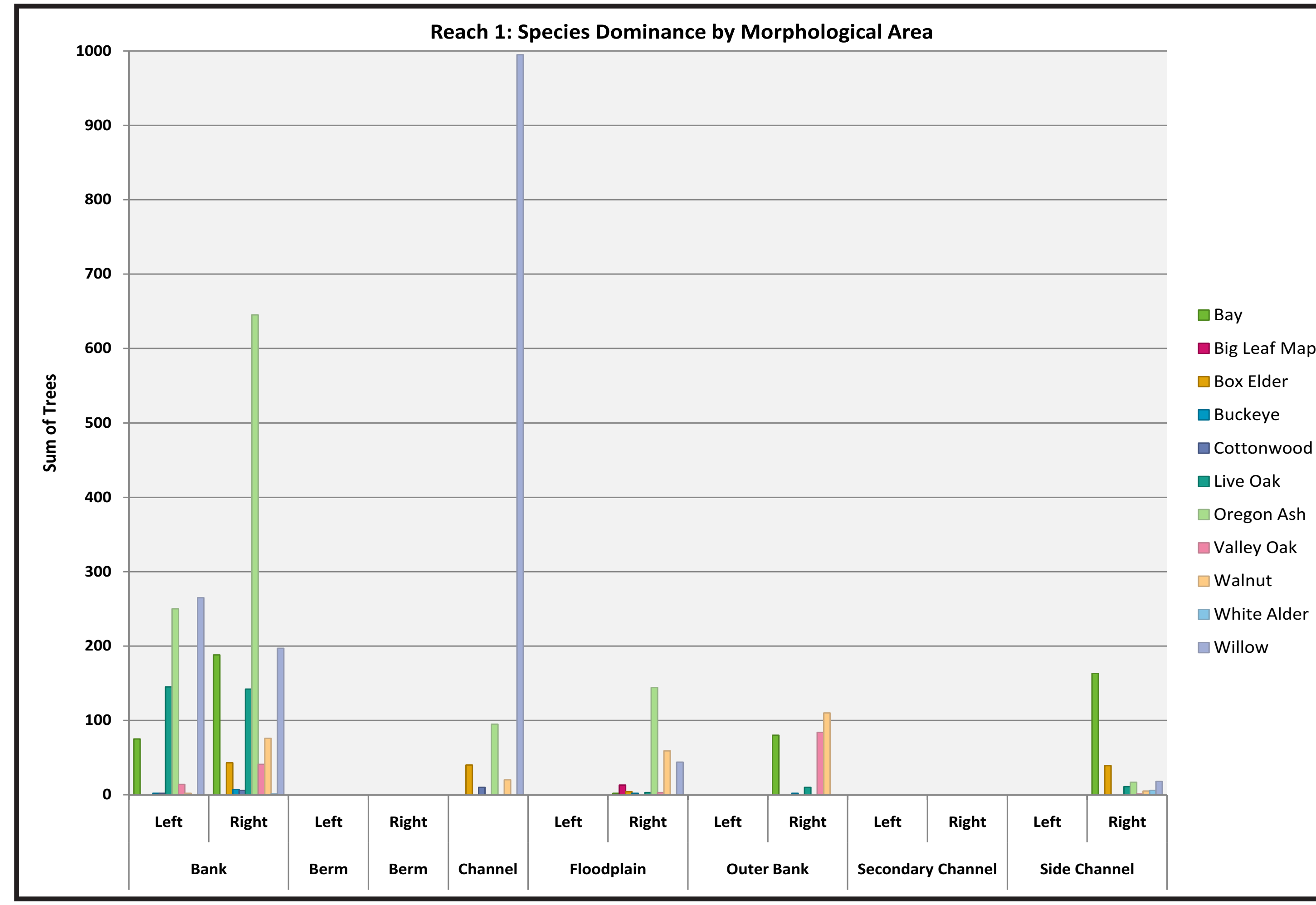
Flood characteristics:

Almost all of Reach 1 experiences out of bank flows during the 5-year flow, with one section flooding during the 2-year flow.

Average velocity during a ten year flood is 3-5 feet per second.



Description: Reach 1 extends for 0.5 river miles and encompasses 15.13 acres. The riparian corridor varies from a maximum of 350 ft. in width to a minimum of 200 ft., and averages 260 ft. Reach 1 includes channel, right and left banks, right floodplain, right outer bank, and right side channel morphological areas. Dry Creek, a major tributary stream, flows into Reach 1.



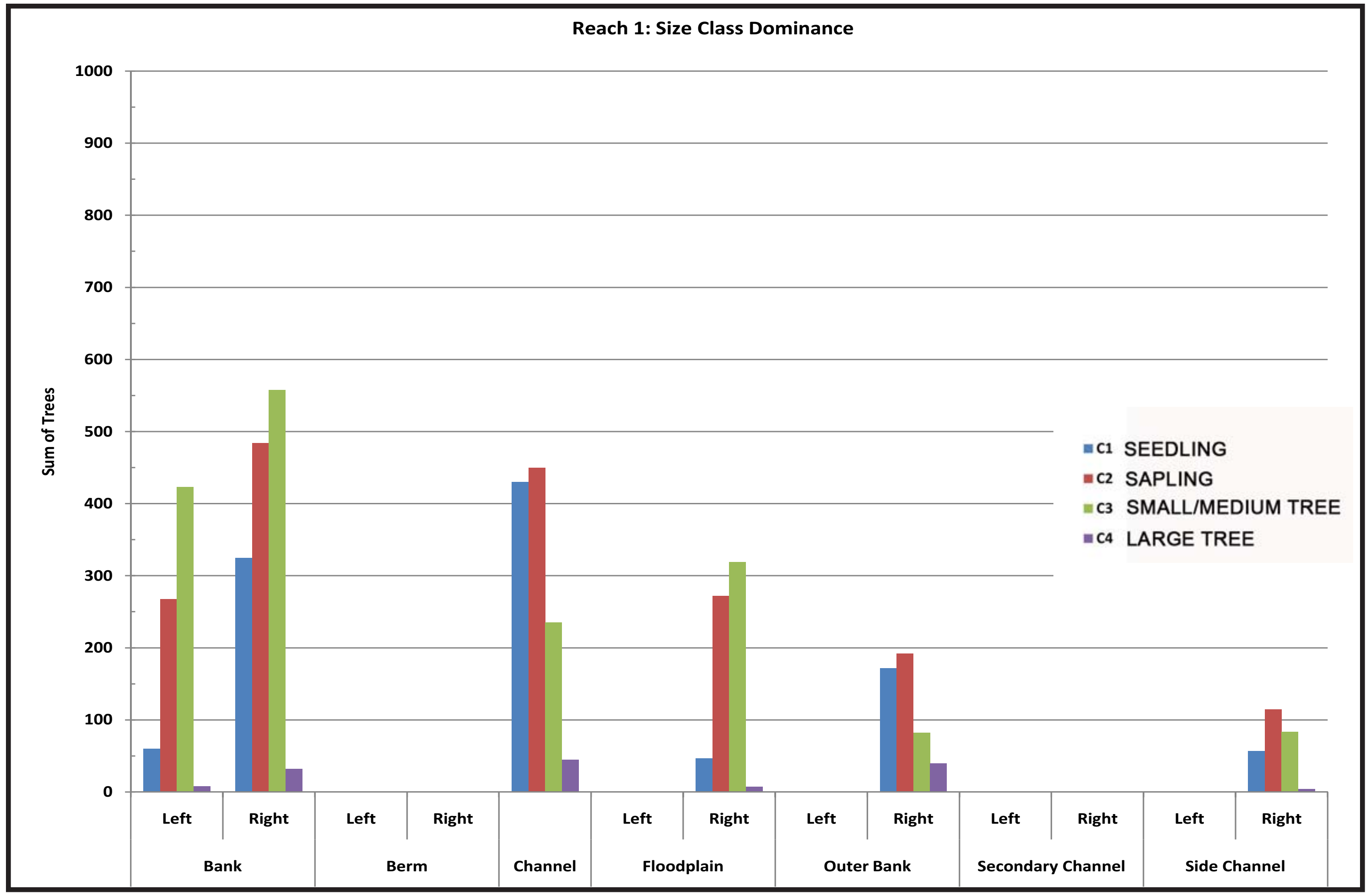
Species Diversity

Willow is abundant in the channel. Oregon ash is the dominant species on the right bank and a co-dominant with willow on the left bank.

Reach 1: Vegetation Density		
Morphological Area	Acre	Vegetation Density in Trees/Acre*
Channel	3.58	350
Bank-left	3.25	248
Bank-right	2.88	536
Floodplain-right	3.29	196
Outer bank-right	1.27	382
Side channel-right	0.84	260

*For morphological areas of less than one acre, the actual tree count is listed

RESISTANT CLAY LAYER IN THE CHANNEL OF REACH 1



Size Class Dominance

Seedlings (C1) and saplings (C2) are co-dominants in the channel area and right outer bank. Saplings (C2) and small trees (C3) are co-dominants in the other areas of the corridor except the left bank, which has C3 trees as the only dominant size class. C2 and C3 trees are co-dominants in the side channel.

Distribution of Size Classes and Species: Seedling willows are abundant in the channel area with low numbers of box elder, Fremont cottonwood and Oregon ash seedlings. Seedling Oregon ash are abundant on the right bank with willow, live oak, valley oak, and Ca. bay laurel C1 size class trees on the banks. The left bank has a low density of seedlings. The floodplain has low numbers of seedlings of Ca. walnut, willow, and live oak. The outer bank has numerous valley oak, Ca. walnut, and Ca. bay laurel, with a few live oak seedlings. The side channel has numerous box elder seedlings with a few Ca. bay laurel, live oak, Oregon ash, Ca. walnut, and white alder seedlings.

Sapling willows are abundant in the channel with a few Ca. walnut, Oregon ash, and box elder C2 trees present as well. The right bank has abundant Oregon ash saplings. Both banks have moderate densities of a variety of species including willow, Ca. walnut, live oak, box elder, and Ca. bay laurel. Oregon ash saplings also dominate the floodplain area with big-leaf maple, willow, and box elder. Ca. bay laurel saplings dominate the outer bank and side channel areas with willow, Oregon ash, and Ca. walnut.

Willow C3 size class trees dominate the channel with a few Oregon ash and box elder. Oregon ash and willow C3 size class trees dominate the banks with Ca. bay laurel, live oak, and a few valley oak. Oregon ash C3 trees also dominate the floodplain area with a few willows and Ca. walnut. Ca. bay laurel C3 size class trees dominate the outer bank and side channel. A variety of other trees also occur in low numbers in these areas.

Distribution of Size Classes and Species (cont.): There are a large number of C4 willow trees in the channel. C4 Ca. bay laurel trees are numerous on the outer bank. The banks have willow, Ca. walnut, valley oak, and live oak C4 trees. Ca. bay laurel and valley oak C4 trees occur in the side channel.

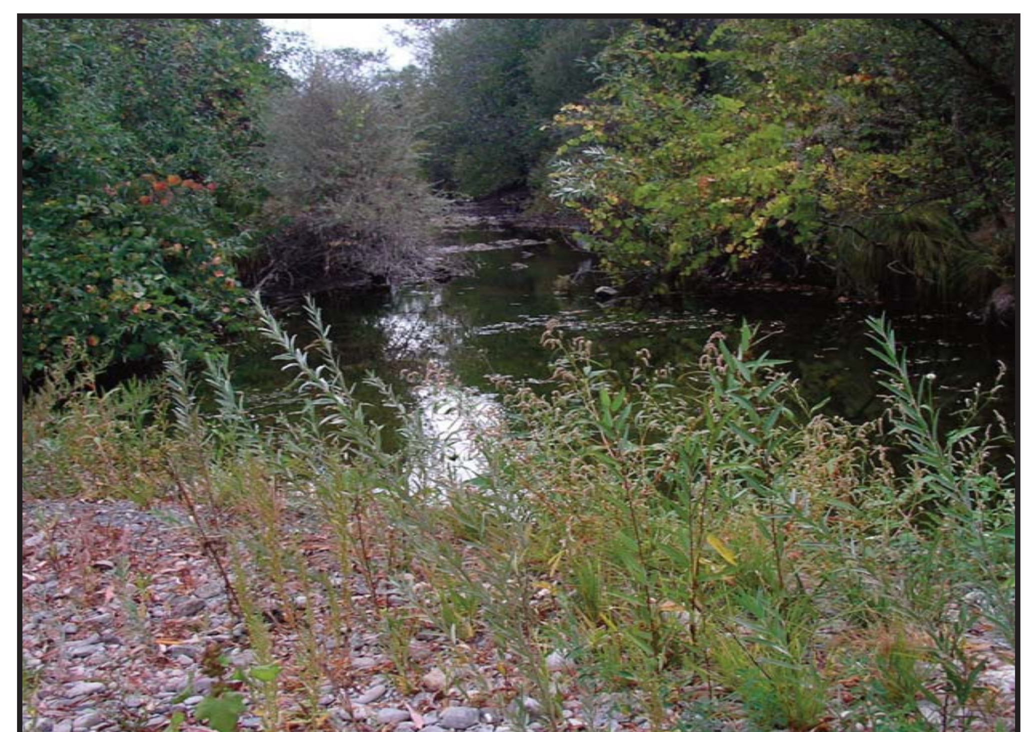
Invasive Species: No *Arundo donax* was recorded in Reach 1. Black locust was found in high densities on the right outer bank. A few black locust and Eucalyptus were recorded on the banks. On the floodplain a large number of redwood trees were planted and are being irrigated. Coast redwood are not naturally occurring in this location. The redwood plantings likely account for the low densities of other native trees in this area.

Spider Trees: Reach 1 has a low number of spider trees. The right bank has Ca. bay laurel, Ca. walnut, valley oak, and Oregon ash spider trees. The side channel has Ca. bay laurel spider trees.

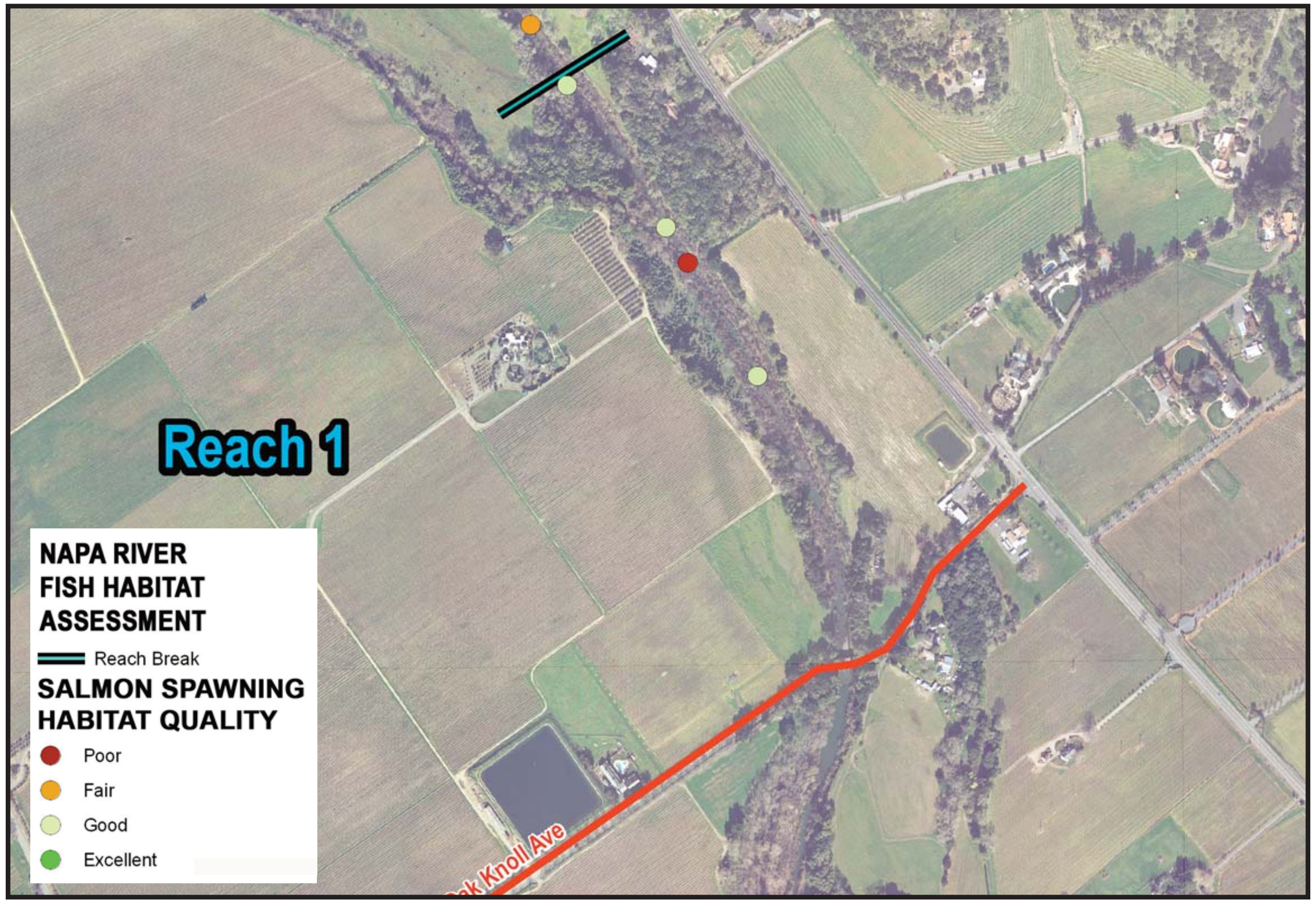
Understory: Understory species recorded include snowberry, Ca. wild grape, Himalayan blackberry, blue periwinkle, Ca. blackberry, Ca. rose, mugwort, coyote brush, pokeweed, poison oak, and fennel. Understory species along the channel include torrent sedge, cattails, river sedge, and grasses.

Riprap: Reach 1 has a moderate level of riprap on the right outer bank area totaling 148 linear feet.

Ecological Trends: The channel, outer bank, and right bank areas have large numbers of seedlings and are regenerating. Willow is the primary species regenerating and dominating the channel area. The right bank has larger numbers of Oregon ash as C1, C2, and C3 size class trees than any other species. On the left bank both Oregon ash and willow appear to be regenerating. Ca. bay laurel is regenerating on the outer bank and in the side channel where inundation levels are lower and infrequent. C4 trees are relatively numerous in Reach 1 and many are not being undercut but are stable. These are primarily Ca. bay laurel, valley oak, and willow. The mouth of Dry Creek exhibits bank erosion and the loss of large trees of several species including white alder and Ca. bay laurel. Overall tree density is high in comparison to other reaches.



IN LOCATIONS WHERE GRAVEL BARS OCCUR IN REACH 1 SEEDLINGS OF RIPARIAN TREES ARE ABUNDANT.

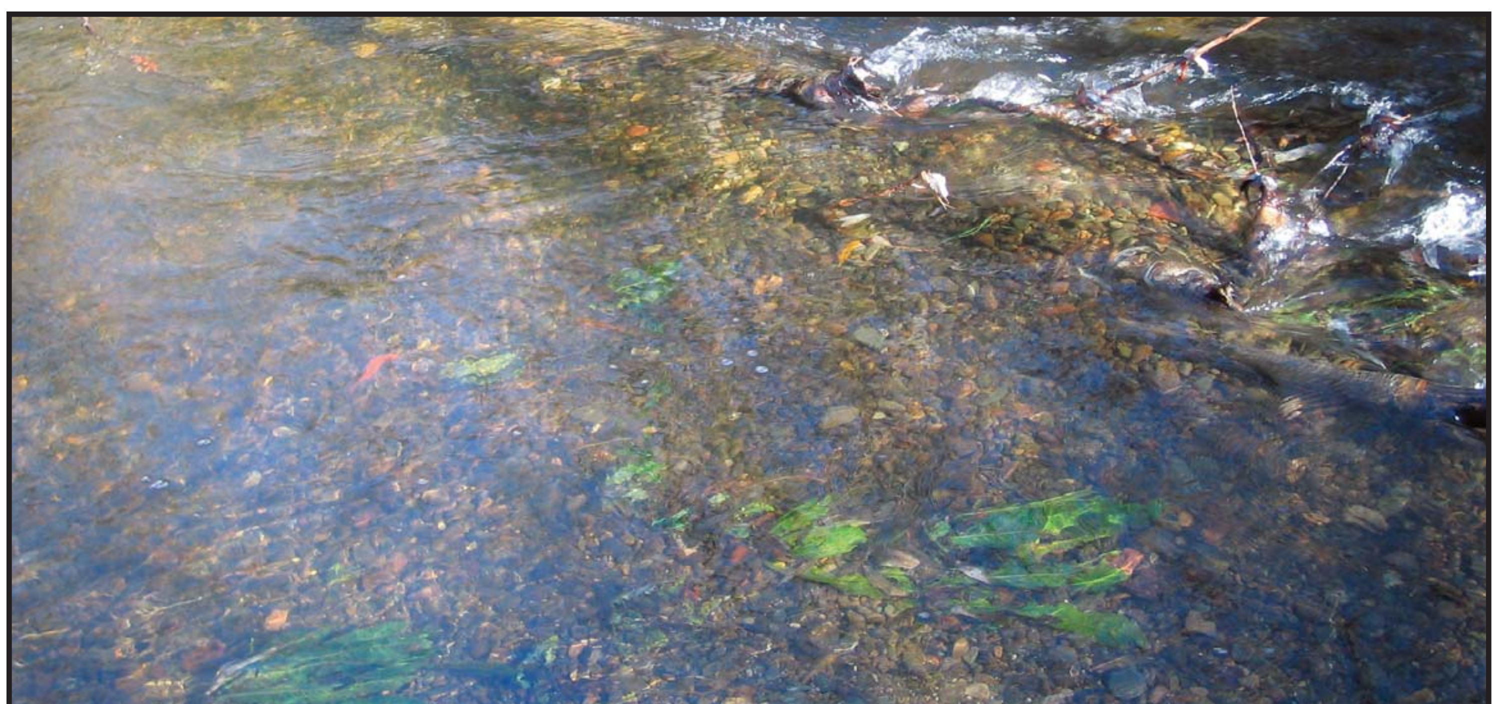


Reach 1 is characterized by relatively entrenched channel morphology with extensive hardpan clay in the bed and banks. This reach contains the highest ratio of flatwater units (i.e. runs, glides) in the project area and has relatively few potential spawning sites for salmon. The highest quality spawning habitat observed in this reach was at the confluence of Dry Creek, where a channel confluence pool and associated gravel bar had formed providing well sorted gravel patches and favorable velocities for salmon spawning.

No evidence of salmon spawning was observed in this reach in 2007, but this was a very low abundance year for salmon in Napa and much of California. We did observe high densities of juvenile Chinook salmon in this reach in May 2007 from the previous year's spawning, but it appears that the reach was not used by salmon in fall/winter 2007. Salmon would be expected to spawn in Reach 1 in higher abundance years.

This reach had a relatively low number of pools overall. The average pool shelter rating was 83, which is in the moderate range for providing rearing habitat and refugia for juvenile salmonids. The primary source of shelter in pools was small woody debris (<12" diameter) and overhanging vegetation.

No backwater or side-channel pools were present in this reach, and overall the amount of adjacent flood terrace or high flow refugia habitat was very low. Juvenile salmonids, primarily early fry stages, likely have a difficult time escaping high water velocities during winter storm flows.



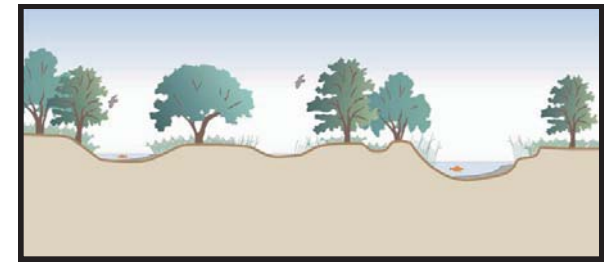
THE AREA OF HIGH QUALITY SPAWNING HABITAT IN REACH ONE OCCURS AT THE CONFLUENCE OF THE RIVER AND DRY CREEK.

Summary of Conditions in the Oakville to Oak Knoll Reach

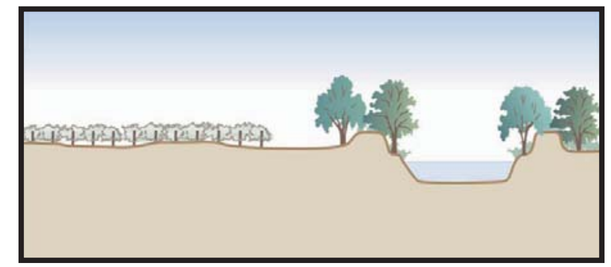
The geomorphic assessment found the Napa River in the project area to be deeply incised throughout the project area. There is evidence of around 10-15 feet of incision in the last 50 or so years, creating trench-like conditions in many areas (see Stages 3 and 4 opposite). Eighty-one percent of the cross sections reviewed had morphologies indicating some combination of entrenchment, lack of well defined low flow channels, lack of secondary floodplain terraces and oversteepened banks, while only 19% of sections had these features indicating more stable conditions. There is a shortage of riffle-pool habitat compared with what we would expect in a more naturally-functioning river of this type. There is abundant evidence that the Napa River is currently out of equilibrium with its watershed, with excess sediment transport capacity and a deficit of coarse sediment to transport, leading to continued erosive energy. The most favorable geomorphic conditions are found in Reaches 3, 9 and 10, with the most degraded conditions in Reaches 2, 4, 6 and 8. Although there is extensive bank instability along the river, the Napa River has been laterally stable in that its banktop position has not migrated much in the last 50-100 years. Incised rivers typically have high banks and a lack of bed deposition limits channel migration. A notable exception is Reaches 9 and 10, which have experienced several hundred feet of lateral change in the channel. In addition, the channel has relatively resistant cohesive bank materials, albeit with pockets of gravel and sand that allow faster erosion in places. This incised condition combined with high bank resistance has created a somewhat 'fossilized' condition in which the river has remained static and formerly active gravel bars and secondary channels have been colonized by vegetation. The presence of many reaches where the banks are starting to fail and the bank tops are eroding suggests that the river has reached a critical depth and that the next phase of the Napa River's evolution will be dominated by widening and bank erosion.

Under a no-action scenario with no additional bank stabilization, we expect that the banks will gradually fail and the river channel will widen, eating into the riparian vegetation at the top of bank. The first phase of such widening will involve a lot of bank top and levee erosion and will reduce and remove vegetative cover and increase solar heating of the river (Stage 4). As it widens, the channel will become less confined, and excess energy that currently causes erosion will be dissipated as friction in an increasing channel cross section (Stage 5). At some point the system will reach dynamic equilibrium, where the sediment transport capacity balances the incoming sediment load (Stage 6). At this width, the river will shift from eroding to transporting sediment. There will be balance between the volume of sediment entering and leaving a reach. There will still be erosion on the outside of bends, but at a reduced rate than currently. Material eroded from bends will be deposited and reworked in the channel to create new floodplain areas and gravel bars. Deposition of bars will create riffle-pool habitat and better riparian conditions. Deposition of sediment will also lead to periodic channel avulsions within the riparian corridor, creating secondary channels that form fish refugia. Deposition and periodic avulsion will create a dynamic environment for riparian vegetation, with colonizing species growing in patches and a range of ages and ecological niches formed by disturbances. Based on the lateral stability of the river we might expect this process to take over a hundred years to play out, and the resulting river to be in the order of 100-300 feet wider at the bank top than currently. The erosion would be most severe in the early stages, and would be expected to decrease exponentially over time. There still would be erosion after equilibrium had been reached – the river would form a meandering corridor within the wider riparian corridor, and would periodically erode where it encountered the outside edge of the riparian corridor. Channel avulsions would be somewhat less predictable than at present, though there would be less total erosion.

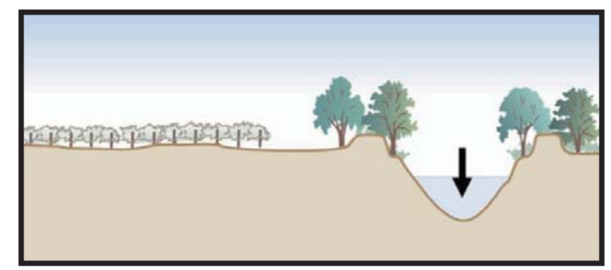
CONCEPTUAL MODEL OF INCISED CHANNEL EVOLUTION
(MODIFIED FROM SCHUMM, 1984 BY SIMON AND HUPP, 1986)



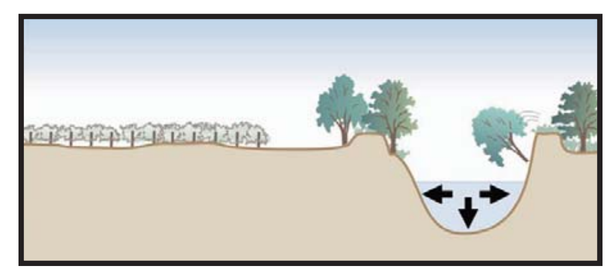
Stage 1
Prior to Euro-American settlement the Napa River had a multi-thread channel with primary and secondary channels and islands. Much of the floodplain was poorly drained wetland as alluvial fans (e.g. at the site of Yountville) spread runoff through distributary channels and impeded flow down valley. The main channel was probably around the same width as present, but around half the depth.



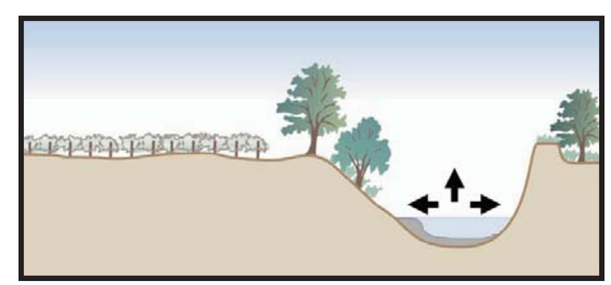
Stage 2
Over the last 150 years the floodplain was drained and secondary channels were filled in to allow farming. Levees were built to reduce flooding, concentrating more water in the main channel, and increasing velocity and erosion. Channel management to increase flood capacity such as gravel and vegetation removal also simplified the channel, thereby reducing habitat.



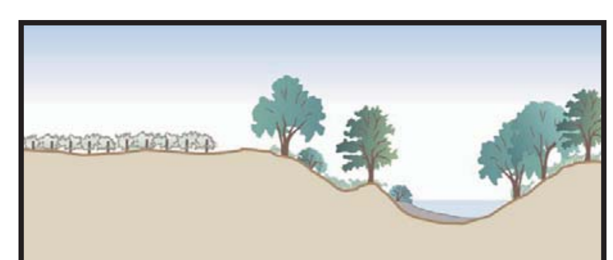
Stage 3
In response to more concentrated flows and a smoother channel, the mainstem cut downwards, eroding out many of the gravel bars and riffle-pool habitat areas. Incision also lowered the water table, making riparian regeneration harder. Incision was magnified by dam construction cutting off gravel from the headwaters, and by urbanization and drainage in the watershed increasing the amount of water in the mainstem.



Stage 4
Once the banks reached a critical height they begin to erode and slump, causing widespread channel widening and loss of riparian trees. This combination of incision and widening produces the "trench" channels we see in much of the Project area, and upstream in Rutherford.



Stage 5
Once the channel has widened to a certain point, the erosive capacity of the river comes more into equilibrium with its sediment load and net erosion slows. Typically the banks still erode back to a more stable angle, and the surplus sediment is deposited in the bed to eventually form a new floodplain, gravel bars etc.



Stage 6
As the system reaches dynamic equilibrium there is a balance between sediment brought in and sediment eroded, slowing erosion. Riparian vegetation colonizes the new floodplain and more stable banks. Over time sediment is reworked, producing secondary channels and terraces at different heights. These features promote shade and create diverse ecological niches.

Riparian features are summarized by reach and provide a detailed description of riparian conditions. This section compares the features of the reaches, summarizes trends over the entire project area, and answers the seven questions posed by this study and outlined below:

1. Is there a reference reach in the project area representing undisturbed or target ecological conditions?
2. How do different reaches vary in vegetation density, and can these differences be related to physical parameters such as channel width and depth, or flow velocity?
3. How do different reaches vary in their biodiversity and successional status, and can these differences be related to physical parameters of channel width and depth, or flow velocity? Are riparian tree species able to regenerate and undergo ecological succession with the altered physical dynamics of the current Napa River?
4. Is there a relationship between invasive non-native plants and regeneration of native riparian species?
5. Where are existing trees in danger of being undercut and lost along the entrenched channel?
6. Where does rock riprap affect regeneration of riparian vegetation?
7. Where do areas of significant ecological value occur?

1. Riparian Reference Reach

A reference reach is an area of habitat that is representative of undisturbed ecological and physical conditions which can serve as an example for restoration efforts. Although Reaches 10 and 1 are wider than the other reaches, they do not have ecologically representative conditions. Reach 10 rapidly widened in a large flood event from a much narrower channel and has a complex level of morphology. The riparian forest developed after the widening and has not formed a mature forest. Reach 1 is also wider than most of the other reaches; however, the channel bottom in this reach is dominated by a resistant clay layer and therefore does not represent a reference ecological condition. It appears that none of the reaches in the project area can serve as a reference for the ecological conditions the Napa River ecosystem would have under relatively undisturbed conditions. Instead, Reaches 1 and 10 represent two different types of adjustment in the river channel and the succession of vegetation in response to these adjustments.

In Reach 10 the upstream portion of the channel widened and developed complex morphology including floodplains, a secondary channel and an outer bank. Bank erosion as evidenced by spider trees and riprap is very low. Over time, Reach 10 will likely develop mature riparian forest as well as regenerate new forest and provide large wood to the aquatic habitat. Reach 10 also has the highest level of Arundo in the project area, which will affect its future ecological processes. Reach 10 represents an evolution of the riparian system in response to channel widening in an area dominated by alluvial substrate.

In Reach 1 the river channel has widened and deepened but has a great deal of resistant hardpan clay on the bed and banks. In this reach, plant growth and regeneration are limited by this clay layer. The channel bottom has areas of gravel where willow grows densely. This clay layer is prevalent in Reaches 7-2 and therefore Reach 1 could represent the outcome of channel widening in these other reaches.

Reaches 1 and 10 represent two potential future ecological conditions on the Napa River.

2. Vegetation Density and Physical Processes

The 2-year, 5-year and 10-year average velocities (in ft./second) for each reach were plotted against the density of all trees (trees/acre) in the channel only, in the channel and bank areas and in the channel,

REACH 10 REPRESENTS AN EVOLUTION OF THE RIPARIAN SYSTEM IN RESPONSE TO CHANNEL WIDENING IN AN AREA DOMINATED BY ALLUVIAL SUBSTRATE.

IN REACH 1, PLANT GROWTH AND REGENERATION ARE LIMITED BY A LAYER OF HIGHLY RESISTANT CLAY WHICH DOMINATES THE BED AND BANKS.

bank, and floodplains, outer bank and secondary channel if present. These velocities were also plotted against just seedlings in the channel area only. In addition, the width/depth ratio of each reach was plotted against the density of seedlings in the channel area only, the density of all trees in the channel and the density of all trees in the channel, banks, and other in-channel morphological areas.

We expected to find lower densities of trees in reaches with high flow velocities and a deep narrow entrenched channel while wider reaches with lower velocities were expected to have higher densities of trees. Reaches between widest and narrowest with medium width to depth ratios were expected to present median tree density values.

The three reaches with the highest width to depth ratio and the widest riparian corridors are 10, 5, and 1. Average flow velocities for the 2-year event are similar at 5.1-5.2 ft./sec. (see table on next page). However, tree densities in the channel vary greatly with a high density of 350 trees/acre in Reach 1, low density of 103 trees/acre in Reach 10 and a very low density of 8 trees/acre in Reach 5. The modeled average velocities for the 10-year event vary from 7.2 ft/sec. in Reach 1, 5.7 ft/sec. in Reach 10, and 6.3 ft/sec. in Reach 5. Tree densities in the combined morphological areas (banks, channel, floodplains, outer bank and secondary channels) of these reaches vary from high (332 trees/acre) in Reach 1 to low (123 trees/acre) in Reach 10 and low (130 trees/acre) in Reach 5. In the 10-year event, Reach 1 with the highest velocity had the highest tree density. Reaches 10 and 5, with nearly the same tree densities, had different velocities and far lower tree densities than Reach 1.

The reaches with the lowest width/depth ratio and narrowest riparian corridor are 4, 6, and 7. Reaches 3A and 3B are considered two separate channels and were not included here for comparison. The 2-year event average flow velocities are slightly different at 5.2 ft./sec. for Reach 4, 5.5 ft./sec. for Reach 6 and 5.9 ft./sec. for Reach 7. The density of trees in the channel area varies with Reach 7 which has the highest average velocity flow and a medium density of 183 trees/acre. While Reach 4 with lower flow velocity has a very low density of 24 trees/acre. Reach 6 has a low 99 trees/acre in the channel. The 10-year event produces an average velocity of 7.1 ft./sec. in Reaches 4, 6, and 7. Tree density in the combined morphological areas are medium at 220 trees/acre in Reach 4, medium at 238 trees/acre in Reach 7 and a low in Reach 6 of 199 trees/acre.

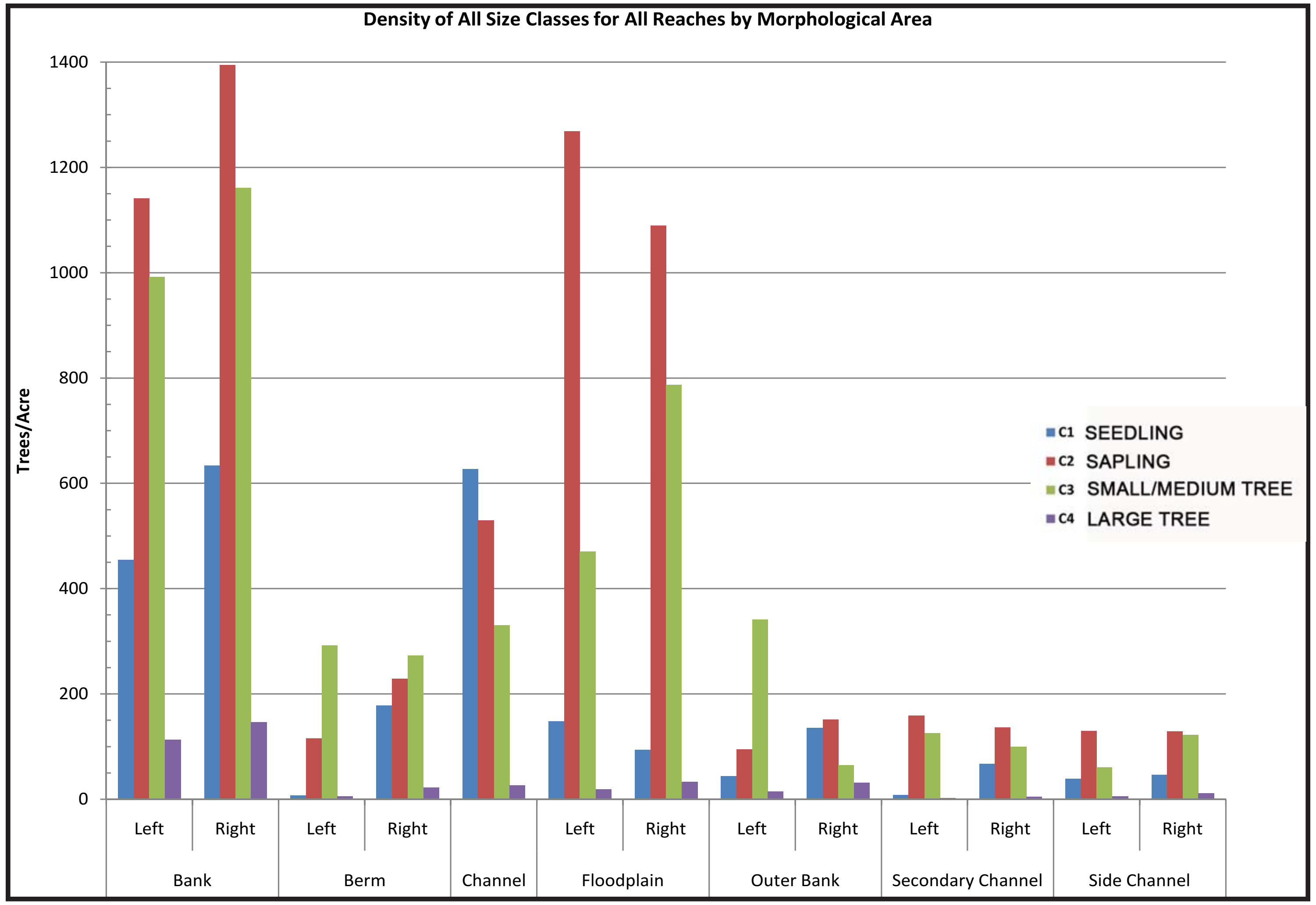
The reaches with a medium width to depth ratio and riparian corridor width are Reaches 2, 8, and 9. In these reaches the 2-year event average flow velocities are 6.1 ft./sec. for Reach 2, 5.8 ft./sec. for Reach 8, and 5.3 ft./sec. for Reach 9. Densities of trees in the channel were a low 93 trees/acre in Reach 2, a medium 139 trees/acre in Reach 8, and a high of 287 trees/acre in Reach 9. For the 10-year event, average velocities varied from 7.7 ft./sec. for Reach 2, 6.7 ft./sec. for Reach 8, and 6.2 ft./sec. for Reach 9. Tree densities for the combined morphological areas are high in Reach 2 at 326 trees/acre which has higher 10-year event velocity flows than Reach 9 with a medium density of 242 trees/acre. Reach 8 has a low density of162 trees/acre and a 10-year event average flow velocity at 6.7 ft./sec.

The analysis showed that there are differences in tree density between the narrowest and widest reaches. Reach 4 is the narrowest and most entrenched and has extremely low densities of trees in the channel. Reach 1 is one of the widest, least entrenched and has the densest vegetation in the channel.

However, the analysis does not show a consistent relationship in all reaches between tree density with either entrenchment or flow velocity. A feature that may be affecting tree growth in the channel is the highly resistant clay that becomes more and more dominant in the river channel downstream of Reach 7. From Reaches 6 to 2 where this hardpan clay dominates the bed, vegetation density in the channel is low. In Reach 1 there are gravel deposits and areas eroded through the hardpan likely due to the greater width of this reach and the influence of Dry Creek, a major tributary.

THE WIDEST REACHES IN THE PROJECT AREA ARE 10, 5 AND 1. ABOVE: REACH 10 HAS SEVERAL FLOODPLAIN AREAS AND SECONDARY CHANNELS AND IS THE WIDEST REACH OF THE PROJECT AREA.

BELOW: REACH 5 HAS LOW DENSITY VEGETATION IN ALL ITS MORPHOLOGICAL AREAS AND NO REGENERATION IN THE CHANNEL AREA DESPITE BEING ONE OF THE WIDER REACHES.

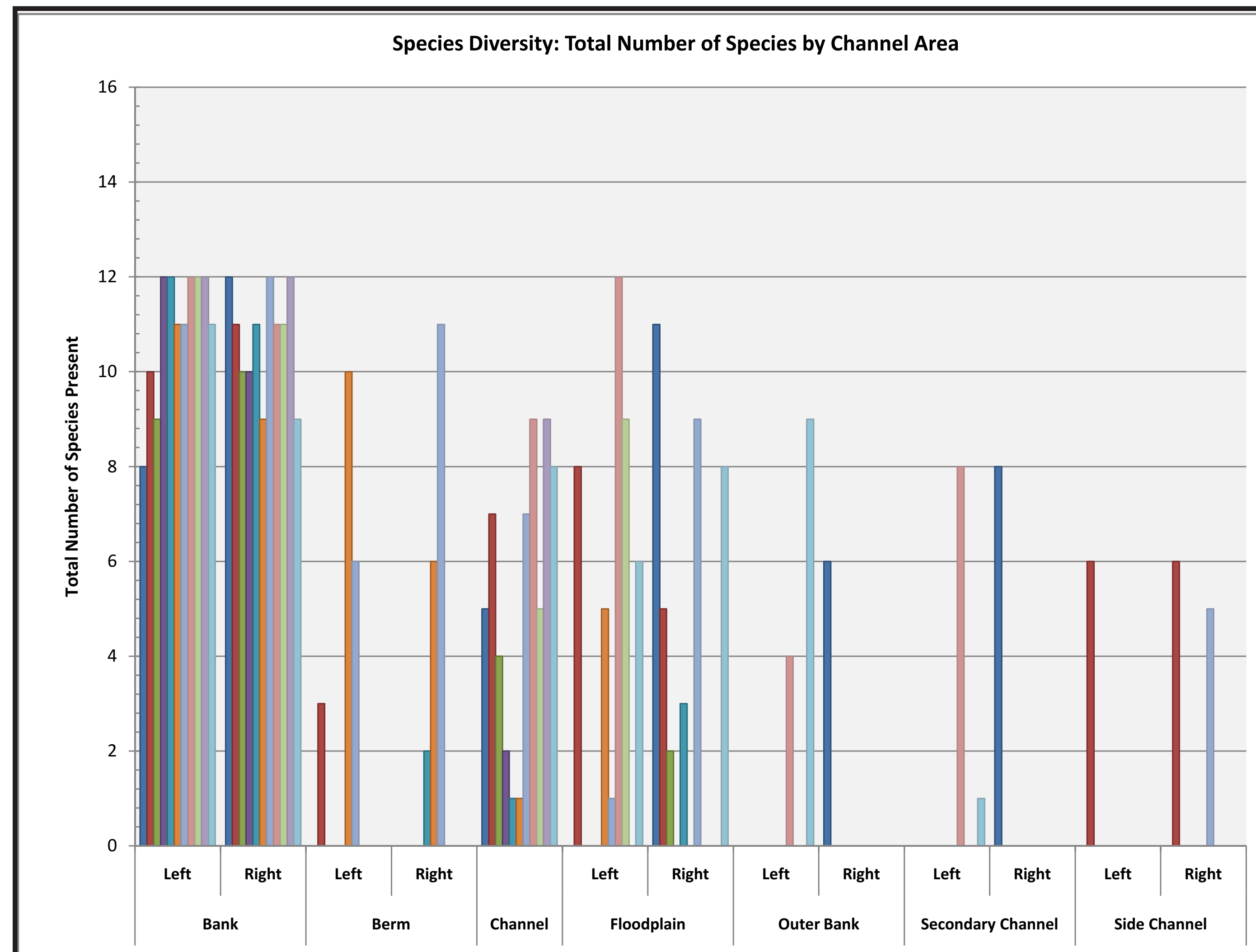


Summary of Features

Reach	Tree Density** (number of trees/acre) Channel Only	Tree Density (number of trees/acre) All Morphological Areas*	2-Year Flood Event Average Velocity (in ft./sec.)	5-Year Flood Event Average Velocity (in ft./sec.)	10-Year Flood Event Average Velocity (in ft./sec.)	Relative Corridor Width
1	High (350)	High (332)	5.2	6.6	7.2	Wide
2	Low (93)	High (326)	6.1	7.1	7.7	Medium
3a	Medium (166)	Medium (212)	4.2	5.3	5.8	Narrow
3b	Low (63)	Medium (216)	3.8	4.6	5.0	Narrow
4	Very Low (24)	Medium (220)	5.2	6.5	7.1	Narrow
5	Very Low (8)	Low (130)	5.1	5.8	6.3	Wide
6	Low (99)	Low (199)	5.5	6.6	7.1	Narrow
7	Medium (183)	Medium (238)	5.9	6.7	7.1	Narrow
8	Medium (139)	Low (162)	5.8	6.5	6.7	Medium
9	High (287)	Medium (242)	5.3	6.1	6.2	Medium
10	Medium (103)	Low (123)	5.1	5.6	5.7	Wide

* Includes channel, banks, floodplains, secondary channels and outer banks. Berms and side channels are not included. ** Densities are compared to both the median and the average of all measured values and rated as high, medium or low. Ratings reflect relative density between reaches

A RESISTANT CLAY LAYER DOMINATES THE BED AND LOWER BANKS OF THE NAPA RIVER CHANNEL FROM THE YOUNTVILLE CROSSROAD DOWN AND SEVERELY LIMITS VEGETATIVE GROWTH.



The other factor which must be considered in this analysis is the temporal nature of the riparian vegetation data. This data set represents what was present in the summer of 2007, a relatively dry year following a flood year in 2006. This data is unique to the conditions of 2007 and the study should be repeated after 5-10 years to provide an analysis of changes and trends in the system. This longer term approach may demonstrate a stronger correlation between vegetation density and particular physical parameters of the channel.

3. Biodiversity, Successional Status and Physical Parameters

Biodiversity

A total of 12 native tree species were recorded over the project area. These include willow, Fremont cottonwood, white alder, Oregon ash, box elder, big leaf maple, California walnut, live oak, valley oak, California buckeye, California bay laurel, and blue elderberry. Most reaches have 9-11 tree species. The greatest biodiversity occurs on the banks and in the floodplain areas.

Willow is the most abundant type of tree in the project area and dominates the channel and bank areas. Oregon ash and California walnut are co-dominants on the banks. At the top of the bank valley oak, live oak, and California bay laurel are abundant.

The dominance of willow in the Napa River may reflect the physical conditions of relatively high flow velocities and channel entrenchment. Willow is favored by these conditions as it is a pioneer species. Willow will sprout from the stems and roots of trees upended through erosion as well as from seeds. With the general lack of floodplains the channel and banks are the main areas available for tree growth. During the 10-year flood event flow velocities range from 5.1 ft./sec. to 7.7 ft./sec. With velocities greater than 6 ft./sec. it is difficult for many riparian seedlings to become established and develop into saplings.

Willows are the only species with large numbers of seedlings and saplings in the channel. Willow seedlings are much less abundant on the banks but saplings are very abundant. Willow is often planted as part of bank stabilization projects and such planted willow saplings were found midway up on 20 ft. vertical banks or even near the top of the bank. Two reaches—Reaches 4 and 5—have less than 20 willow seedlings in the channel and do not have any other species of seedlings. Reach 4 is the narrowest reach and highly entrenched. Reach 5 is one of the widest reaches but may have recently eroded to a wider condition and its channel is dominated by a resistant clay layer. Reaches 9 and 10 have low numbers of white alder and Fremont cottonwood in the channel at the base of the bank and on the floodplains. This is the only reach with any significant numbers of these other pioneer species; however, willow still dominates the channel.

THE NARROWEST REACHES ARE 4 ,6 AND 7.

REACH 4 (LEFT AND RIGHT) HAS NO TREE REGENERATION AND MOST OF THE TREES ON THE BANKS ARE BEING ERODED OUT.

ABOVE: REACH 1 IS WIDE BUT VEGETATIVE GROWTH IS RESTRICTED BY A HIGHLY RESISTANT CLAY LAYER ON THE CHANNEL AND BANKS.

Oregon ash is the second most abundant species and seedlings were often found in the midbank area of eroding disturbed areas. The Oregon ash seedlings appeared to do well underneath the canopy of other trees, unlike many species which need full sunlight. Oregon ash saplings are the most numerous size class but seedlings are also abundant on both banks.

California walnut is also fairly abundant on the banks with saplings and small/medium trees. There are also a large number of seedlings and over 100 large C4 trees.

Live oak and valley oak are most abundant near the top of the bank and have numerous seedlings. Live oak saplings are nearly as numerous as seedlings.

For the valley oaks, large C4 trees are particularly numerous with nearly 200 of these trees on each bank. The California walnut, live oak, and valley oak occupy the upper and top of bank areas where inundation and scour are infrequent.

Comparing biodiversity by reach with the width to depth ratio and flow velocity, it appears the majority of wide and medium reaches (1, 2, 8, 9, and 10) have high to medium levels of biodiversity. By comparison, the narrow reaches (4, 6, and 7) have low biodiversity. Reach 5, with a high width to depth ratio, has a low level of biodiversity even though its 2-year and 10-year event flow velocities are lower than many of the other reaches. Reach 5 recently eroded to a wider form and during this process lost much of its riparian vegetation.

Size Class, Ecological Succession, and Regeneration

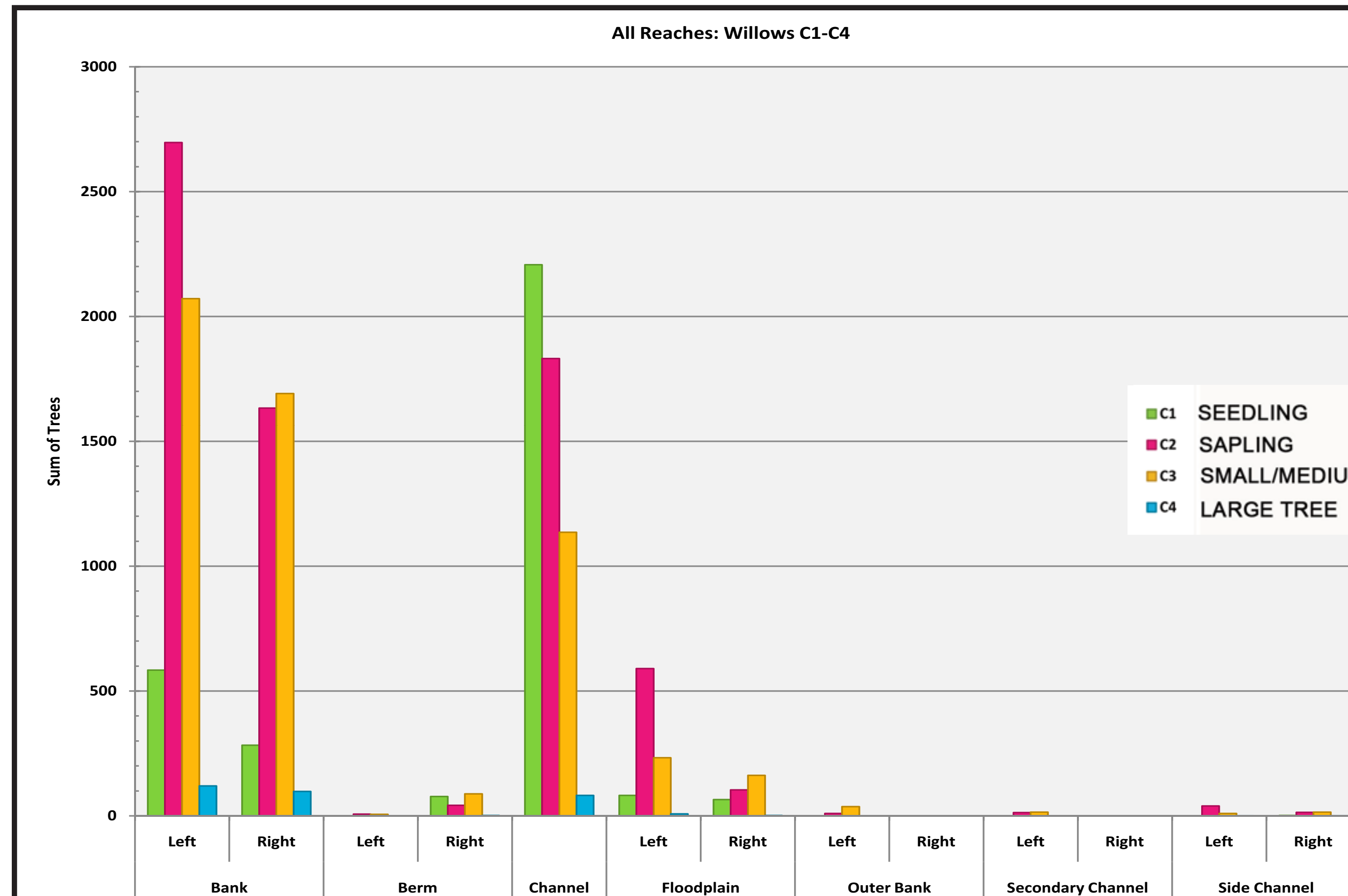
The size class (seedling or C1, sapling or C2, small/medium tree or C3, and large tree or C4) was recorded for all trees counted. This data provides an indication of succession status and what species are regenerating in what morphological areas and reaches.

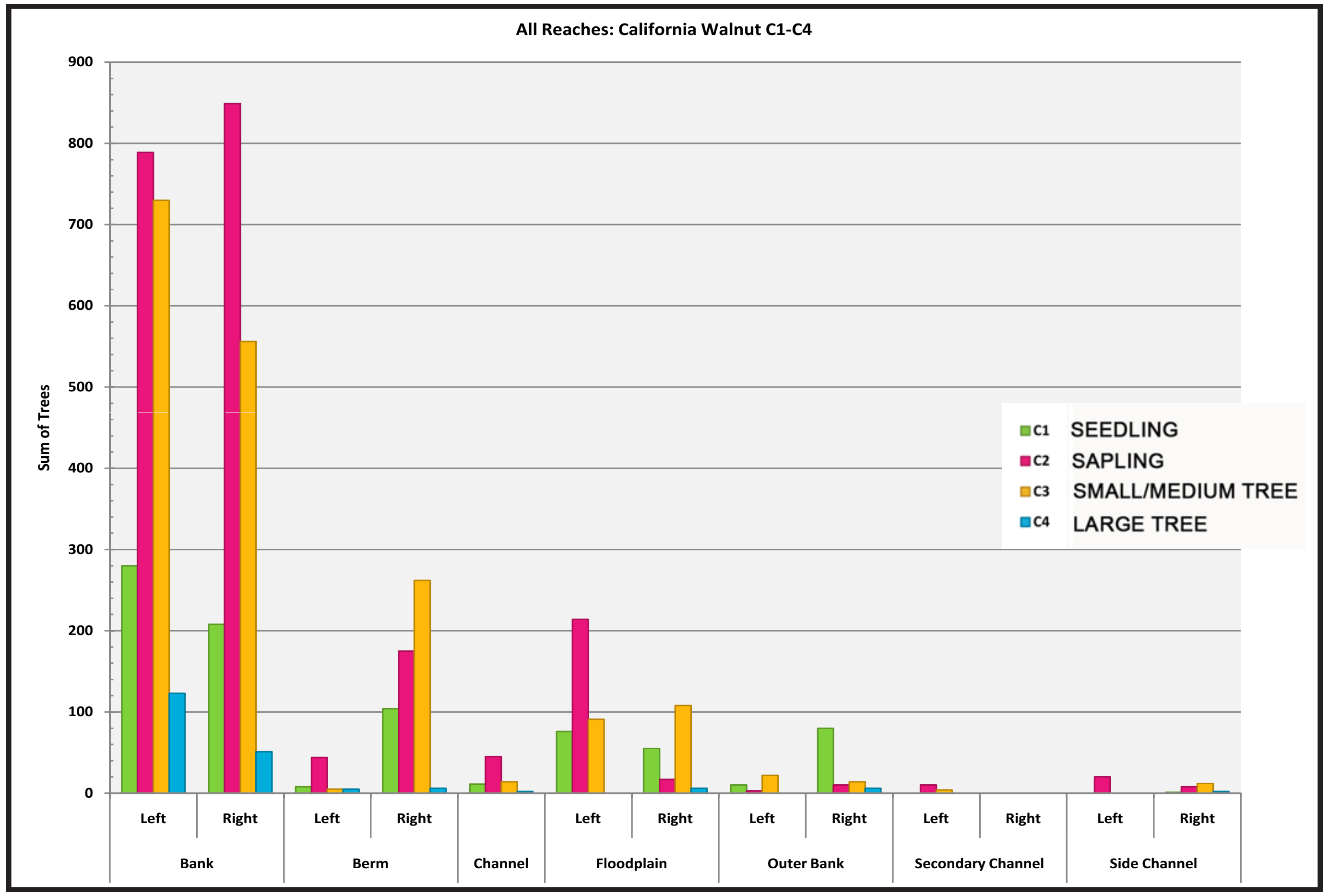
An indication of ecological condition is the proportion of different size classes of trees. For the purpose of this analysis a tree species was considered to be regenerating in a particular reach only if the count of C1 trees was 50% or greater than the C2 or C3 count. Seedlings tend to germinate and die prior to becoming saplings or small/medium trees. Because this study only encompasses one count of trees and size classes, it cannot document actual regeneration. Another study completed in 5-10 years after this one will be needed.

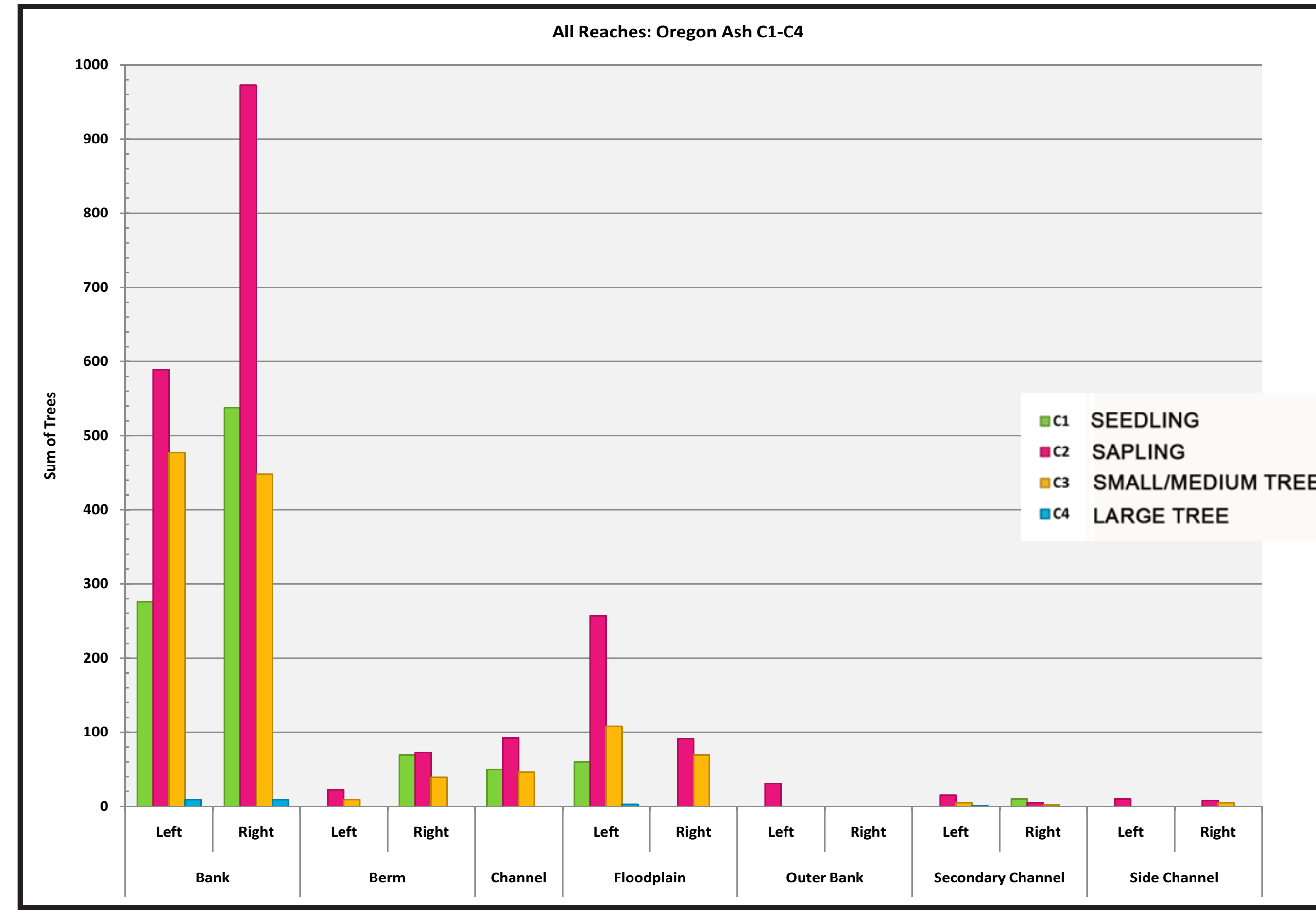
As discussed in the previous section, certain tree species occur in certain areas of the channel and demonstrate high numbers of seedlings. Over the project area willow is regenerating in most parts of the channel, but not on the banks. Willow saplings and small trees are numerous on the banks and in the channel, very few large willow trees occur. Oregon ash and California walnut are co-dominants on the banks, particularly the low and middle bank areas, and are regenerating on the banks and floodplains but not in the channel. Oregon ash saplings and small/medium trees are very abundant on the banks, but large trees are very rare. California walnut saplings and small/medium trees are very abundant on the banks. Large walnut trees are also relatively numerous. Live oak and valley oak occur primarily on the upper and top of bank and berm areas and are regenerating in these areas. Live oak saplings are as abundant as seedlings, but small/medium trees are much less numerous. Live oaks are often planted along the border of vineyards and the river. Large trees are moderate in abundance. Valley oak saplings and small/medium trees are much less abundant than live oak. Large valley oak are the most abundant species of large tree.

The classic ecological model for riparian ecosystems describes a physical system with a non-entrenched meandering channel and a horizontal floodplain. In the Napa River the channel is highly entrenched with

REACH 6 HAS A LARGE AMOUNT OF RIPRAP, LITTLE REGENERATION AND LOW VEGETATION DENSITY.




All Reaches: California Walnut C1-C4
Sum of Trees
C1 SEEDLING
C2 SAPLING
C3 SMALL/MEDIUM TREE
C4 LARGE TREE
Left Right Left Right Left Right Left Right Left Right Left Right
Bank Berm Channel Floodplain Outer Bank Secondary Channel Side Channel


All Reaches: Oregon Ash C1-C4
Sum of Trees
C1 SEEDLING
C2 SAPLING
C3 SMALL/MEDIUM TREE
C4 LARGE TREE
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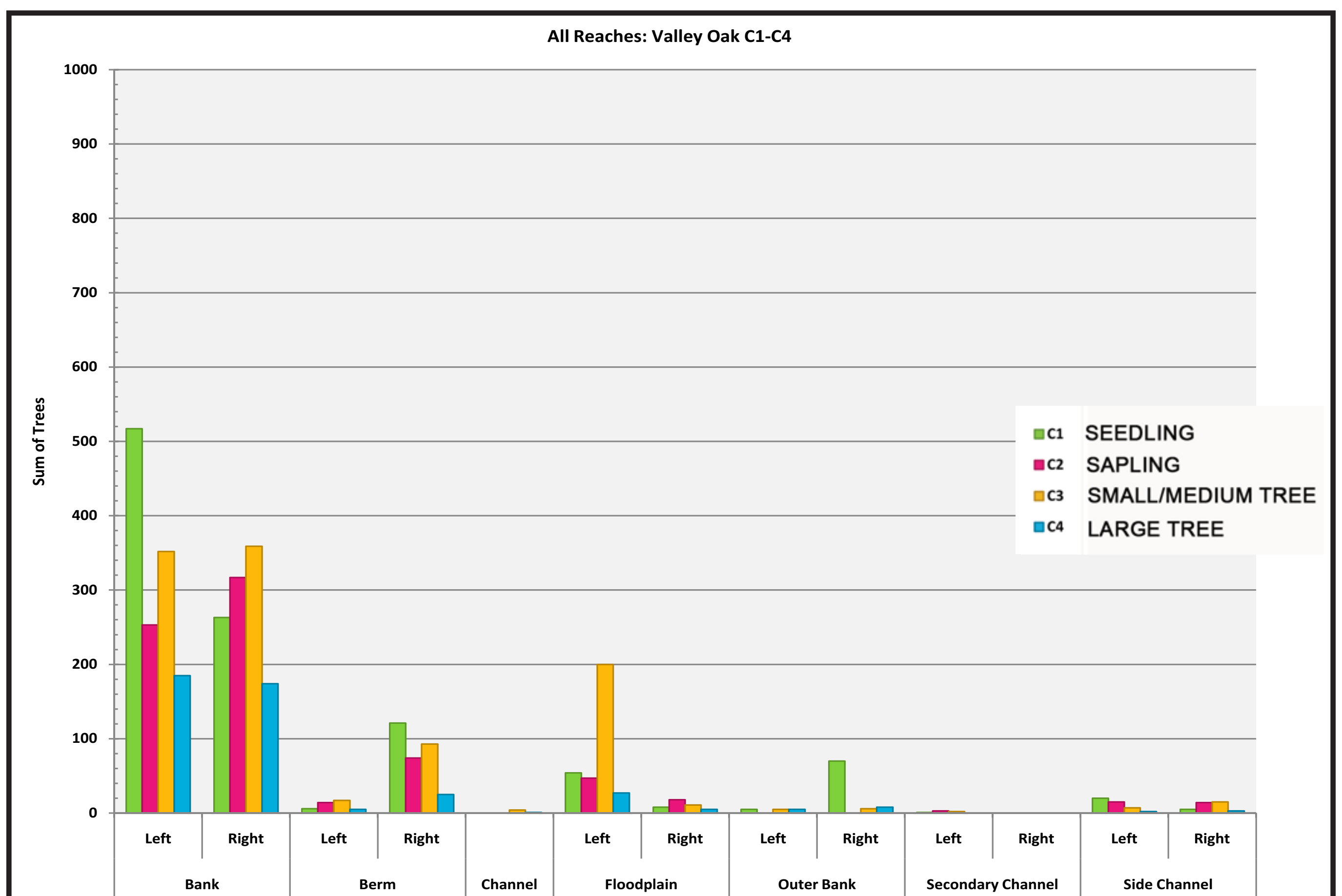
Bank Berm Channel Floodplain Outer Bank Secondary Channel Side Channel


All Reaches: Valley Oak C1-C4
Sum of Trees
C1 SEEDLING
C2 SAPLING
C3 SMALL/MEDIUM TREE
C4 LARGE TREE
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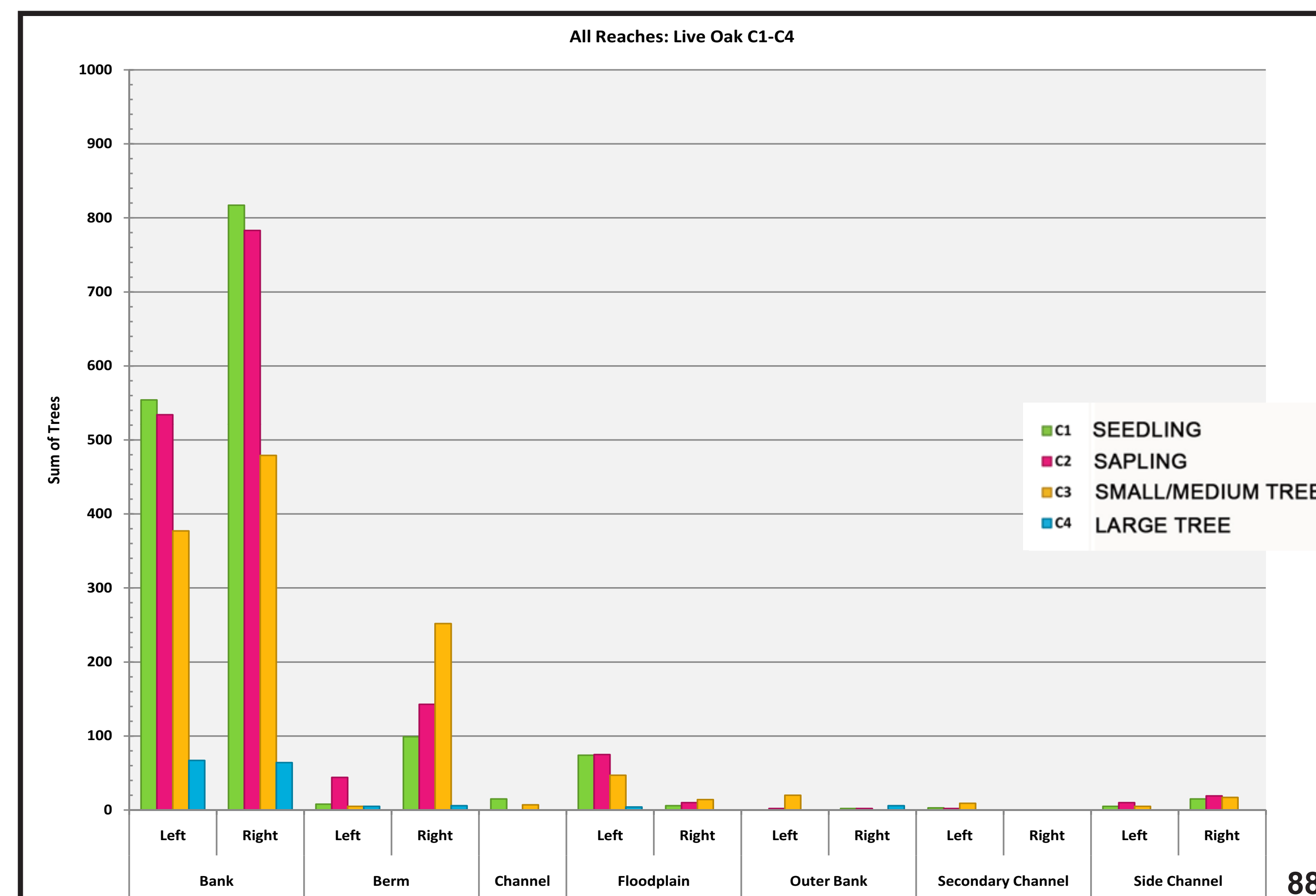
Bank Berm Channel Floodplain Outer Bank Secondary Channel Side Channel


All Reaches: Live Oak C1-C4
Sum of Trees
C1 SEEDLING
C2 SAPLING
C3 SMALL/MEDIUM TREE
C4 LARGE TREE
Left Right Left Right Left Right Left Right Left Right Left Right
Bank Berm Channel Floodplain Outer Bank Secondary Channel Side Channel

vertical banks that are subject to various levels of scour and inundation. There is very limited space for plant growth. The riparian plants appear to be vertically distributed over the channel and banks as a condition of inundation frequency. Willows are distributed in the channel, where scour and inundation are frequent. Oregon ash and California walnut appear on the mid to upper bank where scour and inundation occur during less frequent flood events. On the top of the bank and berm where only a large flood inundates the area, live and valley oaks are numerous.

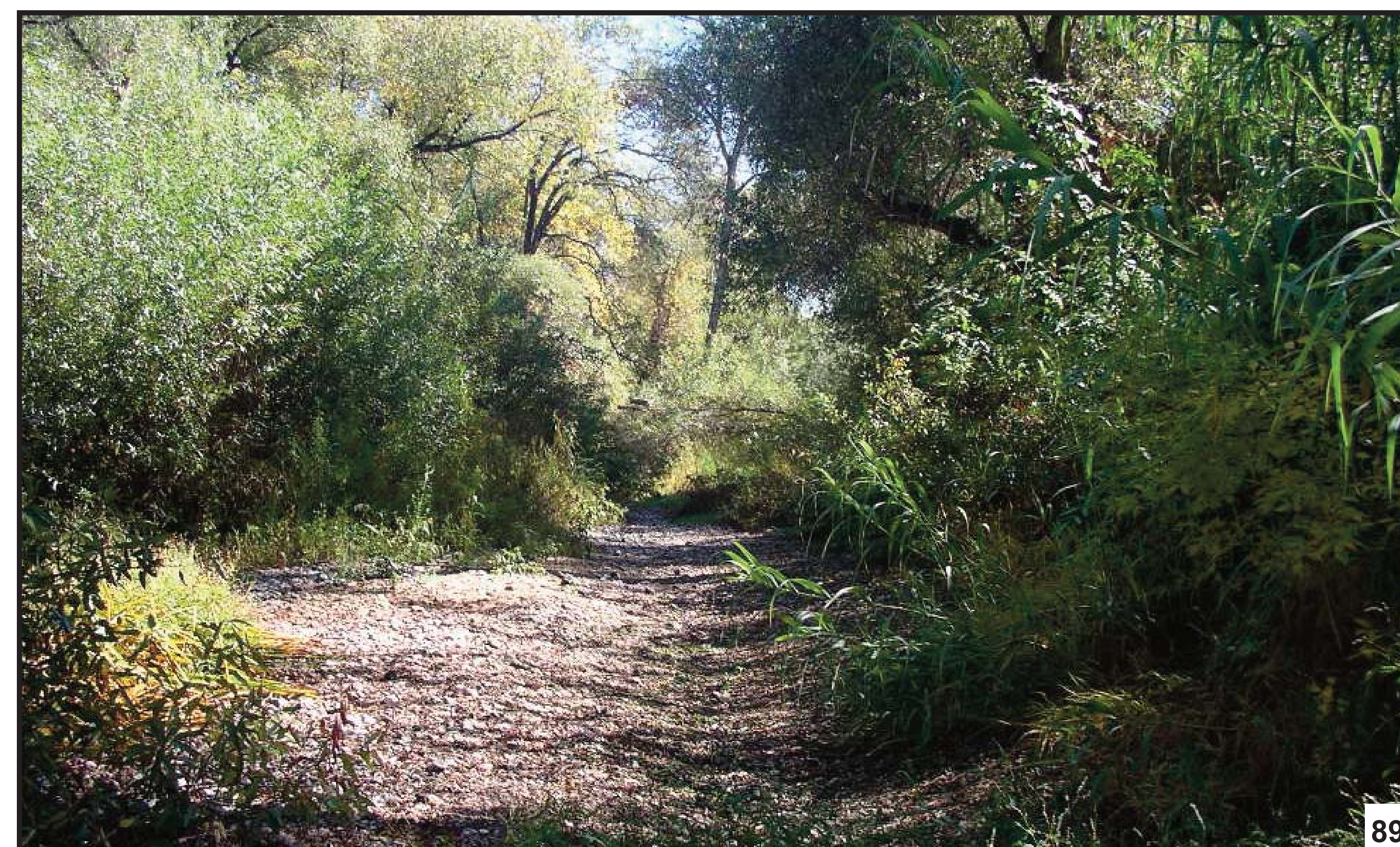
While this vertical distribution is unique it is likely far less stable than a horizontal floodplain/channel system. As is discussed in the “Spider Trees” section below, many of the medium and large trees are being undercut and will be eroded out. It is likely that the smaller size class trees are also regularly eroded out. The size class distribution of each species in each reach was compared to the width to depth ratio and 2- and 10-year flow velocities. The abundance of Arundo donax and other invasive plants were also reviewed as these plants will compete with native seedlings, saplings, and small trees. The wide reaches

Regeneration, Spider Trees and Physical Features

Reach	Width to Depth Ratio - Corridor Width	2-Year Flood Event Average Velocity (ft./sec.)	10-Year Flood Event Average Velocity (ft./sec.)	Density*** of Trees in Channel Only	Density of Trees in all Morphological Areas**	Species* Regenerating	Abundance of C4 Size Class Trees	Spider Trees/ Mile	Riprap Abundance	Arundo Abundance
1	High - Wide	5.2	7.2	High	High	WI, OA, WN, LO, VO	High	Low	Medium	None
2	Medium - Medium	6.1	7.7	Low	High	WI, LO, OA, VO, WA	High	High	Medium	Very Low
3a	Low - Narrow	4.2	5.8	Medium	Medium	WI, WN OA & LO-very low	Medium	Medium	Medium	Low
3b	Low - Narrow	3.8	5.0	Low	Low	OA-very low	Medium	Medium	Medium	None
4	Low - Narrow	5.2	7.1	Very Low	Low	No WI, LO & VO-low	High	High	High	Medium
5	High - Wide	5.1	6.3	Very Low	Low	None	Low	Low	Medium	Medium
6	Low - Narrow	5.5	7.1	Low	Medium	Low to None	Medium	Medium	High	Medium
7	Low - Narrow	5.9	7.1	Medium	High	Low to None	High	High	Very High	Medium
8	Medium - Medium	5.8	6.7	Medium	Medium	WI-low, LO, VO, WN	High	High	Medium	Medium
9	Medium - Medium	5.3	6.2	High	Low	WI; LO & WA,& FC-low	Medium	Low	High	Very High
10	High - Wide	5.1	5,7	Medium	Low	WI; LO & VO & WN & FC-low	High	Low	Low	High

*** WI = Willow; OA = Oregon ash; WN = California walnut; WA = White alder; FC = Fremont cottonwood; LO= Live oak; VO = Valley oak ** Includes channel, banks, floodplains, secondary channels and outer banks. Berms and side channels are not included.**
*****Densities are compared to both the median and the average of all measured values and rated as high, medium or low. Ratings reflect relative density between reaches.**

REACH 7 HAS LITTLE TO NO REGENERATION AND A HIGH LEVEL OF BOTH SPIDER TREES AND RIPRAP.



THE REACHES WITH A MEDIUM WIDTH ARE 2 , 8 AND 9.
ABOVE: REACH 8 HAS MEDIUM DENSITY VEGETATION IN ALL OF ITS MORPHOLOGICAL AREAS.

with a high width to depth ratio had a mix of successional status and regeneration conditions. For example, the wide reaches such as Reach 1 had willow, Oregon ash, California walnut, live oak, and valley oak regenerating. Reach 10, however, had high willow regeneration but low regeneration of live oak, valley oak, California walnut, and Fremont cottonwood. Reach 10 also had a high abundance of Arundo donax, which competes with native seedlings. Reach 5 had almost no regeneration of any tree species despite having a much lower abundance of Arundo donax than Reach 10.

All of the medium width reaches had regeneration occurring. Reach 2 had willow, live oak, valley oak, and Oregon ash regenerating. Reach 8 had regeneration of live oak, valley oak, and California walnut, but very low willow regeneration and a medium abundance of Arundo donax. Reach 9 had live oak and willow regenerating in abundance, low numbers of white alder and Fremont cottonwood regenerating and a high abundance of Arundo donax.

The narrow reaches demonstrated low to no regeneration. Reaches 6 and 7 had no regeneration of any species. Reach 4 had low regeneration of live oak and valley oak at the top of the bank and no regeneration of any species in the channel. Reaches 3A and 3B had low regeneration of Oregon ash (3B), live oak (3A), California walnut (3A) and high regeneration of willow (3A).

The successional status and regeneration conditions are clearly affected by corridor width and the level of entrenchment. The most entrenched reaches have no regeneration. The medium and wide reaches have medium to high levels of regeneration. The exception is Reach 5, which despite its high width to depth ratio has no regeneration. This reach may have recently widened and eroded out many of its trees but is not currently regenerating new growth.

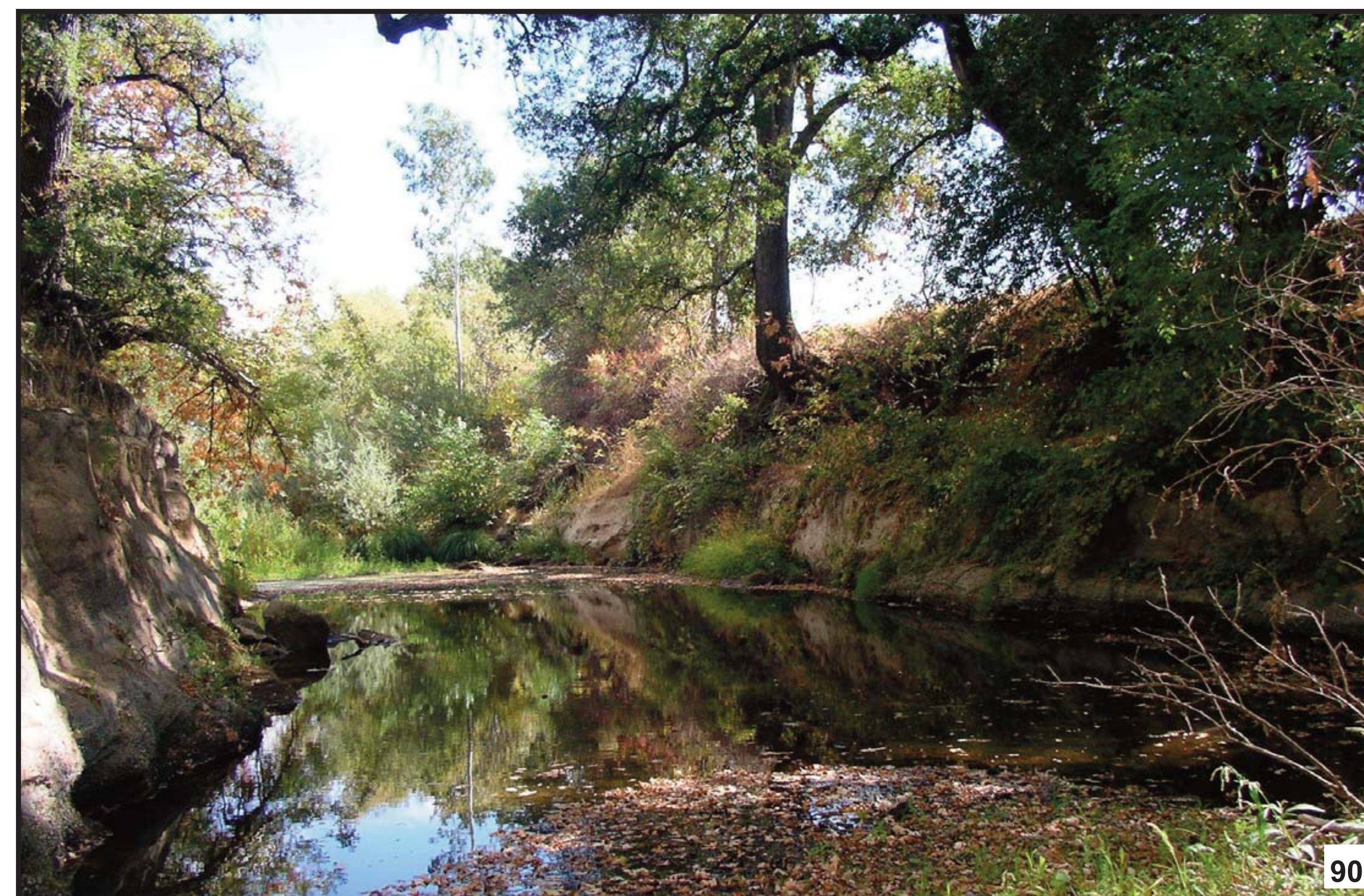
4. Invasive Non-Native Plants

Arundo donax, or giant reed, is a non-native invasive species which invades riparian areas. It is the largest grass in the world and spreads vegetatively. Arundo can grow up to two inches a day and can grow to over 20 feet in height. Due to its rapid growth and tall stature, Arundo can out-compete slower growing native seedlings. The occurrence of Arundo was mapped in the project area. The highest occurrences of Arundo are in Reaches 9 and 10. There is a lack of regeneration of many mid and upper bank species in Reach 9 and 10, which may be due to the abundance of Arundo. Arundo abundance diminishes downstream of Reach 8 and may be related to the hardpan clay which dominates the channel.

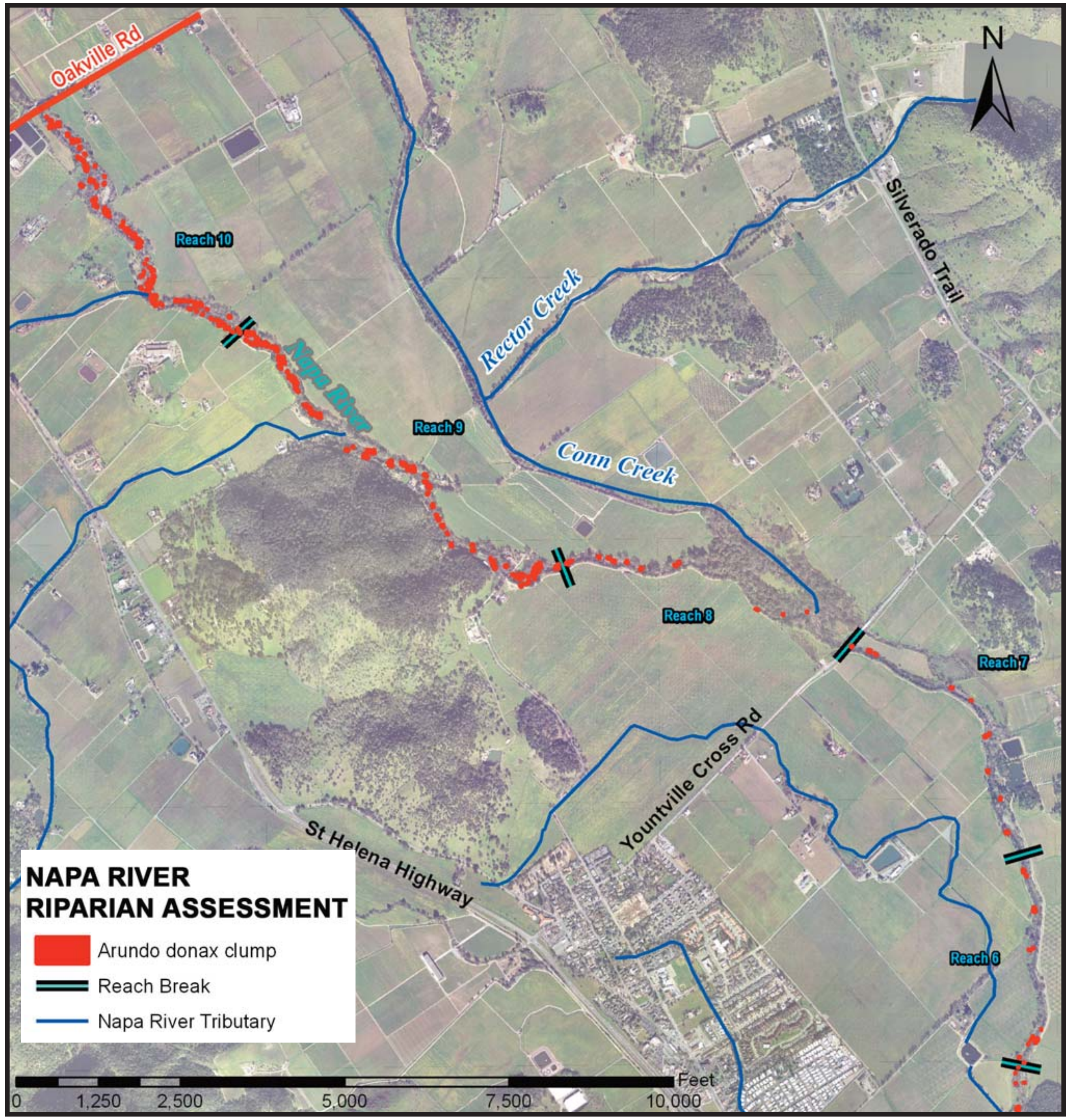
A number of other invasive trees were also mapped. These include black locust, tree-of-heaven, Eucalyptus, and acacia. Ornamental trees such as London planetree, Lombardy poplar, plum, pine, and planted coastal redwood were also mapped. Planting coastal redwood was a recommendation made in the past for controlling Pierce's Disease, a fatal disease of winegrapes. There are large numbers of redwoods planted in Reach 1. Black locust is most abundant in Reaches 1, 6, 7, and 9. Eucalyptus is most abundant in Reaches 2, 3, 5, 6, and 10. These invasive tree species were mapped against the density of C1 and C2 size class trees to evaluate if the invasive trees were affecting regeneration. No relationship between native seedling and sapling density and density of invasive tree species was apparent.

The understory vegetation of most of the reaches was dominated by invasive non-native plants such as Himalayan blackberry and blue periwinkle. Wild grape was also very common. The non-native understory species can reduce the germination of native seedlings and play a role in reducing regeneration. The invasive understory species tend to grow outside the scour channel on banks and floodplains. In many locations, the invasive species have been removed due to Pierce's Disease problems and a native understory was installed.

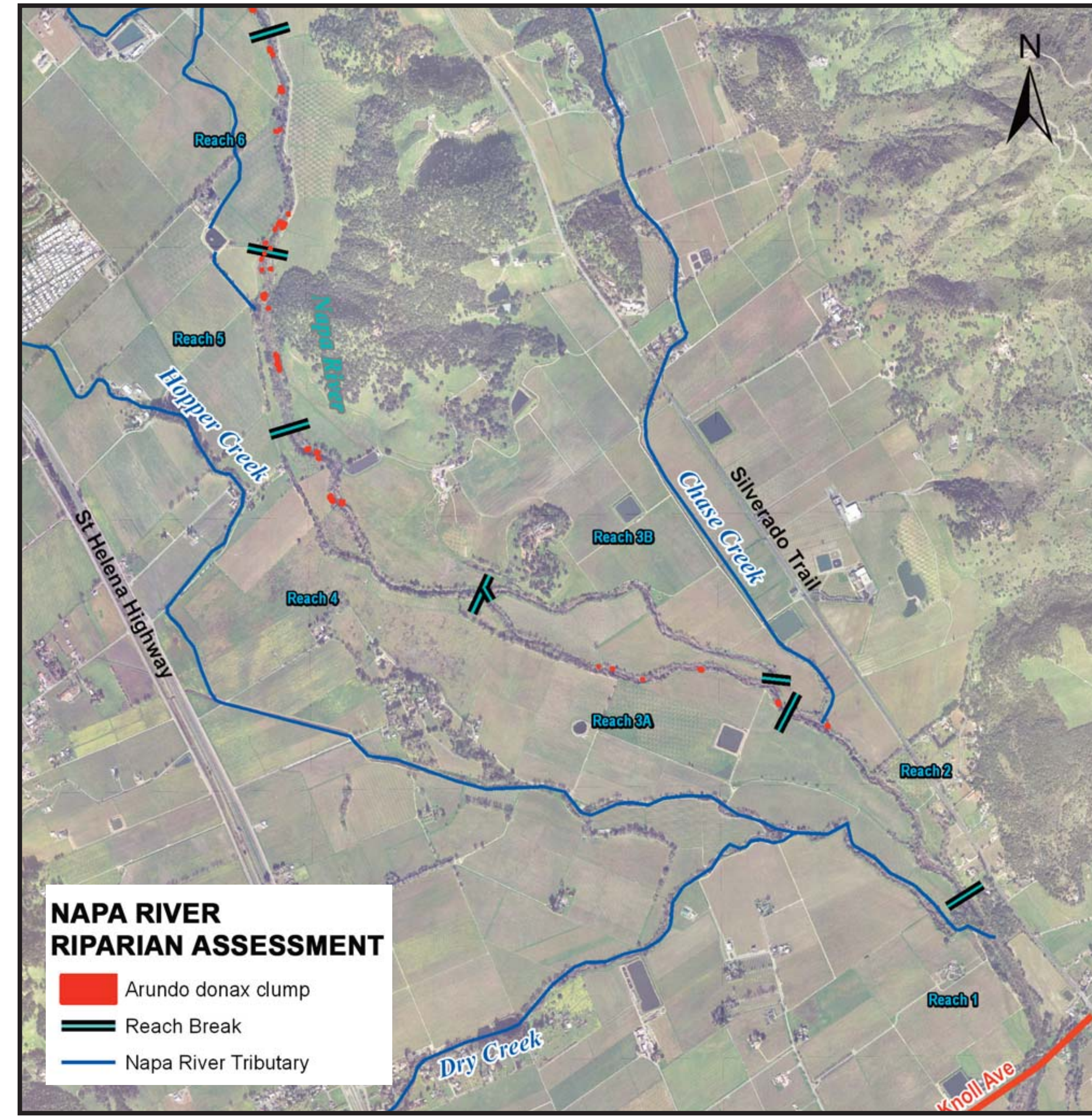
REACH 9 HAS A HIGH TO MEDIUM DENSITY OF TREES AND A GOOD LEVEL OF REGENERATION BUT ALSO HAS A HIGH ABUNDANCE OF ARUNDO DONAX.



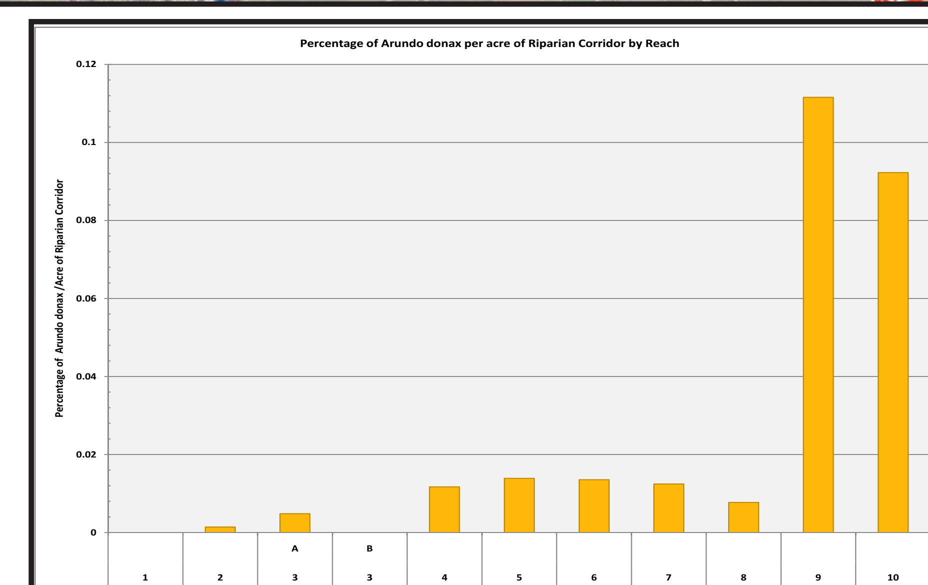
REACH 2 HAS A MEDIUM WIDTH TO DEPTH RATIO BUT THE CHANNEL AND BANKs ARE DOMINATED BY HIGHLY RESISTANT CLAY WHICH LIMITS PLANT GROWTH IN THE CHANNEL



Oakville Rd
N
Reach 10
Reach 9
Reach 8
Reach 7
Reach 6
Napa River
Rector Creek
Conn Creek
Silverado Trail
Yountville Cross Rd
St Helena Highway
NAPA RIVER
RIPARIAN ASSESSMENT
Arundo donax clump
Reach Break
Napa River Tributary
0
1,250
2,500
5,000
7,500
10,000
Feet



N
Reach 6
Reach 5
Reach 4
Reach 3B
Reach 3A
Reach 2
Reach 1
Napa River
Hopper Creek
Chase Creek
Silverado Trail
St Helena Highway
Dry Creek
Knoll Ave
NAPA RIVER
RIPARIAN ASSESSMENT
Arundo donax clump
Reach Break
Napa River Tributary



Percentage of Arundo donax per acre of Riparian Corridor by Reach
Percentage of Arundo donax /Acre of Riparian Corridor
0.12
0.1
0.08
0.06
0.04
0.02
0
1
2
A
3
B
3
4
5
6
7
8
9
10

5. Spider Trees

Spider trees are medium and large trees which have a large amount of their root mass exposed due to erosion, creating a resemblance to a spider. Individual spider trees were mapped throughout the project area. Spider trees of fifteen different native and non-native species were recorded. The most numerous species of spider trees are valley oak, California bay laurel, live oak, Oregon ash, California walnut, and California buckeye. Most of the spider trees are located on the banks. Once these large trees erode and fall into the river, they do become large wood in the river, but the shade canopy is reduced.

The occurrence of spider trees by reach is depicted on page _. This was compared to width/depth ratio and the density of all C4 size class trees in each reach. Reaches 2, 4, 7, and 8 have the highest number of spider trees per mile of river. These reaches are narrow and medium in width and all have a high abundance of C4 trees; more of these trees are undercut in these reaches than in most of the other reaches. The other narrow reaches—Reaches 6, 3A, and 3B—have fewer spider trees, but also have fewer C4 trees to be undercut. This may indicate that many C4 trees already have been eroded out. Reaches 10, 9, 5, and 1 have low numbers of spider trees and have a high to medium width to depth ratio. Reaches 1 and 10 have a high abundance of C4 trees while Reaches 5 and 9 have a low and medium abundance of C4 trees. Reach 5 likely eroded out C4 trees when it widened. For Reach 10, the widening process occurred decades ago, allowing larger trees to develop in the interim.

6. Rock Riprap

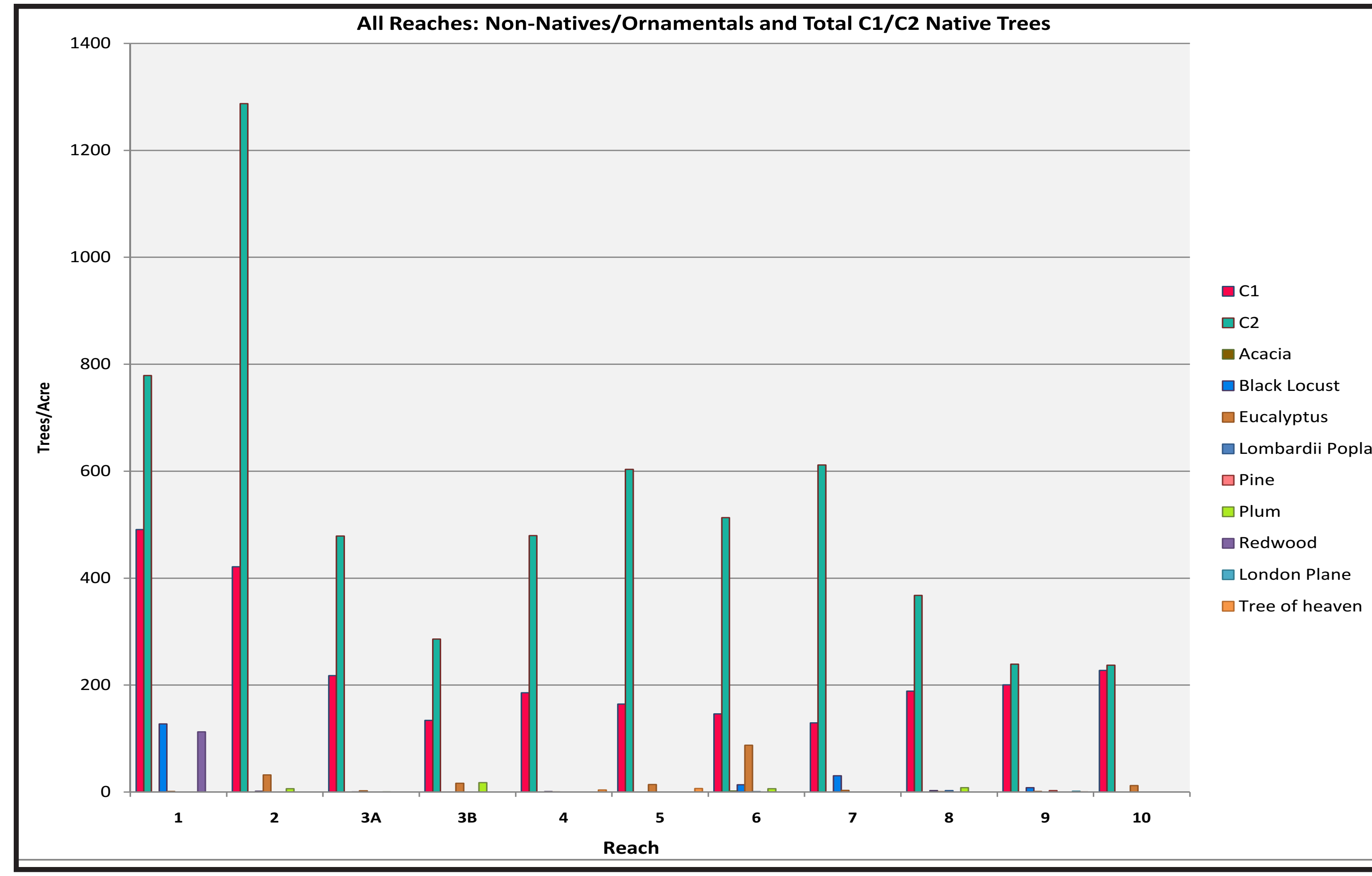
Rock riprap is large rock used to armor stream banks against erosion. On the Napa River rock riprap is often dumped onto eroding banks following major floods. Much of the riprap is not functioning to protect the banks, but has been moved or undercut from the bank and lies in the middle of the river channel.

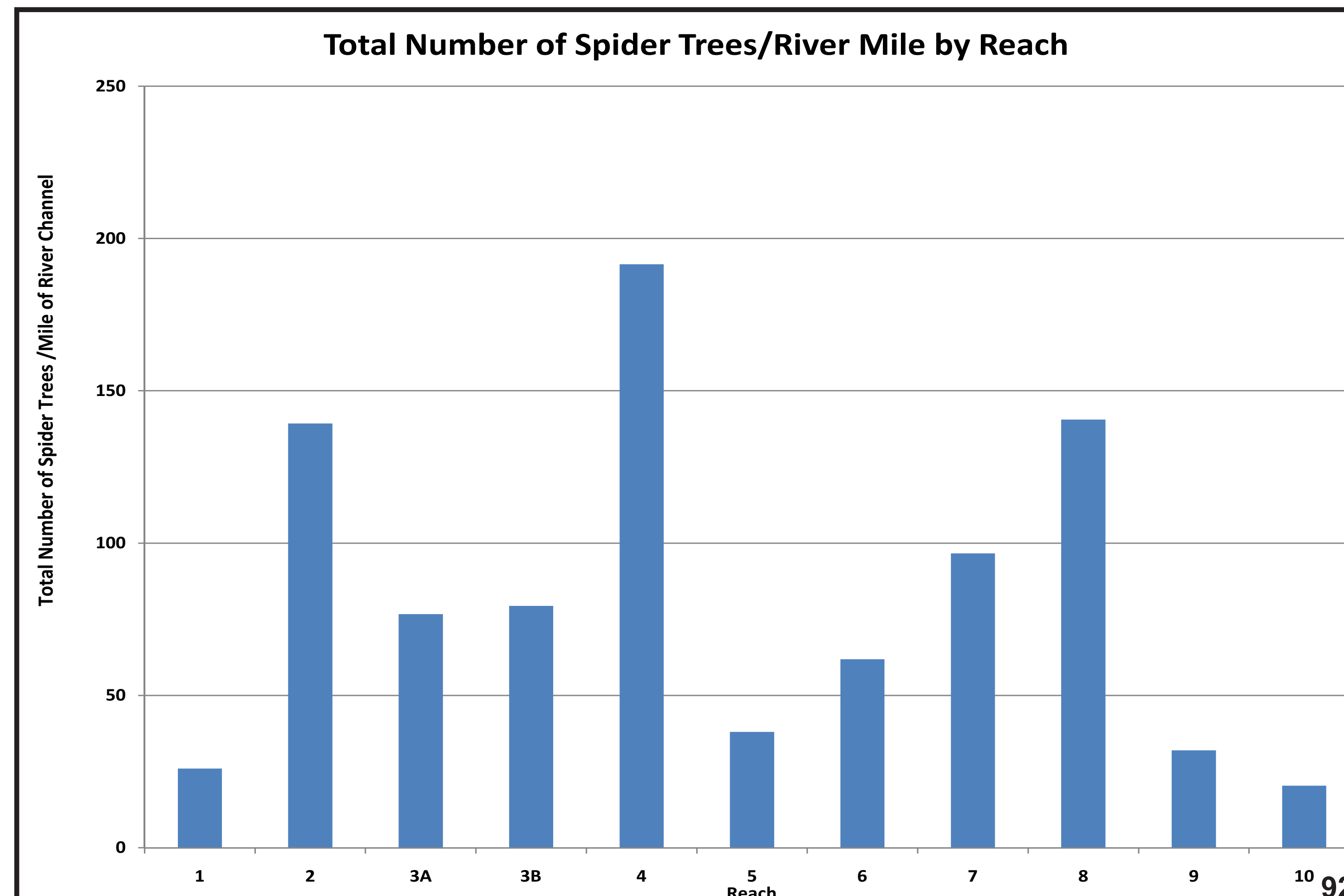
Reaches 4, 6, 7, and 9 have the highest level of rock riprap. Reaches 4, 6, and 7 are the narrowest, most entrenched reaches with the highest flow velocities and have the most erosion. These reaches have low densities of vegetation and are not regenerating. Rock riprap is also high in Reach 9 which has a medium level of entrenchment.

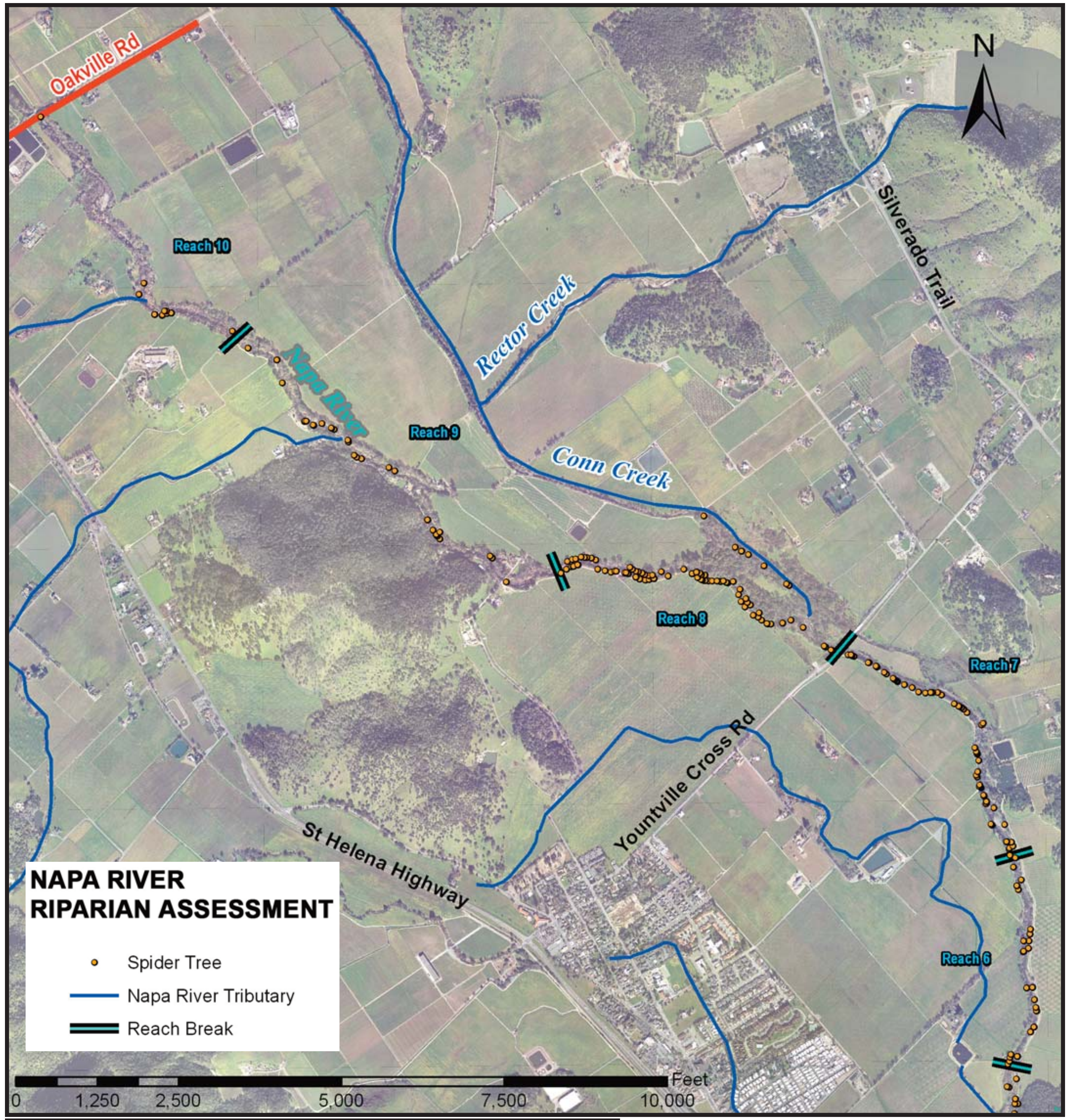
7. Reaches with Unique Ecological Features

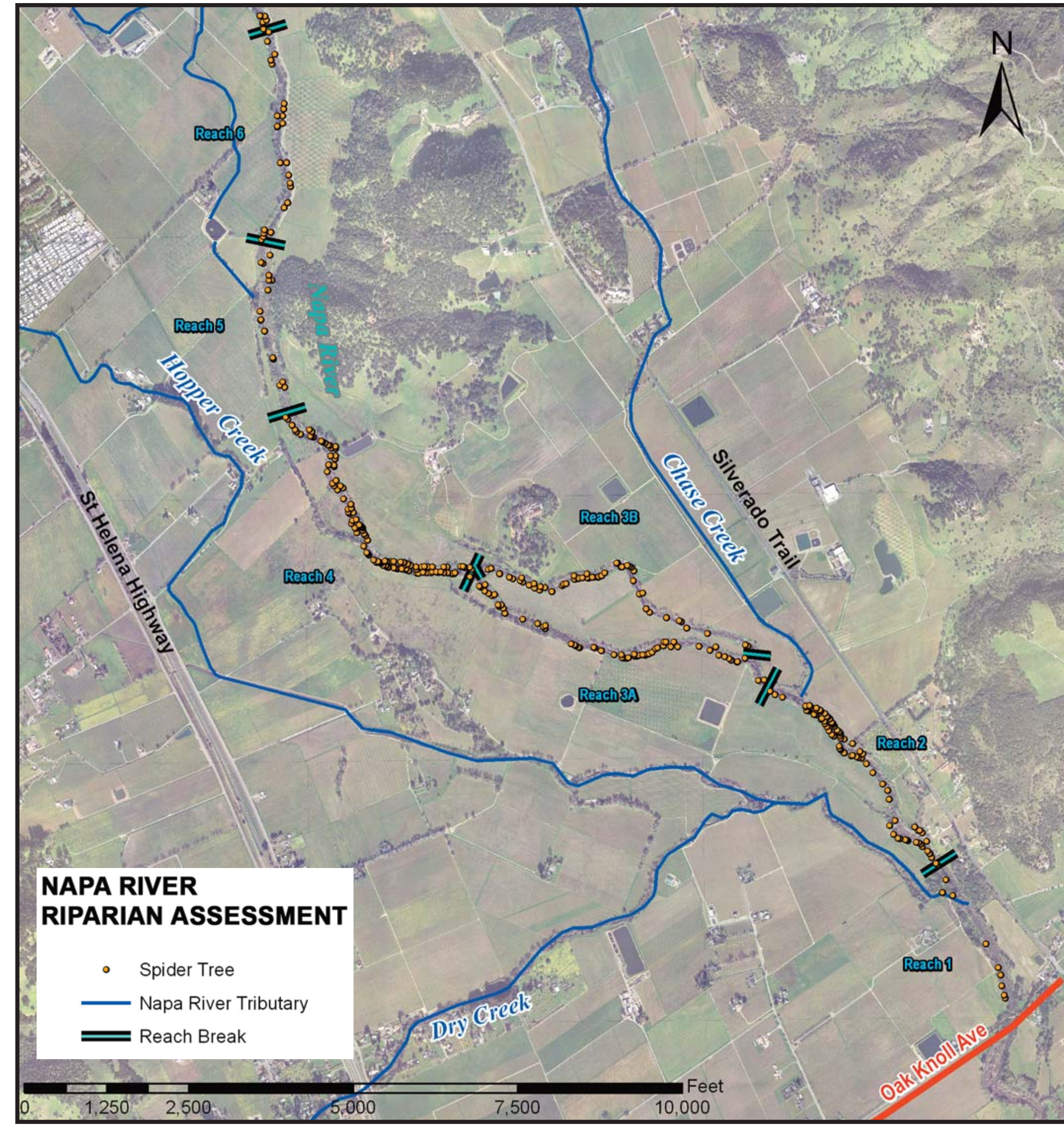
Old Growth
Reach 8 has the largest concentration of old growth trees anywhere in the river project area. Large valley oak, live oak and California bay laurel are abundant. Portions of Reach 8 are in the Napa River Ecological Reserve. Large trees are common in both the Reserve and upstream on private lands. Many of these large trees are being eroded out by channel erosion. Old growth trees support a number of bird species that do not make use of younger trees. The pileated woodpecker was heard only in areas with numerous large oak trees. The pileated woodpecker is associated with old growth trees of many species.

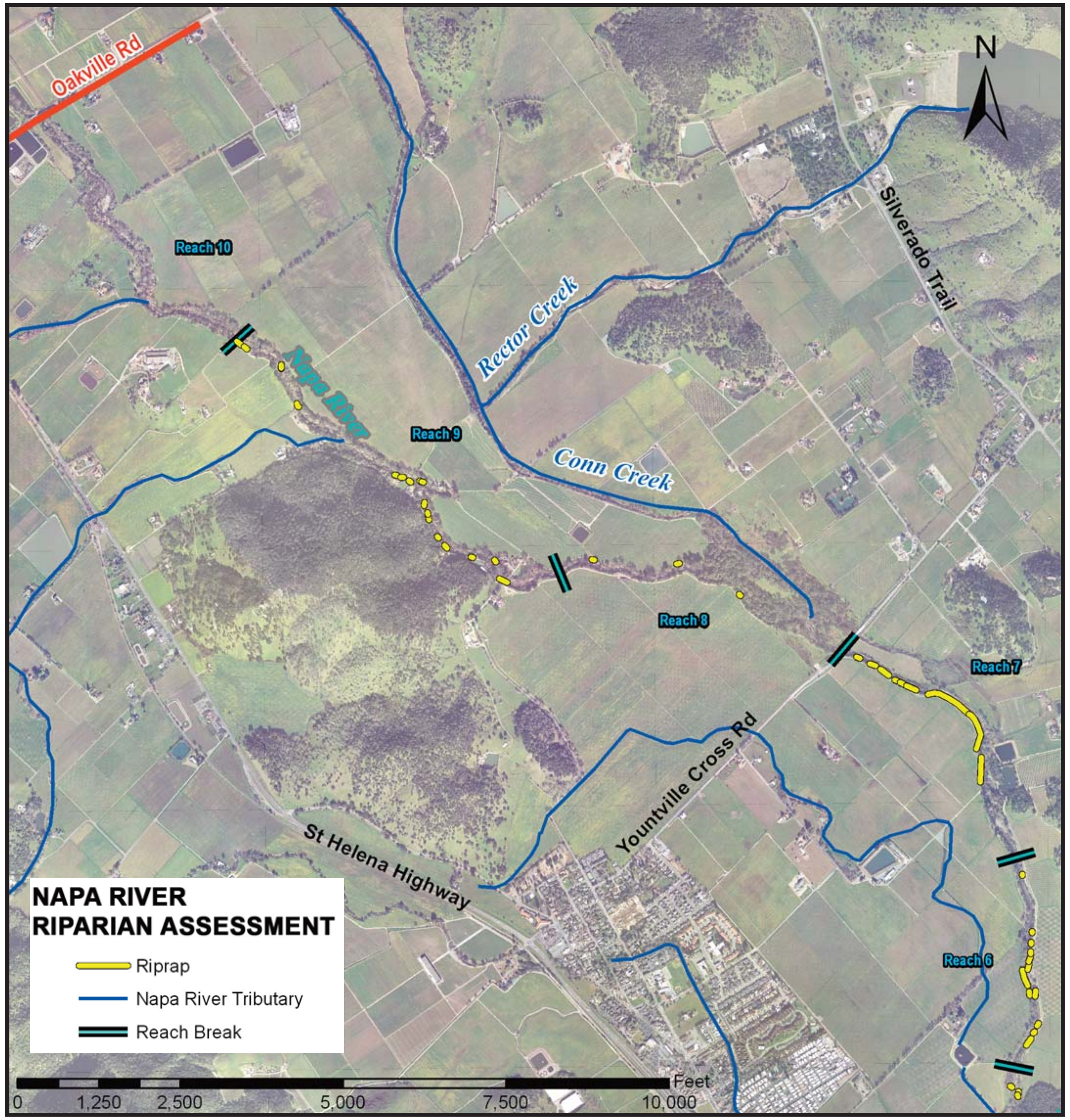
Biodiversity
Reach 10 is the widest reach in the project area and has a complex of morphological areas and high biodiversity. Reach 9 also has a high level of biodiversity. Both of these reaches have high levels of Arundo donax which should be removed to increase native plant regeneration.






Oakville Rd
Reach 10
Napa River
Reach 9
Rector Creek
Conn Creek
Silverado Trail
Reach 8
Reach 7
Yountville Cross Rd
St Helena Highway
Reach 6
N
NAPA RIVER
RIPARIAN ASSESSMENT
Spider Tree
Napa River Tributary
Reach Break
0 1,250 2,500 5,000 7,500 10,000 Feet


Reach 6
Reach 5
Napa River
Hopper Creek
St Helena Highway
Reach 4
Reach 3B
Reach 3A
Chase Creek
Silverado Trail
Reach 2
Reach 1
Dry Creek
Oak Knoll Ave
N
NAPA RIVER
RIPARIAN ASSESSMENT
Spider Tree
Napa River Tributary
Reach Break
0 1,250 2,500 5,000 7,500 10,000 Feet


Oakville Rd
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Napa River
Reach 9
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Riprap
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Reach Break
Feet
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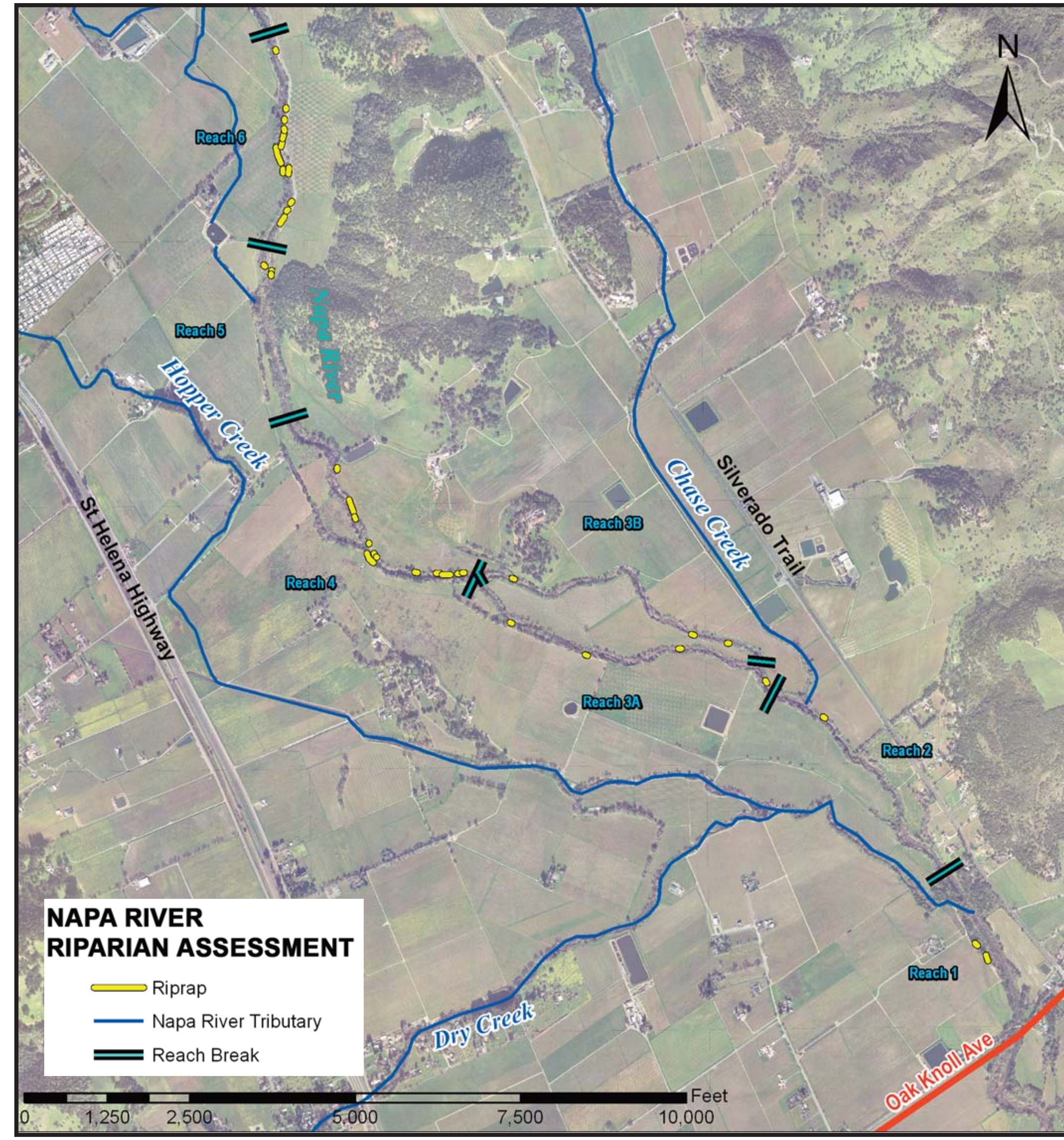
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Napa River Tributary
Reach Break
Feet
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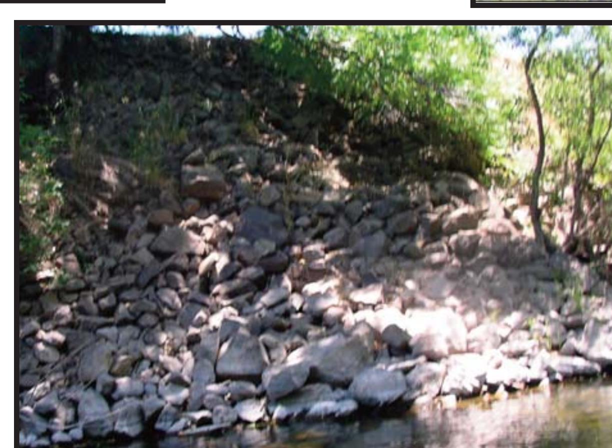


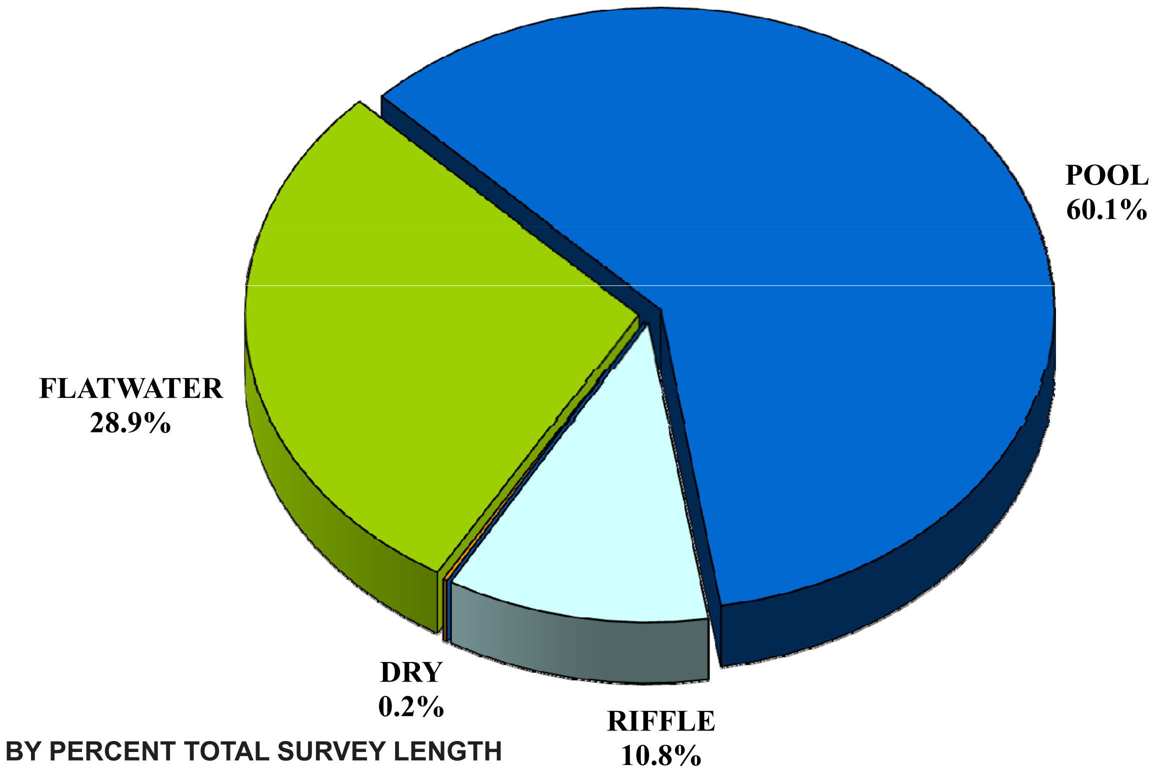
HABITAT TYPING RESULTS

The stream habitat inventory was conducted by Jonathan Koehler and Chad Edwards of the Napa RCD between 6/28/2007 and 7/5/2007. The total length of the survey was 44,801 feet (13,659 m) with an additional 344 feet (105 m) of side channel. The survey began approximately 500 feet (152 m) upstream of Oak Knoll Avenue bridge and extended approximately 9 miles upstream to the Oakville Crossroad bridge. The objective of the habitat inventory was to document the quantity and quality of instream habitat available to native fishes in the Napa River, with emphasis on Chinook salmon and steelhead trout.

Stream flow at the time of survey was typical of early summer baseflow conditions in the reach. Average daily discharge was measured at approximately 3 cubic feet per second (cfs) during the survey period at the USGS stream gage at the Oak Knoll Avenue Bridge.

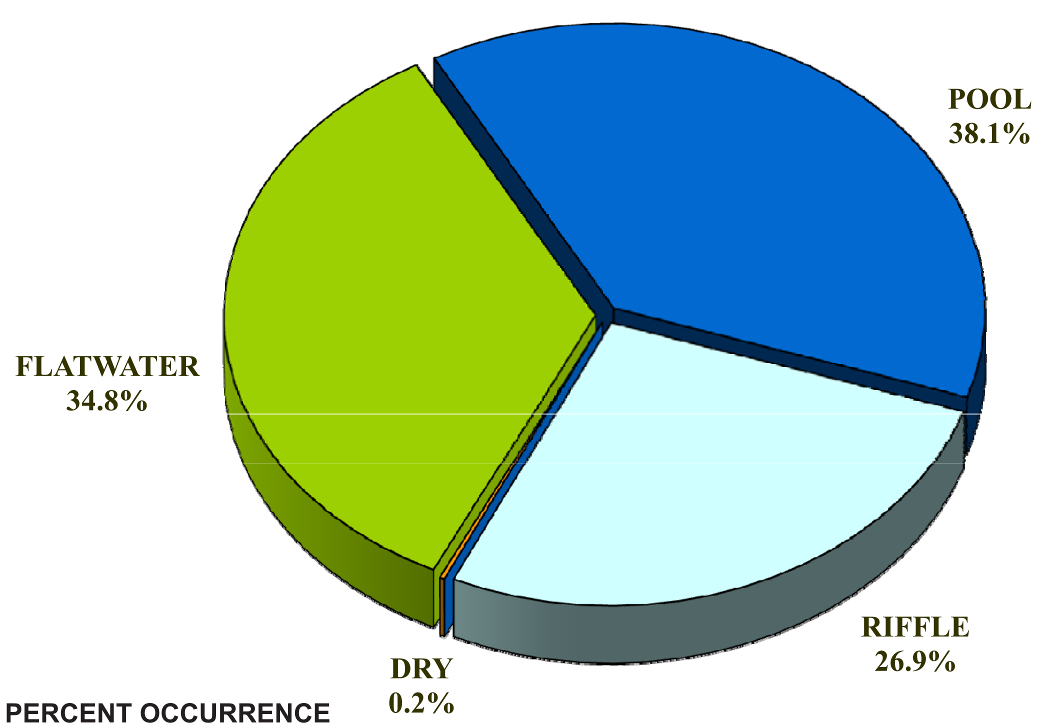
Instantaneous water temperatures taken at regular intervals throughout the survey ranged from 18° to 24° C (66-75° F). Air temperatures ranged from 18° to 34° C (66-93° F). The water temperatures documented during this survey and in previous studies are generally too warm to support juvenile salmonid rearing during the summer period. A combination of low baseflow during the summer, channel entrenchment and areas of sparse riparian canopy appear to be the main causes of elevated temperatures from June through October. A few coldwater pools were found throughout the survey.

Based on frequency of occurrence there were 38% pool units, 35% flatwater units, and 27% riffle units in the project area. However, the total length of the survey was comprised of 60% pool units, 29% flatwater units, and 11% riffle units.

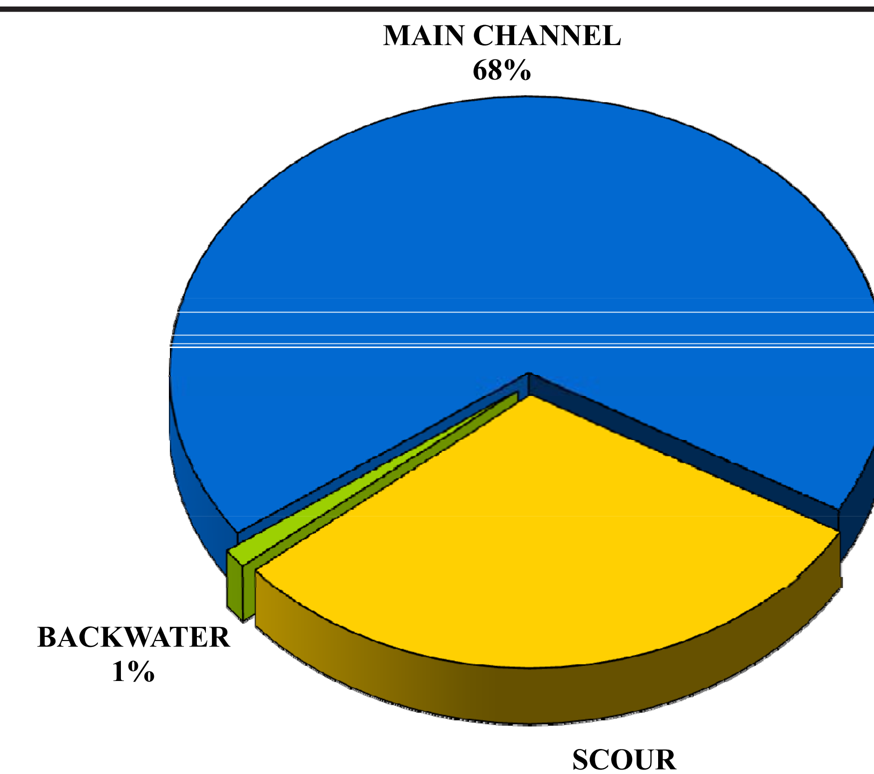


HABITAT TYPES BY PERCENT TOTAL SURVEY LENGTH

A total of 18 habitat types were identified, with the most common being mid-channel pools, glides, and low gradient riffles. A total of 177 pools were identified. Main channel pools were the most frequently encountered, at 68%, and comprised 81% of the total length of all pools.

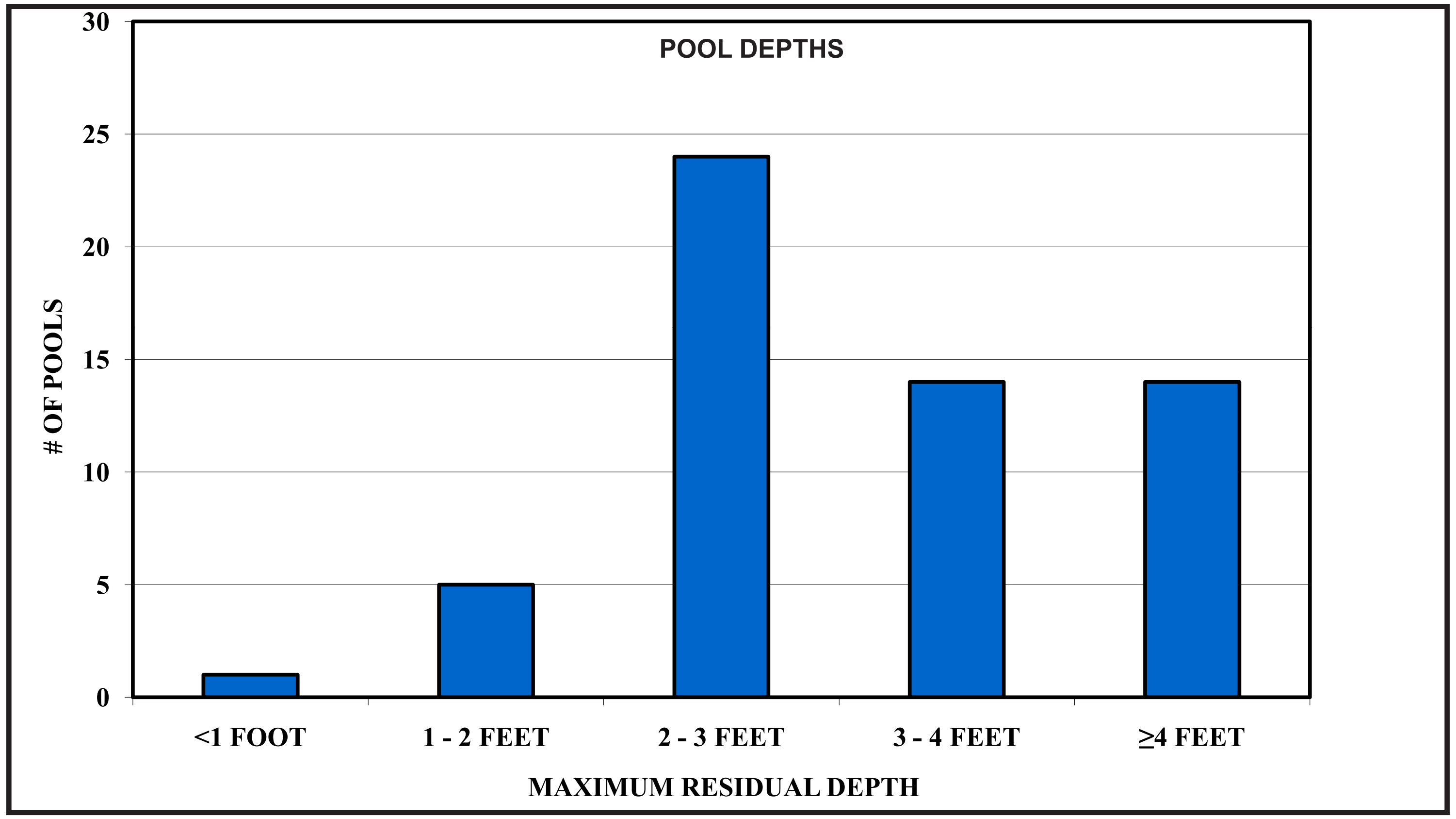


HABITAT TYPES BY PERCENT OCCURRENCE

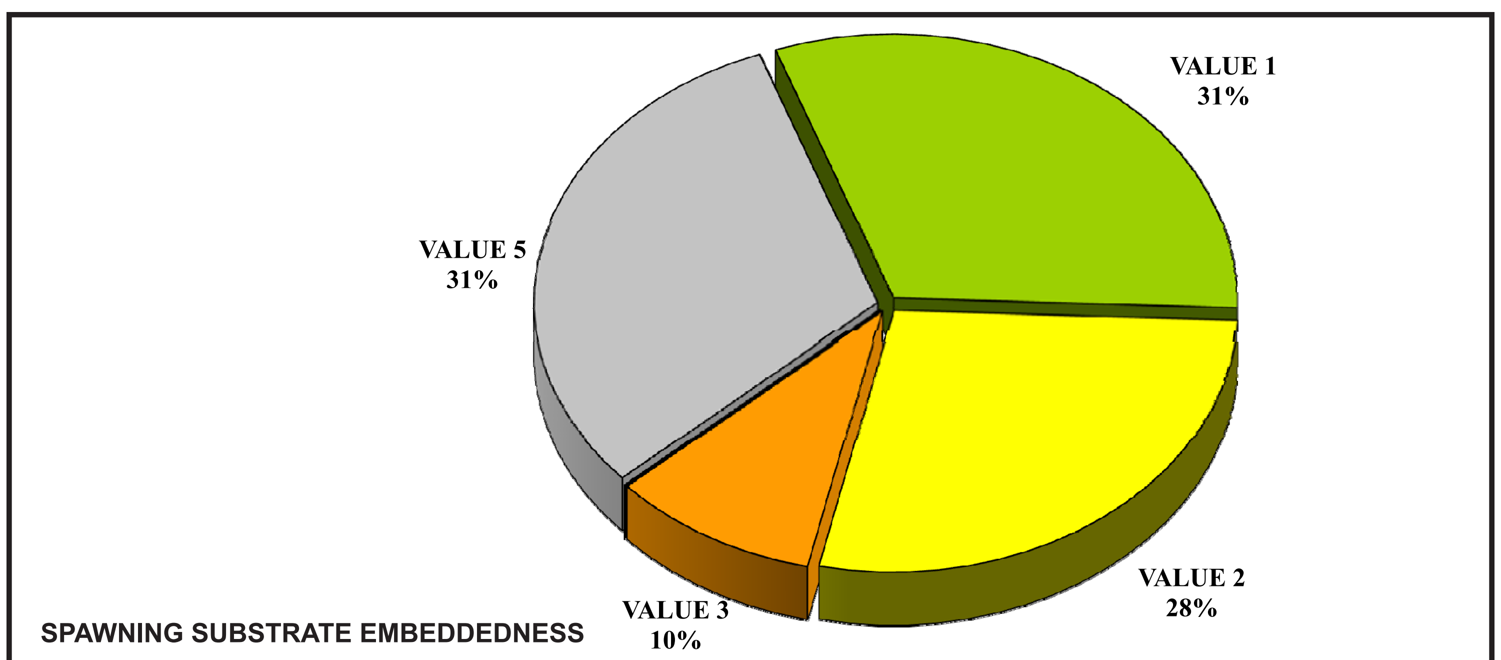


POOL TYPES

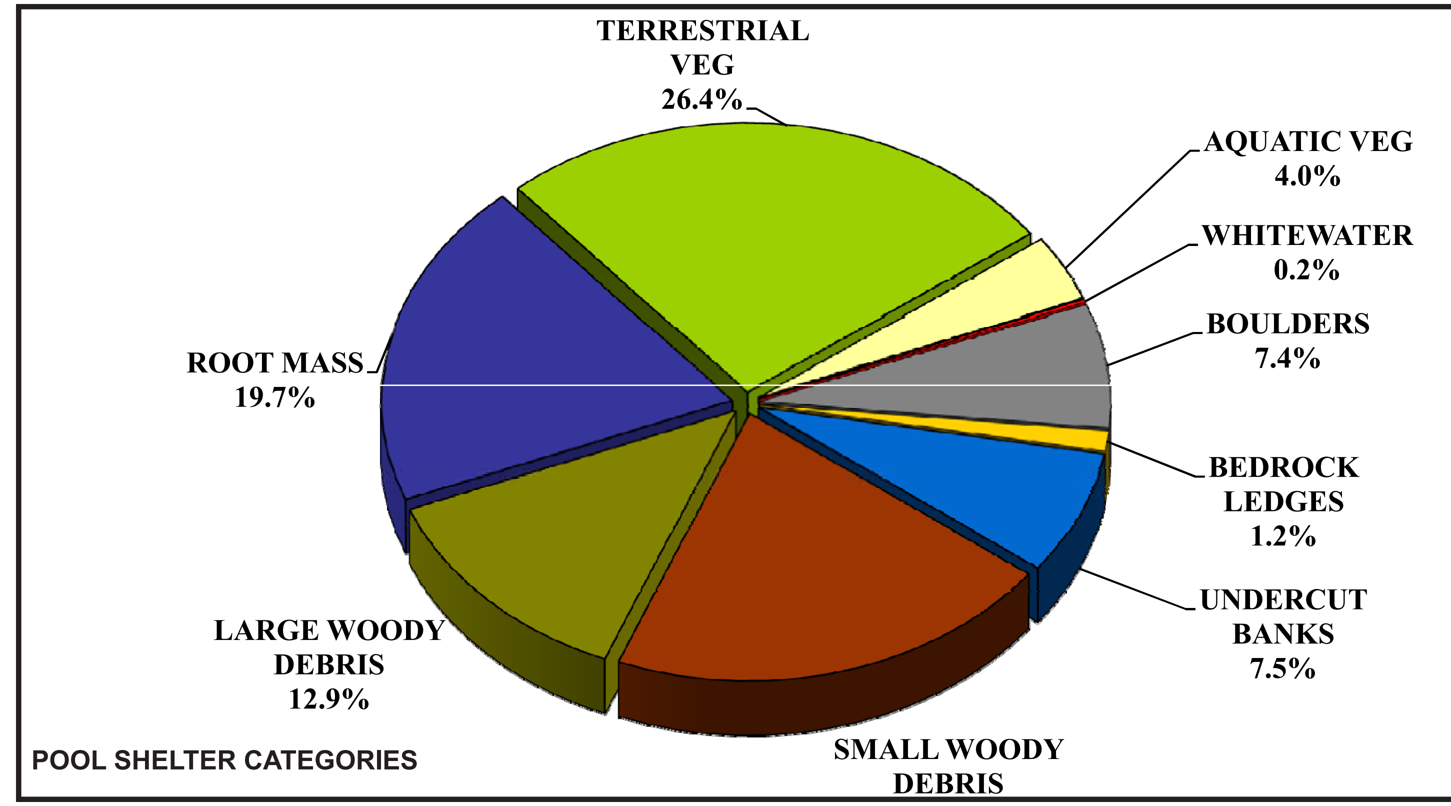
The figure below shows a summary of maximum residual pool depths by pool habitat types. Based on pool tail crest elevations, a total of 52 of the 58 pools (90%) fully measured had a residual depth of two feet or greater and 48% had a residual depth of three feet or greater at an average flow of 3 cfs at the Oak Knoll USGS stream flow gage.



Cobble embeddedness was visually estimated at potential salmonid spawning patches in pool tail-outs. A value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to sites deemed unsuitable for spawning due to inappropriate substrate such as bedrock, sand, log sills, boulders, or other considerations. Of the 62 pool tail-outs assessed, 20 had a value of 1 (32%); 17 had a value of 2 (27%); 6 had a value of 3 (10%); and 19 had a value of 5 (31%).



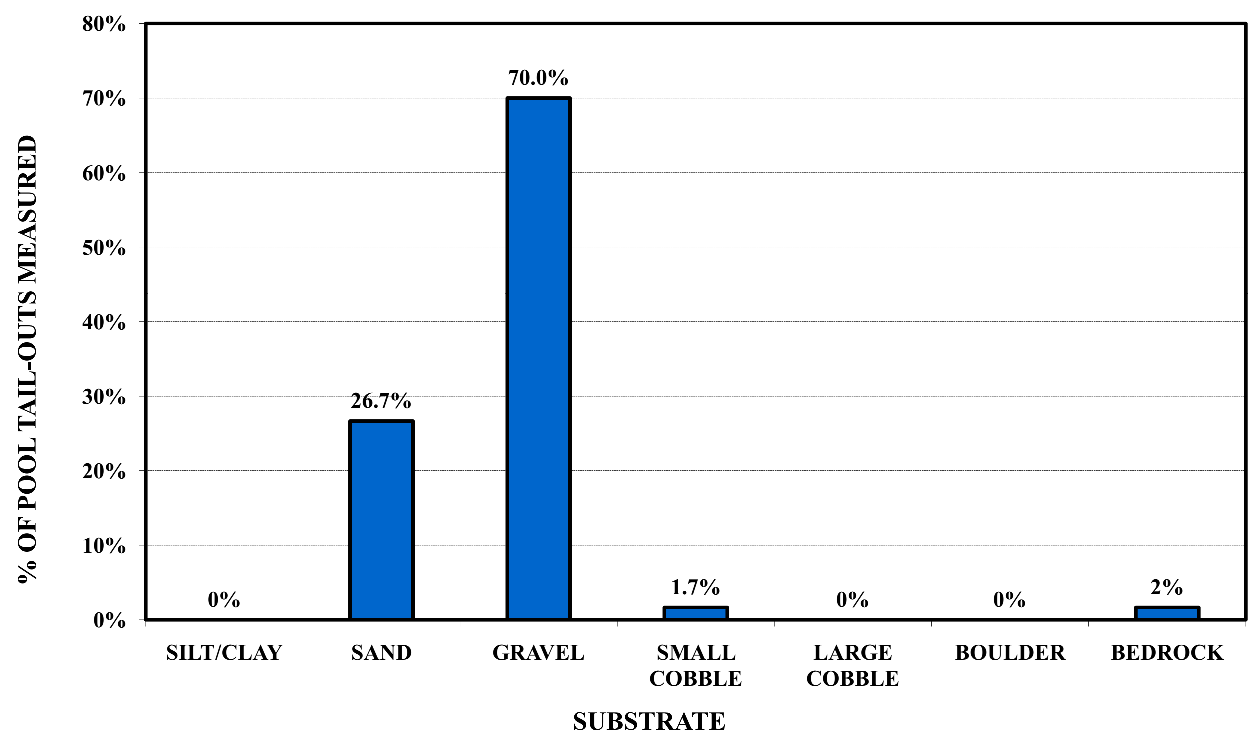
A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had an average shelter rating of 15, flatwater habitat types had a mean shelter rating of 41, and pool habitats had a mean shelter rating of 89. Of the pool types, the main channel pools had a mean shelter rating of 101, scour pools had a mean shelter rating of 78, and backwater pools had a mean shelter rating of 70. A pool shelter rating of approximately 100 is desirable to provide rearing fry with protection from predation, rest from water velocity, and also divide territorial units to reduce density related competition.



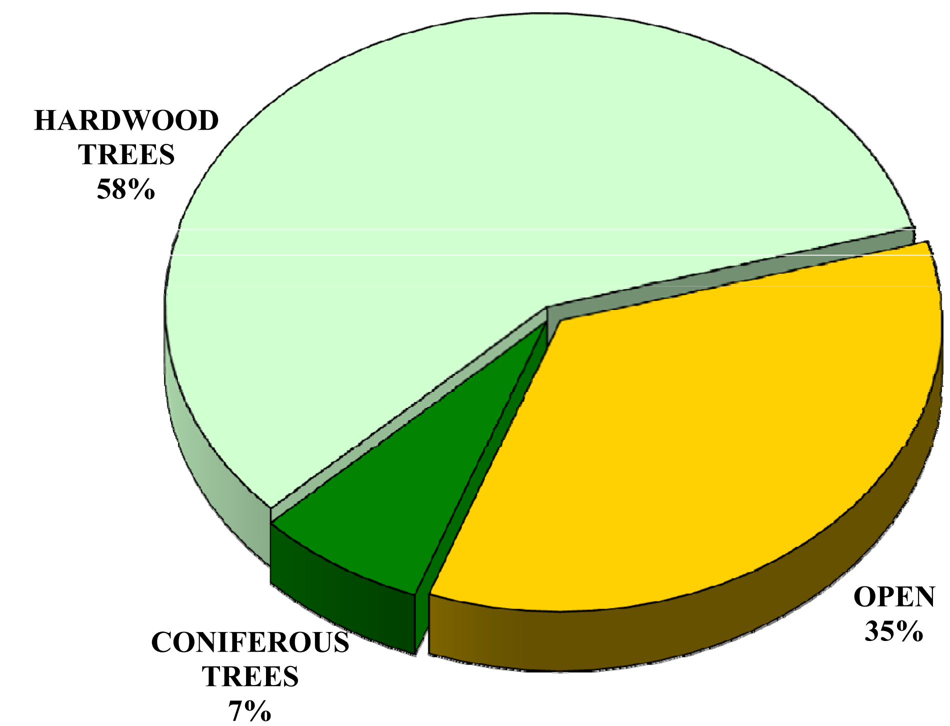
Terrestrial vegetation was the dominant cover type in the survey reach. Terrestrial vegetation in conjunction with small woody debris was found to be the dominant cover type in pools.

Gravel was the dominant substrate in 70% of the pool tail-outs assessed, while sand was the dominant substrate in 26%. The remaining 4% of pool crests were bedrock, or small cobble.

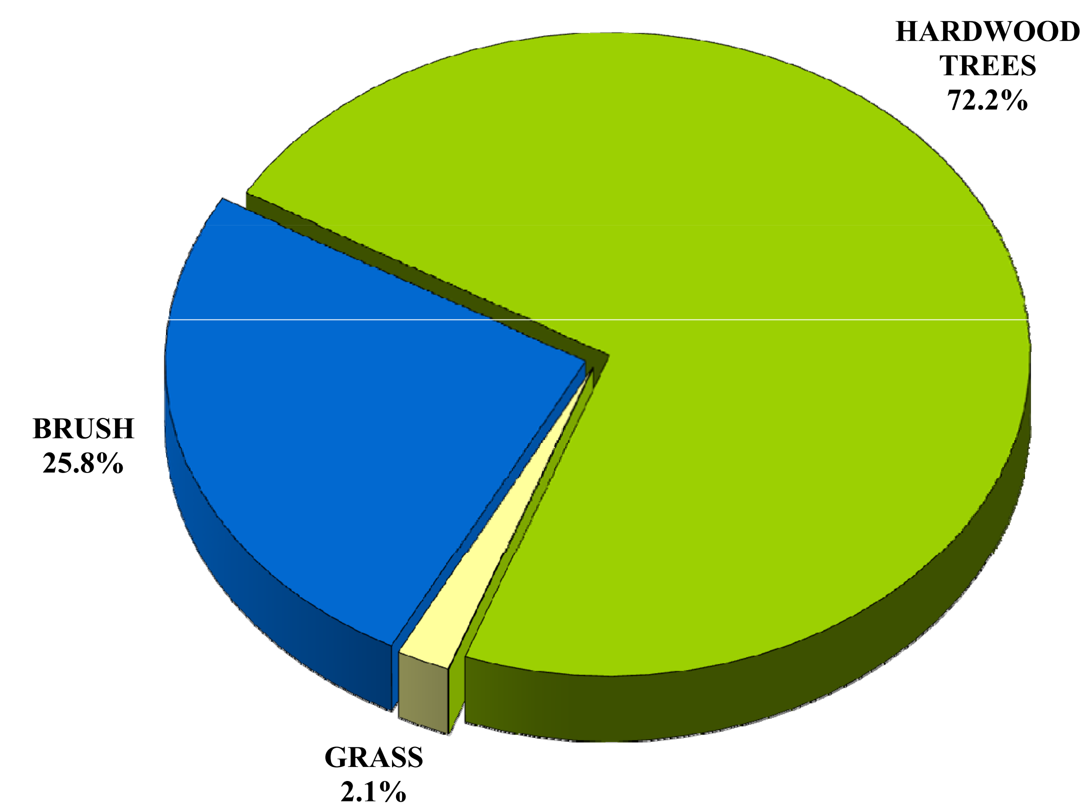
The mean percent canopy density for the entire survey was 65%. The mean percentages of hardwood and coniferous trees were 89% and 11%, respectively. The mean percent right bank vegetated was 86%. The mean percent left bank vegetated was 91%. Deciduous trees were the dominant vegetation type observed in 72% of the units surveyed. Additionally, 26% of the units surveyed had brush as the dominant vegetation type, and 2% had grass as the dominant vegetation.



DOMINANT SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



CANOPY DENSITY FOR ENTIRE SURVEY



BANK VEGETATION TYPES

SALMON SPAWNER RESULTS

A total of five salmon spawner surveys were conducted in the study reach – three surveys covering all ten reaches in December 2007, and two surveys in Reaches 5-7 in December 2006. From December 1 through December 15, 2006 we counted a total of 25 Chinook salmon redds, 34 live fish, and five carcasses in 12,302 feet of surveyed channel. Surveys in 2006 were limited to this reach due to pending landowner access.

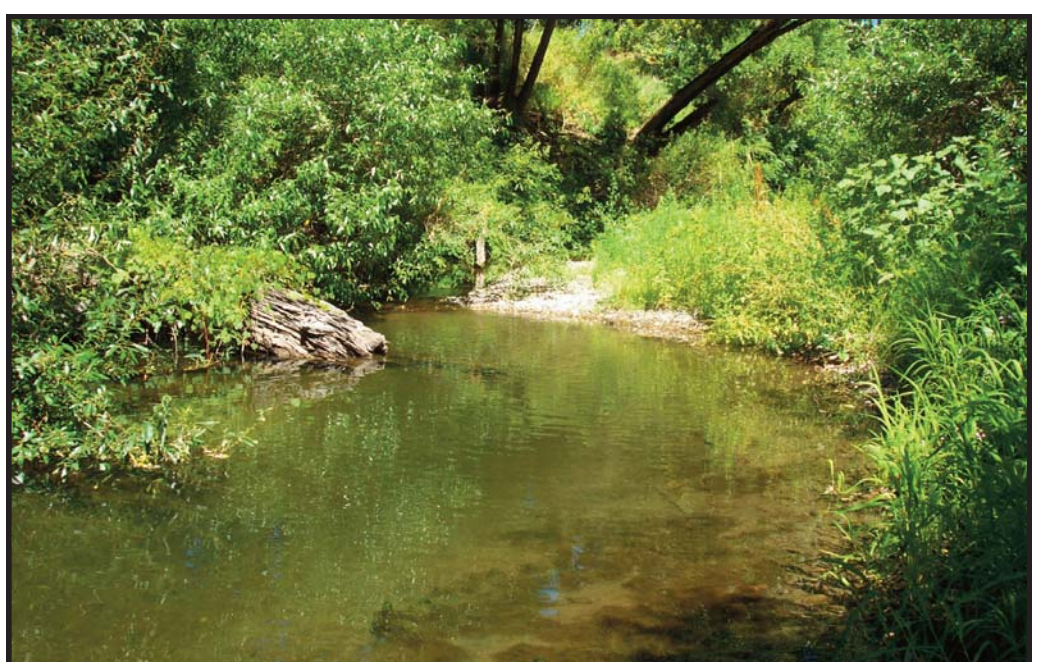
In 2007, we counted a total of 23 redds, two live fish, and one carcass in 41,533 feet of channel. Some pools were too deep to wade, so bank observations were made when possible. Tissue samples were collected from all carcasses for genetic analysis by the NOAA National Marine Fisheries Service laboratory in Santa Cruz, California. Results have not yet been received from the lab for either year.

No evidence of spawning was documented in Reaches 1 though 3, despite the presence of suitable spawning habitat in these reaches. Reach 4 has a long deep pool/glide sequence that likely serves as holding habitat for salmon; however no salmon were seen holding in Reach 4 from bank observations. The highest densities of redds were in Reaches 5-7 with 25 redds in 2006 and 12 redds in 2007.

No visible hatchery marks (i.e. fin clips, tags) were observed on live fish or carcasses in either year.

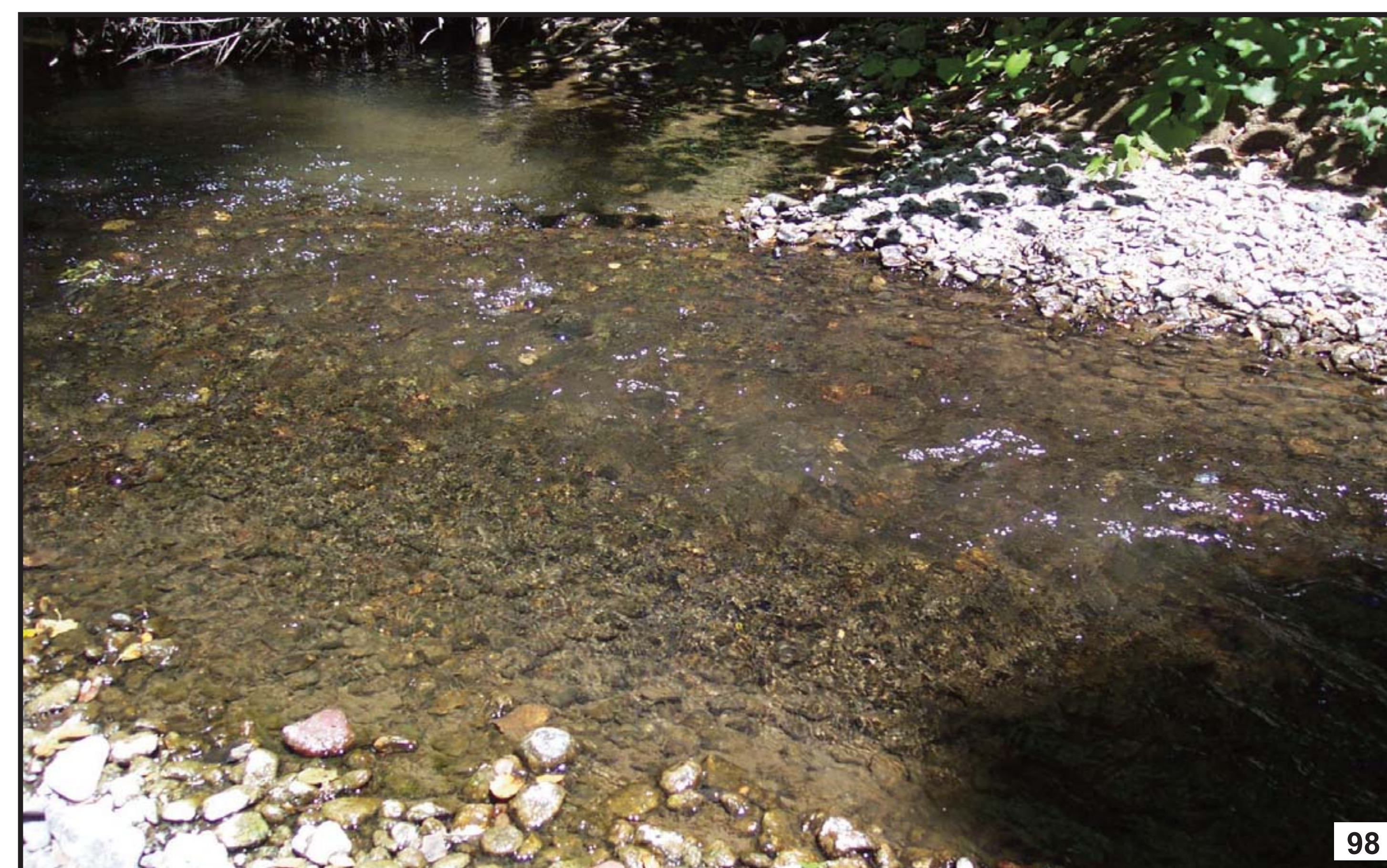
	2006	2007
Survey length (ft)	12,302	12,302
Redds	25	12
Carcasses	5	1
Live fish	34	2
Redds per km	6.7	3.2
Redds per 1,000ft	2.0	1.0

CHINOOK SALMON DATA COMPARISON FOR REACHES 5-7



Survey Date	Dec 1 2006	Dec 15 2006	Dec 23 2007	Dec 24 2007	Dec 27 2007
Sampling Reach	5-7	5-7	8-10	1-3	5-7
Survey distance (ft)	12,302	12,302	17,269	11,962	12,302
Live Chinook salmon observed	8	26	2	0	0
Chinook carcasses	4	1	0	0	1
Mean fork length (cm)	83	68	N/A	N/A	75
Range fork length (cm)	80-85	68	N/A	N/A	75
Fin clipped fish	0	0	0	0	0
Skeletons	0	1	0	0	0
Newly constructed redd count	7	18	11	0	12

CHINOOK SALMON DATA FOR 2006 AND 2007 SPAWNING YEARS



SNORKEL SURVEY RESULTS

A snorkel survey of all reaches was conducted on May 8-9, 2007. The survey began at the Oakville Crossroad and continued downstream continuously to the Oak Knoll Avenue Bridge. Flow in the Napa River was approximately 18 cfs as measured at the Oak Knoll USGS stream gage. Water temperatures were measured periodically throughout the survey, and ranged from 18 to 19.5° C (64 - 67° F).

A total of twelve fish species were observed, including nine natives and three exotics. Overall densities of the three exotic species, largemouth bass, smallmouth bass, and bluegill were very low with only a few individual specimens observed in Reaches 5 and 8.

Juvenile Chinook salmon were abundant throughout the entire survey. Higher densities and silvery appearance of these fish in the lower reaches suggest they were actively migrating downstream (smolting) at the time of survey. Chinook parr were almost exclusively observed in riffle and run habitats in groups of approximately 15-20 fish per habitat unit in the upper reaches and 40+ fish per habitat unit in the lower reaches.

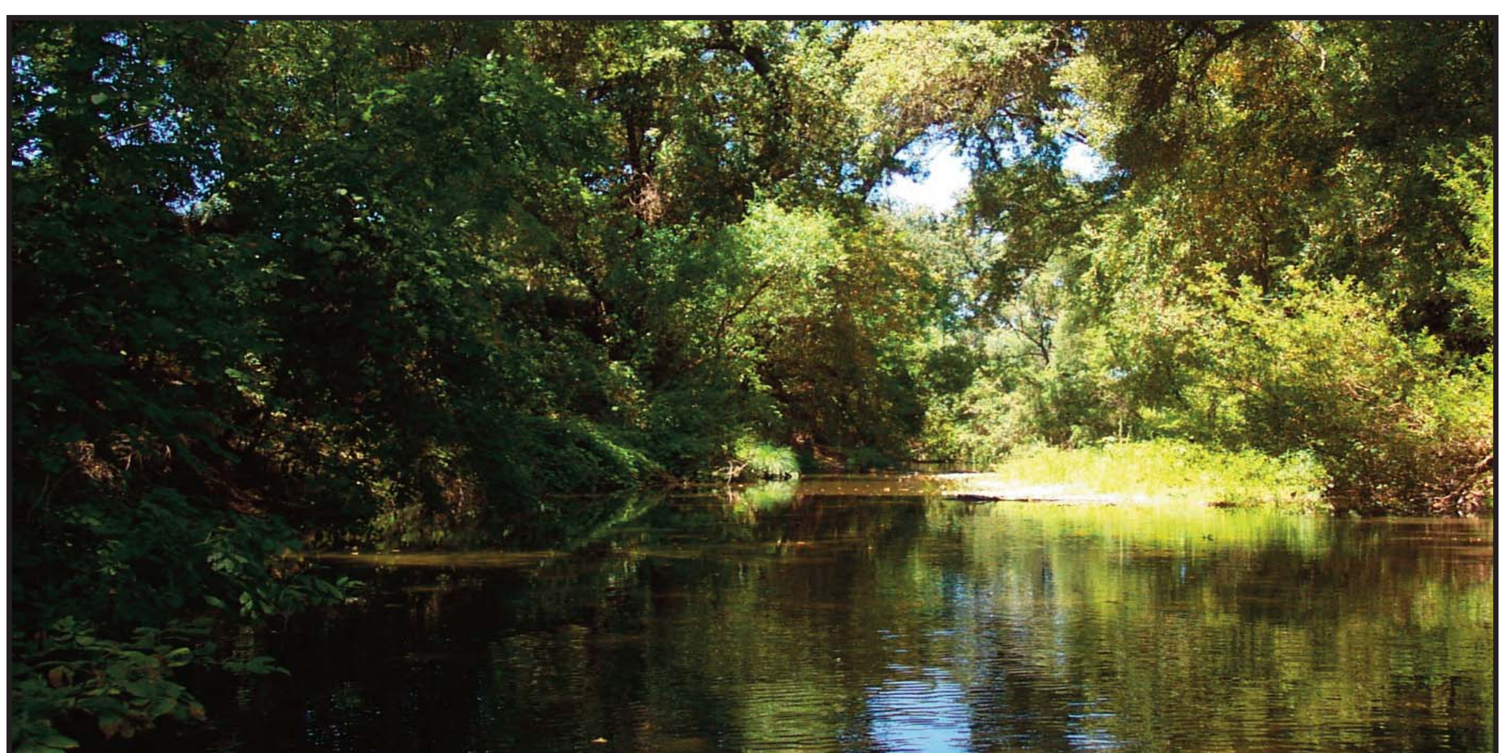
Juvenile steelhead were observed in all reaches except Reach 4 and 8. They ranged from approximately 15-20 cm (6-8 inches), which corresponds to typical smolt size. Overall, their densities were very low with approximately 1-2 fish observed per reach. One adult steelhead approximately 45 cm (18 inches) in length was observed holding under a bank in Reach 3A. The fish appeared to be a male in good condition.

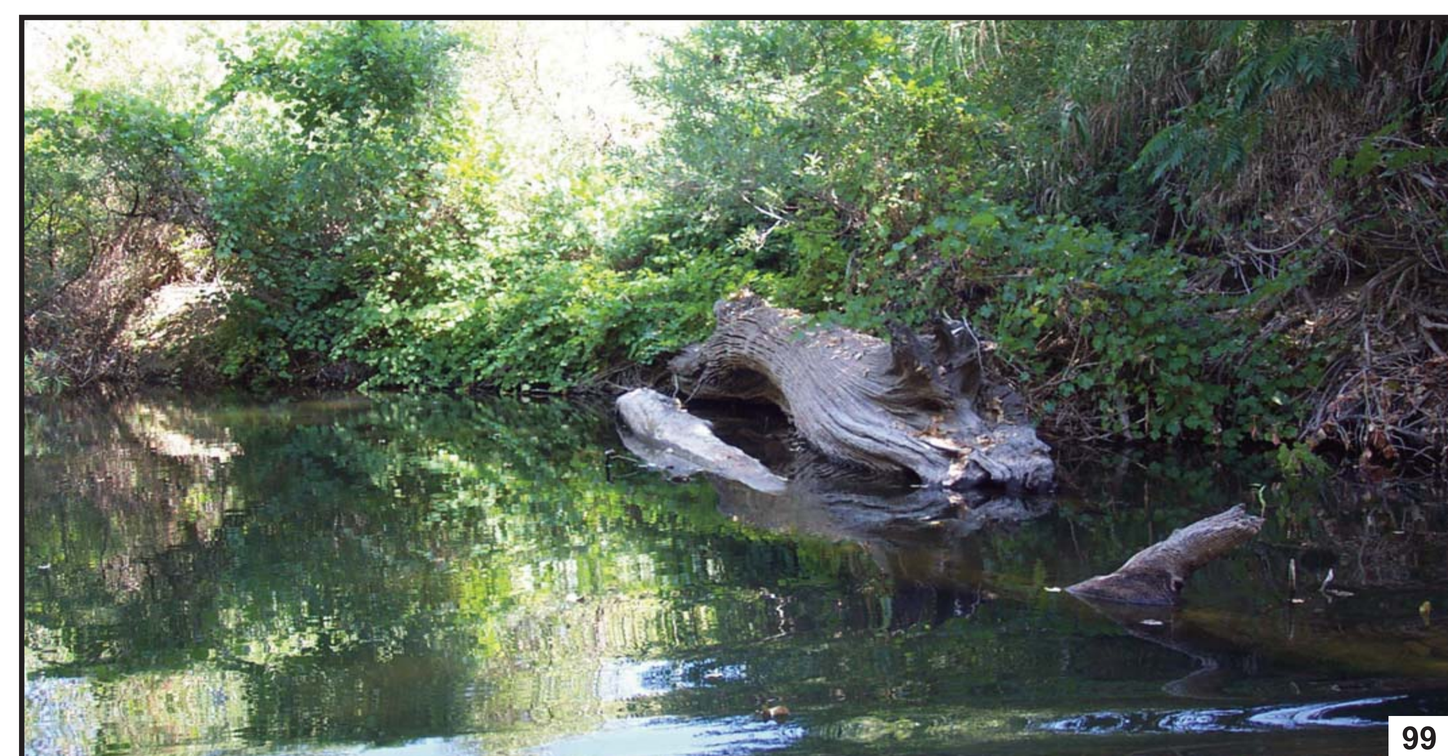
Large schools of Sacramento pikeminnow and Sacramento sucker were observed in deep pool habitats in Reaches 7, 8, and 10. Larger individuals (> 30 cm) of both species were commonly seen in long pool/glide habitat units.

One partial carcass of a Pacific lamprey was recovered in Reach 9. The total length of this specimen was estimated to be approximately 61 cm (24 inches).

Count	Species	Abundance	Habitat Preference	Size	Comments
1	California Roach	High	all	2-5”	Extremely abundant throughout entire survey
2	Chinook Salmon	High	run/riffle	1.5-4”	Parr 2-4”, many silvery, higher densities further downstream
3	Sacramento Sucker	High	pool	3-16”	Large adults to 16”, juveniles abundant
4	Steelhead	Low	pool/run	6-18”	Broadly distributed, but infrequent smolt size steelhead
5	Hardhead	Moderate	pool	4-14”	Patchy distribution-mixed with other cyprinids and suckers
6	Sacramento Pikeminnow	High	pool	3-20”	Large adults in pools,-schools of 10-20 large pikeminnow
7	Tule Perch	Low	pool	3-5”	One school of ~5-10 observed new Yount Mill Road
8	Threespine Stickleback	High	pool/glide	1-2.5”	Abundant in glides and pool edges
9	Pacific Lamprey	Low	unknown	~24”	One tail (12”) recovered-estimated total length ~24’
10	Bluegill	Low	pool	3”	One fish observed just upstream of the Napa River Ecological Reserve
11	Largemouth Bass	Low	pool	8”	Two fish observed near Yount Mill Road
12	Smallmouth Bass	Low	pool	8”	One fish observed in Reach 5

FISH SPECIES OBSERVED IN ALL REACHES





OPPORTUNITIES AND CONSTRAINTS TO IMPROVEMENT OF THE NAPA RIVER: OAKVILLE TO OAK KNOLL SUMMARIZED BY REACH

REACH	OPPORTUNITIES	CONSTRAINTS	RECOMMENDATIONS
10	Wide reach with high width to depth ratio, low scour potential, relatively low velocities, and complex morphology. Riparian system is regenerating but affected by abundance of Arundo donax. Revegetation, creation of backwater habitats, installation of large wood possible in wider areas.	Low canopy cover in some locations. Relatively high fine sediment levels in spawning areas. Abundant Arundo donax on banks and in channel. Downstream area of Reach 10 is entrenched and will require widening to enhance habitats.	Plan and coordinate an Arundo donax removal/native plant restoration. Evaluate backwater fish habitat area creation.
9	High density of salmon habitats with well defined pools formed by LWD and backwater pools. These areas could serve as model for restoration of additional habitat areas. Riparian system is regenerating but affected by abundance of Arundo donax.	Reach 9 is somewhat entrenched with a moderate level of scour, moderate to average velocities. Highest levels of Arundo donax in project area. High level of riprap. Residential area adjacent to channel.	Plan and coordinate an Arundo donax removal/native plant restoration. Reduce future incision by reducing the placement of anymore riprap. Could benefit from a watershed based flood water detention program.
8	Protect one of the last stands of old growth riparian forest by reducing channel erosion through flood flow volume reduction upstream. Could support improved salmon habitat. Ecological Reserve was created to protect riparian habitats; many areas need restoration due to hydrologic isolation from channel entrenchment and levees.	Most of reach is one long, deep pool in an entrenched channel with relatively high velocities and moderate scour. Numerous old growth riparian trees line the banks and are being undercut. This reach has numerous spider trees.	Investigate increasing floodplain area in Ecological Reserve through removal of berms. Could benefit from a watershed based floodwater detention program.
7	Secondary channel remains east of river channel Chinook use even marginal areas for spawning although this may be due to the Yountville Crossroad acting as a low flow barrier.	Yountville Crossroad acts as low flow migration barrier. Large berm on right bank. Resistant clay layer occurs over most of the Reach 7 channel. Highly entrenched channel with high velocity flow and high channel scour. High level of spider trees and riprap. Limited spawning areas. Little to no regeneration of riparian system.	Through landowner cooperation and potential acquisition, restore secondary channel and floodplain in between main and parallel river channels. Additional spawning and back water habitat can only be created after widening the channel and setting back the levee. Could benefit from a watershed based flood water detention program. Revegetation along main river channelmay be limited by hard pan clay layer.

REACH	OPPORTUNITIES	CONSTRAINTS	RECOMENDATIONS
6	Riparian and aquatic habitat conditions cannot be improved without significant widening this reach.	Berm along entire left bank. Deeply entrenched channel with high velocity flow and moderate scour. High level of riprap and spider trees. Resistant clay layer on most of the channel. Small amount of spawning habitat. Long shallow glide habitats limit habitat value.	Could benefit from upstream flood water detention program. Revegetation limited by hard pan clay layer. A number of widened restoration areas could create off channel habitat and support riparian canopy.
5	Reach 5 has widened and lost most of its riparian canopy. Average flow velocities and scour and moderate. The large trees have been eroded out of the banks. Several areas of high quality spawning habitat were created by large wood in the channel. This is not a sustainable condition as the riparian corridor is not regenerating. There is a large flood overflow area adjacent to the river.	Resistant clay layer dominates bed and banks of Reach 5. Reach 5 has very low density tree cover and no regeneration. Canopy cover is very low and algal mats cover pools.	Since Reach 5 has widened it is a good location to experiment with revegetation measures for hard pan clay. Some type of grade control/rebuilding of the stream bed may be needed to allow gravel to accumulate and restore aquatic habitats. Could benefit from a watershed based flood water detention program.
4	There is a large flood overflow area adjacent to the river.	Highly entrenched channel with high scour potential and relatively high average flow velocities. Resistant clay layer dominates bed and banks of Reach 5. High level of bank erosion and high level of spider trees and riprap. The riparian system is not regenerating. Reach 4 consists of one long pool/glide.	Could benefit from a watershed based flood water detention program. Revegetation limited by hard pan clay layer. Additional spawning and back water habitat can only be created after widening the channel.
3 A&B	Two channels occur in this reach, instead of one. Reach 3A had the highest salmon spawning habitat value in the project area.	Both Reach 3A and B are entrenched with a moderate average flow velocity and moderate scour potential. Each channel is narrow with a medium level of spider trees and riprap. Riparian vegetation is medium density.	Some widening is needed to improve habitat. Lay back some vertical banks and create biotechnical bank stabilization.
2	Abundant run habitats in Reach 2 are favorable for juvenile salmon growth.	Reach 2 is entrenched with high velocity flow and high scour. Resistant clay dominates the channel and banks of Reach 2. There is little vegetation growing in the channel. There is a high number of spider trees and bank erosion. There is little salmon spawning habitat and a generally low diversity of habitat types.	The constraint posed by the resistant clay severely limits habitat restoration. Could benefit from a watershed based flood water detention program.
1	Reach 1 is wide but still entrenched. A major tributary enters Reach 1 and provides gravel to channel. Spider tree numbers are low and bank erosion is low.	Average flow velocities are relatively high and potential scour is high. Resistant clay dominates the channel. The hardpan clay limits salmon spawning habitat.	The constraint posed by the resistant clay severely limits habitat restoration. Could benefit from a watershed based flood water detention program.

APPROACHES TO RESTORING THE NAPA RIVER

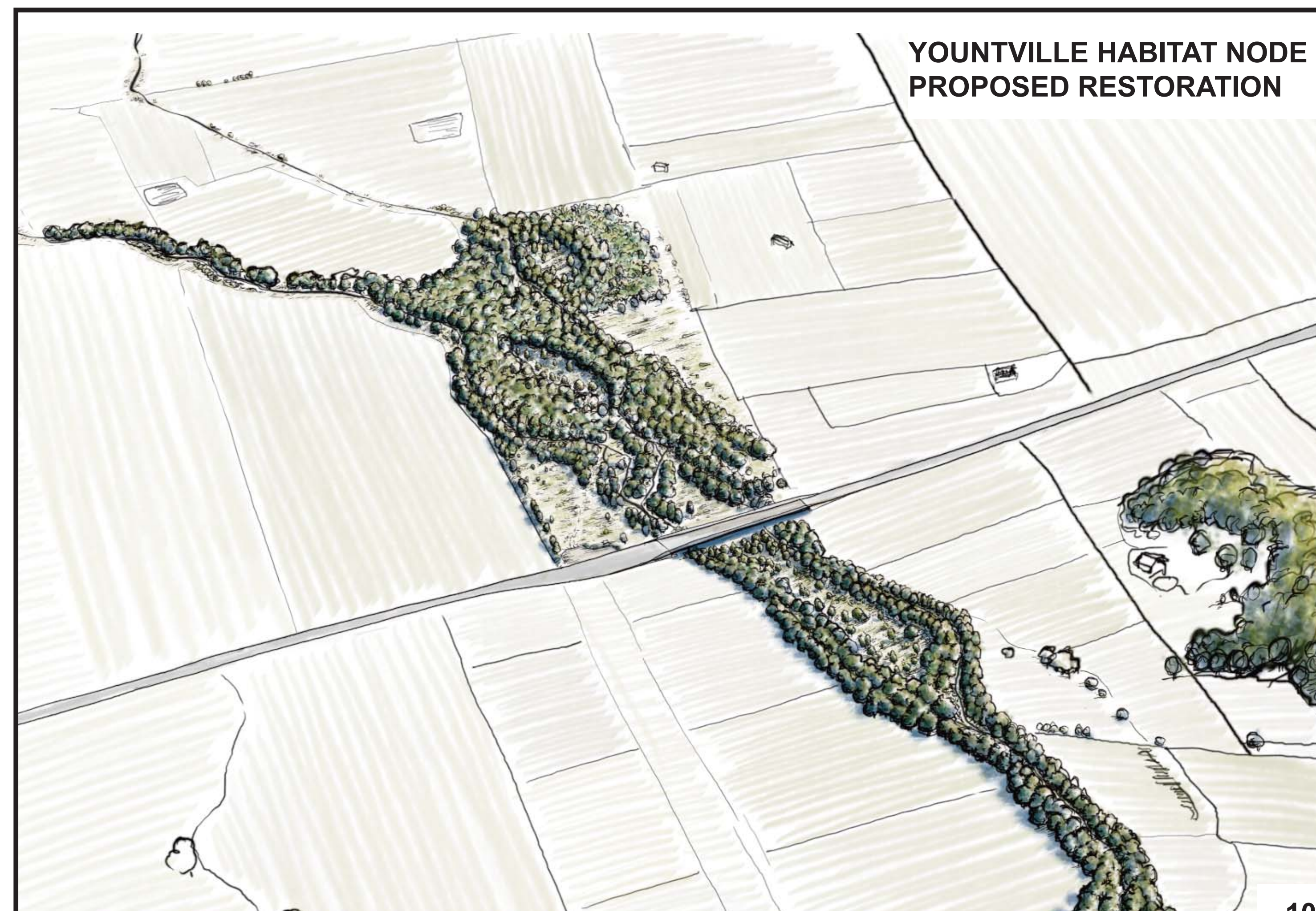
INTRODUCTION

The analysis of existing conditions and processes in the Oakville to Oak Knoll reach of the Napa River demonstrated a need for a reach wide approach to restoration. System-wide improvements are needed to fulfill our goals of improving the quality and sustainability of fish and riparian habitat; increase the natural stability in the river system and reduce property damage from floods and channel erosion. As is described in the summary of findings section, fish habitats are limited by a lack of gravel, complex channel habitat and riparian canopy. For most of the project area the deep narrow form of the river channel, lack of a functional floodplain, high velocity flows and hardpan clay limit the extent and regeneration of riparian habitats. These limitations cannot be addressed without addressing the cause of the limitations – too deep and narrow of a channel and too great a volume of flood water confined to the channel.

Downstream of the Yountville Cross Road the majority of the reaches (7-1) are too narrow and deep with high velocity flood flows for either riparian revegetation or instream habitat improvements. These physical conditions will not naturally form and sustain aquatic and riparian habitats. Additionally the dominance of hardpan clay on the bed and banks of these reaches poses a very major constraint to restoration. There are several ways we can improve the physical functions of the river and lay the foundation to sustain improved ecological functions and reduce channel erosion.

HABITAT NODES

Habitat restoration is focused in four major “nodes” along the river. These nodes allow for a larger area of habitat to be produced in one location rather than distributing smaller areas of habitat restoration throughout the project area. The Ecological Reserve and several areas of protected and fallow land offer an opportunity to restore several large habitat nodes. Within these larger areas, a wider river channel, floodplains, secondary channels and uplands can be restored, creating a mosaic of varied habitat and, most importantly, restoring the flood and meandering processes needed to sustain riparian and aquatic habitats. In a geomorphically varied system, multiple channels can develop along with floodplains of varying size and elevation. These geomorphic areas, if frequently flooded, will support a high biodiversity of native riparian vegetation, generate large wood to the river channel and provide high water refuge and alcove habitats for salmonids. Many other species of mammals, birds, reptiles and amphibians benefit as well. The ecosystem benefits of large varied patches of habitat are well documented (Dramstad et al 1996). In smaller linear restoration areas, the physical processes may not be changed to a great enough degree to foster a variety of geomorphic forms and habitats. Focusing restoration actions in several large nodes provides for ecological succession processes and therefore a sustainable improvement in the ecosystem. Various restoration techniques are proposed including: active channel widening and floodplain construction; secondary channel restoration, managed bank retreat and invasive non-native plant eradication



ACTIVE WIDENING

Channel Widening

Active widening is a way of jump starting the natural recovery process of the Napa River, creating the physical conditions to support ecosystem recovery and reducing erosion and local flooding. It has the advantage of reducing one of the underlying causes of instability and degradation in the river, albeit at the expense of the adjacent land. When the width:depth ratio reaches or exceeds 10:1, the Napa River channel appears to support a high degree of geomorphic and ecological functions and reduced bank erosion. Since the average channel depth is around 23 feet, this implies a target width of 230 feet. On average, this would require 100 feet of widening along the entire river channel.

These numbers are based on average existing conditions; reaches that are more entrenched than average would require greater widening. It is clearly infeasible to widen all reaches that are entrenched due to the high construction cost, impact to the existing riparian corridor and impact on agricultural land. Instead, we considered selected areas for widening, focusing on fallow land and land protected for habitat but in need of restoration. Active widening areas are interspersed with reaches that function as transit corridors for fish. As well as being sufficiently wide to allow natural geomorphic functions to operate, the active restoration areas need to be long enough. From review of aerial photos, it appears that reaches with good gravel bar formation are between 500 and 1,000 feet long and approximately 2 acres in area. It is also desirable that any channel widening include variations in channel width rather than uniform setbacks. Increases and decreases in width induce local erosion and deposition that are important pre-requisites for riffle-pool persistence. Active restoration areas should ideally be located in reaches where there is known to be gravel supply upstream.

Floodplain Restoration

One of the missing elements in the Napa River system is floodplain areas adjacent to the bankfull channel. Floodplains serve to spread out and slow down flood water and are the primary areas where riparian plants grow. As part of widening the river channel, floodplain benches would be graded at approximately the 2-year flood elevation. This allows for frequent enough flooding to support riparian plants, sediment deposition, and a reduction in velocity and erosion in the Napa River.

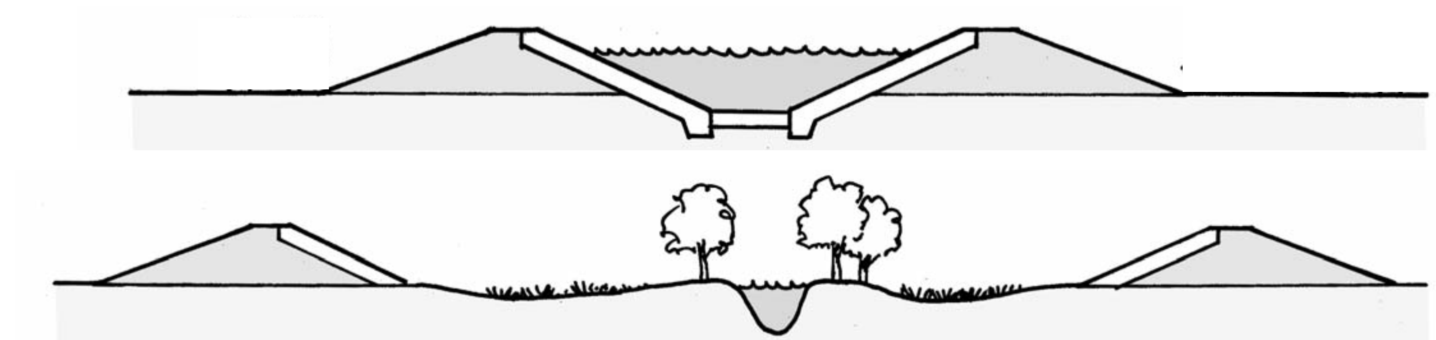
Secondary Channel Restoration

Secondary channels are one of the primary features of the Napa River that have been lost. Restoration of secondary channels would bring about several benefits. It would create areas of lower velocity flow off the main stem that would function as fish refugia and nutrient sources. It would also reduce erosion potential in the adjacent main stem and increase functional channel width and, to some extent, flood capacity.

Levee Setbacks

In some reaches, there may be benefits to setting back levees or replacing them with rolling levees (linear mounds that are sufficiently low gradient to be planted with grapes). Levee setbacks potentially increase flood capacity and reduce erosion risk. Levee setbacks could be combined with a managed retreat policy to create a future riparian corridor area.

STEEP BANKS LIKE THIS ONE IN REACH 10 CAN BE SETBACK AND REVEGETATED TO PROVIDE IMPROVED STABILITY TO THE VINEYARD WHILE REDUCING FLOW VELOCITIES AND ALLOWING FOR AN IMPROVED RIPARIAN CORRIDOR AND SHADE CANOPY



ACTIVE WIDENING BASED ON RESTORATION AREAS 27 AND 29

EXISTING CONDITIONS

FALLOW AREA WHICH LANDOWNER OFFERED FOR RESTORATION

RIVER CHANNEL IS ENTRENCHED AND BANK IS ERODING. LARGE TREE IS BEING UNDERCUT. HIGH FLOW VELOCITIES ARE ERODING GRAVEL FROM THE RIVER CHANNEL

JUST AFTER RESTORATION

FLOODPLAIN BENCH IS GRADED FROM EXISTING RIPARIAN AREA AND FALLOW LAND TO THE 2-YEAR FLOOD ELEVATION TO ASSURE FREQUENT FLOODING CONDITIONS FOR RIPARIAN GROWTH. NATIVE PLANTS ARE INSTALLED. A VERY SMALL AMOUNT OF VINEYARD IS REMOVED

ERODING BANK IS SET BACK AND PLANTED WITH NATIVES. A SMALL AMOUNT OF VINEYARD IS REMOVED. RIVER BANK IS STABILIZED.

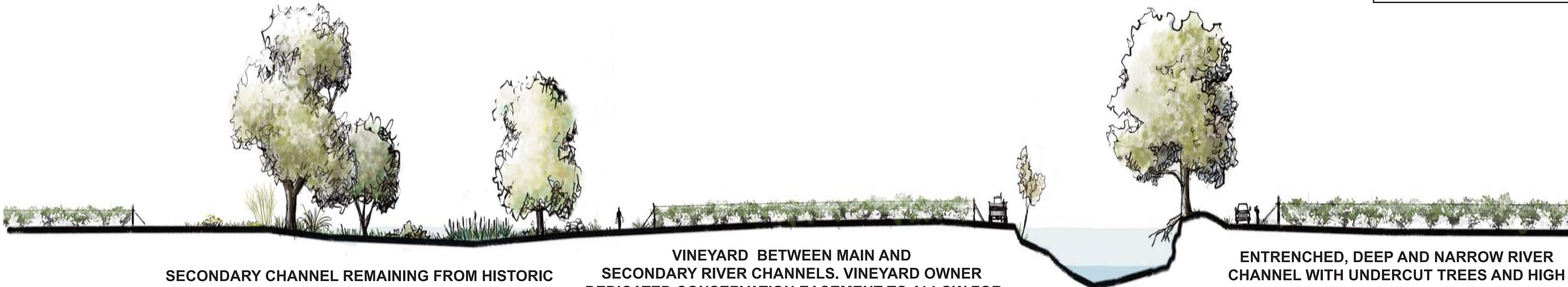
AFTER 10 YEARS

NEW FLOODPLAIN BENCH HAS FREQUENTLY FLOODED CONDITIONS MOST FAVORABLE TO RIPARIAN SPECIES REDUCING INVASIVE PLANTS AND SUPPORTING BIODIVERSITY AND A RANGE OF WILDLIFE HABITATS. BERM ALONG EDGE OF BENCH REDUCES FLOODS IN VINEYARD

RIVER CHANNEL IS NOW MORE STABLE AND COSTS LESS TO MAINTAIN. PLANTED NATIVE TREES NOW PROVIDE WILDLIFE HABITAT AND SHADE TO THE RIVER CHANNEL

RIVER CHANNEL AND FLOODPLAIN RESTORATION BASED ON RESTORATION AREA 17

EXISTING CONDITIONS

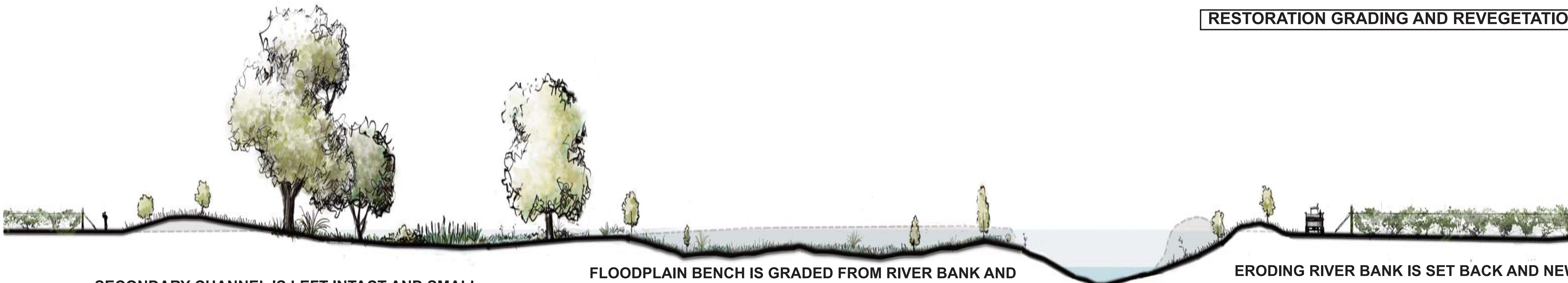


SECONDARY CHANNEL REMAINING FROM HISTORIC MULTIPLE PARALLEL CHANNEL SYSTEM

VINEYARD BETWEEN MAIN AND SECONDARY RIVER CHANNELS. VINEYARD OWNER DEDICATED CONSERVATION EASEMENT TO ALLOW FOR RESTORATION OF VINEYARD TO HABITAT

ENTRENCHED, DEEP AND NARROW RIVER CHANNEL WITH UNDERCUT TREES AND HIGH LEVELS OF EROSION

RESTORATION GRADING AND REVEGETATION

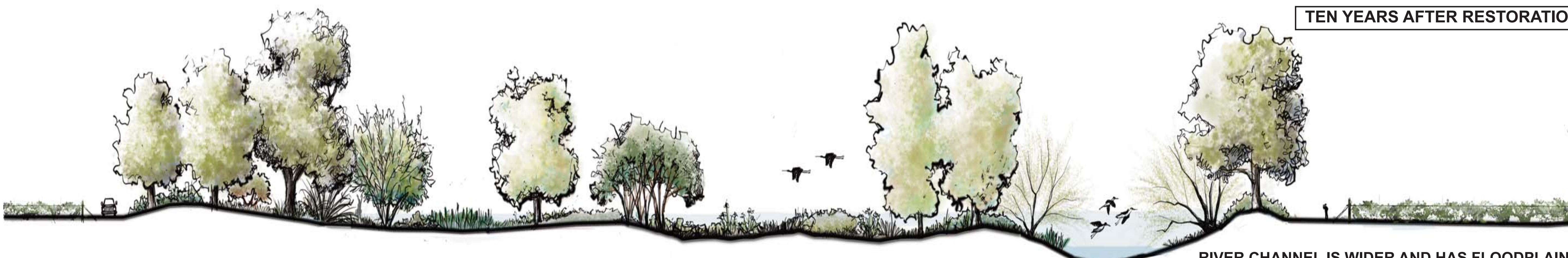


SECONDARY CHANNEL IS LEFT INTACT AND SMALL BERM IS CONSTRUCTED ON OUTSIDE EDGE

FLOODPLAIN BENCH IS GRADED FROM RIVER BANK AND VINEYARD TO 2 YEAR FLOOD ELEVATION AND PLANTED WITH NATIVE TREES

ERODING RIVER BANK IS SET BACK AND NEW BERM IS CONSTRUCTED. BANK IS PLANTED WITH NATIVE TREES

TEN YEARS AFTER RESTORATION

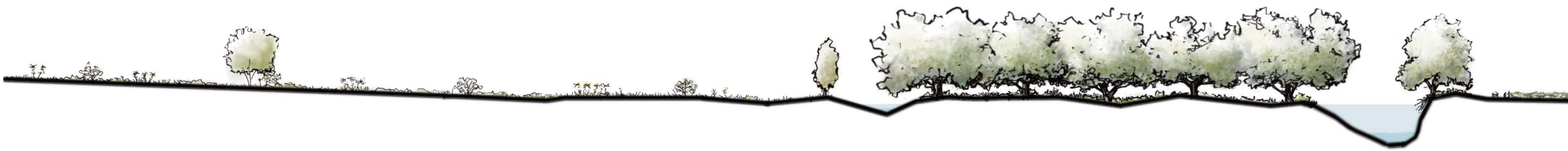


LARGE NODE OF RIPARIAN AND AQUATIC HABITAT IS CREATED WITH BIODIVERSITY AND MANY DIFFERENT WILDLIFE SPECIES. HIGH FLOW REFUGIA HABITAT FOR SALMONIDS IS CREATED IN SECONDARY CHANNEL.

RIVER CHANNEL IS WIDER AND HAS FLOODPLAIN SO FLOW VELOCITIES ARE LOWER AND CHANNEL EROSION IS GREATLY REDUCED AND SALMONID SPAWNING HABITAT IS IMPROVED

RESTORATION OF HISTORIC FLOODPLAIN BASED ON RESTORATION AREA 19

EXISTING CONDITIONS



FORMER RIPARIAN FLOODPLAIN HAS BEEN DEWATERED DUE TO THE ENTRENCHMENT OF THE NAPA RIVER AND CONN CREEK. FLOODING ONLY OCCURS DURING LARGE STORMS. WEEDY NON-NATIVE VEGETATION WITH A FEW ISOLATED WILLOWS DOMINATES THE AREA

CONN CREEK CHANNEL HAS BEEN STRAIGHTENED AND LEVEED UPSTREAM

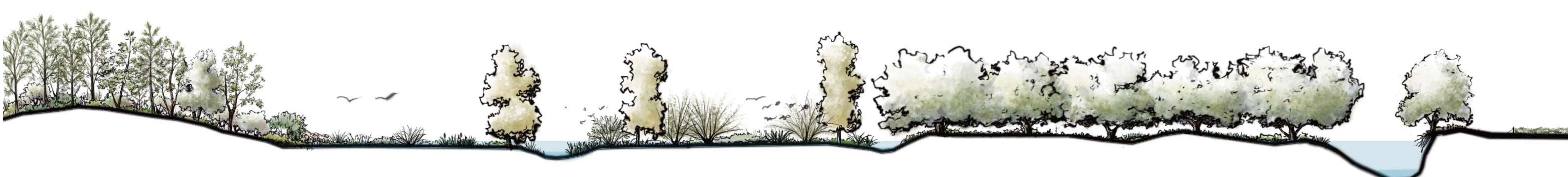
NAPA RIVER CHANNEL HAS ENTRENCHED AND AQUATIC HABITATS ARE POOR FOR SALMONIDS. OLD GROWTH FOREST LINES THE RIVER BUT MOST TREES ARE UNDER-CUT AND LIKELY TO FAIL AS BANKS ERODE.

RESTORATION GRADING AND REVEGETATION

FLOODPLAIN IS GRADED DOWN TO THE 2-YEAR FLOOD ELEVATION WITH A SECONDARY CHANNEL SO THAT FREQUENT FLOODING WILL RE-CREATE RIPARIAN CONDITIONS. NATIVE RIPARIAN TREES ARE INSTALLED. THE EXCAVATED MATERIAL IS USED TO CREATE A BERM AND UPLAND AREA.

NAPA RIVER CHANNEL IS ALLOWED TO ADJUST THROUGH MANAGED RETREAT

AFTER 10 YEARS



THE COMBINATION OF RIPARIAN, CHANNEL AND UPLAND HABITATS SUPPORT A LARGE NUMBER OF WILDLIFE SPECIES AND PROVIDE REFUGIA HABITAT FOR SALMONIDS

OLD GROWTH FOREST OF CA. BAY LAUREL, VALLEY OAK AND LIVE OAK IS A UNIQUE HABITAT ALONG THE NAPA RIVER.

MANAGED BANK RETREAT

Another approach to bank erosion in entrenched reaches is to identify areas where bank retreat is likely, delineate an acceptable setback and plan for gradual retreat without countermeasures such as rock riprap. For example, in a reach that is currently 120 feet wide, we might plan on the corridor eventually widening by 50 feet on each bank over the next 50 years. Future replanting of vineyard within the projected bank top line would be phased out over time and allow natural erosion processes to widen the river. To provide shade and habitat between periods of natural widening, willows are sprigged at the base of the newly eroded banks and the bank would be re-shaped and oaks and other trees planted on the mid and upper bank. When the target width is reached, bank stabilization or flow deflectors would be used to hold the outside limit of the bank in place to prevent further retreat, taking advantage of the wider corridor to dissipate erosive energy. This method has the advantages of avoiding construction costs and giving up developed vineyard, while allowing the river to recover to a stable form. This method is appropriate where the existing riparian corridor cannot be impacted because of high value trees or the removal of shade canopy would impact important fish habitat. Riprap that is not associated with infrastructure or houses should be removed to allow for natural channel adjustment over time. Because this could be a slow form of channel restoration given observed rates of bank retreat along the river, it is only applied in a few areas.

ERADICATION OF ARUNDO DONAX

In the upstream reaches of the project area, an invasive non-native species, Arundo donax, or giant reed, is widespread. Arundo donax is believed to be native to freshwaters of eastern Asia, and then it was brought into cultivation throughout Asia, southern Europe, north Africa, and the Middle East for thousands of years. It has been planted widely in North and South America and Australia. Its introduction into California from the Mediterranean in the 1820's for erosion control in Los Angeles drainage canals. It was also used as thatching for roofs of sheds, barns, and other buildings. Subsequent plantings have been made for the production of reeds for a variety of musical instruments.

Arundo is the largest grass in the world and can reach 30 feet in height. The California Invasive Plant Council lists this plant in their highest ranking for having severe impacts on ecosystems, plant and animal communities, and has nominated Arundo as among 100 of the "World's Worst" invaders
This plant out-competes native trees, but offers little habitat value, shade canopy or bank protection. A. donax provides neither food nor habitat for native species of wildlife or insects. The stems and leaves contain a wide array of noxious chemicals, including silica, tri-terpines and sterols, cardiac glycosides, curare-mimicking indoles, hydroxamic acid, and numerous other alkaloids which protect it from most native insects and other grazers. The lack of insects also means a lack of birds. Areas taken over by A. donax are therefore largely sterile areas devoid of wildlife. As a result, native flora and fauna do not offer any significant control mechanisms for A. donax. Arundo transpires large amounts of water literally drying up streams. It also burns easily. Removing Arundo is a major project which should occur before any other restoration actions.

FLOOD MANAGEMENT AND FLOODPLAIN STORAGE

One of the flood issues which is of great concern to the landowners in the Oakville reach is overland flow along the western side of the valley during larger floods. It is believed that floodwater overtops the river channel at the Zinfandel Lane Bridge. This water creates overland flow which courses down the western side of the valley and erodes many areas. As this flow drops over the various cross roads it erodes the road fill and vineyards.

The hydrodynamic modeling does not suggest an easy solution to the flood issues in the Oakville to Oak Knoll reach during 10 year frequency and greater flood events. Flooding is strongly controlled by backwater conditions at the downstream end of the project area rather than by limited channel capacity within the project area. This situation can be seen by the shape of the water surface profiles generated by the model. Increasing the capacity of the river channel to carry flood water in the upstream part of the reach would effectively hasten water to this backwater point, at which point it would back up and flood the surrounding area. There is some potential to reduce flood peaks on smaller events (2 or 5 year frequency) by creating floodplain detention storage in secondary channels and floodplain benches. As part of this planning effort we evaluated the effectiveness of large floodplain detention basins and found that these facilities would need to be so large that they would represent a hazard should one rupture while full. We also modeled a flood basin just downstream of the Yountville crossroad and found it had the effect of lowering water levels in the river for a very short distance downstream. The Oakville reach is too far downstream for many of these facilities to be effective. The details of the needed evaluation is outlined in the Recommendations section.

MANAGED RETREAT BASED ON RESTORATION AREA 23

1. EXISTING CONDITIONS OF UNDERCUT LARGE TREES, HIGH VELOCITY FLOWS, DEEP AND NARROW OR ENTRENCHED CHANNEL AND ERODING BANKS

2. BANK EROSION. RIVER CHANNEL IS ADJUSTING AND WIDENING. LARGE TREE IS POSITIONED IN CHANNEL TO AVOID ERODING OPPOSITE BANK WHILE CREATING IMPROVED FISH HABITAT

3. IMPLEMENTING REVEGETATION. AFTER BANK ERODES IT IS SHAPED TO A 2 OR 3:1 SLOPE. WILLOWS ARE SPRIGGED INTO THE BASE OF THE BANK AND OTHER NATIVE TREES ARE PLANTED

4. RESTORED CHANNEL AND RIPARIAN CORRIDOR COMPLETED OVER TIME BY WORKING WITH NATURAL PROCESSES. MINIMAL LOSS OF VINEYARD

SOME PRECAUTIONS ABOUT BANK STABILIZATION

When considering bank stabilization, it is important to distinguish between local bank erosion and systematic channel enlargement. Small areas of bank stabilization to prevent local erosion of infrastructure in otherwise stable reaches do not significantly disrupt the system, provided they are well designed and installed. However, when an entire reach is undersized and eroding to enlarge the cross section, as is the case on much of the project area, bank stabilization can make the overall problem worse. Bank stabilization with rock can deflect erosion to the bed or downstream areas and makes it harder for vegetation to become established and provide stability. A better approach is to combine increases in resistance with measures that reduce the underlying instability, for example by laying the banks back to a more stable angle (or 3:1), allowing vegetation to establish while reducing some of the confinement pressure.

Where the stresses and natural environment allow, biotechnical stabilization is more desirable than hard bank stabilizing (e.g. rock rip rap) alone because of the habitat benefits it provides and the fact that it increases friction, slowing water. However, biotechnical treatments need to be healthy to provide strength, and this requires that appropriate native species are planted in locations where they can thrive. For example willows must be planted no more than 6 feet above the low water line. It is also important that the substrate be able to support vegetation. For much of the Napa River there is potentially a major problem for revegetation where hardpan clay dominates the bed and lower banks. This material is not capable of supporting willows or other riparian species.

In high velocity reaches biotechnical treatments will be hard to establish and may wash out. It is important that bank treatments (hard or biotechnical) are keyed into the bed and banks of the river and are designed based on hydraulic calculations. There are standard methods available to calculate the type of material that can withstand the existing stresses, the size of rocks and the depth and width to which elements should be keyed in to prevent outflanking and failure.

AN ATTEMPT AT BANK STABILIZATION USING ROCK DUMPED FROM THE BANK TOP WILL LIKELY CAUSE MORE PROBLEMS THAN IT SOLVES DUE TO THE LACK OF PROPER CONSTRUCTION AND USE OF THIS TREATMENT IN A REACH THAT IS SO NARROW IT HAS HIGH BANK EROSION RATES. THE RIPRAP WILL INCREASE FLOW VELOCITIES AND EROSION OF DOWNSTREAM AREAS.

ALONG THE NAPA RIVER THERE WERE NUMEROUS EXAMPLES OF BIOTECHNICAL BANK PROJECTS SUCH AS THIS WILLOW WALL WHICH DID NOT GROW AND PROVIDED LITTLE BANK PROTECTION OR HABITAT

CHANNEL MANAGEMENT AND HABITAT IMPROVEMENT

Vegetation Management

In reaches where the Napa River has limited flood conveyance or where vegetated point bars are deflecting the river against an eroding bank, vegetation management is often considered. As with bank hardening, it is important to determine the cause of erosion and flooding in a location, as well as the consequences of the proposed action. Some of the incision problems in the Napa River are in part the result of vegetation removal, creating faster, straighter flow lines and less deposition. In reaches that are undersized, removing vegetation is likely to deflect erosion from the banks to the bed, potentially making the overall erosion problem worse. One approach to vegetation management in less confined reaches is to selectively remove a portion of the brushy material such as willow stems less than 6 inches in diameter and sand bar willow while tagging a number of red willows to allow them to grow to maturity. As red willows mature they become less brushy and their hydraulic roughness is reduced. In addition, as they mature they shade out understory, further reducing friction and increasing flood conveyance. This approach requires that an ecologist work with maintenance crews to flag and identify trees and allow them to grow over the years, until it is obvious which specimens to leave untouched.

Alcove Creation

The evaluation of fish habitats in the project area indicated that there was a shortage of alcoves or high flow refugia. Alcoves are important fish refugia during high flows, and form where side channels join the channel. Since many of the side channels have been filled in, have been disconnected by levees, or been left hanging by channel incision these features have been greatly reduced in the project area. Artificial alcoves can be created in a relatively small area by constructing backwaters along the main channel. It is important to understand that while artificial alcoves will 'jump start' the recovery process they are likely to fill with sediment over time unless maintained by scour. A more sustainable approach is to restore secondary channels that will restore not just the alcove form but the underlying physical process that sustains the form.

A NEWLY CONSTRUCTED ALCOVE ON THE TRINITY RIVER

Gravel Augmentation

Given the scarcity of spawning gravels in the main stem river and the aggradation and flood issues in some alluvial fan tributary channels, there is potential to transfer gravel directly to locations on the main stem. Potential locations include immediately downstream of Yountville Road, where many fish attempt to spawn but where gravel is limited or locations upstream of the project area. It is important to either place gravel where pre-existing geomorphic conditions will produce desirable habitat and spawning features, or to create such conditions as part of an integrated restoration plan. Placing gravel in an incised reach is unlikely to lead to good ecological conditions without the associated channel widening and diversification.

GRAVEL BUILDUP IN ALLUVIAL FANS IN THE NAPA RIVER WATERSHED MAY OFFER AN OPPORTUNITY FOR GRAVEL AUGMENTATION FOR THE RIVER CHANNEL

PRELIMINARY ALTERNATIVES

Thirty-two separate restoration sites were identified along the project reach. CLSI staff met with most of the landowners many times over the course of preparing this plan. Many of the restoration sites were suggested by landowners and some were developed by the project team.

The selection of restoration sites also included:

- Increasing habitat areas on contiguous sites and adjacent to existing habitat areas, such as the Napa River Ecological Reserve, in order to increase the size and diversity of habitat nodes.
- Increasing habitat areas by converting uplands, fallow agricultural land and to a very limited extent vineyard to habitat areas.
- Addressing actively eroding bank areas to reduce sediment loading and property loss.
- Avoiding the loss of existing habitat areas to the greatest degree feasible. The exception is riparian areas with spider trees which are unlikely to survive for a long period.
- Avoiding removal of old growth riparian forest.
- Avoiding removal of riparian canopy over long reaches of channel where high levels of salmonid spawning and rearing occur.
- Avoiding restoration actions near bank areas with numerous structures.

The 32 restoration areas were given an initial rating of high, medium or low based on potential ecological value and landowner approval. Each site was evaluated by the project team of fluvial geomorphologists, ecologists, fish biologists and engineers and a conceptual design was prepared. Each design was digitized into the GIS system and boundaries were adjusted to match the highly accurate LIDAR contours used in the riparian vegetation mapping. The conceptual designs were analyzed for their acreages, effects on existing riparian habitats, potential benefits to salmonids, new acres of riparian habitat created, excavation quantities and other features.

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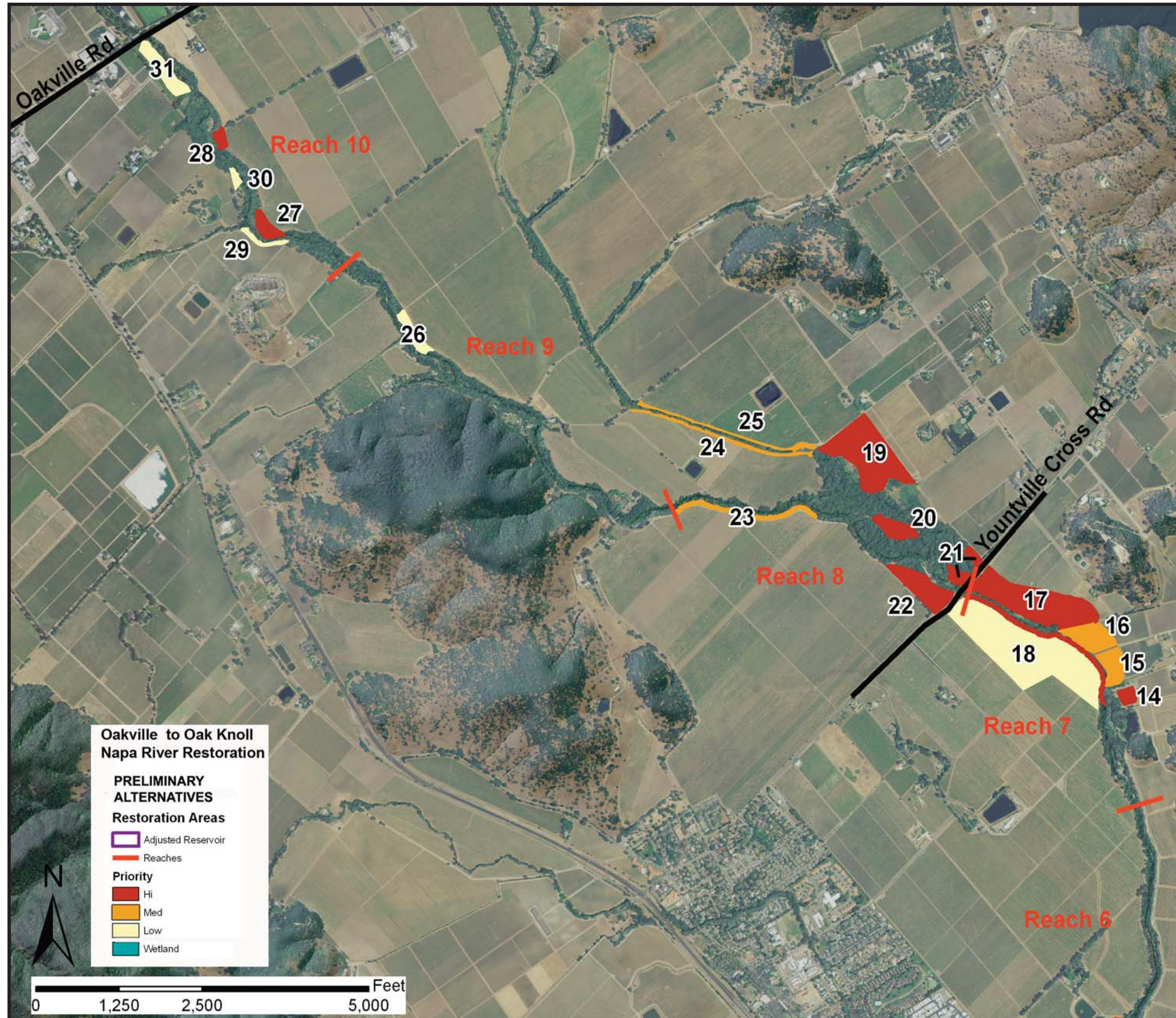


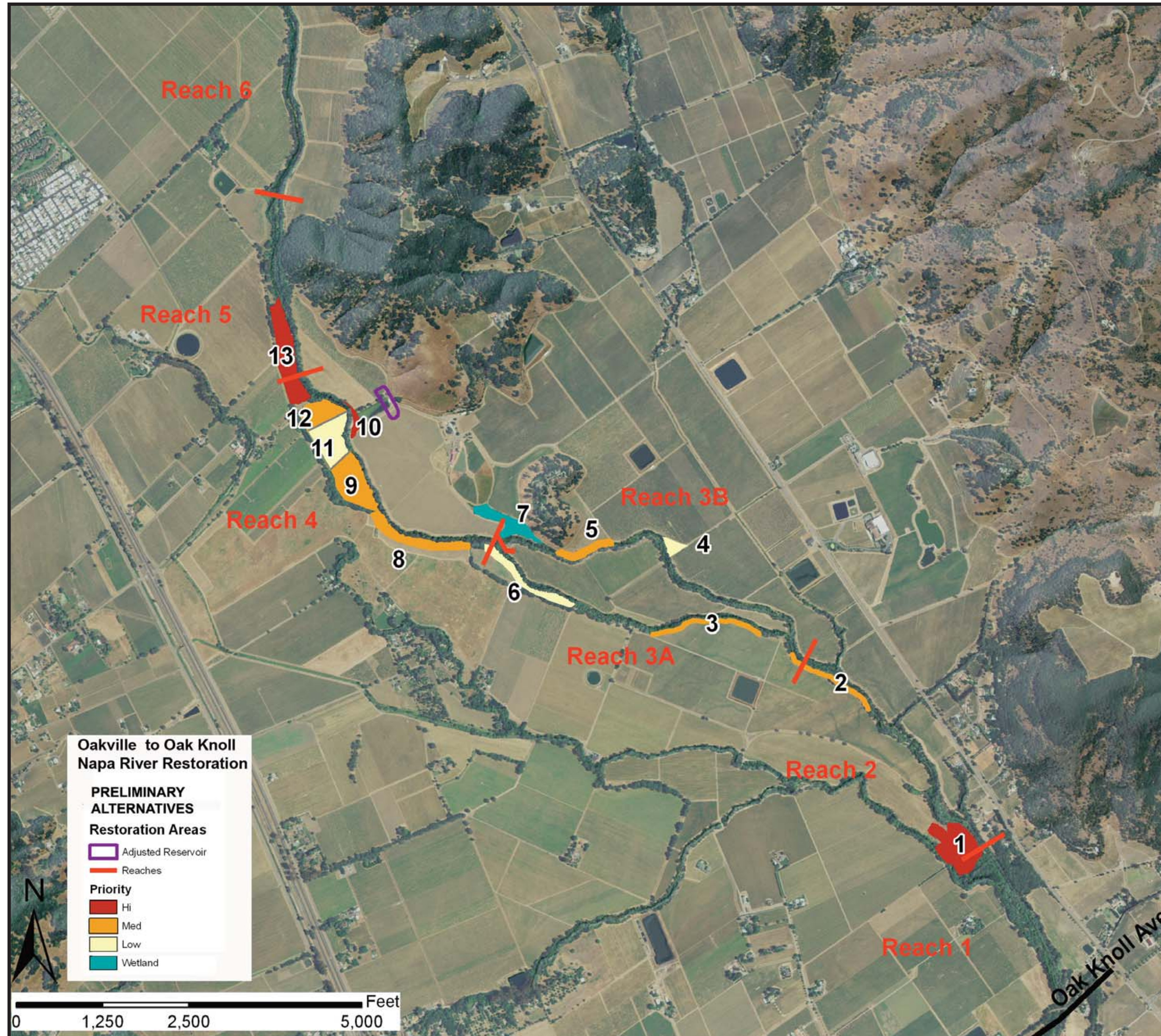
The conceptual designs were also configured for use in a two-dimensional hydrodynamic model to evaluate changes to flood levels and channel erosion and scour.

The three alternatives include:

Alternative 1 – the high priority restoration areas;

Alternative 2 – the high and medium priority restoration areas;

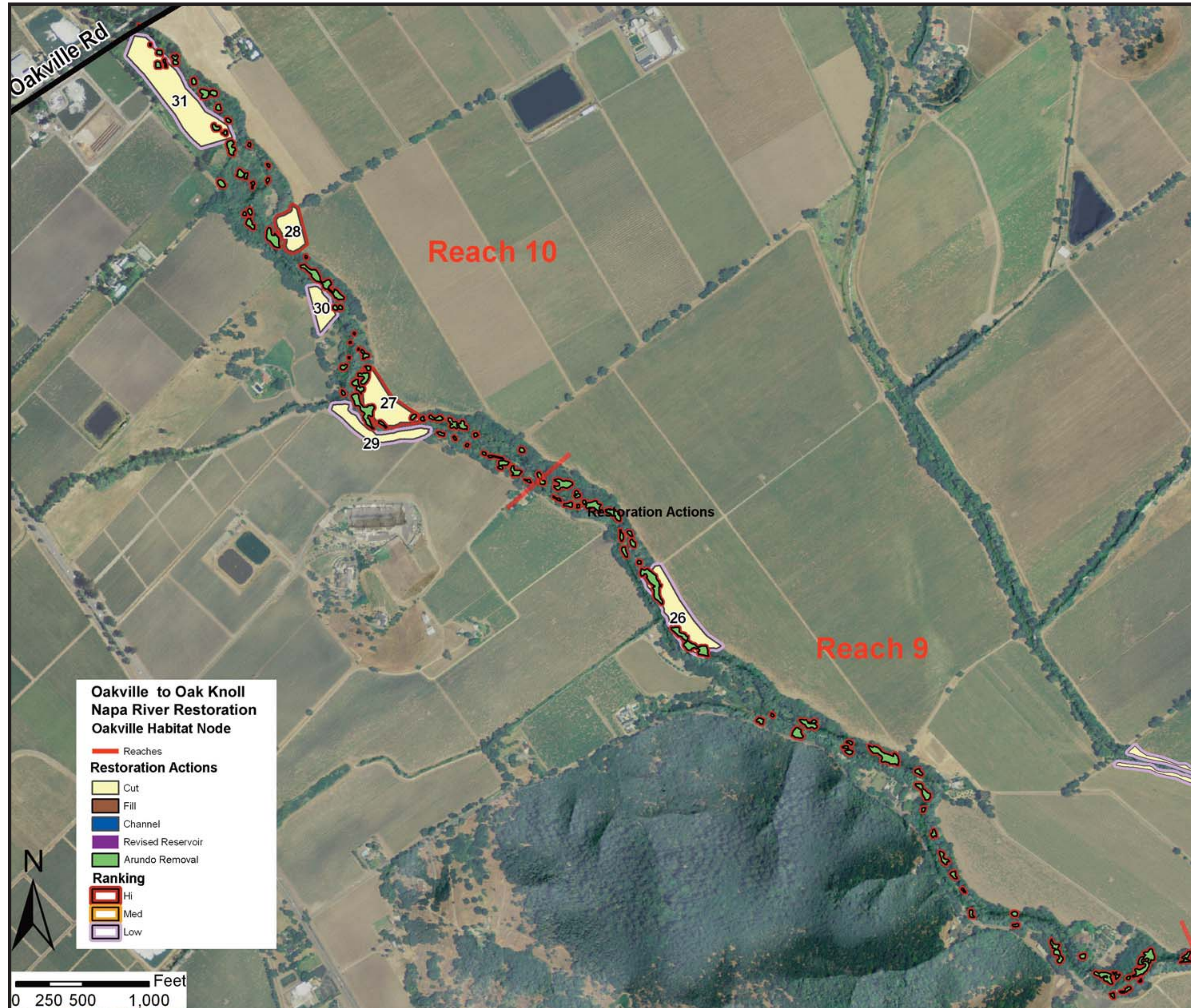
Alternative 3 – the high, medium and low priority restoration areas.

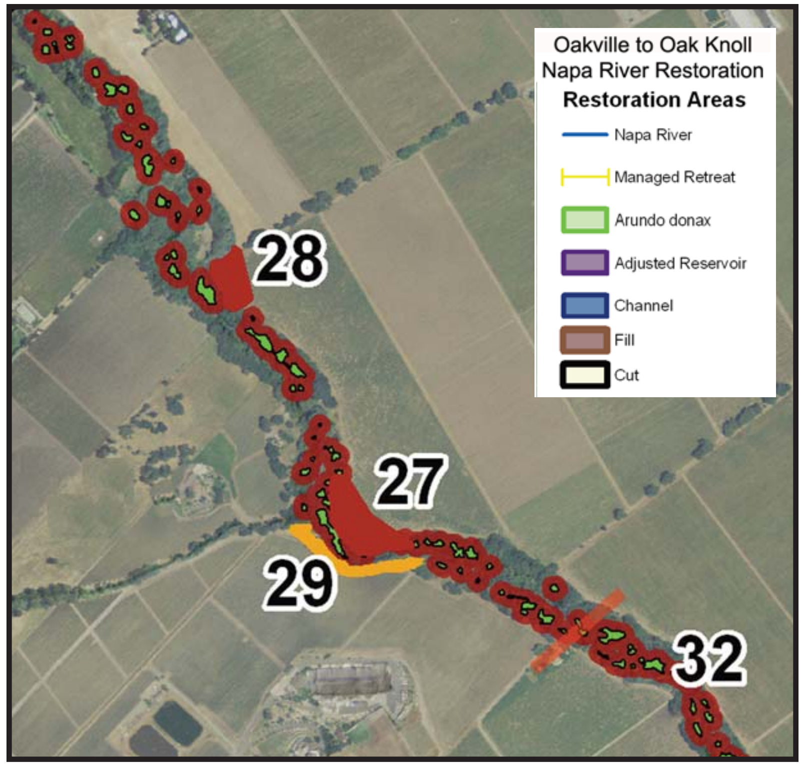


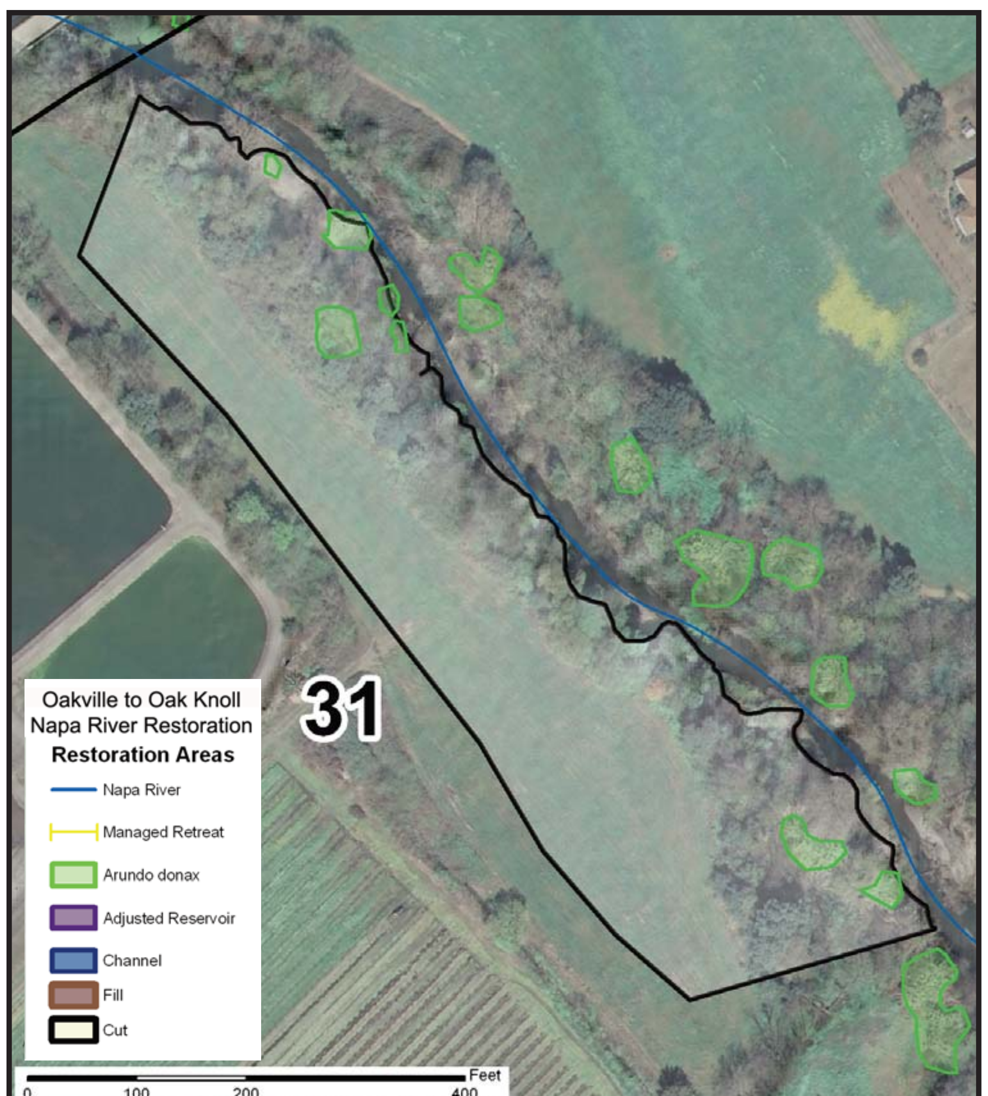
Each of the 32 restoration areas are described along with the analysis of benefits and impacts. The acres of new riparian area and affected riparian area were analyzed using the GIS layers of the field mapping of riparian vegetation completed by geomorphic area. The "Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event" analysis was a product of the hydrodynamic model and is the change in excess shear stress from existing conditions. Excess shear stress is the difference between applied shear stress (the force of running water through the channel) and critical shear stress (the point at which erosion starts). Critical shear stress was defined for spawning size gravel a value that is also similar to the value for cohesive alluvial soils.

Reaches 10 and 9 - the Oakville Habitat Node

Reach 10 has the widest, most diverse habitat in the project area. Reach 10 has the widest cross section at an average of 214 feet and has the highest width to depth ratio. There are gravel bars, secondary channels and a variety of off channel aquatic habitats. Velocities during the 10-year flood are low at 4-6 ft/second with low redd scour. Reach 9 is deeper and more entrenched than Reach 10 with eroding banks in several locations There are numerous houses and a public road along the right bank adjacent to the hillslope which have riprap or other hard materials on the bank. The riparian system is affected by Arundo but in-stream salmon habitats are numerous. The existing riparian corridor would be enhanced by active widening in several restoration acres to create a large node of diverse habitat.







Restoration Area 32: *Arundo donax* Eradication

Size: 4.52 acres distributed in Reaches 10 and 9.

Existing Condition: This large invasive non-native grass covers approximately 2.09 acres in Reach 10 and interferes with native plant growth and regeneration of the riparian ecosystem.

Proposed Condition: Eradication of Arundo and replanting with native trees will increase shade canopy and bank protection. Arundo is sprayed with glyphosate and/or imazopyr in the fall when the plant is becoming dormant and moving nutrients to the roots. The Arundo is left standing and any new growth is re-sprayed until the entire plant is dead. Once dead, the biomass is then cut and chipped on-site or burned. Then, native trees are planted.

New Riparian Area Gained: 2.09 acres in Reach 10 and 2.43 acres in Reach 9 for a total of 4.52 acres.

Existing Riparian Corridor Affected: The 4.52 acres are distributed over the corridor and treatment of the Arundo can temporarily disturb the riparian corridor.

Potential Benefits to Salmonids: Increased riparian cover, biodiversity and insect life. Reduced bank erosion, improved stream flow and a regenerating riparian corridor are also benefits.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: This feature was not evaluated for this restoration area.

Initial Ranking; High; **Final Ranking**: High

ARUNDO DONAX IS THE LARGEST GRASS IN THE WORLD AND AN INVASIVE PLANT PEST

Restoration Area 31: Active Widening

Size: 4.6 acres total

Existing Condition: Grass spray field for winery process water. Landowner suggested studying for restoration while still retaining function as spray field.

Proposed Condition: Grade site to function as floodplain or as a secondary channel with surrounding floodplain.

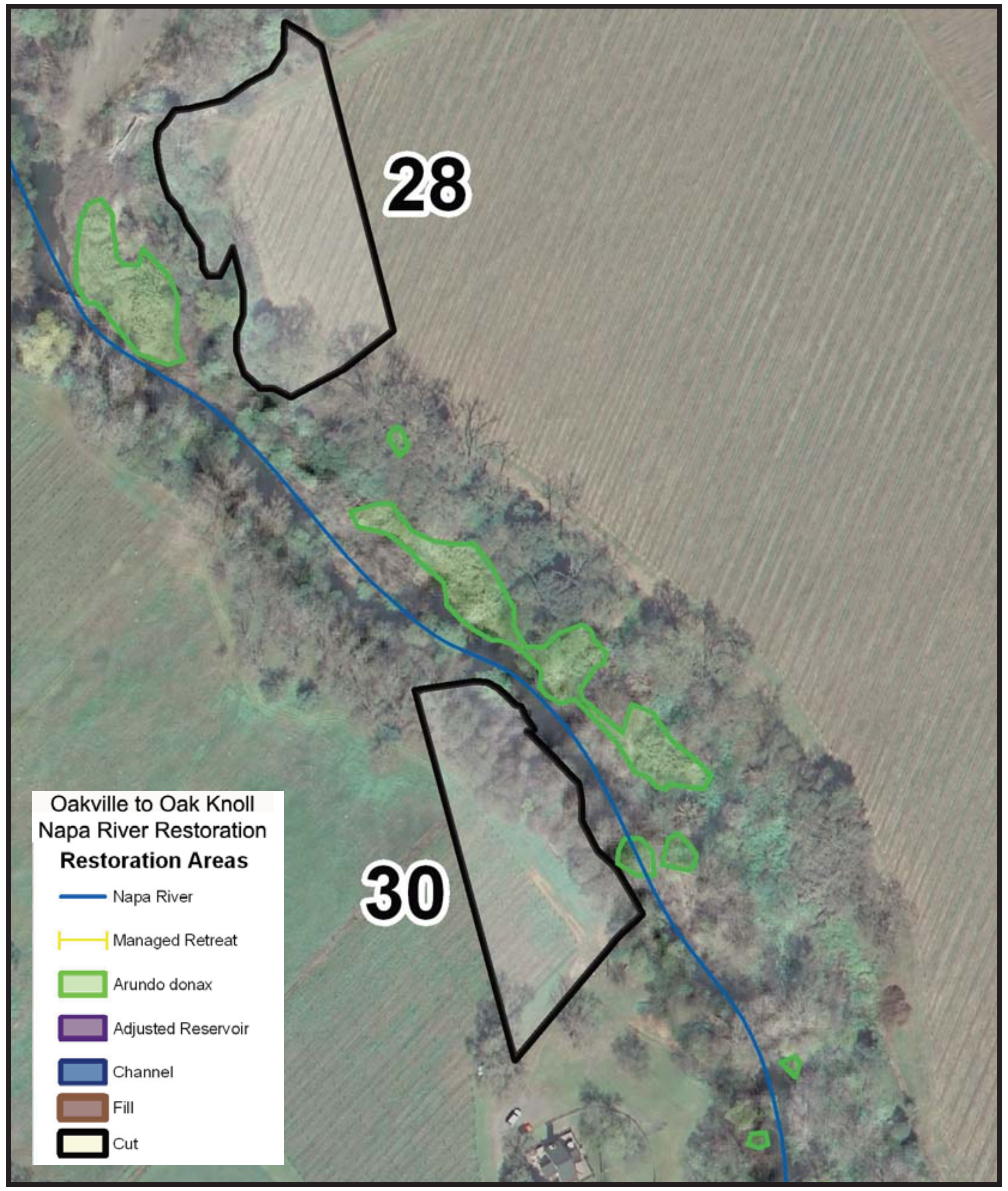
New Riparian Area Gained: 3.0 acres

Existing Riparian Corridor Affected: 1.6 acres between spray field and river channel. This area includes mostly willow and Ca. walnut sapling and small/medium size trees, with six large trees.

Potential Benefits to Salmonids: Could provide off-channel refugia and additional shade canopy.

Change in Erosive Energy (bed and bank sheet stress) during a 2-year Frequency Flood Event: This site was not evaluated in the modeling.

Initial Ranking: Low; **Final Ranking**: Low, Area 31 was ranked low when it was clear that restoration actions and continued use of the spray field were not compatible



Restoration Area 30: Active Widening

Size: 0.8 acres

Existing Condition: This site occupies the inside of a meander and includes an eroding bank, the riparian corridor above the river channel and a vineyard/upland area.

Proposed Condition: Active widening would be done through excavation of a 150 ft. wide floodplain bench to just below the 2-yr. flood elevation. Bank would be set back and willow and other biotechnical improvements installed to stabilize the bench. The new floodplain would be frequently inundated and planted with a variety of native riparian plants.

New Riparian Area Gained: 0.6 acres

Existing Riparian Corridor Affected: 0.2 acres made up primarily of Fremont cottonwood, willow, and Ca. walnut small and medium size trees would be graded to create the bench and then revegetated.

Potential Benefits to Salmonids: Reduction of fine sediment loading from channel erosion into spawning gravel would benefit salmonids as would high water refugia on new floodplain.

Change in Erosive Energy (bed and bank sheer stress) during 2-yr Frequency Flood Event: -9% (Alt. 3)

Initial Ranking: Low; **Final Ranking**: Low, inside of meander, landowner needs to approve

Restoration Area 28: Active Widening

Size: 1.0 acres

Existing Condition: This site is on the inside of a bend, adjacent to a wide area of the channel

Proposed Condition: A floodplain bench would be cut out of the existing vineyard/upland terrace to an elevation 3 ft. below the 2-yr. flood elevation, sloping towards the river channel. Native trees would be planted with valley oaks nearest the vineyard and willow and cottonwood on the channel edge.

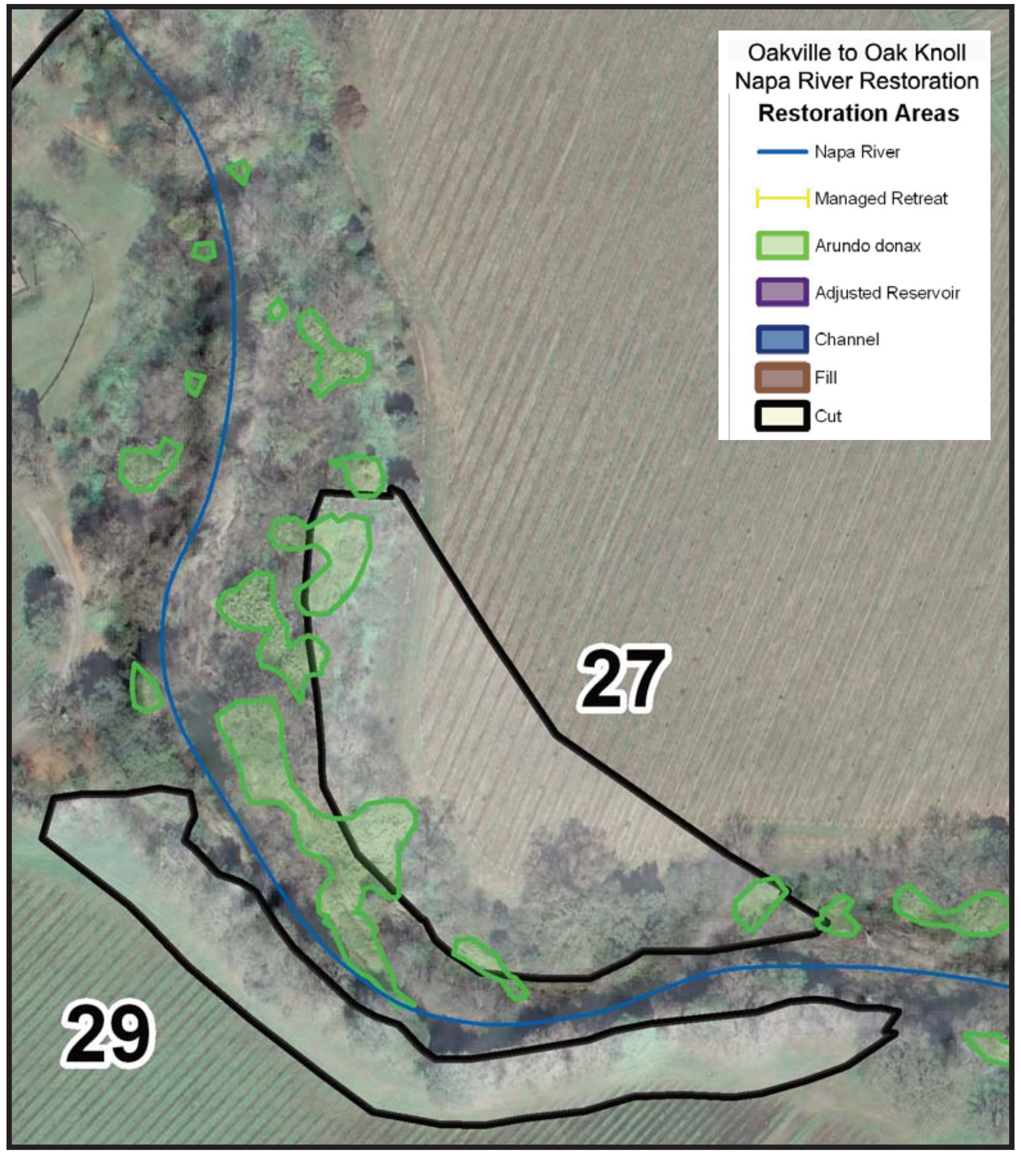
New Riparian Area Gained: 0.5 acres

Existing Riparian Corridor Affected: 0.5 acres including small and medium willow, Ca. walnut, Fremont cottonwood and live oak. Several large valley oak also occur in this area of the corridor.

Potential Benefits to Salmonids: This restoration area would provide high flow refugia area for salmon and increase channel stability from a wider cross section.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -15% (Alt. 1), -15% (Alt. 2), -36% (Alt. 3)

Initial Ranking: High, landowner suggested site; **Final Ranking**: High



ERODING BANK AT RESTORATION SITE 29

Restoration Area 29: Active Widening

Size: 1.2 acres

Existing Condition: This is an actively eroding bank on the outside of a meander

Proposed Condition: A 30 ft. wide floodplain bench would be cut into the eroding bank and the bank would be stabilized using biotechnical measures. The bench would be planted with willow and cottonwood and oaks would be installed on the top of the bank.

New Riparian Area Gained: 0.7 acres

Existing Riparian Corridor Affected: Approximately 0.5 acres would be graded for the project, removing a variety of small and medium sized Ca. bay laurel, live oak, valley oak, and willow and 13 large trees. Many of these trees are undercut spider trees which are likely to erode out. The graded area would be revegetated with native trees.

Potential Benefits to Salmonids: Actively eroding stream bank would be stabilized and revegetated, reducing sediment to spawning areas.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event:: -27% (Alt. 3)

Initial Ranking: Low; **Final Ranking**: Medium, reducing erosion at this site would benefit the river and the property owner. However the bank has hardpan clay and needs additional analysis, landowner needs to approve.

Restoration Area 27: Active Widening

Size: 2.0 acres

Existing Condition: This site consists of the inside of the river bend across from Restoration Area 29. The site consists primarily of vineyard and the existing riparian corridor.

Proposed Condition: A 180 ft. wide floodplain bench would be excavated to 3 ft. below the 2-yr. flood elevation. A berm would be constructed on the upland edge of the site to reduce flooding of the adjacent vineyard. The bench will be planted with a range of native species from valley oaks and Ca. bay laurel along the berm to Oregon ash, Fremont cottonwood and willow on the bench.

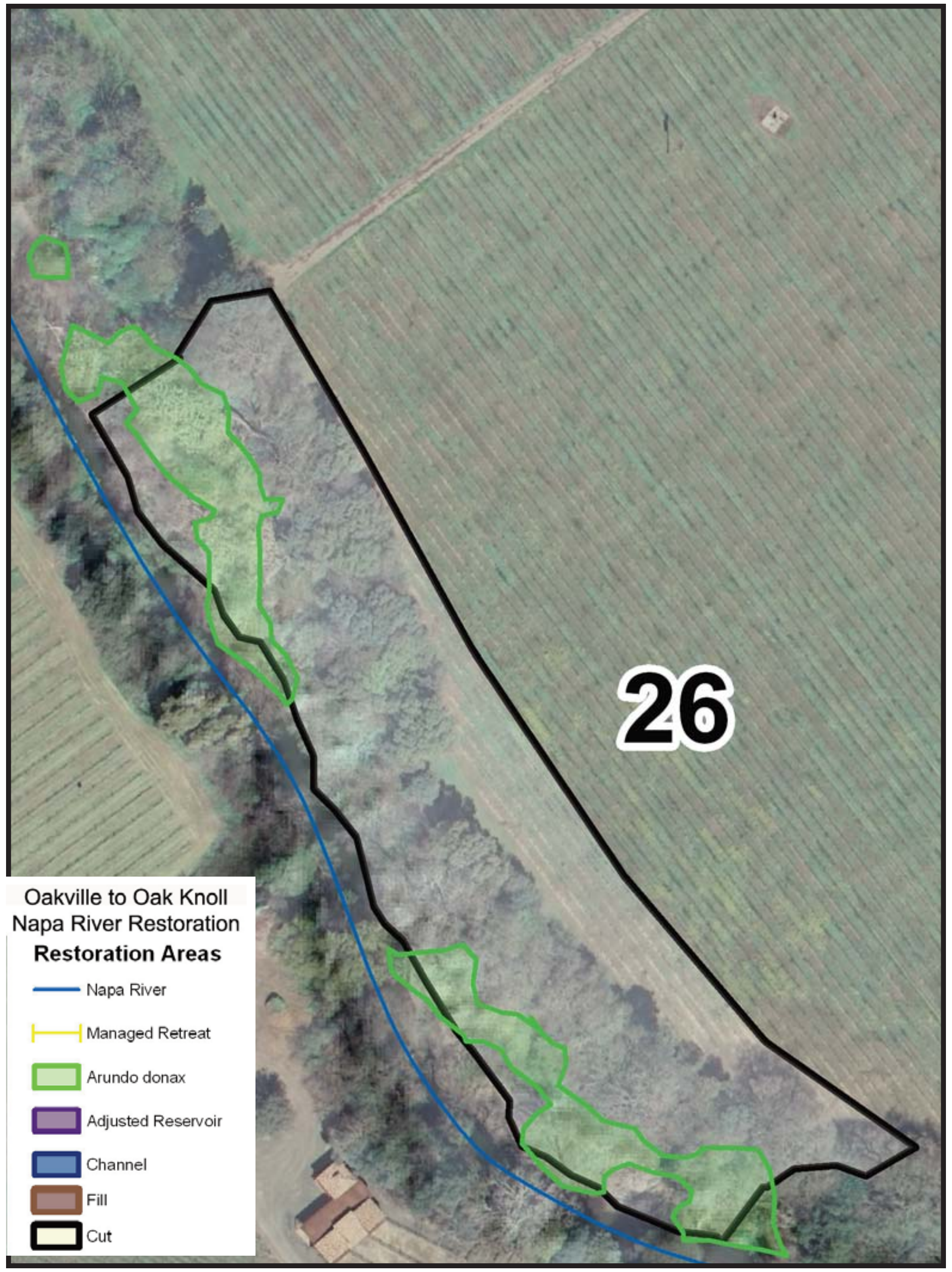
New Riparian Area Gained: 1.4 acres

Existing Riparian Corridor Affected: 0.56 acres of riparian habitat along the bank would be removed. This area contains 15 large valley oaks and a large number of small/medium sized willow, Ca. walnut and Fremont cottonwood.

Potential Benefits to Salmonids: This site would create a large off-channel habitat for salmonids.

Change in Erosive Energy (bed and bank sheer stress) During a 2-year Frequency Flood Event: +12% (Alt. 1), +12% (Alt. 2), -27% (Alt. 3)

Initial Ranking: High, landowner suggested site; **Final Ranking**: High, Additional hydraulic analysis needed to assure widening on inside of meander does not increase flow velocities and erosive stresses.



Restoration Area 26: Active Widening

Size: 2.6 acres

Existing Condition: This site is on the inside of a bend.

Proposed Condition: A floodplain bench would be graded into the bank near the 2-year flood elevation. The bench would be planted with a variety of native species. A new berm would be constructed on the upland edge of the new bench.

New Riparian Area Gained: 1.6 acres

Existing Riparian Corridor Affected: 1.0 acres which includes several large (C4) valley oak, live oak, and willow, a variety of small/medium trees and over a half acre of Arundo.

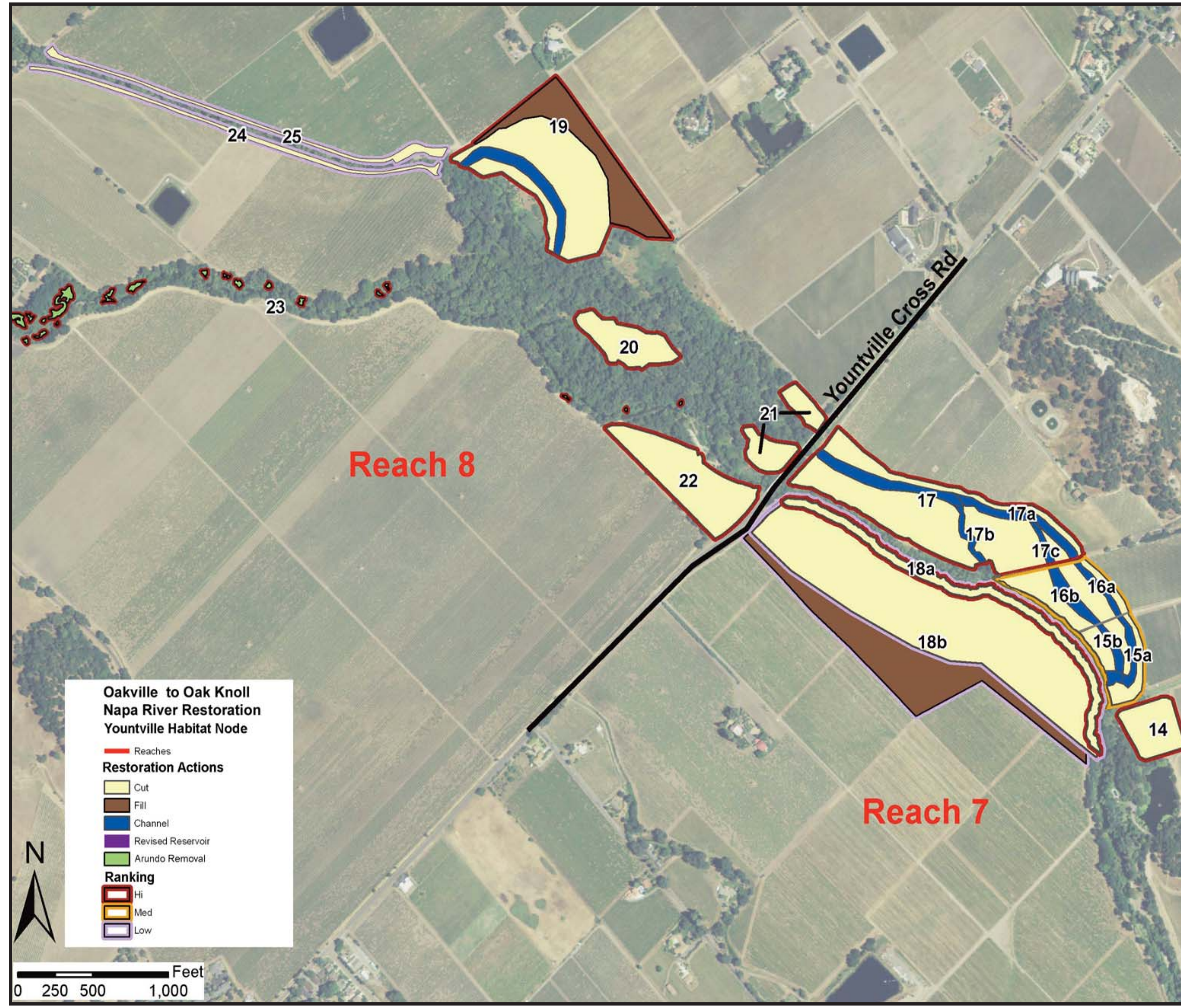
Potential Benefits to Salmonids: This project would reduce bank erosion and create high flow refugia.

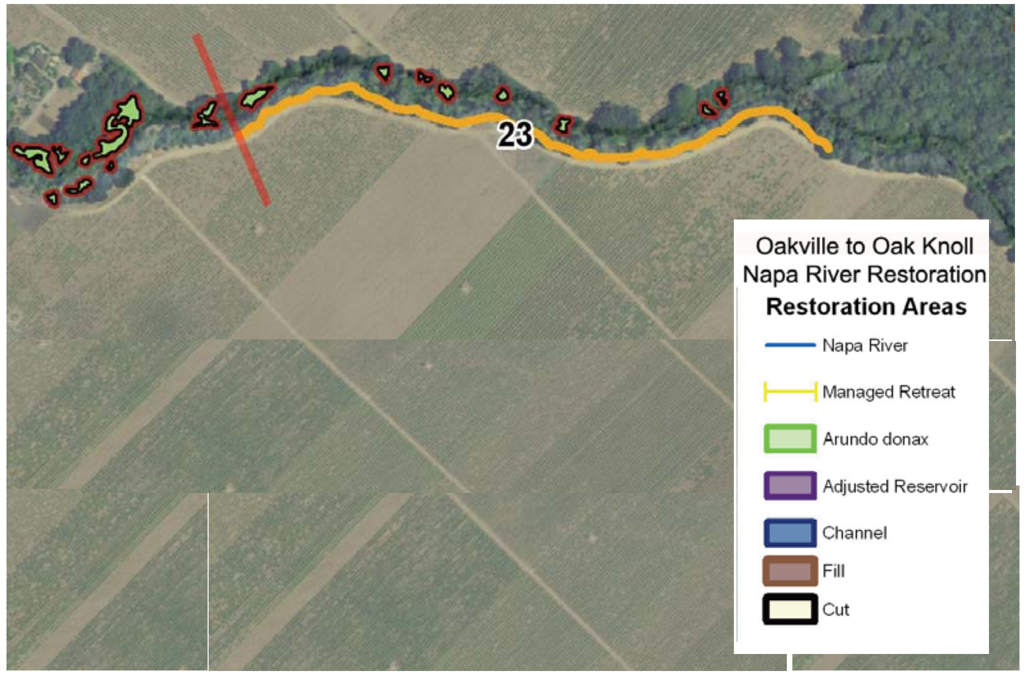
Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -41% (Alt. 3)

Initial Ranking: Low; **Final Ranking**: Low, inside of meander, landowner needs to approve

Reaches 8 and 7 - the Yountville Habitat Node

Reach 8 includes the state Ecological Reserve which was created to protect riparian habitat. Conn Creek, the largest tributary in the watershed, joins the Napa River in this reach. Numerous old growth valley oak and Ca. bay laurel grow in this reach. Reach 8 is slightly more entrenched and is narrower than Reach 7 and has one long pool/glide and no gravel bars except at the confluence with Conn Creek. Scour levels are high. The channel is likely to widen through bank failure. The river channel in Reach 7 is also highly entrenched and has incised into a resistant clay layer. Bank erosion is very high and scour of gravel occurs during the smaller flood events. There is a secondary channel just to the east of the main river which is a remnant of the multi-channel system that occurred historically. A large part of this secondary channel is covered by a conservation easement with the Napa Land Trust and is slated for restoration. This area, combined with the Ecological Reserve, anchors a large node of habitat restoration.





Restoration Area 32: Arundo Eradication

Size: 0.43 acres distributed in Reaches 8 and 7.

Existing Condition: This large invasive non-native grass covers approximately 2.09 acres in Reach 10 and interferes with native plant growth and regeneration of the riparian ecosystem.

Proposed Condition: Eradication of Arundo and replanting with native trees will increase shade canopy and bank protection. Arundo is sprayed with glyphosate and/or Imazopyr in the fall when the plant is becoming dormant and moving nutrients to the roots. The Arundo is left standing and any new growth is re-sprayed until the entire plant is dead. Once dead, the biomass is then cut and chipped on-site or burned. Then, native trees are planted.

New Riparian Area Gained: 0.26 acres in Reach 10 and 0.17 acres in Reach 9.

Existing Riparian Corridor Affected: The 0.43 acres are distributed over the corridor and treatment of the Arundo can temporarily disturb the riparian corridor.

Potential Benefits to Salmonids: Increased riparian cover, biodiversity and insect life. Reduced bank erosion, improved stream flow and a regenerating riparian corridor are also benefits.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: This feature was not evaluated for this restoration area.

Initial Ranking: High; **Final Ranking**: High

Restoration Areas 25/24: Active Widening

Size: Area 25 - 1.1 acres; Area 24 - 1.5 acres

Existing Condition: These two areas line Conn Creek just upstream of the Ecological Reserve, where the creek is channelized.

Proposed Condition: Levee would be set back, enlarging Conn Creek and its floodplain. The new areas would be revegetated with native trees.

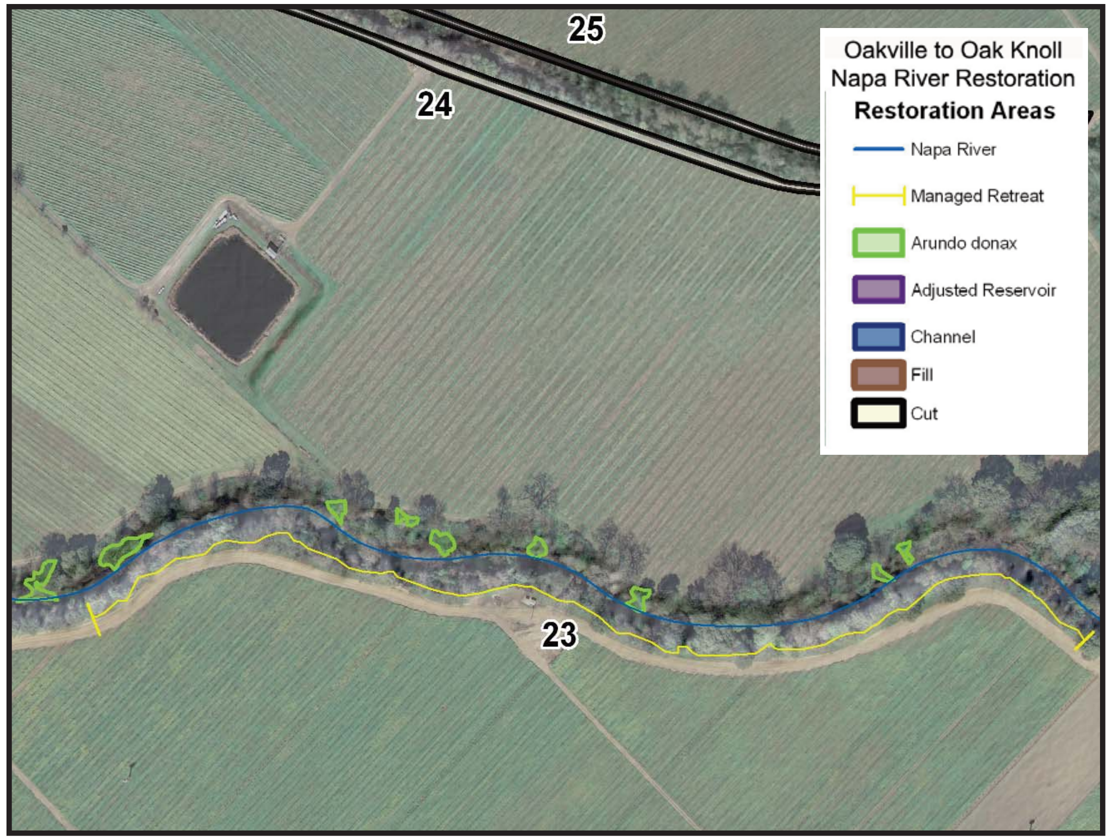
New Riparian Area Gained: 2.6 acres

Existing Riparian Corridor Affected: 0.0 acres would be affected.

Potential Benefits to Salmonids: Conn Creek can serve as a high flow refuge in wet years. However, flows in Conn Creek in drought years may be too low for salmon to use this area.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: Not evaluated

Initial Ranking: Low; **Final Ranking**: Low



Restoration Area 23: Managed Retreat

Size: 2,370 linear feet of Napa River channel

Existing Condition: The right bank of the Napa River upstream of the Ecological Reserve supports numerous old growth oak and Ca. bay laurel trees. The channel is highly entrenched, actively eroding and banks are about 20 feet tall. The river channel has few bed-forms or diversity in aquatic habitats.

Proposed Condition: Although most of the large trees on this site are undercut, they still provide a unique ecological area. For this reason, active widening is not being considered for this site. Instead, managed bank retreat is recommended. Under this concept, the river bank is allowed to erode during flood events and is than re-shaped and revegetated. As the banks fail and the channel widens, flood flow velocities decrease and the channel erodes less. The banks will likely first fail on the outside of each bend as this is where the greatest stress is exerted on the bank. These areas are already having erosion problems.

The eroded bank is shaped to a stable angle (2 or 3:1) and revegetation of the base of the failed bank is done by willow sprigging. Additional native species are planted at the top and mid bank area. These steps will help to stabilize the eroded bank and restore the shade canopy.

A new berm would be considered along the vineyard/new corridor edge on this site as the channel widens to reduce flood problems.

New Riparian Area Gained: There is no method to exactly predict the increase in riparian area. However a 20 ft. bank will erode to a stable angle of 2 or 3:1 affecting between 40-50 ft. at the top of the bank

Existing Riparian Area Affected: Small portions of the riparian corridor would be affected at one time and revegetation would be done as the corridor changes with the natural rate of channel widening.

Potential Benefits to Salmonids: As the banks fail, the larger trees on the top of the bank will become large wood in the channel. These two changes - the addition of large wood and widening of the channel in a few locations, will give the aquatic habitat greater diversity and value to salmonids.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: There is no method to predict the change in channel erosion

Initial Ranking: Medium; **Final Ranking**: Medium

NATURAL BANK RETREAT IN RESTORATION AREA 23

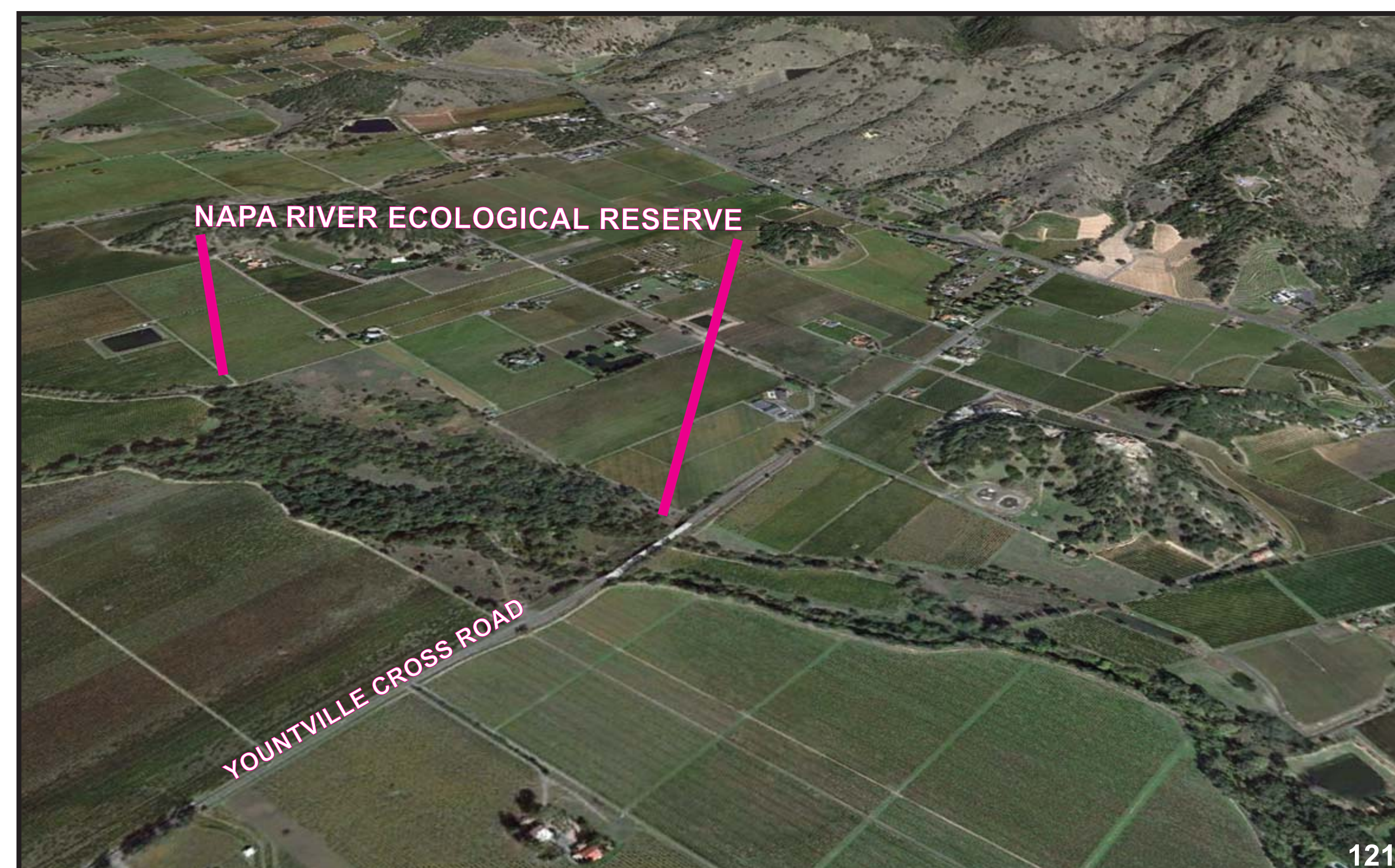
LARGE UNDERCUT TREE IN NAPA RIVER ECOLOGICAL RESERVE. WILLOW BASKET WAS INSTALLED TO REDUCE BANK EROSION

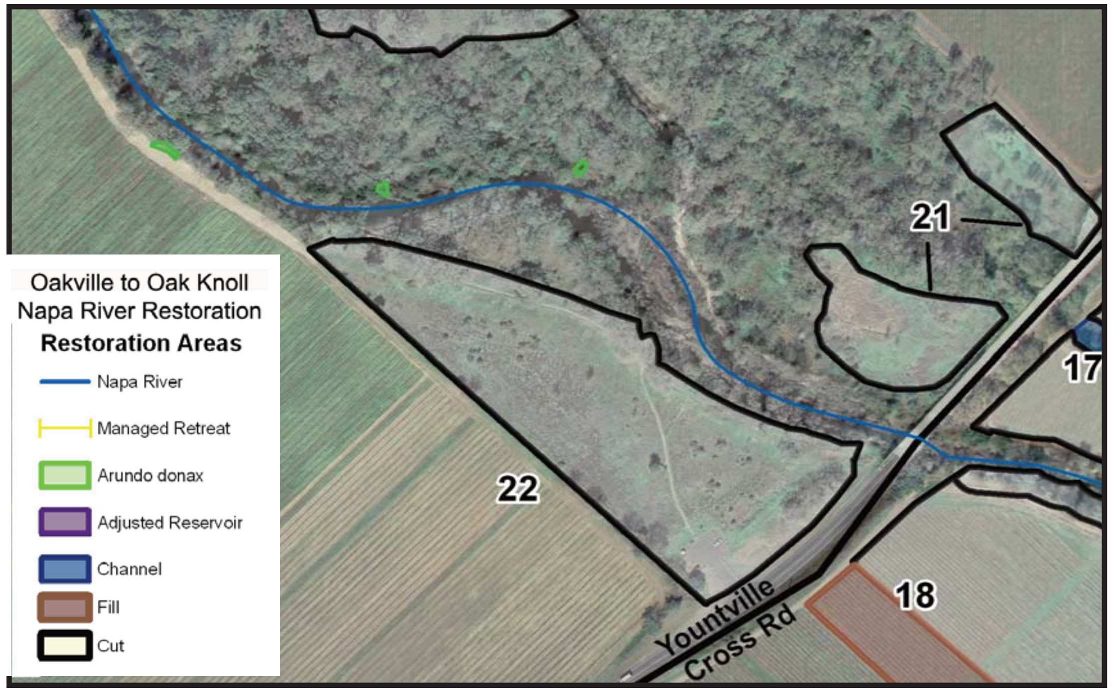
Restoration Areas 22-19 Napa River Ecological Reserve

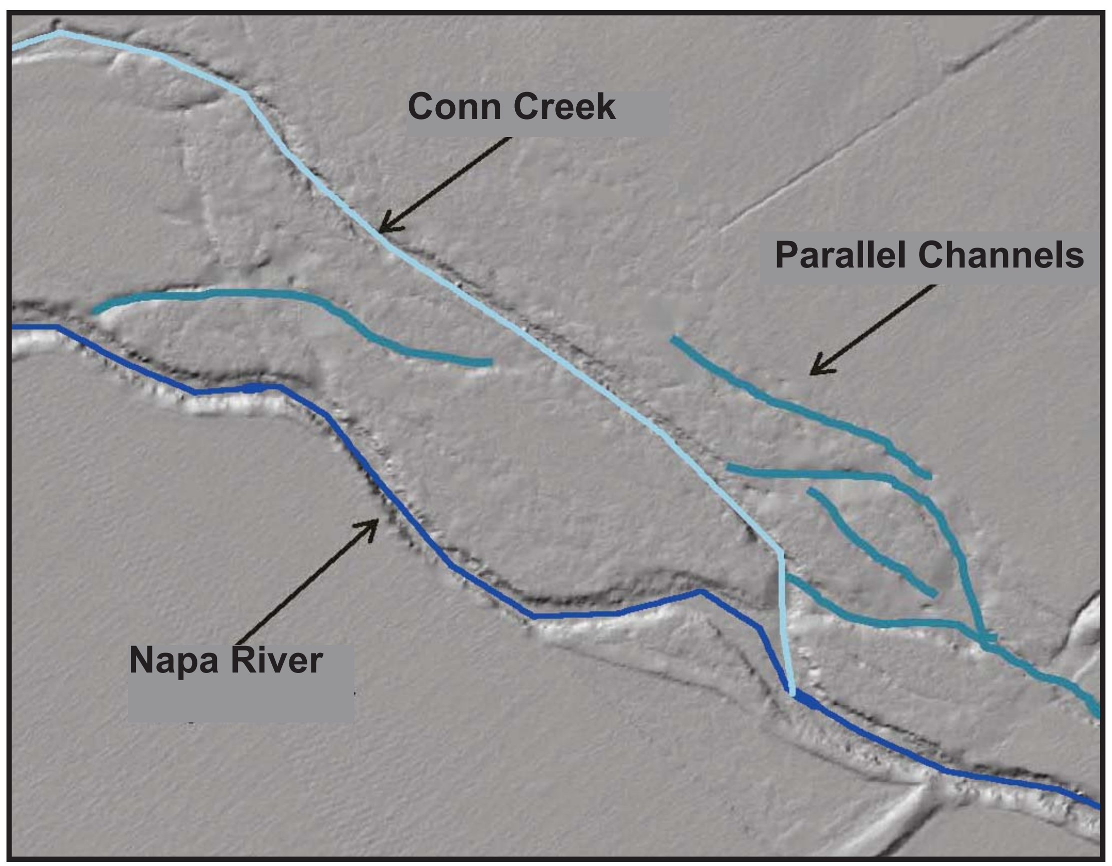
The 73-acre Napa River Ecological Reserve (NRER) upstream of the Yountville Cross Road is an important anchor of riparian habitat in the center of the project area. It is unusual to have such a large open space that has the potential to be restored to the multi-channeled braided fluvial system that historically supported multiple salmonid species in the Napa River. Currently the river through the NRER is a single thread channel and the right bank is bermed. The confluence of Conn Creek and the Napa River occurs in the middle of the reserve. Both the main river channel and Conn Creek are highly entrenched.

While the NRER was purchased to protect riparian habitat, the incision of the Napa River has left the adjacent floodplain and riparian forest isolated from the river and without the frequent flooding needed to sustain riparian areas. These changed hydrologic conditions allow non native plants to invade the former riparian areas. For example, the eastern portion of the NRER is an upland field, mainly supporting Himalayan blackberry, fuller's teasel, and other invasive plants. There are, however, wetland plants such as willows and tules, indicating that groundwater is present. Species of concern on the Napa River include steelhead trout and Chinook salmon. According to the Napa County aerial LIDAR, the floodplain is 15-20 ft above the channel of both the main stem and Conn Creek. These single thread channels are not connected to floodplains and therefore are not providing refuge or alcoves to support salmonids. The Department of Fish And Game (CDFG) manages the NRER. There is no long term management plan for the reserve. The four proposed restoration sites will be reviewed again with CDFG staff and were selected to remove invasive weeds and benefit listed species.

RESTORATION AREA 19 IS LARGELY INVASIVE WEEDS RATHER THAN RIPARIAN FOREST DUE TO A LACK OF FREQUENT FLOODING







LIDAR SHOWS DETAILED TOPOGRAPHY IN THE ECOLOGICAL RESERVE AND THE MANY PARALLEL CREEK AND RIVER CHANNELS WHICH WILL BE RECONNECTED TO FLOW TO IMPROVE RIPARIAN CONDITIONS

Restoration Area 22: Active Floodplain Restoration

Size: 6.2 acres

Existing Condition: This site is part of the Ecological Reserve and has a parking lot and a large levee which isolates most of Area 22 from the Napa River. The levee serves to eliminate the hydrologic processes needed to maintain native riparian forest. Much of the site is a mixture of invasive non-native plants and native plants. A recent project removed invasives and planted some native species.

Proposed Condition: If this floodplain site is to support native riparian habitat, it needs to be re-connected to the river channel. The river channel in this location has a large gravel bar used by salmon for spawning. However, the channel is entrenched, making this gravel subject to high erosive energy. The project would breach the levee in locations without large trees to reconnect the floodplain channel. A new berm would be constructed on the west side of the site and the parking lot would be raised in elevation. By restoring this hydrologic connection, the floodplain area could sustain a variety of native plants and wildlife and have fewer invasive species.

New Riparian Area Gained: 4.7 acres would become frequently flooded riparian floodplain

Existing Riparian Corridor Affected: A portion of the existing levee, about 0.5 acres of riparian forest, would be removed.

Potential Benefits to Salmonids: Reconnecting the Napa River to its floodplain will reduce erosion of spawning gravel and increase refugia habitat.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: The model results for this site are highly affected by the large flood basin proposed at site 18 and do not reflect the actual improvement for this restoration area. This occurs because the river is significantly widened at site18 and the water surface profile is locally steepened affecting the model output for this site to appear to cause erosion.

Initial Ranking: High; **Final Ranking**: High, however, an evaluation of the new revegetation project will be needed.

Restoration Area 21: Active Floodplain Restoration

Size: 2.2 acres

Existing Condition: This area has three remnant parallel channels surrounded by riparian and upland areas.

Proposed Condition: The weedy non-riparian areas would be graded down to an elevation closer to Conn Creek and the other channels to create riparian habitats.

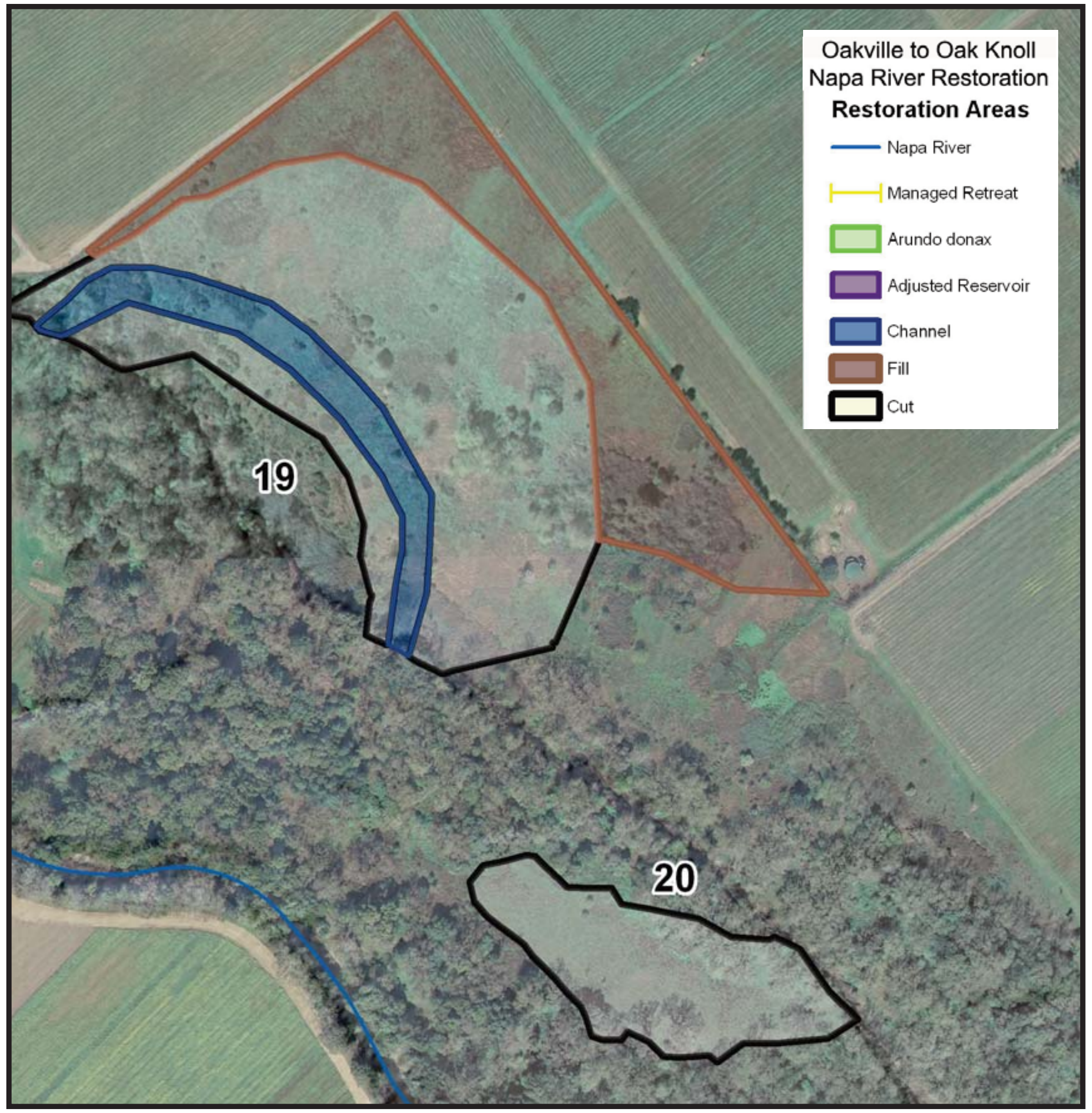
New Riparian Area Gained: 2.2 acres

Existing Riparian Corridor Affected: The existing riparian areas would benefit from improved flooding.

Potential Benefits to Salmonids: This area has great potential to provide off-channel refugia habitat and additional spawning areas.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: The model results for this site are highly affected by the large flood basin proposed at site 18 and do not reflect the actual improvement for this restoration area. This occurs because the river is significantly widened at site18 and the water surface profile is locally steepened affecting the model output for this site to appear to cause erosion.

Initial Ranking: High; **Final Ranking**: High



AREA 20

Restoration Area 20: Active Floodplain Restoration

Size: 2.9 acres

Existing Condition: This site is a grassy field in the floodplain of the Napa River and Conn Creek. European grasses and invasive non-native plants and numerous plum trees cover the site.

Proposed Condition: This area would be graded down to an elevation that would be flooded by a 2-year flood event. The area would also be planted with native trees.

New Riparian Area Gained: 2.8 acres

Existing Riparian Corridor Affected: 0 acres

Potential Benefits to Salmonids: Additional floodplain area will reduce velocities in both the Napa River and Conn Creek and create off-channel habitat areas.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -20% (Alt. 1), -19% (Alt. 2), -19% (Alt. 3)

Initial Ranking: High; **Final Ranking**: High

Restoration Area 19: Active Widening

Size: 16.2 acres

Existing Condition: This area is the northeastern corner of the Ecological Reserve and has a mosaic of weedy upland areas and a few areas of native trees.

Proposed Condition: A secondary channel and floodplain would be graded in one section of Area 19. The fill would be used to create upland habitat and a berm to limit flooding on adjacent property. This project would also lower flood levels during the 2-year event in the local area. The new channel would cover 1.6 acres, the new floodplain 9.4 acres and the upland/berm 5.2 acres. The floodplain would be revegetated with a variety of native trees and understory plants. The upland would be planted with native perennial grasses, herbs and shrubs.

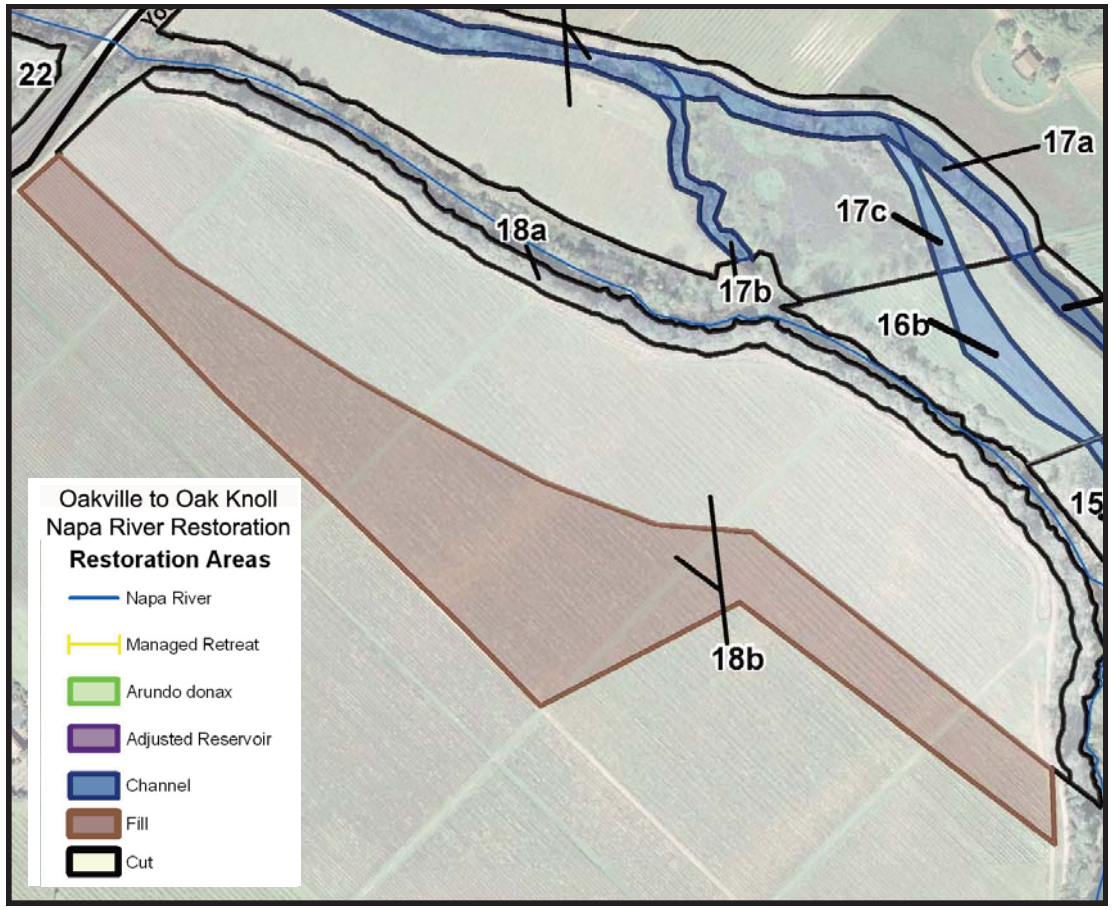
New Riparian/New Channel Area Gained: 9.4 acres riparian area, 1.6 acres new channel

Existing Riparian Corridor Affected: Several areas of native trees species (0.9 acres) will be affected but the majority of the area (15.3 acres) is fennel, fuller's teasel, Himalayan blackberry, nonnative grasses and other invasive plants with some native sedges. The sedges will be salvaged and replanted along the new channel edges.

Potential Benefits to Salmonids: Area 19 would create a new secondary channel and off-channel habitat area. The project would also reduce bank erosion downstream by reducing flood levels and velocities.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -16% (Alt. 1), -15% (Alt. 2), -14% (Alt. 3)

Initial Ranking: High; **Final Ranking**: High



VIEW FROM AREA 18 LOOKING UPSTREAM AT YOUNTVILLE CROSS ROAD BRIDGE

Restoration Area 18: Active Widening and Flood Detention Basin

Size: 18a Setback only - 3.4 acres
18b: Flood basin and setback and new berm - 37.9 acres

Existing Condition: This site includes the right bank of the Napa River and the adjacent vineyard. The right river bank is actively eroding and undermining the large berm on the top of the bank. The riparian corridor is narrow and made up of numerous spider trees. The landowner suggested the adjacent vineyard be studied for use as a flood detention basin.

Proposed Condition: Alternative 18a would set the bank back at a stable angle and create a more stable river bank. The undercut berm on the top of the bank would need to be removed and reconstructed within the existing vineyard. This berm overtops and erodes in larger floods. Setting the bank back and building an engineered berm would improve the current eroding system. The new bank would be stabilized with biotechnical methods such as willow sprigging. The mid and upper bank areas would be planted with a variety of native trees. Under alternative 18a, the vineyard and river bank would be graded to create a flood basin. Material excavated from the basin would be used to build an upland and berm along the western basin boundary. The basin would be graded to the 2-year flood elevation and be managed as a floodplain/flood basin. This would remove about 36.4 acres of vineyard and require acquisition of this property.

New Riparian Area Gained: 18a – 1.1 acres, 18b – 22.2 acres assuming the basin would have wetland/riparian species throughout.

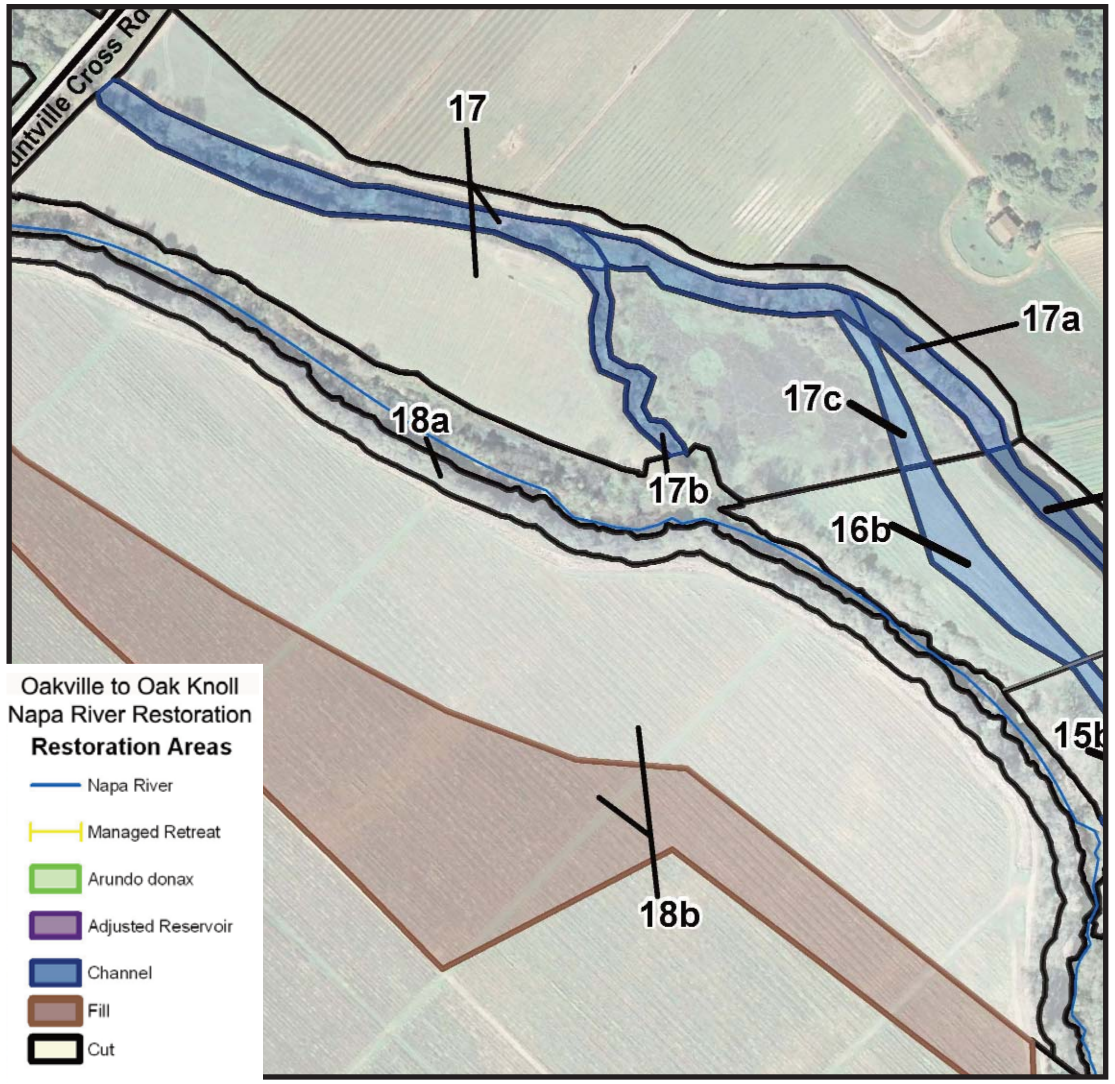
Existing Riparian Area Affected: 2.3 acres of the narrow riparian corridor along the right river bank would be removed under 18a and 2.5 acres under 18b. This corridor includes some large (C4) valley and live oak, Ca. walnut and willow but most of the trees are undercut spider trees. Small/medium and sapling trees in the corridor include willow, Ca. walnut and Oregon ash as well as invasive non-native black locust.

Potential Benefits to Salmonids: The 18a project would reduce sediment delivery to the river and reduce erosive energy which scours spawning gravel from the river channel. The 18b project would create a large off-channel habitat area.

Change in Erosive Energy (bed and bank sheer stress) During a 2-year Frequency Flood Event: 18a -59% (Alt. 1), -85% (Alt. 2), -57% (Alt. 3); 18b -85% (Alt.3).

Initial Ranking: 18a – High; 18b - Low.

Final Ranking: 18a - High; 18b - Low. Downstream of the Yountville Cross Road bridge, the Napa River channel is dominated by hard pan clay. This condition may preclude major restoration projects and additional study is needed.



Restoration Area 17: Active Widening and Floodplain Restoration

Size: 17a, b, c – 15.9 acres

Existing Condition: This site includes the left bank of the Napa River which is eroded with many of the trees undercut. A second parallel channel marks the eastern edge of this site. This secondary channel is broad and shallow and vegetated with wetland and riparian plants. Between the two channels there is a vineyard.

Proposed Condition: The owners, the Missimer Family, have dedicated an easement over the parallel channel and adjacent habitat, the vineyard and left bank of the river. The vineyard and river bank would be graded down to create a floodplain at the 2-year flood elevation. The existing secondary channel will be retained to avoid wetland habitat loss and a gradual gradient between the secondary channel to the Napa River would be created. The floodplain will be revegetated with native trees. The new floodplain would replace 8.2 acres of vineyard and 6.4 acres of upland. A berm would be built on the eastern edge of the site to protect the adjoining vineyard from flooding. There are three possible locations to connect the secondary channel to the Napa River channel. Under 17a and 17c the historic channel would be used but require that Areas 16 and 15 be included in the restoration. Under 17b only Area 17 would be restored.

New Riparian /New Channel Area Gained: 17a – 13.4 acres riparian; 2.4 acres channel, 17b – 14.2 acres riparian; 1.7 acres channel. 17c - 13.6 acres riparian; 2.3 acres channel

Existing Riparian Corridor Affected: This secondary channel would be retained but the left bank of the Napa River would be graded, removing 0.3 acres of the riparian corridor. The riparian corridor has mostly sapling willow with only a few large trees.

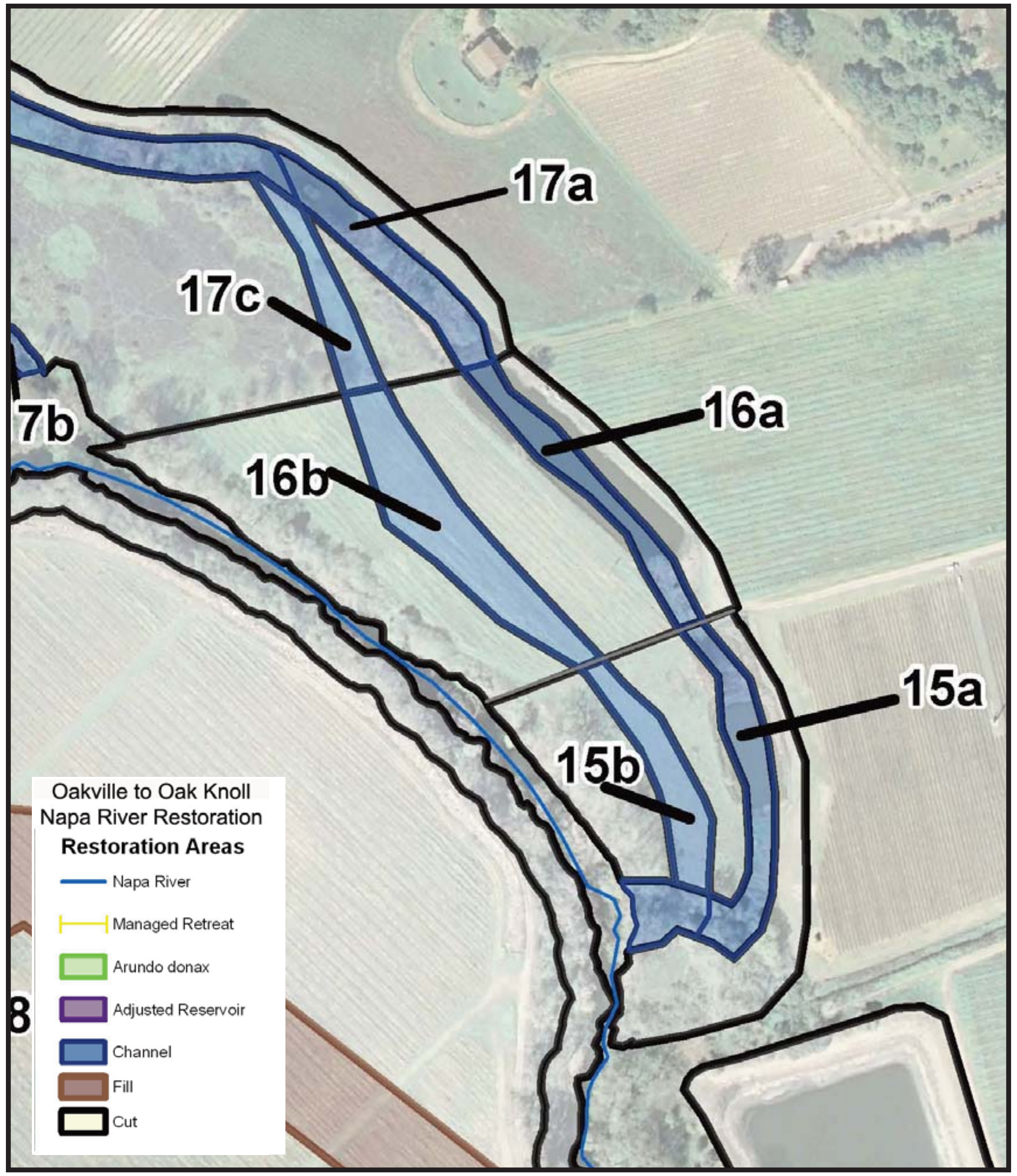
Potential Benefits to Salmonids: The creation of this large floodplain with a secondary channel will create off-channel habitat and, by widening the river cross-section, reduce bank erosion and scour of spawning gravel.

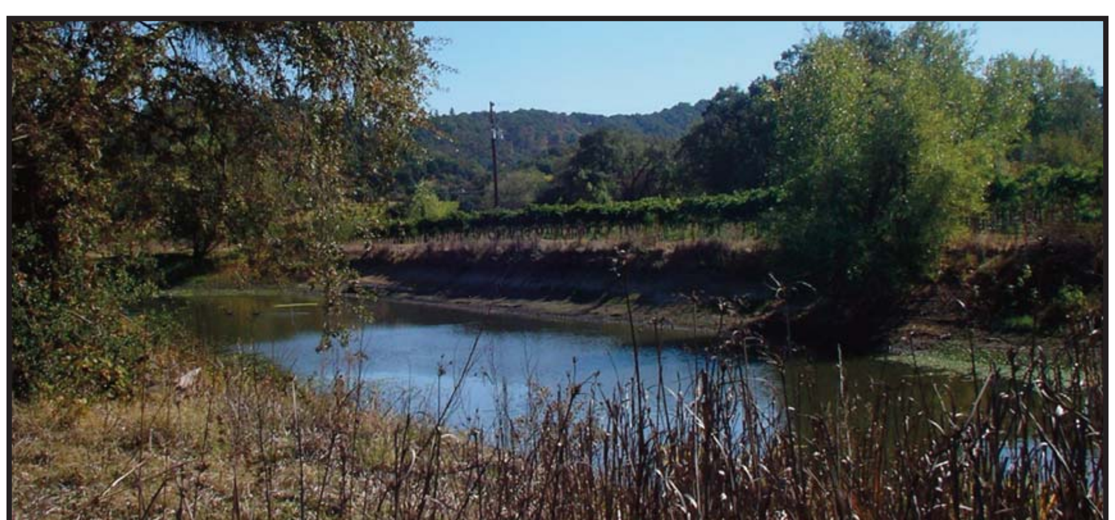
Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -33% (Alt. 1), -94% (Alt. 2), 76% (Alt. 3)

Initial Ranking: 17a, b, c - High; **Final Ranking**: 17a, b, c - High

FAR LEFT: VINEYARD ON RESTORATION AREA 17 ADJACENT TO SECONDARY CHANNEL WOULD BE RESTORED TO HABITAT

LEFT: TULES AND RIPARIAN HABITAT OF SECONDARY CHANNEL





HISTORIC SECONDARY CHANNEL ON RESTORATION AREA 16
IS USED AS A RESERVOIR

Restoration Area 16: Active Widening

Size: 16a - 5.1 acres; 16b - 2.9 acres

Existing Condition: This site includes the left bank of the Napa River, the historic secondary channel which has been excavated to create a reservoir and the vineyard in between the channels.

Proposed Condition: The left bank of the Napa River and vineyard would be graded to create a floodplain at the 2-year flood level. The floodplain would be revegetated with native trees. The secondary channel/reservoir would either be filled and a new channel created (16b) with the area east of the new channel remaining as vineyard, or the channel would be filled and re-contoured to match the upstream area of this channel (16a) and the entire site would be restored. A berm would be built along the eastern edge of the vineyard.

New Riparian Area Gained: 16a - 4.7 acres of new riparian habitat and 0.4 acres of restored channel/wetland habitat; 16b - 2.1 acres of new riparian habitat and 0.8 acres of restored channel

Existing Riparian Corridor Affected: 0.47 acres of existing riparian corridor along the river would be removed. This area includes mostly sapling and small/medium trees of willow and Ca. walnut with few large trees.

Potential Benefits to Salmonids: The secondary channel and floodplain will provide off-channel habitat for salmonids. The project will also widen the cross section of the river and reduce erosion and scour.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: N/A (Alt. 1), -67% (Alt. 2), -85% (Alt. 3)

Initial Ranking: Medium; **Final Ranking**: Medium. Landowner needs to approve; land may need to be purchased.

Restoration Area 15: Active Widening

Size: 15a - 3.6 acres; 15b - 2.2 acres

Existing Condition: This site encompasses the left bank of the Napa River, a secondary channel, and upland in between. The secondary channel has a small in-ground reservoir.

Proposed Condition: The riverbank and upland area would be excavated to create a floodplain that would be planted with native trees. The secondary channel would either be filled and graded to match the elevation of the upstream area of the channel (15a) or a new channel would be created (15b) and the area east of the newchannel would not be restored. The secondary channel will reconnect to the Napa River on this site. A berm would be built on the eastern side of the new secondary channel to reduce flooding.

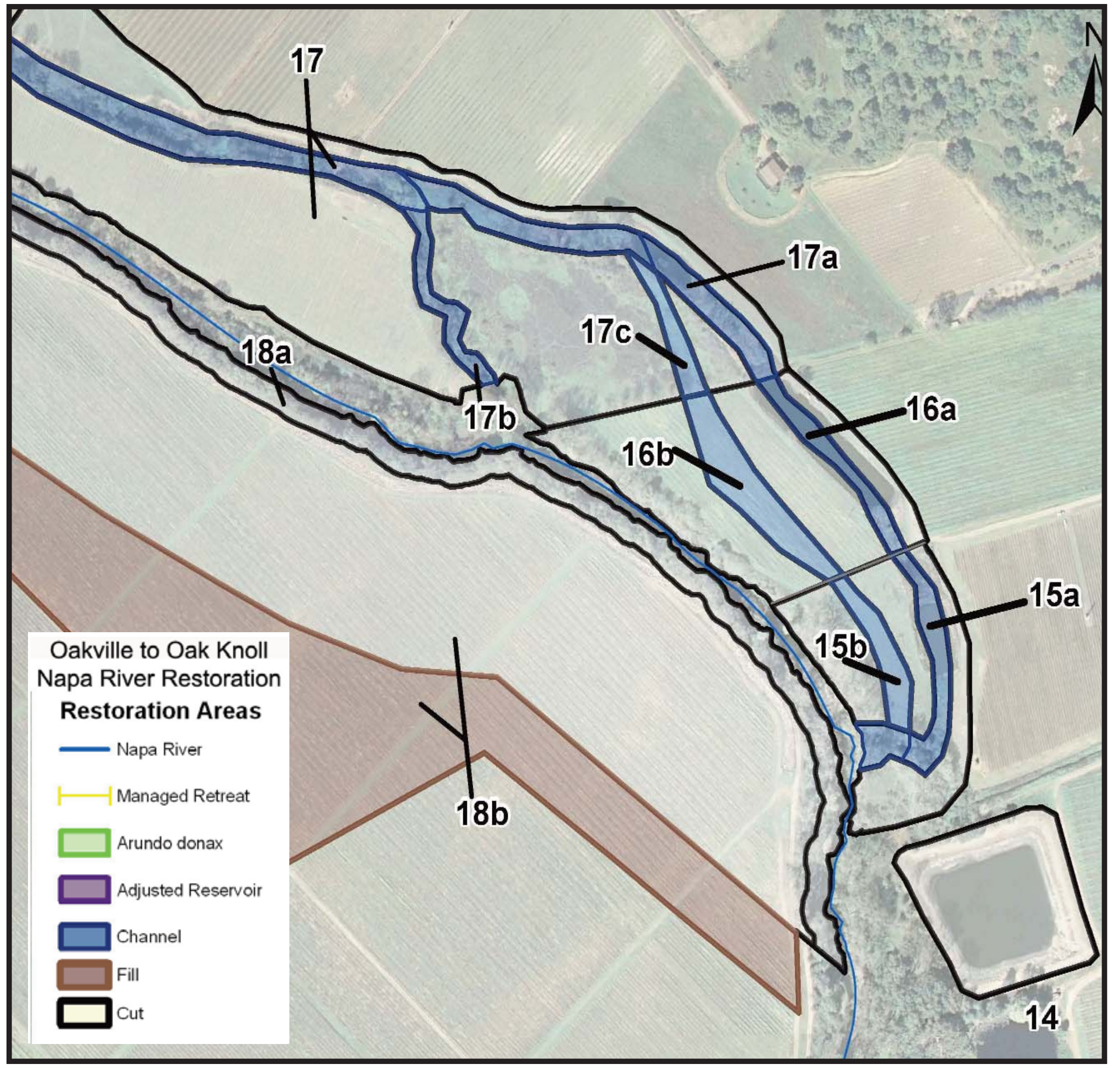
New Riparian/New Channel Area Gained: 15a - 2.9 acres riparian, 0.7 acres channel; 15b 1.7 acres riparian, 0.6 acres channel.

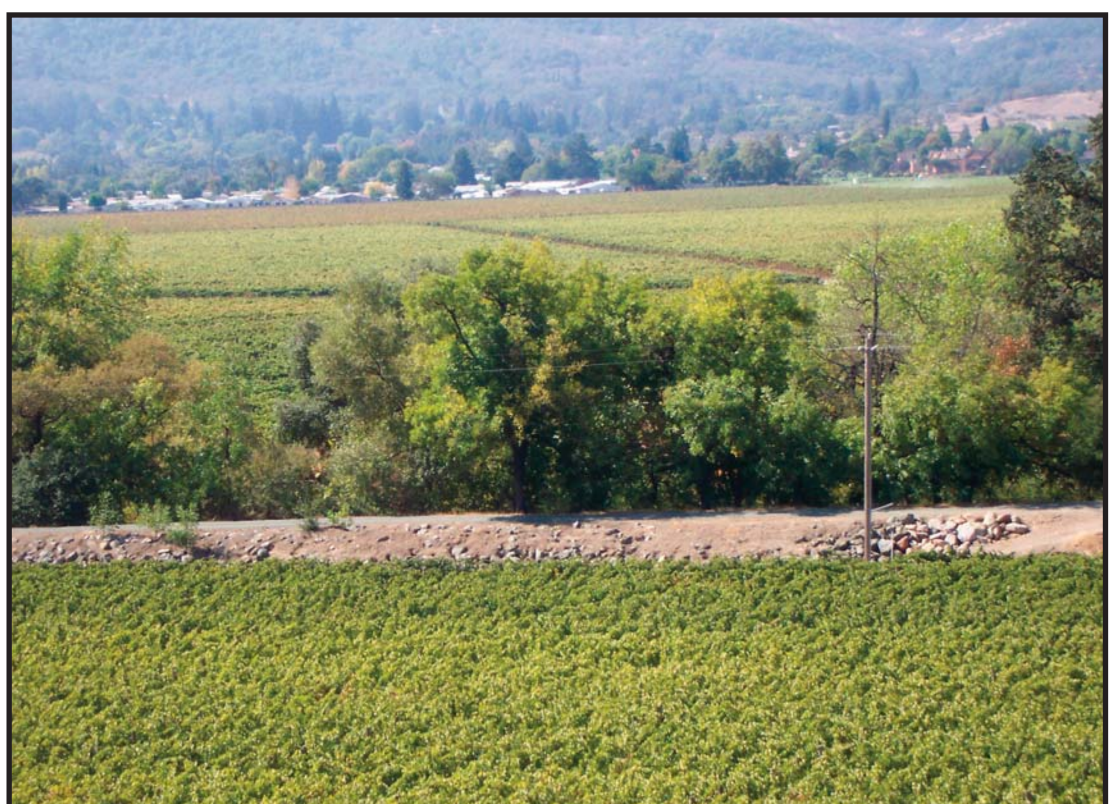
Existing Riparian Corridor Affected: 0.6 acres of the riparian corridor along the river would be removed and is made up primarily of willow and Ca. walnut small/medium trees and saplings. There are few large trees.

Potential Benefits to Salmonids: The secondary channel and floodplain will provide off-channel habitat for salmonids. The project will also widen the cross section of the river and reduce erosion and scour.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: N/A (Alt. 1), -55% (Alt. 2), -54% (Alt. 3)

Initial Ranking: Medium; **Final Ranking**: Medium. Landowner needs to approve; land may need to be purchased.





Restoration Area 14: Floodplain Restoration

Site: 1.2 acres

Existing Condition: A storm water pond consisting of an off-stream bermed enclosed pond.

Proposed Condition: This pond would be removed and the site would be graded to create a flood plain. The floodplain would be planted with native riparian trees. The removal of the existing pond would reduce erosion on the opposite side of the river.

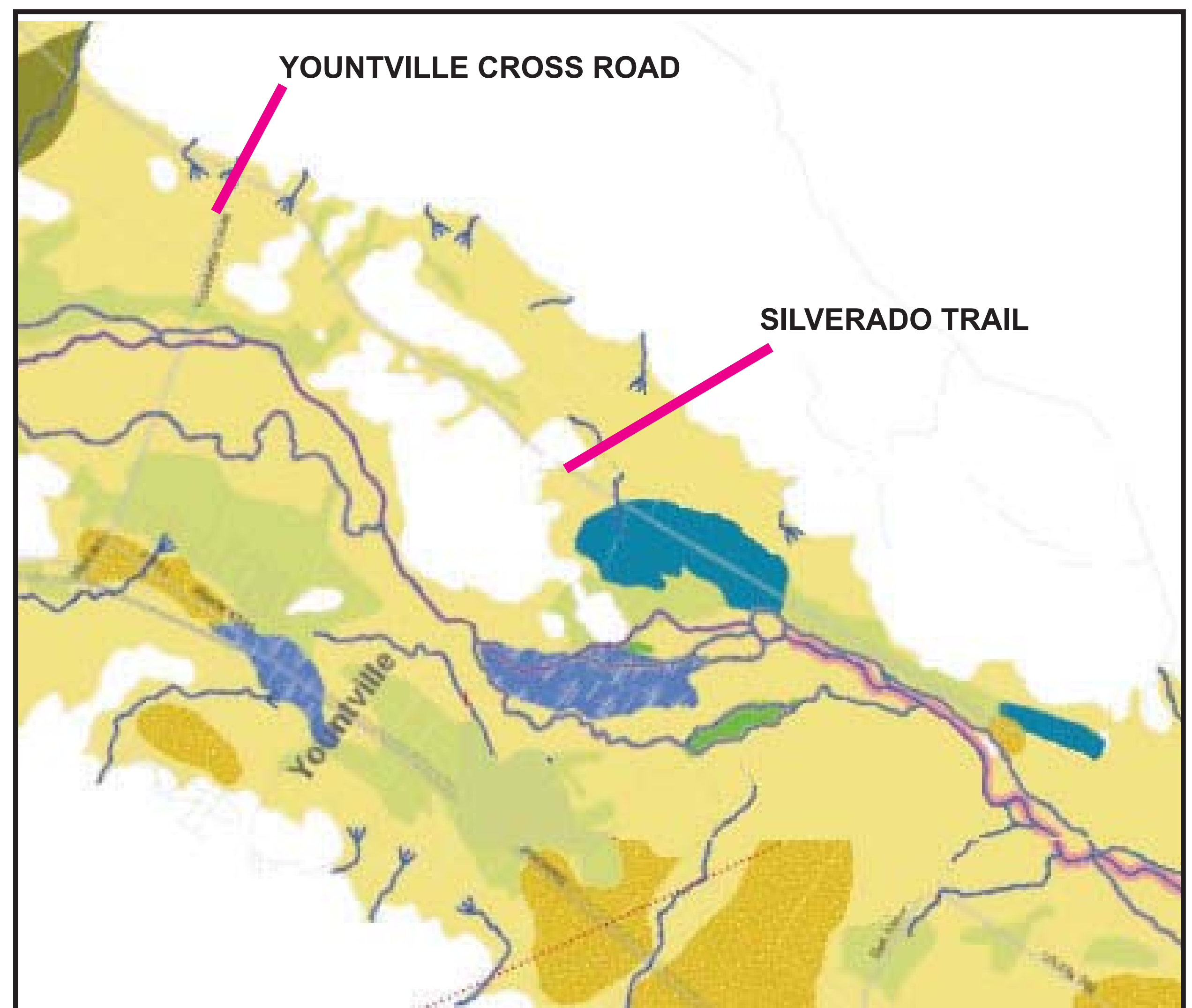
New Riparian Area Gained: 1.2 acres

Existing Riparian Corridor Affected: 0.0 acres

Potential Benefits to Salmonids: This site would increase the floodplain area available at greater than 2-year flood events.

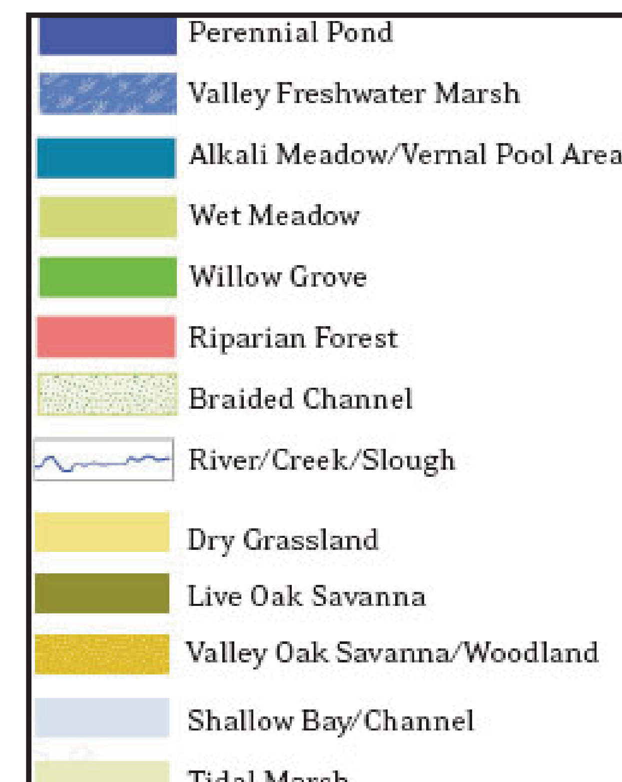
Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -48% (Alt. 1), -18% (Alt. 2), -47 % (Alt. 3)

Initial Ranking: High, landowner suggested; **Final Ranking**: High.



COURTESY OF SAN FRANCISCO ESTUARY INSTITUTE

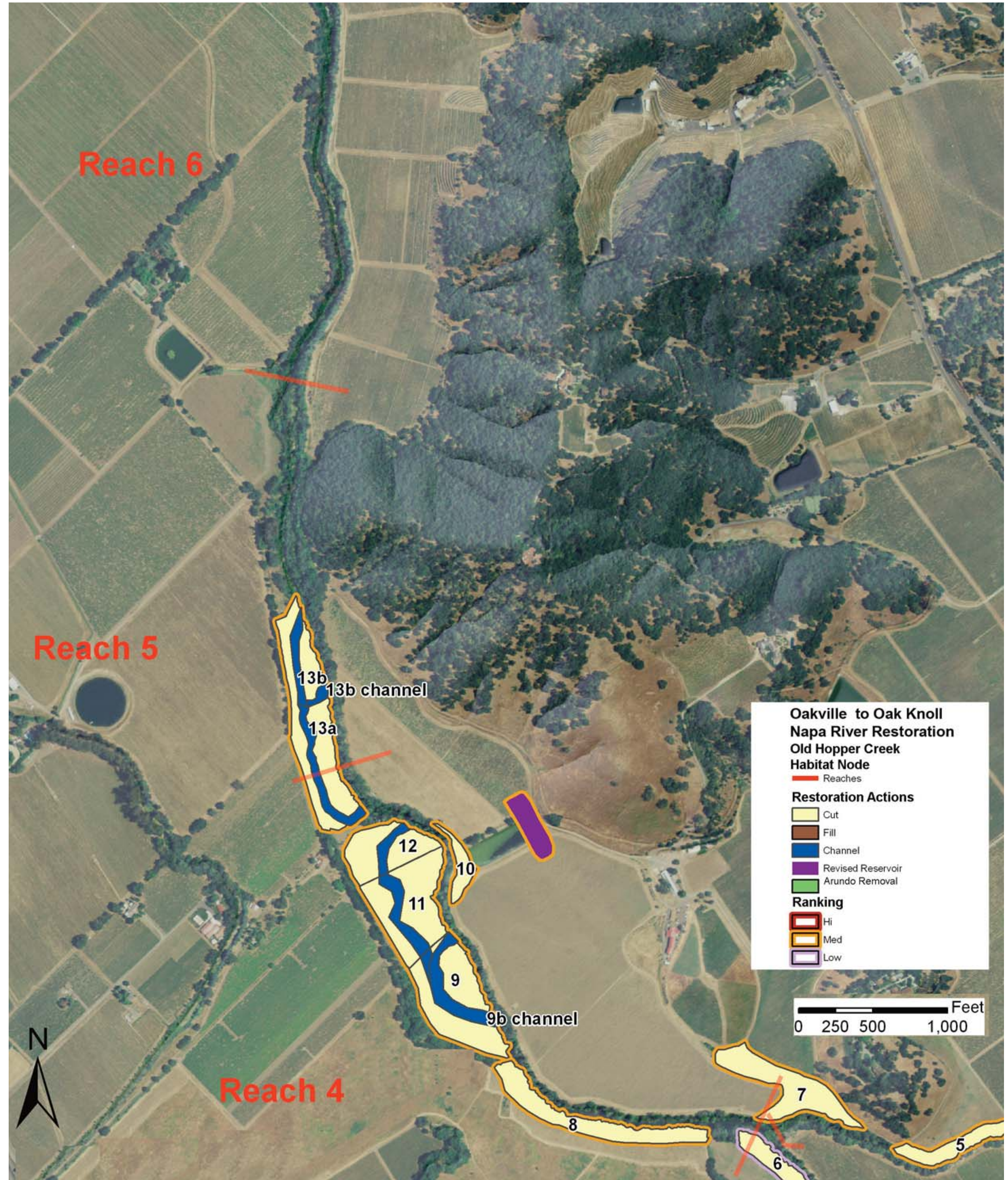
SAN FRANCISCO ESTUARY INSTITUTE COMPLETED AN HISTORICAL ECOLOGY PROJECT FOR THE NAPA RIVER IN WHICH THE PRE-FARMING LANDSCAPE WAS DETERMINED FROM NUMEROUS MAP AND FIRST PERSON SOURCES

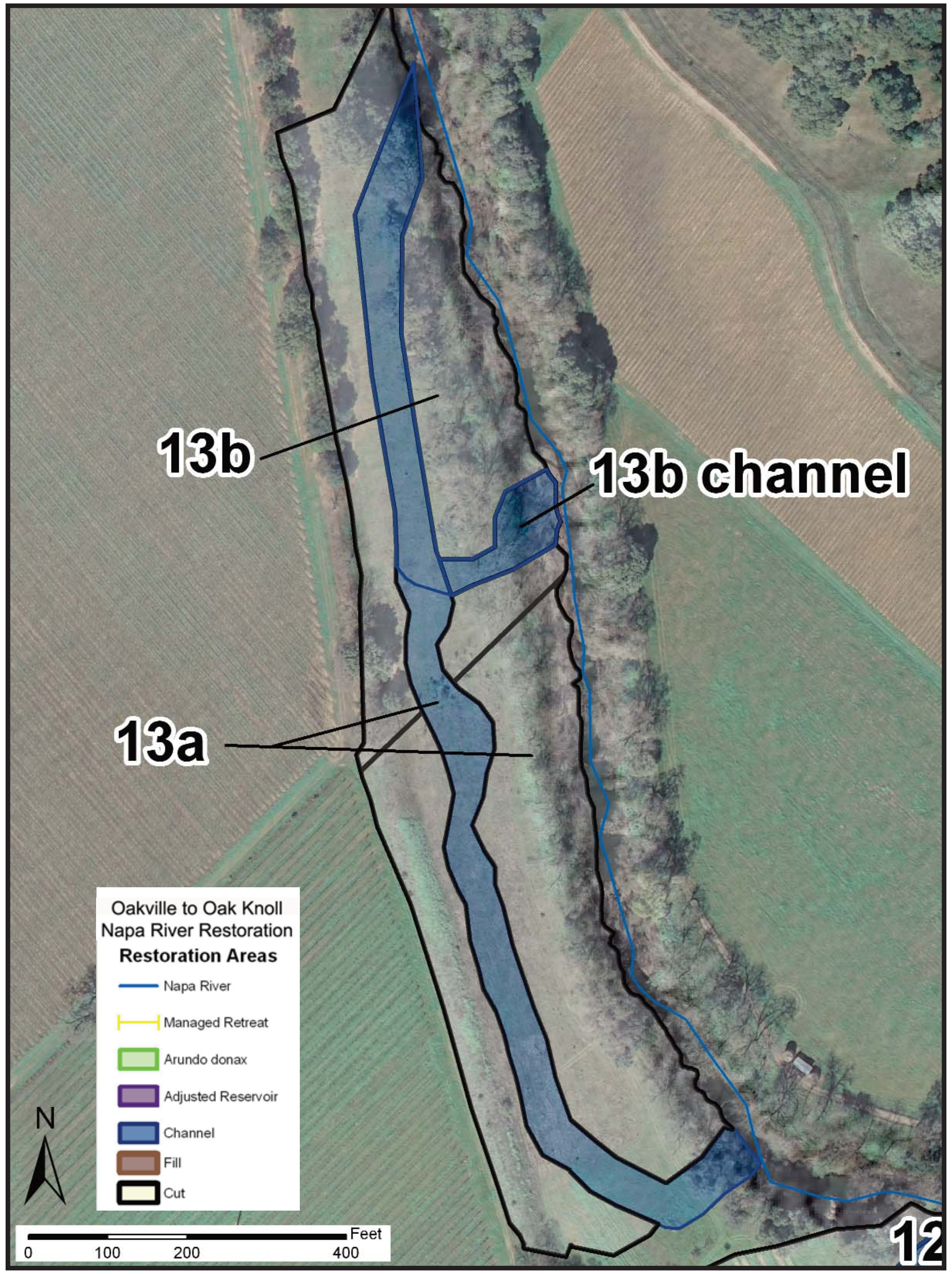


Reaches 6, 5 and 4 - the Old Hopper Creek Habitat Node

Reach 6 is one of the most confined reaches in the project area with few geomorphic features that support fish habitat. However to achieve an equilibrium condition would require substantial widening and removal of vineyard. The river channel has incised into a hard pan clay layer and it is not clear that grading to set back banks and create floodplain benches is a viable restoration action. Instead channel widening is proposed in Reaches 4 and 5 where a flood overflow channel and fallow land offer an opportunity to evaluate methods for restoration in this clay layer. Reach 5 is relatively short and includes a hillslope on the left bank and a flood overflow channel on the right bank. Reach 5 has previously widened and most of the large trees have been eroded out into the channel, which along with narrow gravel bars, create spawning habitat for salmonid. However most of this reach has a very thin riparian corridor. Reach 4 is the most entrenched reach in the project area. There are no gravel bars and the river has incised into hard pan clay creating one very long pool/glide with little value to salmonids.

HARD PAN CLAY DOMINATED THE RIVER BOTTOM IN AREAS 13-8





Restoration Area 13: Active Widening and Floodplain Restoration

Size: 13a – 8.4 acres, 13b - acres

Existing Condition: Area 13 is a flood overflow channel which was created in the 1960's. The western edge of the area is bermed and live oaks cover portions of the berm. The area between the berm and the river riparian corridor is mostly grass with seedling trees.

Proposed Condition: Area 13a would use the entire Area 13. A secondary channel and adjoining floodplain would be graded to the 2-year flood elevation adjacent to the river channel. The berm would be fortified to protect adjacent vineyards. Area 13b would create the same features only confine the changes to the northern parcel.

New Riparian/New Channel Area Gained: 13a –3.8 acres riparian, 1.6 acres channel; 13b — 1.0 acres riparian, 0.5 acres channel

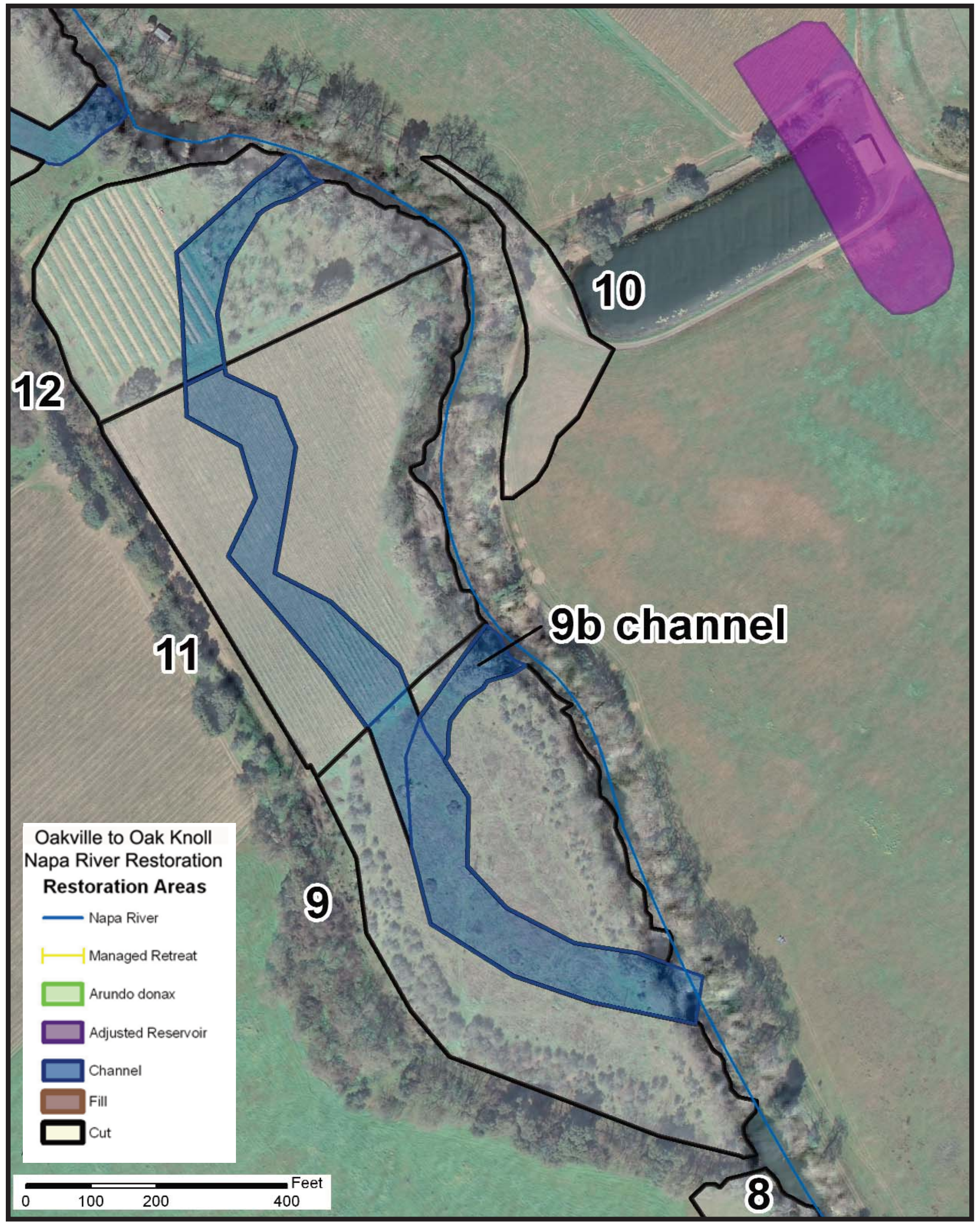
Existing Riparian Corridor Affected: 13a would affect 3.0 acres of riparian forest including small/medium and sapling trees of Oregon ash, willow, Ca. walnut and a number of large Ca. walnut. 13b would affect 1.5 acres of riparian corridor including several large valley oak and Eucalyptus.

Potential Benefits to Salmonids: Creating a floodplain and secondary channel would provide off-channel habitat for salmonids.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: Shear stress produced with this area is reduced below critical shear stress.

Initial Ranking: High. **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created. Landowner needs to approve; land may need to be purchased.

VIEW LOOKING UPSTREAM AT OVERFLOW CHANNEL IN AREA 13. BERM IS ON LEFT AND RIVER CHANNEL IS ON RIGHT.



Restoration Area 12: Active Widening and Floodplain Restoration

Size: 3.6 acres

Existing Condition: Area 12 is part of the flood overflow area. This parcel is planted with vineyard.

Proposed Condition: If Areas 12, 11, and 9 are all restored, Area 12 would have the upstream connection of a secondary channel. The channel and adjoining floodplain would be graded to the 2-year flood elevation adjacent to the Napa River channel. The outer berm would be fortified to protect adjacent vineyards. If Areas 11 and 9 are not restored, Area 12 would not be restored either.

New Riparian/Channel Area Gained: 2.5 acres riparian, 0.4 acres channel.

Existing Riparian Corridor Affected: About 0.7 acres of existing riparian corridor would be affected including seedling and sapling willow, live oak and valley oak. There are a large number of spider trees along the Napa River on this site.

Potential Benefits to Salmonids: Creating a floodplain and secondary channel would provide off-channel habitat for salmonids.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: The increases in erosive stress at Areas 9-12 are partially due to the widening of the river channel at Area 8. Widening at Area 8 lowers the water surface locally, steepening the water surface profile upstream and increasing erosive energy. It is possible that removing the constriction at 10 and 11 also increases the water velocity through this reach.

Initial Ranking: Medium; **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created. Landowner needs to approve; land may need to be purchased.

Restoration Area 11: Active Widening and Floodplain Restoration

Size: 6.0 acres

Existing Condition: Area 11 is another parcel of the flood overflow area where a vineyard has been planted.

Proposed Condition: Area 11 would only be restored if Areas 11 and 9 were also restored. A channel and floodplain would be graded to the 2-year flood level along the Napa River channel.

New Riparian/Channel Area Gained: 3.9 acres riparian, 1.1 acres channel.

Existing Riparian Corridor Affected: 0.9 acres of the corridor along the Napa River would be removed, including seedling and sapling valley and live oak. There are a relatively large number of spider trees along the river at this site.

Potential Benefits to Salmonids: Creating a floodplain and secondary channel would provide off-channel habitat for salmonids.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: There are increases in erosive stress at Areas 9-12 that are partially due to the widening of the river channel at Area 8. Widening at Area 8 lowers the water surface locally, steepening the water surface profile upstream and increasing erosive energy. It is possible that removing the constriction at Areas 10 and 11 also increases the water velocity through this reach.

Initial Ranking: Low; **Final Ranking**: Medium. There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created. Landowner needs to approve; land may need to be purchased.

HARD PAN CLAY DOMINATES THE RIVER BOTTOM AND BANKS
EROSION IS REMOVING THE LARGE TREES ALONG
REACH 4 OF THE NAPA RIVER

Restoration Area 10: Active Widening and Reservoir Relocation

Size: 0.9 acres

Existing Condition: Area 10 is on the outside of a bend in the river where the channel is eroding. Adjacent to Area 10 is a water supply reservoir which is currently oriented perpendicular to the river channel. Floods erode the downstream side of the reservoir.

Proposed Condition: The reservoir would be rebuilt parallel to the river channel at a location away from the channel near the hillslope. Then, the river bank would be setback and revegetated.

New Riparian Area Gained: 0.9 acres

Existing Riparian Corridor Affected: 0.1 acres of riparian corridor on the river would be removed including a number of seedling and sapling valley oak, live oak, Ca. walnut, Oregon ash, and willow. There are a number of spider trees along the Napa River on this site.

Potential Benefits to Salmonids: Setting the bank back will reduce channel erosion and scour of spawning gravel.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: There are increases in erosive stress at Areas 9-12 that are are partially due to the widening of the river channel at Area 8. Widening at Area 8 lowers the water surface locally, steepening the water surface profile upstream and increasing erosive energy. It is possible that removing the constriction at Areas 10 and 11 also increases the water velocity through this reach.

Initial Ranking: High; **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created.

Restoration Area 9: Active Widening and Floodplain Restoration

Size: 9a – 6.5 acres, 9b – 6.5 acres

Existing Condition: Area 9 is the most downstream parcel of the flood overflow channel.

Proposed Condition: 9a – A secondary channel and floodplain would be graded to the 2-year flood level with the channel connecting to Areas 11 and 12. If Areas 11 and 12 are not restored, a secondary channel and floodplain would be graded entirely on Area 9.

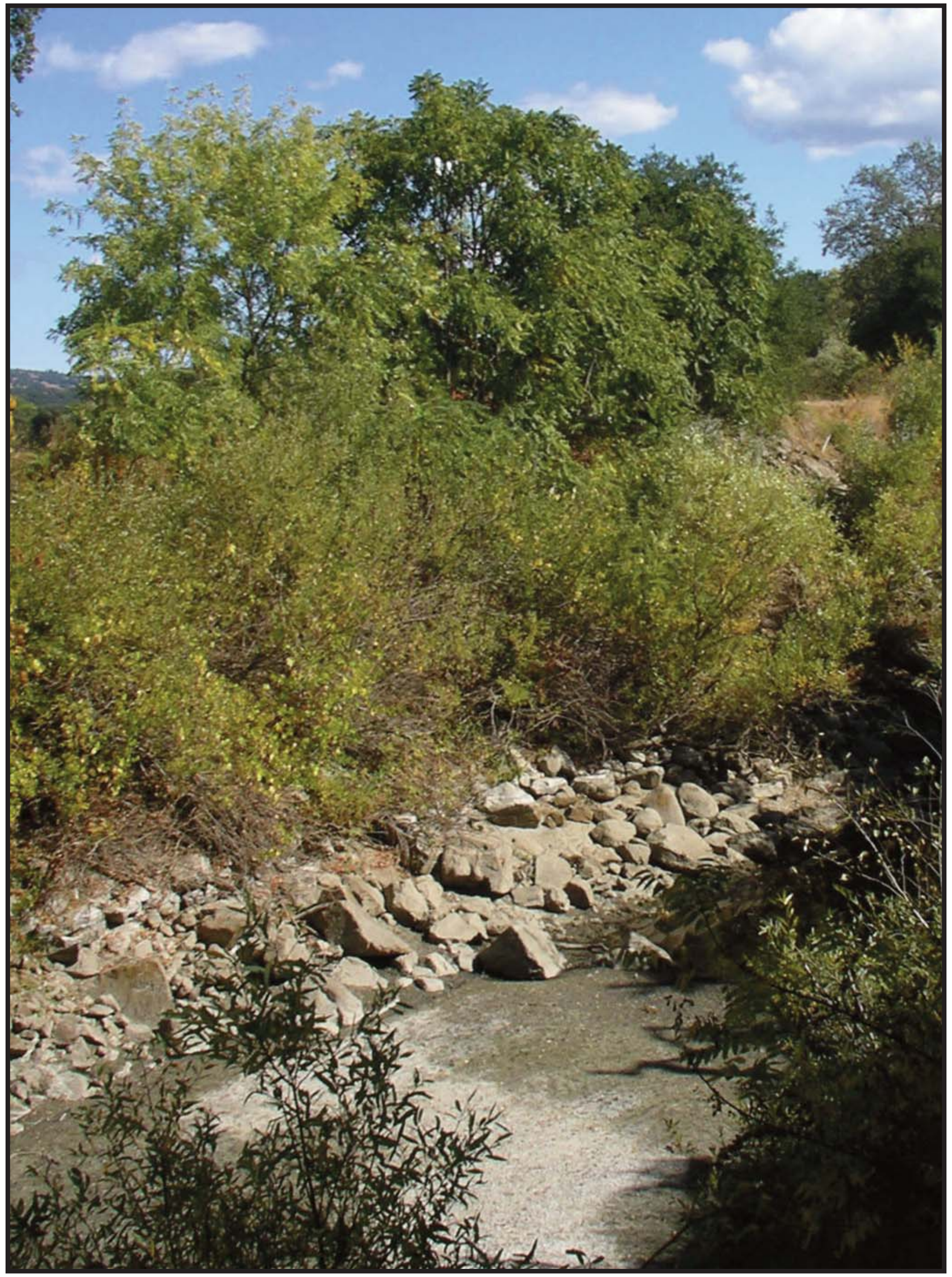
New Riparian/New Channel Area Gained: 9a – 4.1 acres riparian, 1.4 acres channel. 9b – 4.1 acres riparian, 1.3 acres channel.

Existing Riparian Corridor Affected: 9a and 9b 0.9 - acres of riparian corridor along the Napa River would be removed to connect the new floodplain. The corridor has a few large trees but mostly seedling and sapling live and valley oak, Ca. walnut, and willow. There are a large number of spider trees along this section of the Napa River.

Potential Benefits to Salmonids: Setting the bank back and widening this narrow section of the river will reduce channel erosion and scour of spawning gravel.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: There are increases in erosive stress at Areas 9-12 that are partially due to the widening of the channel at Area 8. Widening at Area 8 lowers the water surface locally, steepening the water surface profile upstream and increasing erosive energy.

Initial Ranking: High; **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created.



Restoration Area 8: Active Widening

Size: 4.0 acres

Existing Condition: Area 8 is the outside of a bend on the Napa River and is fallow land. The river channel is very narrow and entrenched on this site.

Proposed Condition: The river banks would be set back to widen the channel and revegetated with native species.

New Riparian/New Channel Gained: 1.8 acres

Existing Riparian Corridor Affected: 2.1 acres of existing riparian corridor would be removed as part of the widening and bank set back. This corridor has a variety of species, mostly saplings and numerous spider trees.

Potential Benefits to Salmonids: Setting the banks back and widening this narrow section of the river will reduce channel erosion and scour of spawning gravel.

Change in Erosive Energy (bed and bank sheer stress) During a 2-year Frequency Flood Event: -91% (Alt 1), -88% (Alt 2), -87% (Alt 3)

Initial Ranking: High; **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created. Restoration Area 7: Wetland Restoration

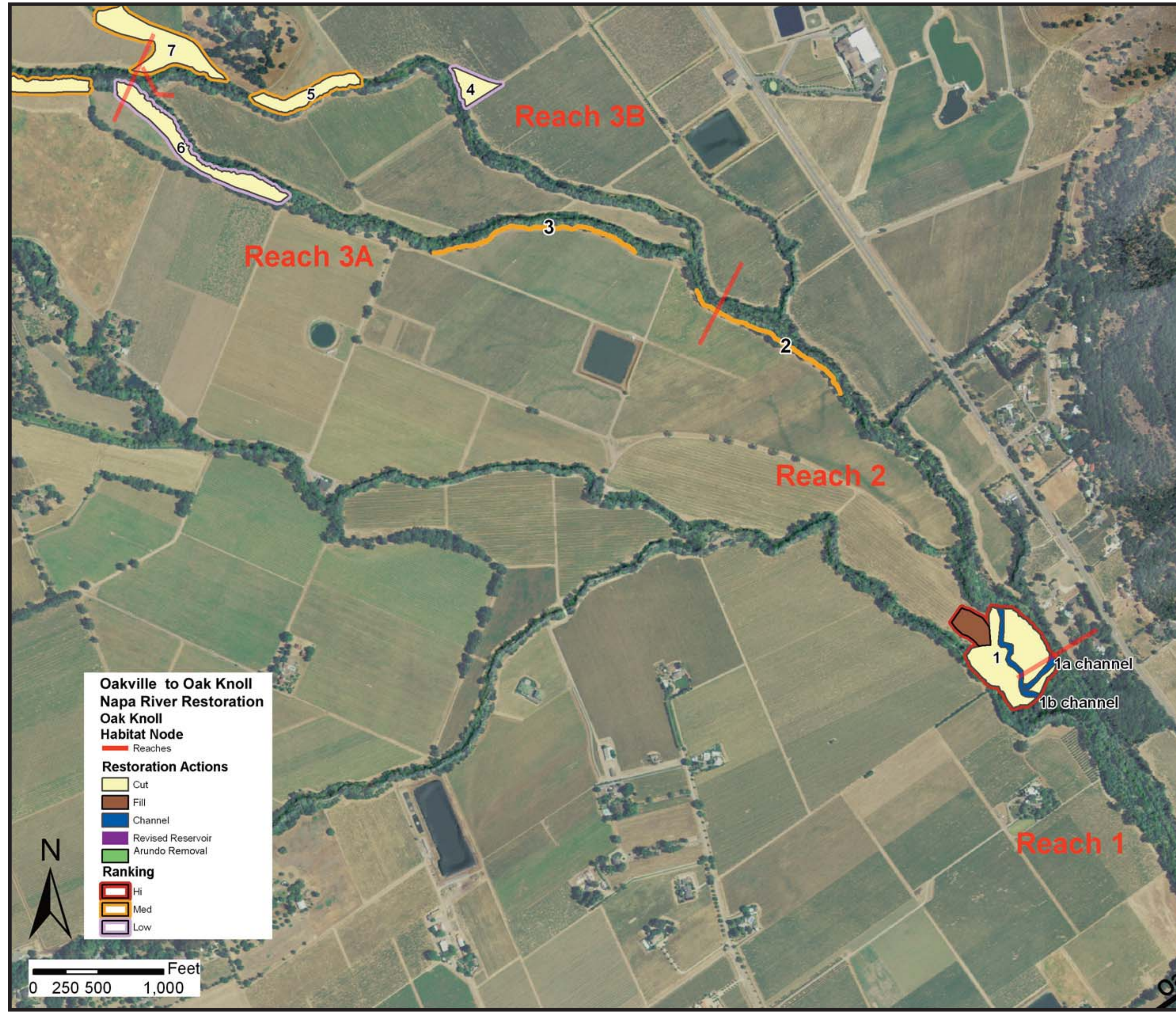
ABOVE: A BIOENGINEERED BANK STABILIZATION PROJECT OF IRRIGATED WILLOW WITH ROCK. THIS APPROACH DOES NOT ADDRESS THE PROBLEM OF HIGH VELOCITY, EROSIVE FLOWS AND HAS CONTRIBUTED TO FURTHER EROSION OF THE RIVER BED AND GREATER ENTRENCHMENT.

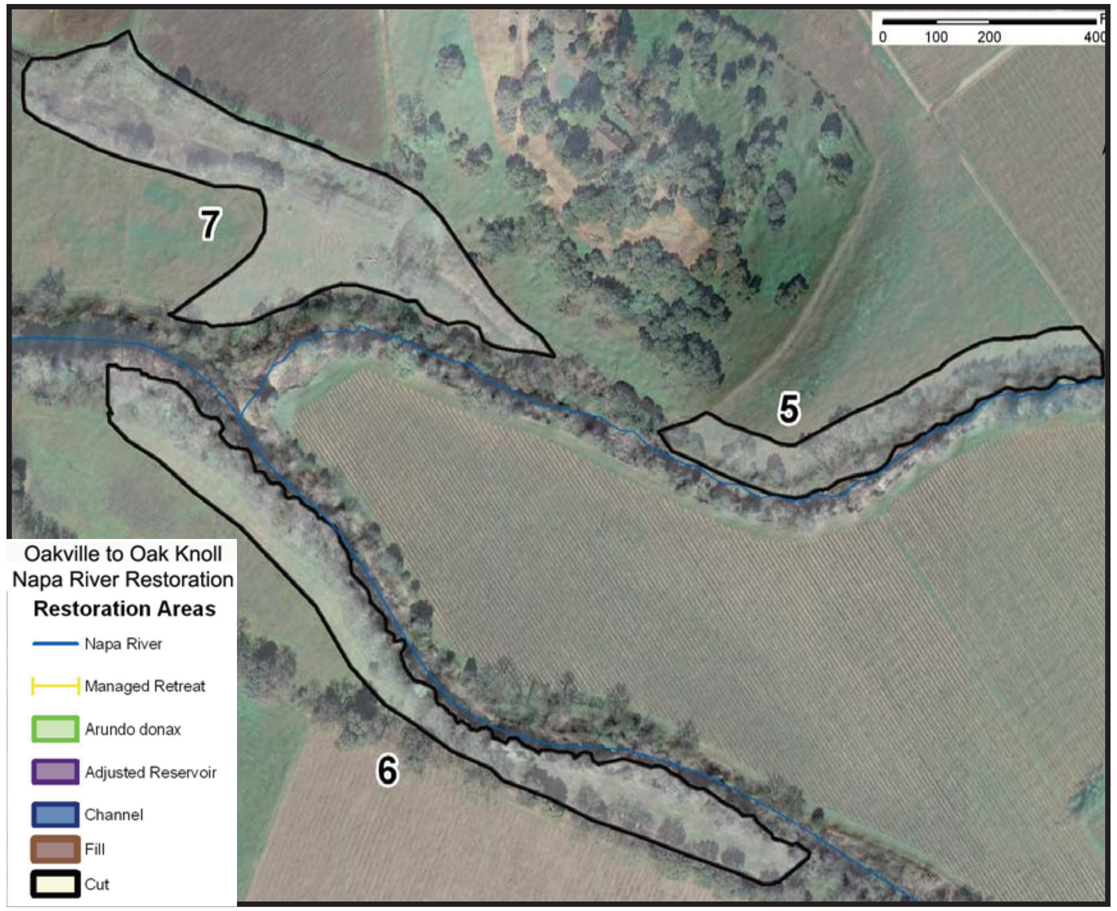
RIGHT: ORANGE LINE MARKS WHERE A FLOODPLAIN BENCH WOULD BE CUT FOR RESTORATION JUST ABOVE THE HARD PAN CLAY LAYER. ADDITIONAL STUDY OF THE CLAY LAYER IS NEEDED TO DETERMINE IF THIS RESTORATION APPROACH WILL WORK ON AREAS 17-1.

Reaches 3A/3B, 2 and 1 - the Oak Knoll Habitat Node

Reach 3 is a split channel where the west branch (3A) is the primary river channel and the east branch (3B) is a bypass channel. Both channels are incised and eroding; however, Reach 3A has good spawning habitat and shade canopy. The river channel in Reach 2 is dominated by a highly resistant clay layer and the banks are actively eroding above the clay material. Reach 2 changes downstream of the confluence with Dry Creek which brings gravel into the river channel. In reach 1 the channel is also incised into the clay but a large amount of gravel covers over the clay material.

RIVER LOW FLOW CHANNEL IS IN A DEEP NARROW TRENCH IN THE CLAY WHILE THE LEFT BANK SUPPORTS LITTLE TO NO VEGETATION. LARGE TREES ARE GROWING ON SOIL ABOVE THE CLAY





RESTORATION AREA 6.
RIVER CHANNEL IS ON THE LEFT AND A TREE COVERED BERM IS ON THE RIGHT

Restoration Area 7: Wetland Restoration

Size: 4.1 acres

Existing Condition: Area 7 is an historic slough channel, wetland and riparian area.

Proposed Condition: The wetland would be evaluated for improvements needed to hold water longer and the feasibility of excavating an off-stream fish alcove.

New Riparian Area Gained: Depending on the final configuration, up to 3.5 acres

Existing Riparian Corridor Affected: Unless Area 7 is graded to connect to the Napa River, no existing riparian vegetation would be affected.

Potential Benefits to Salmonids: Unless this site is connected to the river, salmonids will not use the site.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: Not evaluated.

Initial Ranking: High; **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created.

Restoration Area 6: Active Widening

Size: 3.6 acres

Existing Condition: This area is a flood overflow area inside a berm adjacent to the Napa River.

Proposed Condition: The river bank would be set back and revegetated to reduce velocities and erosion in the river channel.

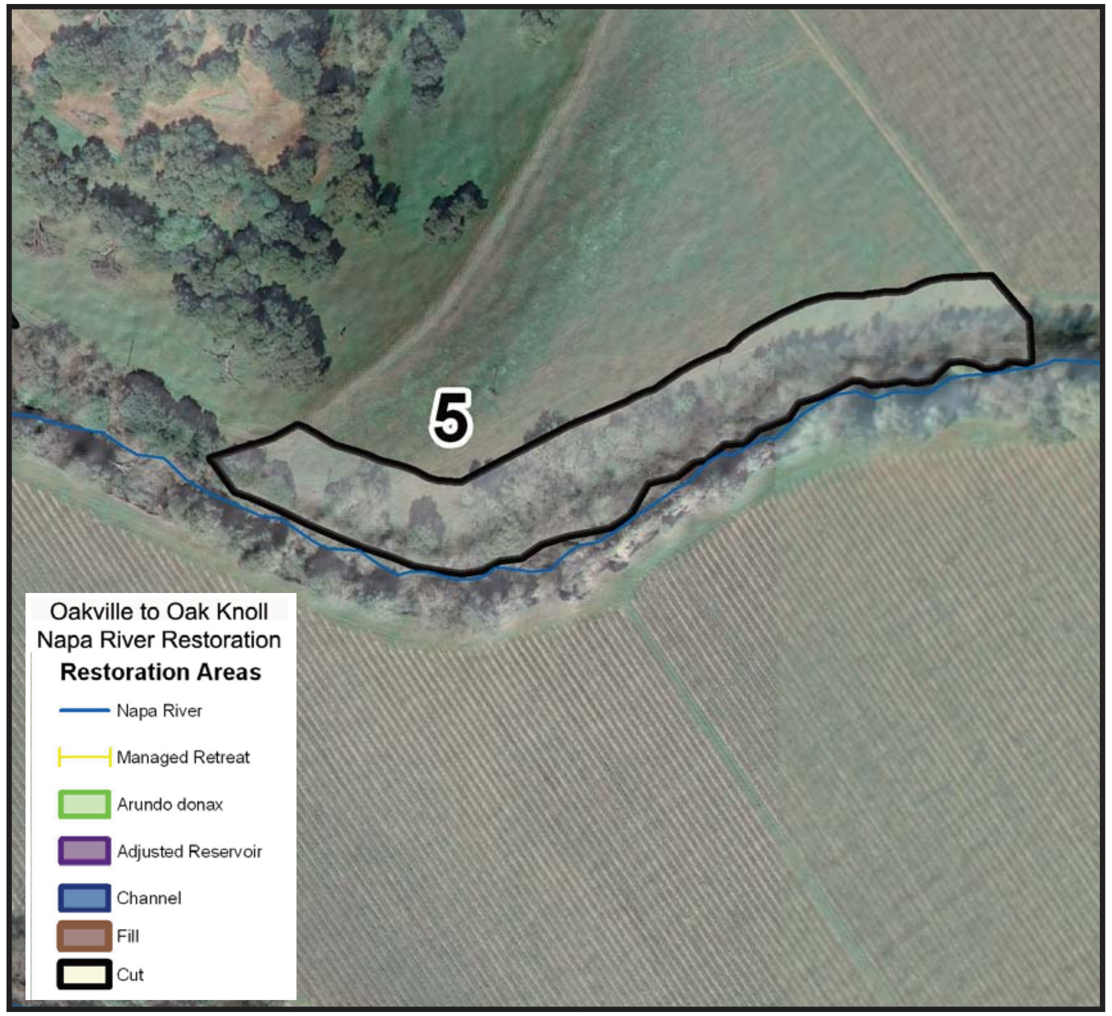
New Riparian Area Gained: 1.9 acres

Existing Riparian Corridor Affected: 1.7 acres of existing riparian corridor would be removed as part of the widening of the river channel. This area includes a variety of tree species and some large valley oak, Ca. walnut, and willow. However, many of these trees are undercut spider trees.

Potential Benefits to Salmonids: Setting the banks back and widening this narrow section of the river will reduce channel erosion and scour of spawning gravel.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -62%

Initial Ranking: Low; **Final Ranking**: Low, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created. Landowner needs to approve; land may need to be purchased.



Restoration Area 5: Active Widening

Size: 1.8 acres

Existing Condition: Area 5 is adjacent to the bypass channel of the Napa River and was suggested by the landowner as a location for active widening.

Proposed Condition: The river bank would be set back and revegetated with native trees.

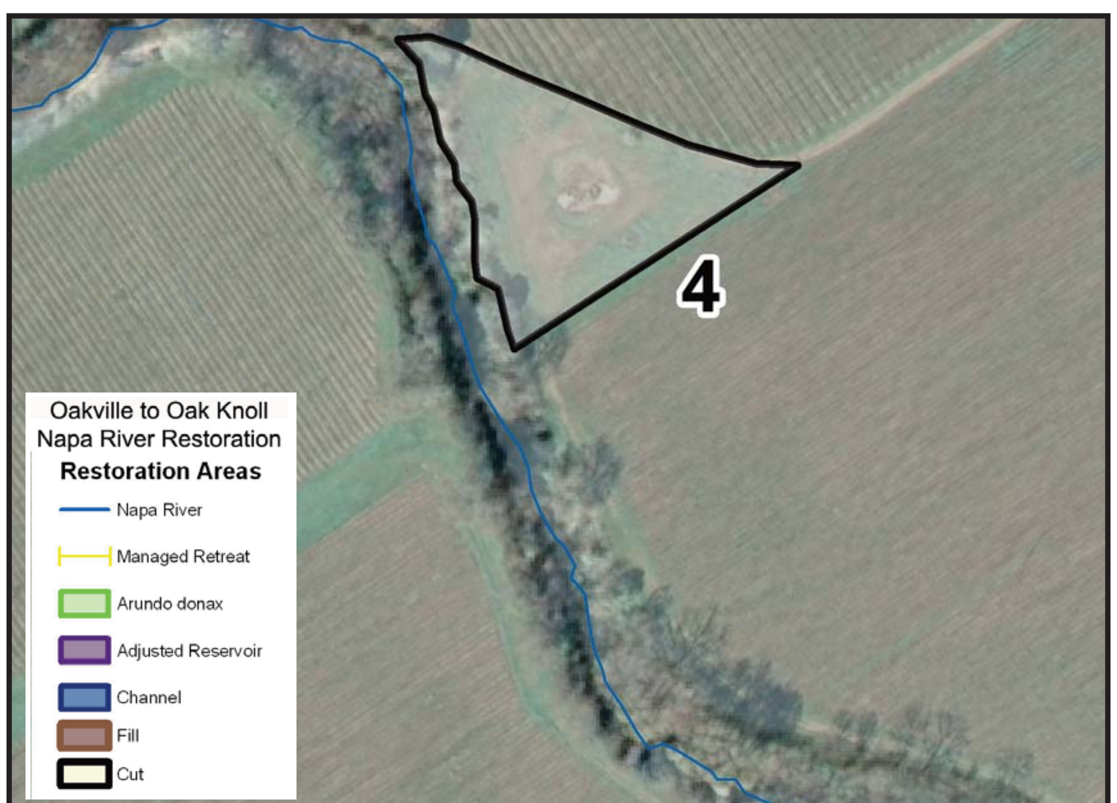
New Riparian Area Gained: 1.1 acres

Existing Riparian Corridor Affected: 0.7 acres of existing riparian corridor would be removed including a number of large trees.

Potential Benefits to Salmonids: Setting the banks back and widening this narrow section of the river will reduce channel erosion and scour of spawning gravel.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: N/A (Alt. 1), -60% (Alt. 2), -67% (Alt. 3)

Initial Ranking: Medium; **Final Ranking**: Medium, There is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created.



Restoration Area 4: Alcove Creation

Size: 1.1 acres

Existing Condition: Area 4 is a triangle of unused upland adjacent to the bypass channel of the Napa River.

Proposed Condition: Area 4 would be graded to create an off-channel alcove for high water refugia.

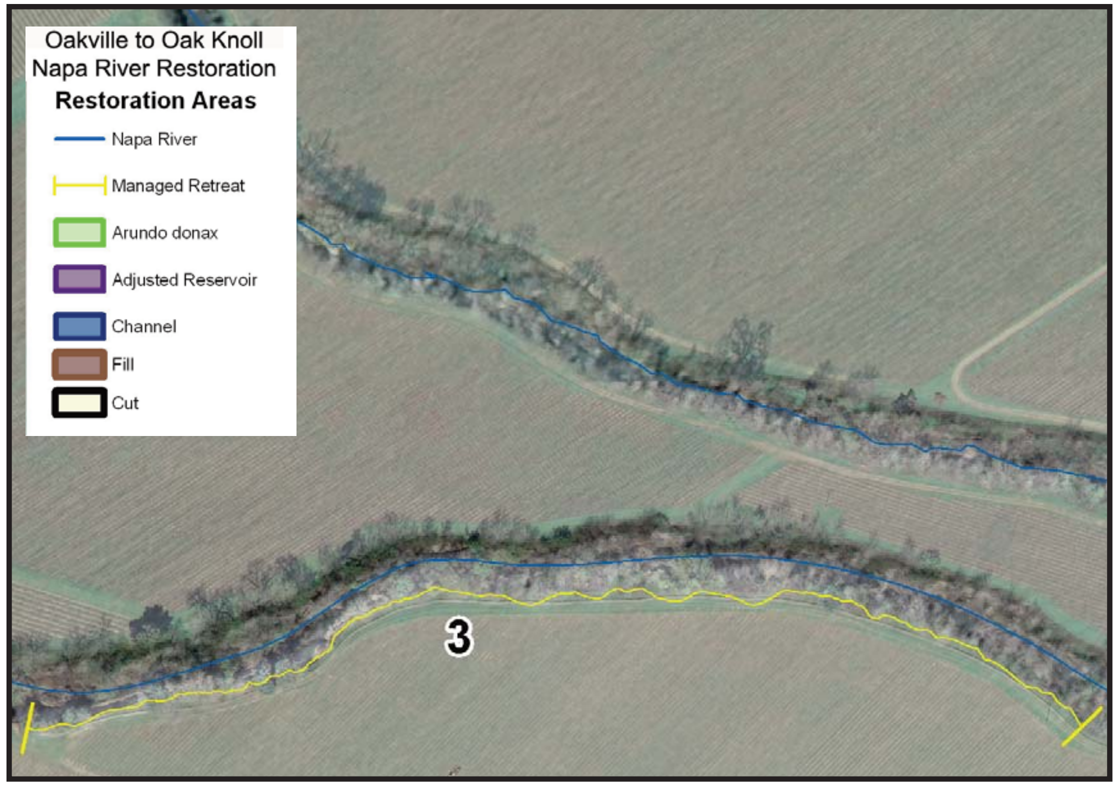
New Riparian/New Channel Gained: 1.1 acres

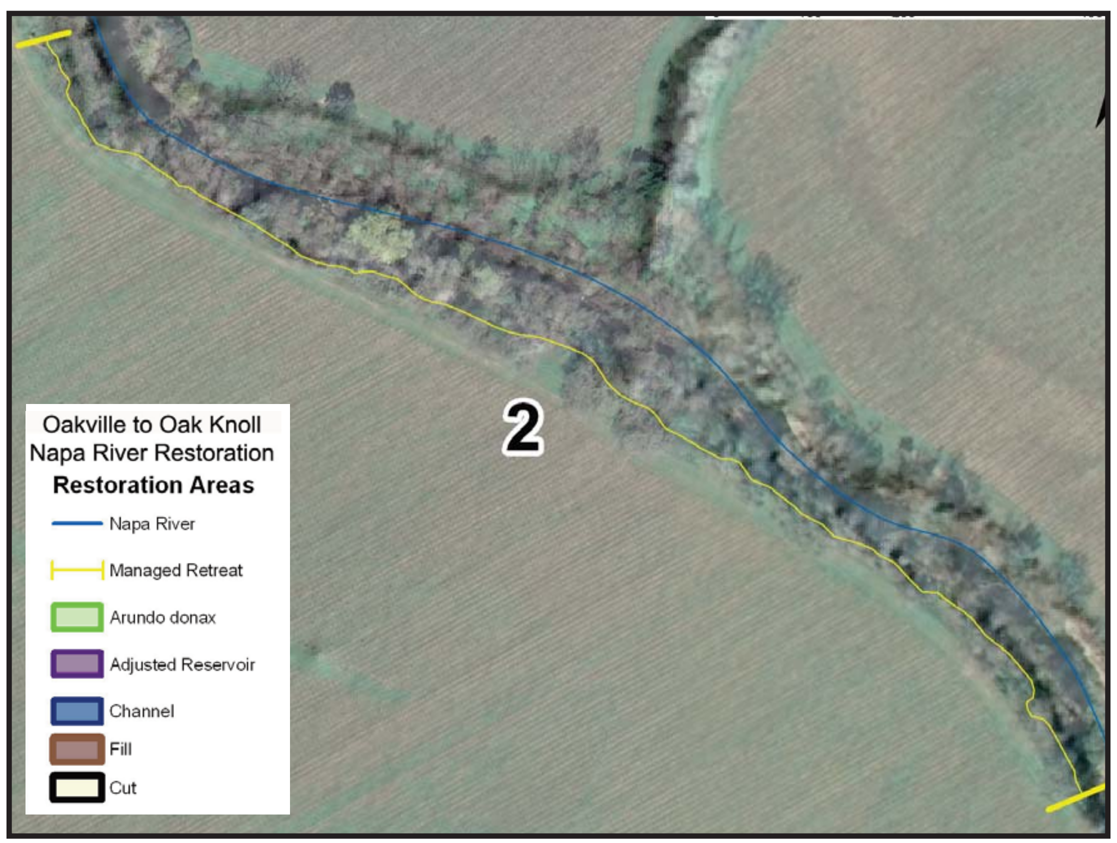
Existing Riparian Corridor Affected: 0.0 acres of existing riparian corridor would be removed to connect Area 4 to the bypass channel.

Potential Benefits to Salmonids: The Napa River is largely missing off-channel alcove habitats and this project would create this type of area.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: N/A (Alt. 1), N/A (Alt. 2), -20% (Alt. 3)

Initial Ranking: Low; **Final Ranking**: Low, site is very small and there is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created.





Restoration Areas 3 and 2: Managed Retreat

Size: Area 3- 1,732 linear feet; Area 2 - 1,425 linear feet

Existing Condition: Area 3 is in the split channel reach where the river channel is entrenched and eroding. Area 2 is just downstream of the confluence of the two river channels and is highly entrenched and actively eroding.

Proposed Condition: Areas 3 and 2 would undergo managed retreat rather than active widening in order to maintain shade canopy over the spawning area and allow a slower restoration mechanism. The river bank is allowed to erode during flood events and is revegetated. As the banks fail and the channel widens, flood flow velocities decrease and the channel erodes less. The banks will likely first fail on the outside of bends as this is where the greatest stress is exerted. These areas are already having erosion problems. The eroded bank is shaped to a stable angle (2 or 3:1) and revegetation of the base of the failed bank is done by willow sprigging with additional native species planted at the top and mid bank area. These steps will help to stabilize the eroded bank and restore the canopy. Area 2 would undergo managed retreat in order to determine if the channel can be revegetated after a natural bank erosion event. Due to the presence of the clay layer, active widening is not recommended. It is not clear what the outcome of the natural widening would be due to the clay layer.

New Riparian Area Gained: There is no method to exactly predict the increase in riparian area.

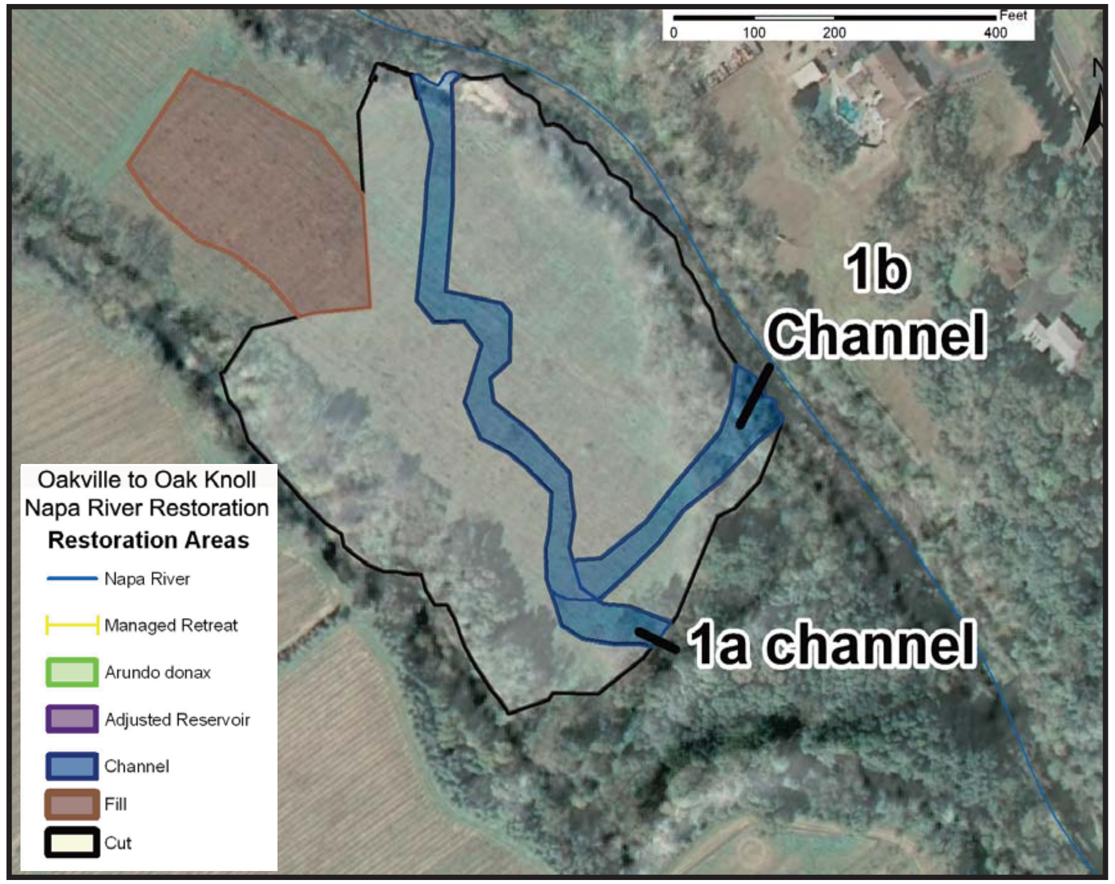
Existing Riparian Corridor Affected: Small portions of the riparian corridor would be affected at one time and revegetation would be done as the corridor changes with the natural rate of channel widening.

Potential Benefits to Salmonids: The river channel in this reach would be allowed to naturally adjust its cross section and reduce bank erosion. As the banks fails, the larger trees on top of the bank will become large wood in the channel. These two changes – the addition of large wood and the widening of the channel, will give the aquatic habitat greater diversity and value to salmonids.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: There is no method to predict the change in channel erosion.

Initial Ranking: Medium; **Final Ranking**: Medium

LOW FLOW CHANNEL OF THE RIVER IS ENTRENCHED INTO THE CLAY LAYER



Restoration Area 1: Active Widening and Floodplain Restoration

Size: 1a – 7.7 acres, 1b – 7.5 acres

Existing Condition: Area 1 is a fallow upland wedged between the Napa River and Dry creek. Both of these waterways are highly entrenched with high scour levels resulting in most gravel being transported out of this reach.

Proposed Condition: Area 1 would be restored to a floodplain and secondary channel complex connected to both the Napa River and Dry Creek. The site would be graded to the 2-year flood level and a channel would connect either to the Napa River – 1a or to Dry Creek 1b. Fill from the excavation would be used to create upland on the site. The floodplain would be revegetated with native trees. The project would create a floodplain for both waterways and reduce channel entrenchment.

New Riparian/Channel Area Gained: 1a –5.3 acres riparian, 0.75 acres channel; 1b –5.3 acres riparian, 0.6 acres channel, 1.2 acres upland.

Existing Riparian Corridor Affected: 1a, 1 – 0.7 acres of the riparian corridor along the Napa River and Dry Creek will be removed. The river corridor in this location has primarily seedling and sapling trees with only a few large trees. There are a number of undercut spider trees also. The riparian corridor on the Dry Creek side of this site was not mapped.

Potential Benefits to Salmonids: This large off-channel habitat site is located at the confluence of Dry Creek, a major steelhead stream, and the Napa River, which supports both steelhead and Chinook salmon. This type of habitat is missing from both waterways and serves to benefit juveniles at several life stages.

Change in Erosive Energy (bed and bank sheer stress) during a 2-year Frequency Flood Event: -8% (Alt. 1), -8% (Alt. 2), -9% (Alt. 3)

Initial Ranking: High; **Final Ranking**: High, there is a concern regarding the clay layer which dominates the river channel in this reach and whether a new floodplain can be created.

FAR LEFT: ENTRENCHMENT FROM THE NAPA RIVER HAS MOVED UP INTO DRY CREEK ERODING THE CHANNEL AND UNDERCUTTING TREES.

LEFT: CLAY LAYER AT CONFLUENCE OF DRY CREEK AND THE NAPA RIVER

SUMMARY OF RESTORATION AREAS

Riparian Area	Restoration Action	Total Acres	New Acres of Riparian Habitat	Existing Riparian Acres Affected	Other Lands Affected	Significant (>25%) Reduction in Erosive Energy	Benefits to Salmonids	Final Ranking	Alternative	Estimated Cost*
Reaches 10 and 9 - Oakville Habitat Node										
32	Arundo Removal	4.52	4.52	0	none	N/A	yes	High	1, 2, 3	$190,000
31	Active Widening and Floodplain Restoration	4.6	3.0	1.6	winery spray field	N/A	yes	Low	3	not completed
30	Active Widening	0.8	0.6	0.2	vineyard, vineyard road	no	yes	Low	3	$144,900
29	Active Widening	1.2	0.7	0..5	vineyard, vineyard road	yes	yes	Medium	2, 3	$603,300
28	Active Widening and Floodplain Restoration	1.0	0.5	0.5	vineyard, vineyard road	yes	yes	High	1, 2, 3	$174,000
27	Active Widening and Floodplain Restoration	2.0	1.4	0.56	vineyard, vineyard road	yes	yes	High	1, 2, 3	$434,000
26	Floodplain Restoration	2.6	1.6	1.0	vineyard, vineyard road	yes	yes	Low	3	$483,600
Reaches 8 and 7 - Yountville Habitat Node										
32	Arundo Removal	0.43	0.43	0	none	N/A	yes	High	1, 2, 3	see above
25/24	Active Widening	1.1; 1.5	2.6	0	vineyard, vineyard road	N/A	maybe	Low	3	not completed
23	Managed Retreat	2,370 linear feet of river	1.5-2.5	1.0	vineyard, vineyard road	N/A	yes	Medium	2, 3	not completed
22	Floodplain Restoration	6.2	4.7	0.5	weedy upland	no	yes	High	1, 2, 3	$162,000
21	Floodplain Restoration	2.2	2.2	0	weedy upland	no	yes	High	1, 2, 3	not completed
20	Floodplain Restoration	2.9	2.8	0	weedy upland	no	yes	High	1, 2, 3	$283,800
19	Active Widening	16.2	9.4 - riparian 1.6 - channel	0.9	weedy upland	no	yes	High	1, 2, 3	$1,317,600
18a	Active Widening	3.4	1.1	2.3	eroding levee	yes	yes	High	1, 2, 3	$1,318,700
18b	Flood Detention Basin	37.9	22.2	2.5	eroding levee, vineyard/vineyard road	yes	yes	Low	3	$3,640,100
17a	Active Widening and Floodplain Restoration	15.9	13.5- riparian 2.4 - channel	0.3	vineyard, vineyard road	yes	yes	High	1, 2, 3	$1,417,600
17b	Active Widening and Floodplain Restoration	15.9	14.2 - riparian 1.7 - channel	0.3	vineyard, vineyard road	yes	yes	High	1, 2, 3	included in 17a
17c	Active Widening and Floodplain Restoration	15.9	13.6 - riparian 2.3 - channel	0.3	vineyard, vineyard road	yes	yes	High	1, 2, 3	included in 17a
16a	Active Widening and Floodplain Restoration	5.1	4.7 - riparian 0.4 - channel	0.47	vineyard, vineyard road	yes	yes	Medium	2, 3	$957,400
16b	Active Widening and Floodplain Restoration	2.9	2.1 - riparian 0.8 - channel	0.47	vineyard, vineyard road	yes	yes	Medium	2, 3	included in 16a
15a	Active Widening and Floodplain Restoration	3.6	2.9 - riparian 0.7- channel	0.6	fallow land	yes	yes	Medium	2, 3	$869,700
15b	Active Widening and Floodplain Restoration	2.2	1.7 - riparian 0.6- channel	0.6	fallow land	yes	yes	Medium	2, 3	included in 15a
14	Floodplain Restoration	1.2	1.2	0	pond	yes	yes	High	1, 2, 3	$138,800

SUMMARY OF RESTORATION AREAS

Riparian Area	Restoration Action	Total Acres	New Acres of Riparian Habitat	Existing Riparian Acres Affected	Other Lands Affected	Significant (>25)%Reduction in Erosive Energy	Benefits to Salmonids	Final Ranking	Alternative	Estimated Cost*
Reaches 6, 5 and 4 Old Hopper Creek Habitat Node										
13a	Active Widening and Floodplain Restoration	8.4	3.8 - riparian 1.6 - channel	3.0	fallow land	yes	yes	Medium	2, 3	$1,556,800
13b	Active Widening and Floodplain Restoration	3.0	1.0 - riparian 0.5- channel	1.5	fallow land	yes	yes	Medium	2, 3	included in 13a
12	Active Widening and Floodplain Restoration	3.6	2.5 - riparian 0.4 - channel	0.7	fallow land	no	yes	Medium	2, 3	$572,100
11	Active Widening and Floodplain Restoration	6.0	3.9 - riparian 1.1 - channel	0.9	vineyard, vineyard roads	no	yes	Medium	2, 3	$995,900
10	Active Widening and Reservoir Relocation	0.9	0.9	0.1	vineyard, vineyard roads	no	yes	Medium	2, 3	$394,000
9a	Active Widening	6.5	4.1 - riparian 1.4 - channel	0.9	fallow land	no	yes	Medium	2, 3	$1,228,300
9b	Active Widening	6.5	4.1 - riparian 1.3 - channel	0.9	fallow land	no	yes	Medium	2, 3	included in 9a
8	Active Widening	4.0	1.8	2.1	fallow land	yes	yes	Medium	2, 3	$999,500
Reaches 3A/3B, 2 and 1 Oak Knoll Habitat Node										
7	Wetland Restoration	4.1	3.5	0	upland	N/A	no	Medium	2, 3	$707,800
6	Active Widening	3.6	1.9	1.7	fallow land	yes	yes	Low	3	$1,054,300
5	Active Widening	1.8	1.1	0.7	fallow land	yes	yes	Medium	2, 3	$396,900
4	Alcove Creation	1.1	1.1	0	fallow land	no	yes	Low	3	$180,200
3	Managed Retreat	1,732 linear feet	1.0-1.5	0.5-1.0	vineyard, vineyard roads	N/A	yes	Medium	2, 3	not completed
2	Managed Retreat	1,425 linear feet	0.75-1.0	0.5	vineyard, vineyard roads	N/A	yes	Medium	2, 3	not completed
1a	Active Widening and Floodplain Restoration	7.7	5.3 - riparian 0.75 - channel	0.7	vineyard, vineyard roads	no	yes	High	1, 2, 3	$673,000
1b	Active Widening and Floodplain Restoration	7.5	5.3 - riparian 0..6 - channel	0.7	fallow land	no	yes	High	1, 2, 3	included in 1a
Totals	All sites	119.1-143.9	87.2-103.6 - riparian 8.6-10.4 - channel	22.4-23.5	96.7-120.4 acres					$20,816,200

* Construction cost only, does not include design, CEQA and permit cost or any land acquisition.

HYDRAULIC MODELING RESULTS

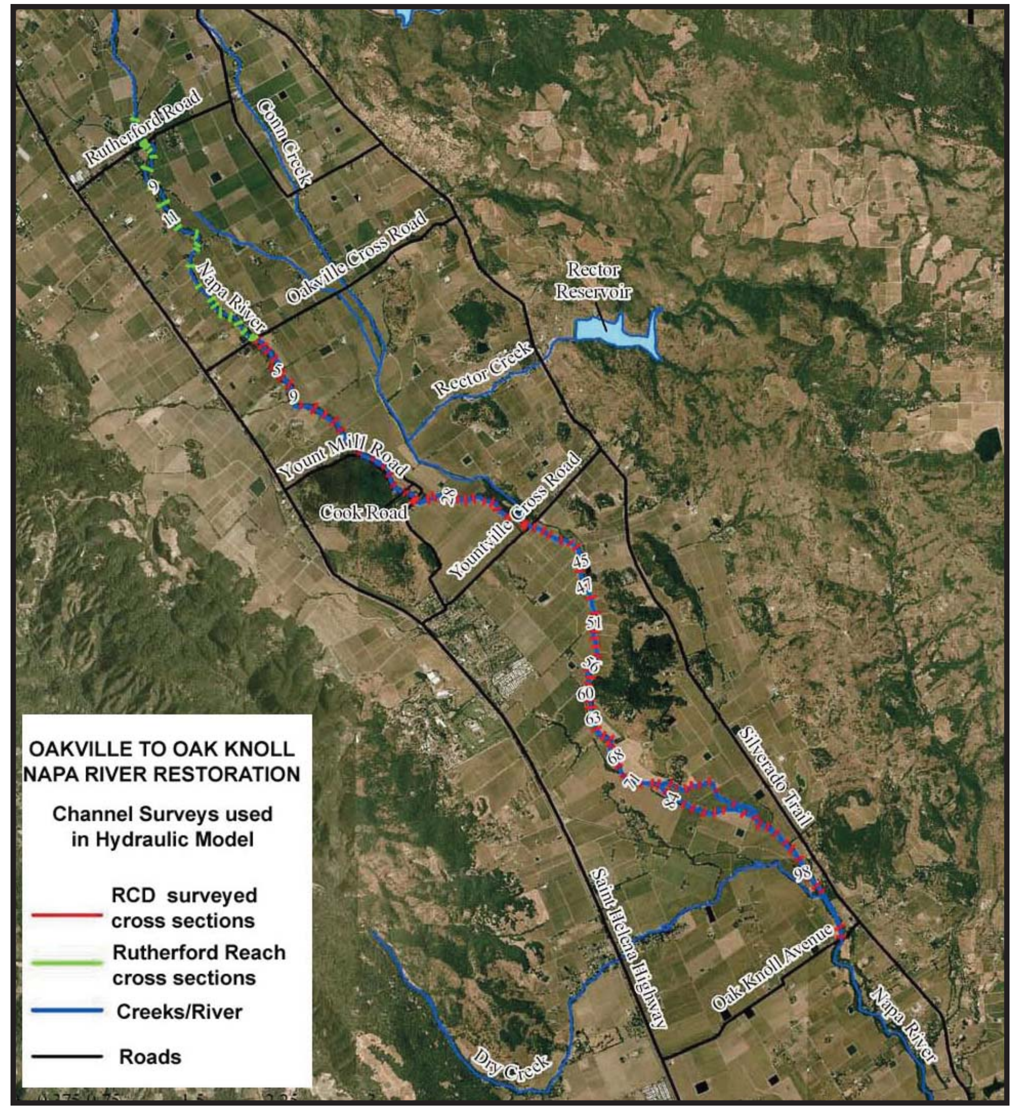
MODELING APPROACH

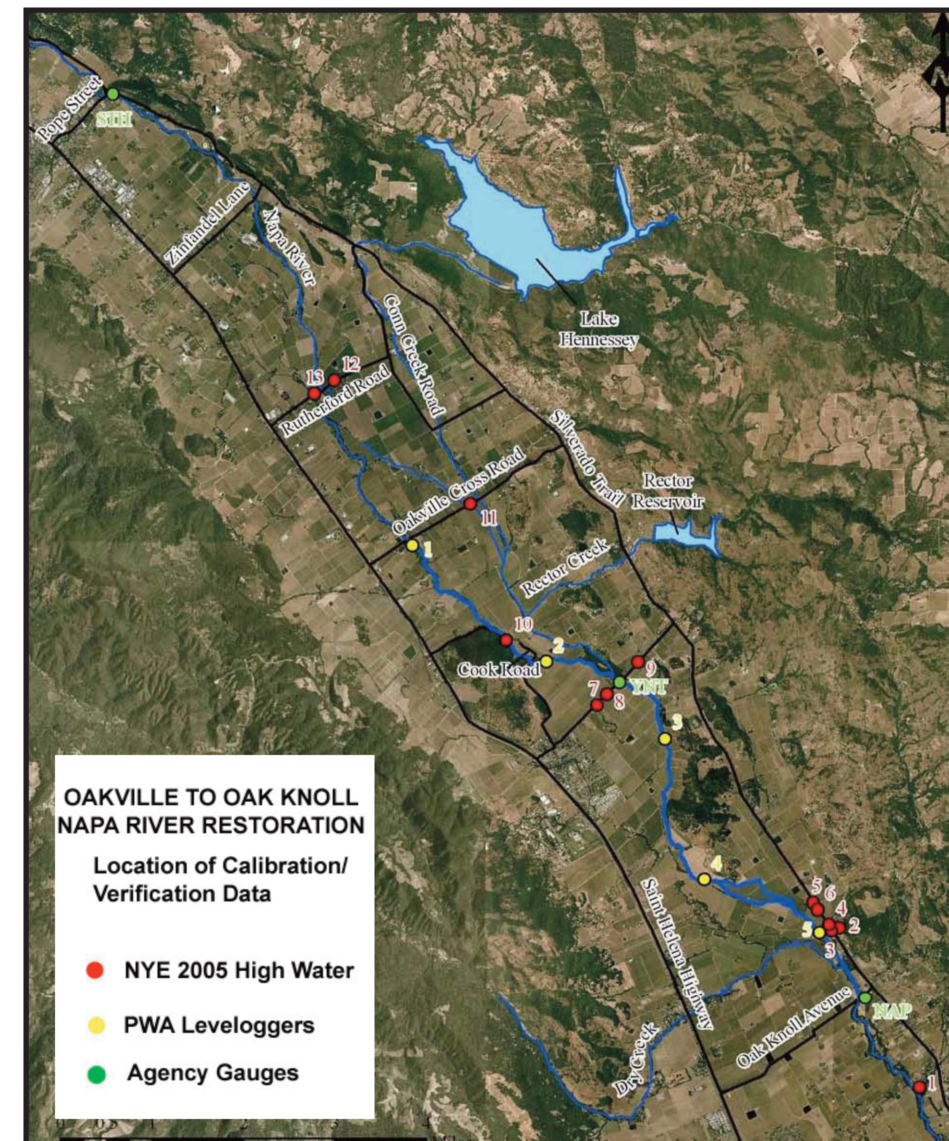
Philip Williams and Associates (PWA), an hydrology and engineering firm, developed a 1D/2D MIKE FLOOD (MF) model to predict the patterns and levels of flooding of the Napa River and its floodplain between Oakville Cross Road and Oak Knoll Ave. The MF modeling platform was selected for this project because it dynamically couples a 1D approximation of the Napa River channel to a 2D overland approximation of the Napa River floodplain. This coupling allowed for accurate and physically-based simulation of flow splits and mapping of flood patterns and levels. The MF model was then modified to assess the flood risks and benefits, changes in channel scour or erosion, geomorphic character, and effects associated with the three alternatives. A series of surveyed cross sections of the river channel were used in the model to depict existing conditions in the river channel. Appendix 1 includes additional details on the hydraulic model.

CALIBRATION / VERIFICATION

PWA used water level data recorded from five locations on the Napa River in the spring of 2007 and from one location in January 2008 to calibrate the Manning n-value roughness values of the MF model. Because no out-of-bank flooding occurred during these periods, only the 1D portion of the model (MIKE11) was used for calibration as it runs more efficiently than the coupled 1D/2D MF model and therefore a longer simulation period can be compared with measured data resulting in a more accurate calibration. Good correlation was found between measured data at PWA Gauge #5 and simulated water levels at the cross section at the same location. Water level comparisons were similar for the other cross sections and time periods where PWA had measured gauge data.

The 1D portion of the model was used to simulate the period of flow beginning in mid-December and ending approximately a week after the December 31, 2005 event or NYE event which has an estimated occurrence interval of approximately 25 to 50 years. This was done to compare water levels for the period of time before and after the large flood when flow remained in the channel. Because the 1D model alone does not account for flow lost out of the channel, it over predicted water levels during the actual NYE flood on December 30th and 31st. For this period, the MF model was used and resulted in more realistic water levels. The extent of inundation and the depth of flooding in the channel and floodplain as predicted by the MF model for NYE event were compared with the measured high water marks within the project reach and showed good correlation.





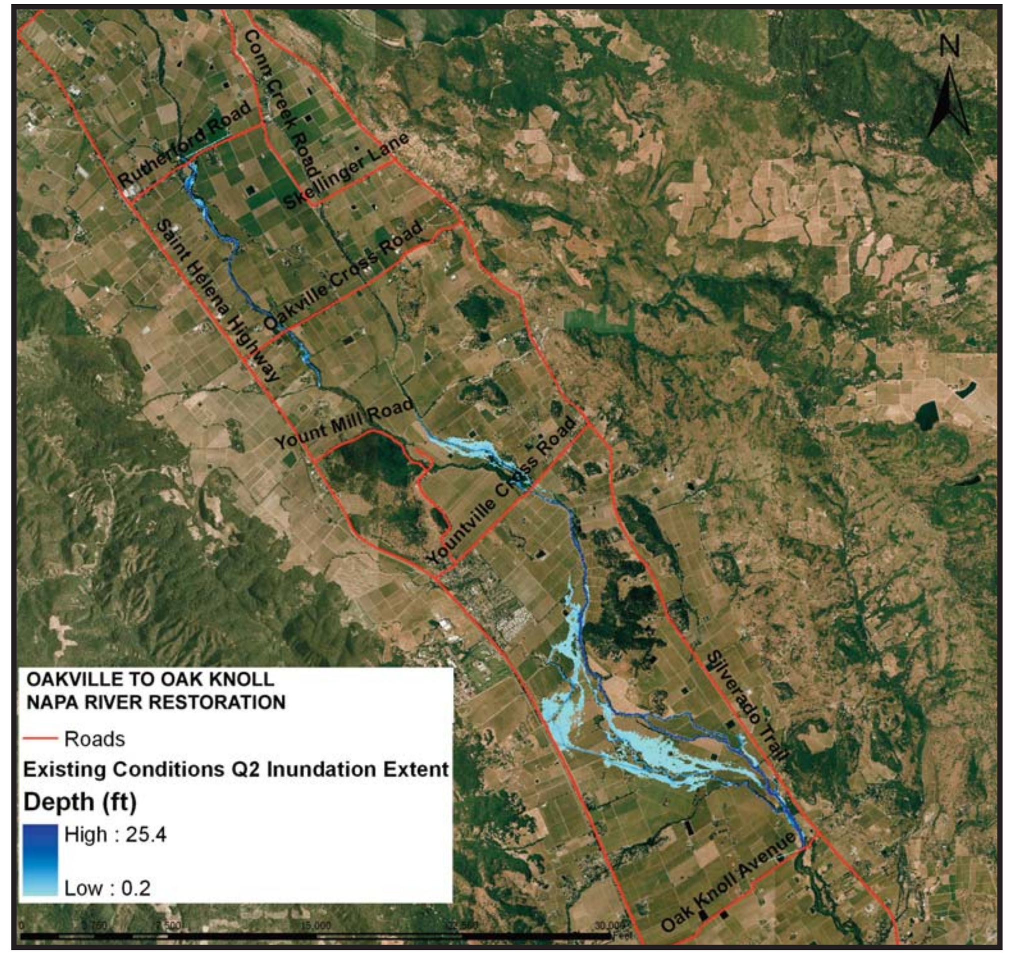
EXISTING CONDITIONS

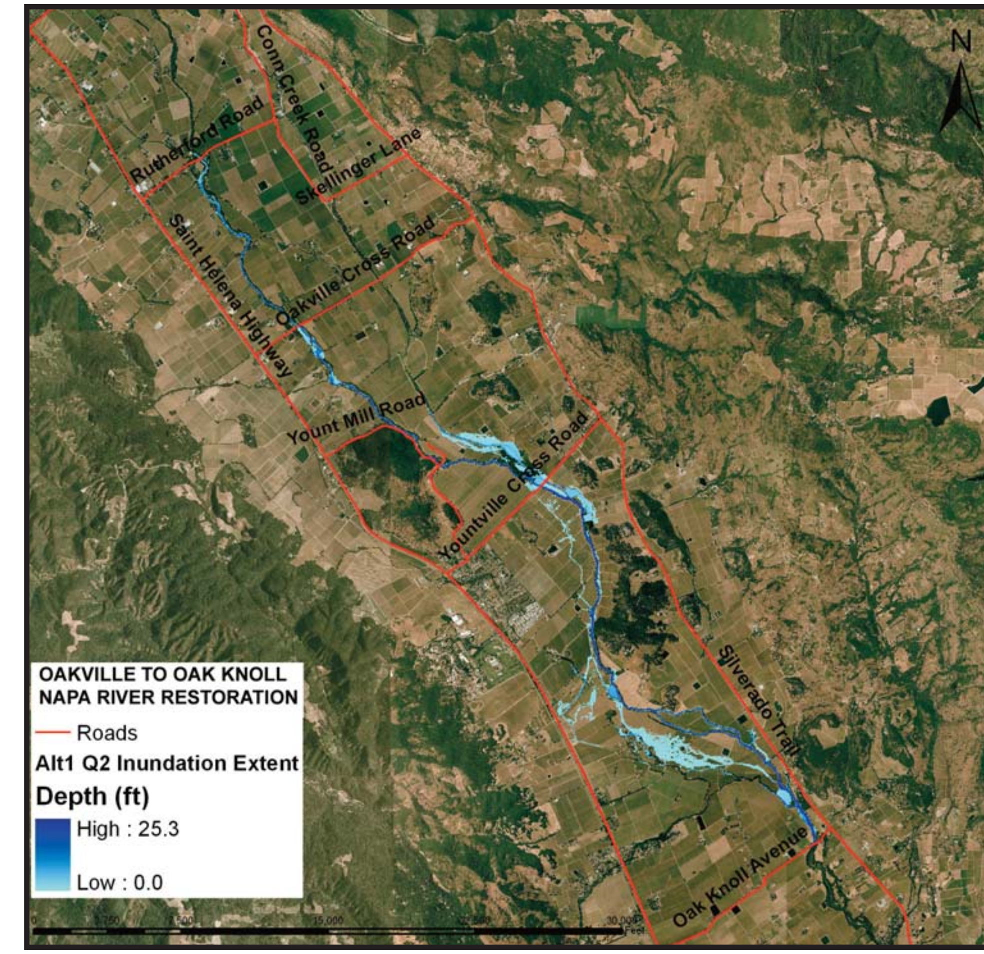
Floodplain inundation extent and water depth mapping was performed for existing conditions during the 2-, 5-, 10-, 25-, 50, and 100-year design flood events.

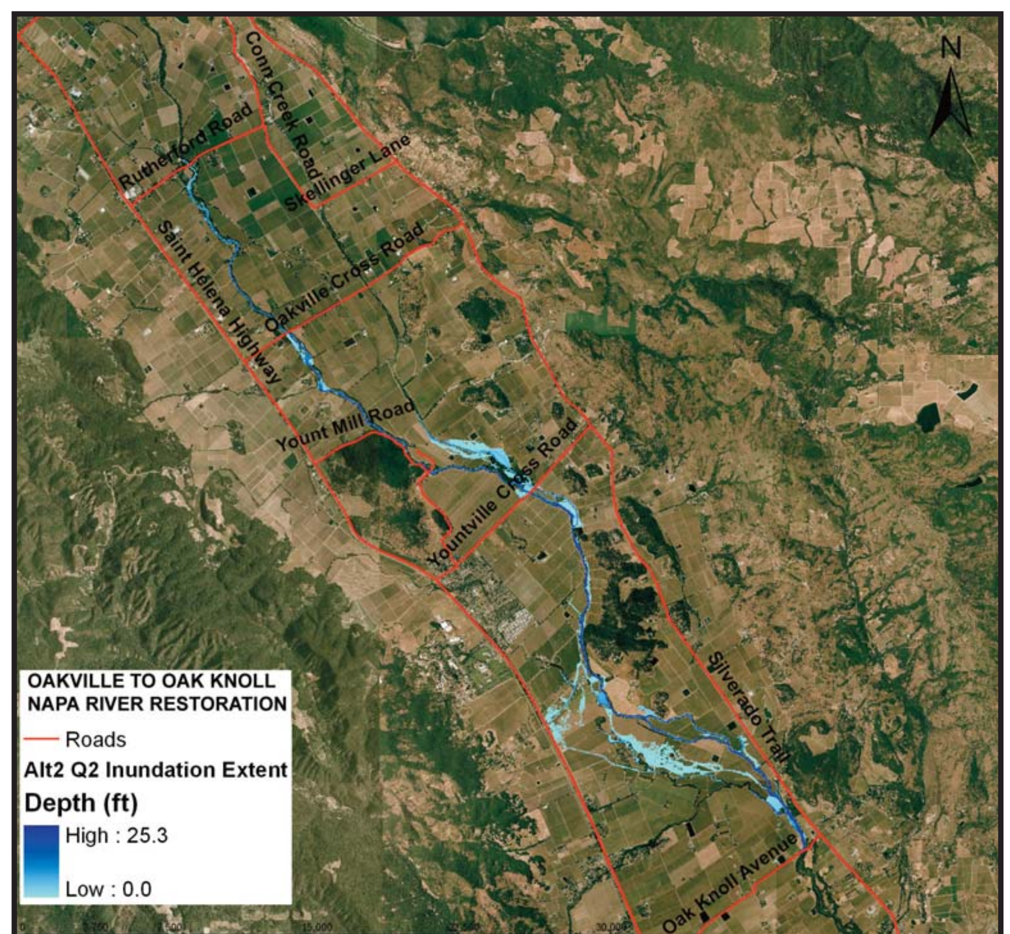
Patterns and Levels of Flooding

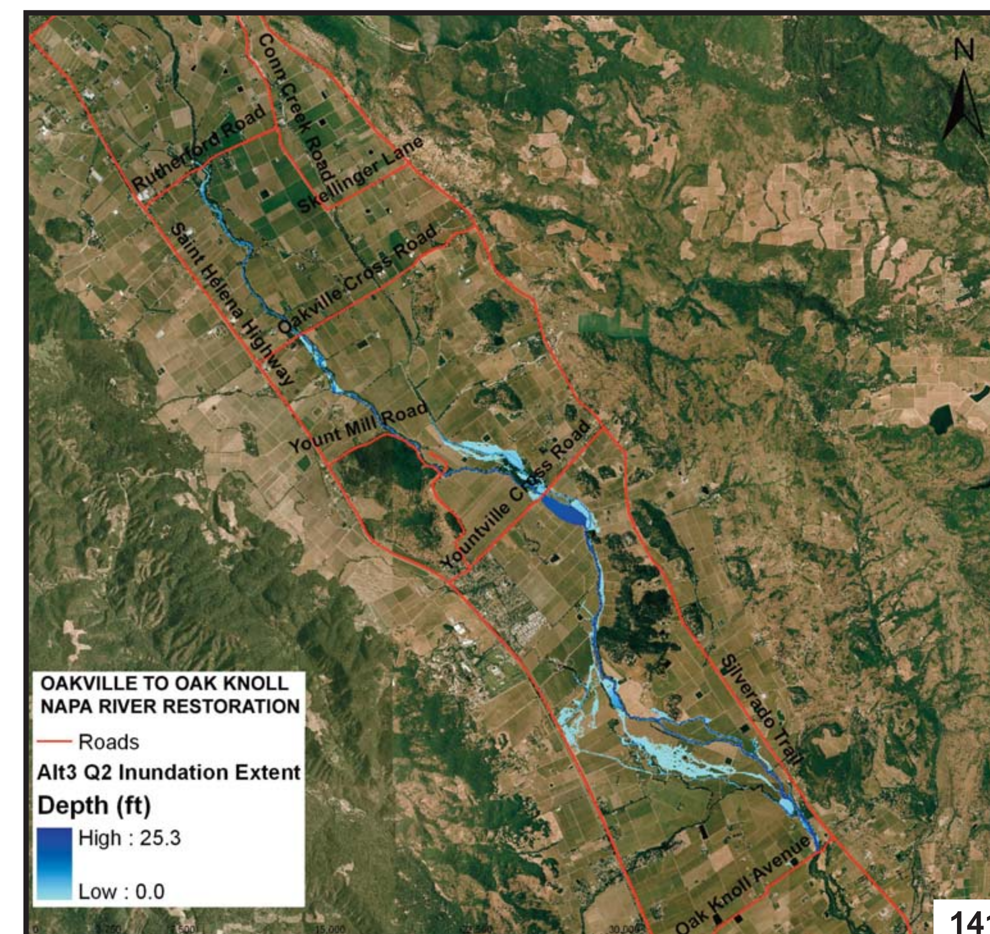
Generally, out-of-bank flooding is fairly extensive from the Napa River in the reach between Yountville Cross Road and Oak Knoll Ave and from Conn Creek in the reach between Oakville Cross Road and Yountville Cross Road for flows equal to and greater than the 5-year event. Additionally, flood waters are mostly contained in the Napa River upstream of Yount Mill Road up to about the 10-year event, above which out-of-bank flows from both the Napa River and Conn Creek contribute to floodplain inundation.

During the 2-year flood event, there is very little out-of-bank flooding on the Napa River and Conn Creek upstream of Yount Mill Road and Cook Road. Conn Creek overtops its banks between Cook Road and Yountville Cross Road, upstream of its junction with the Napa River. At the upstream end of Reach 5, the Napa River spills over its right bank flowing south with some water ponding at Highway 29 and some water flowing southeast back towards the river and its junction with Dry Creek. Compared to the 2-year event, the 5-year event shows much more significant floodplain inundation, beginning along both sides of Conn Creek near Oakville Cross Road. The Napa River begins spilling over its left bank near Cook Road, merging with Conn Creek's floodplain flows. Downstream of the junction, floodplain flows are about a half mile wide on the west side of the main river channel and bounded by Highway 29. About 1.5 miles upstream of Oak Knoll Ave, floodplain flows are on both sides of the channel and are bounded on the east side by Silverado Trail. During the 10-year flow, the floodplain inundation is wider in most locations compared to the 5-year flow.









CONCEPTUAL ALTERNATIVES

Floodplain inundation extent and water depth mapping was performed for the three conceptual alternatives for the 2-, 5-, and 10-year flood events.

Alternative 1 – High Priority Restoration Areas

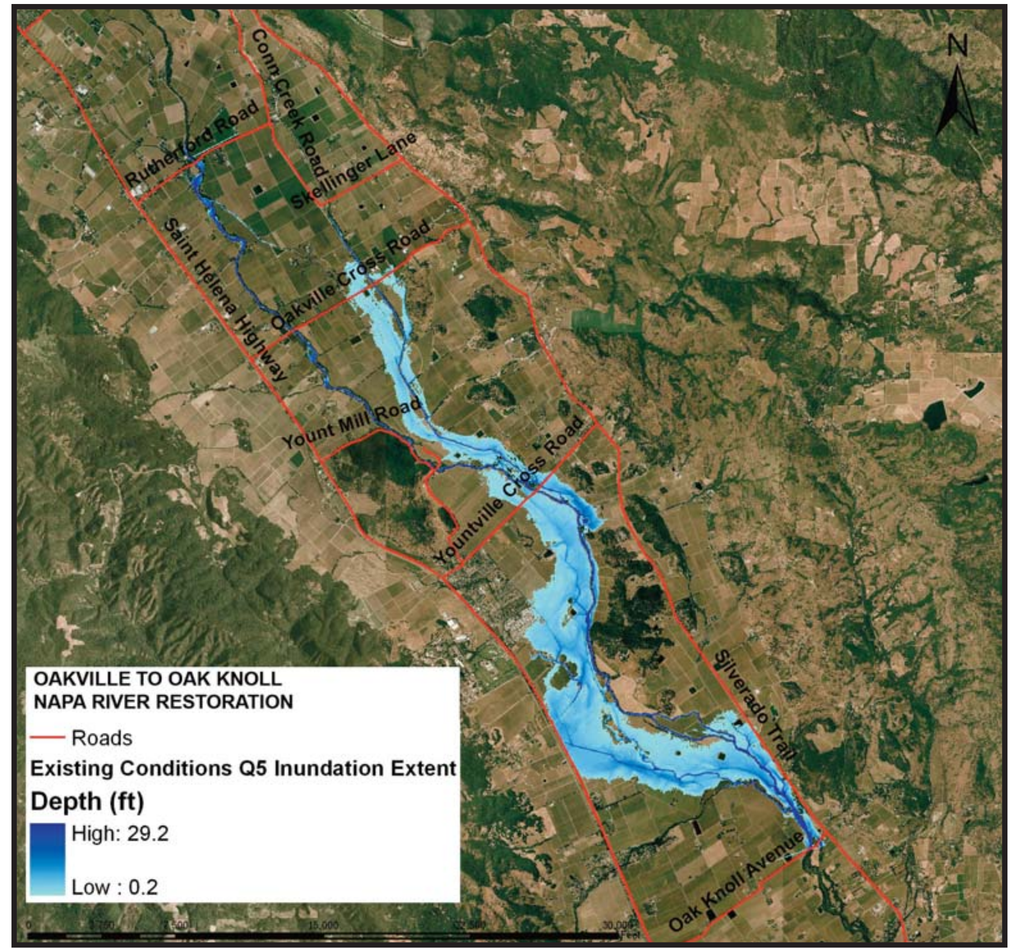
The flooding pattern for the 2-year event is similar to existing conditions; however, inundation extent is significantly reduced from flows overtopping from Reach 5. This reduces the ponding near Highway 29 and around the drainage channels leading to Dry Creek upstream of the Napa River confluence. Flood inundation is also slightly reduced on Conn Creek. Water surface elevations are reduced from approximately Flooding under the 10-year design flow follows the pattern of existing conditions with no significant changes downstream of the Yountville Cross Road to the split in the Napa River downstream in Reach 3. Water levels are unaffected upstream of Yountville Cross Road.

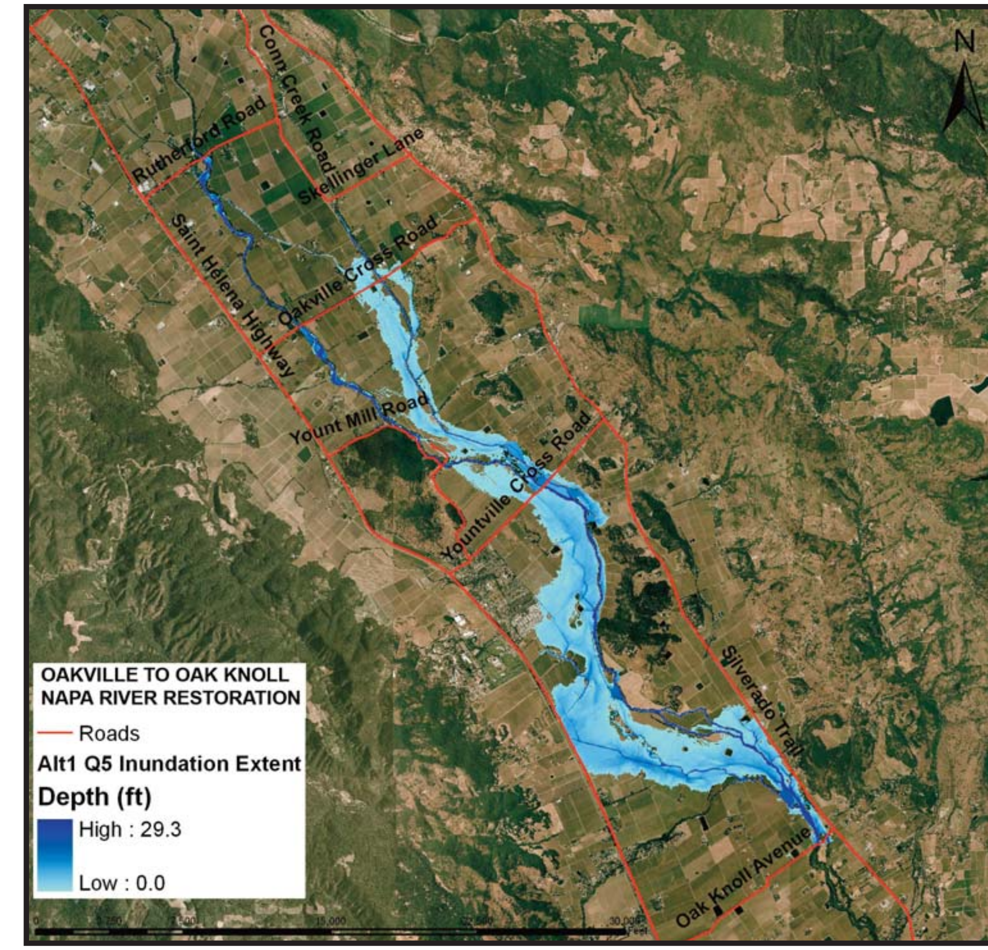
The 5-year event exhibits a similar flooding pattern as existing conditions. Inundation extent is reduced to the west of Napa River just downstream of the Yountville Cross Road. Downstream of this location flood extents are nearly identical to existing conditions. Water levels just downstream of the Yountville Cross Road are slightly reduced from existing conditions downstream to Reach 3.

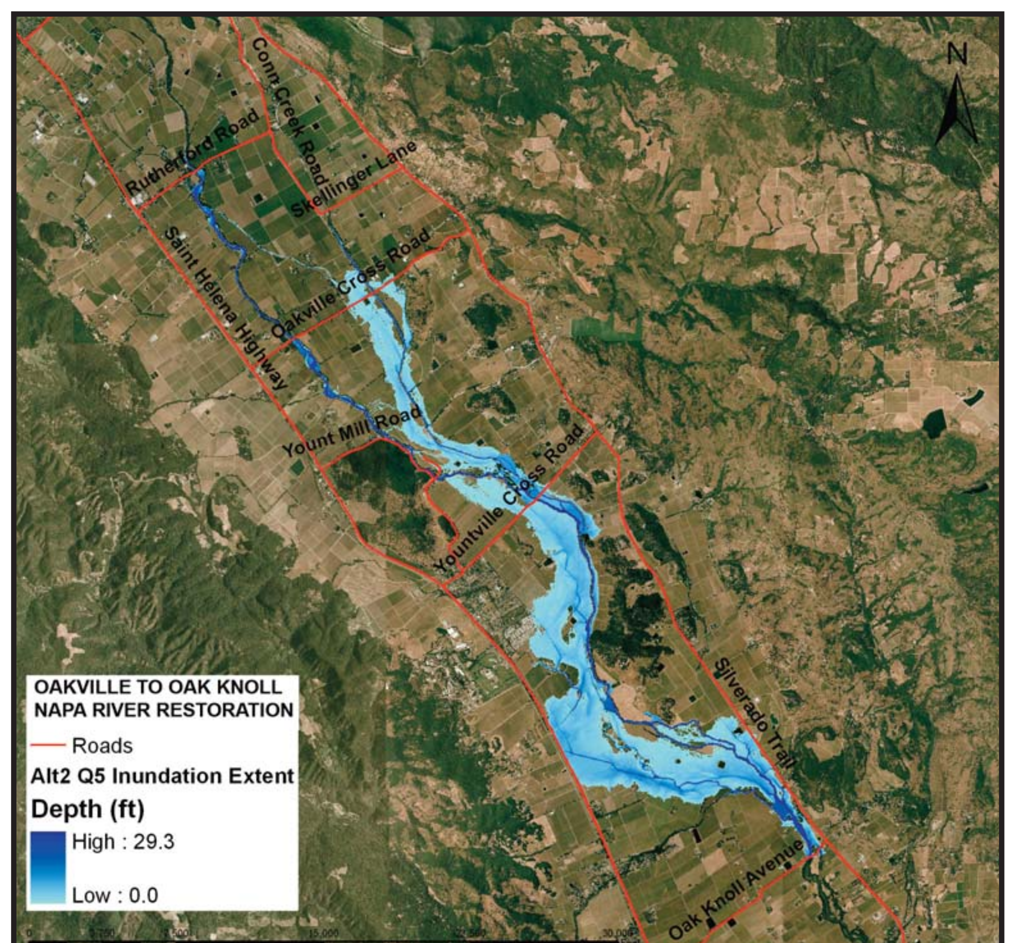
Flooding under the 10-year design flow follows the pattern of existing conditions with no significant changes downstream of the Yountville Cross Road. Alternative 1 does develop additional shallow flowing on the left bank of the Napa River between Oakville Cross Road and Yount Mill Road. Overflow in this area heads southeast connecting with Conn Creek. Slight decreases in water surface elevation between the Yountville Cross Road and the bypass generate lower inundation depths than existing conditions.

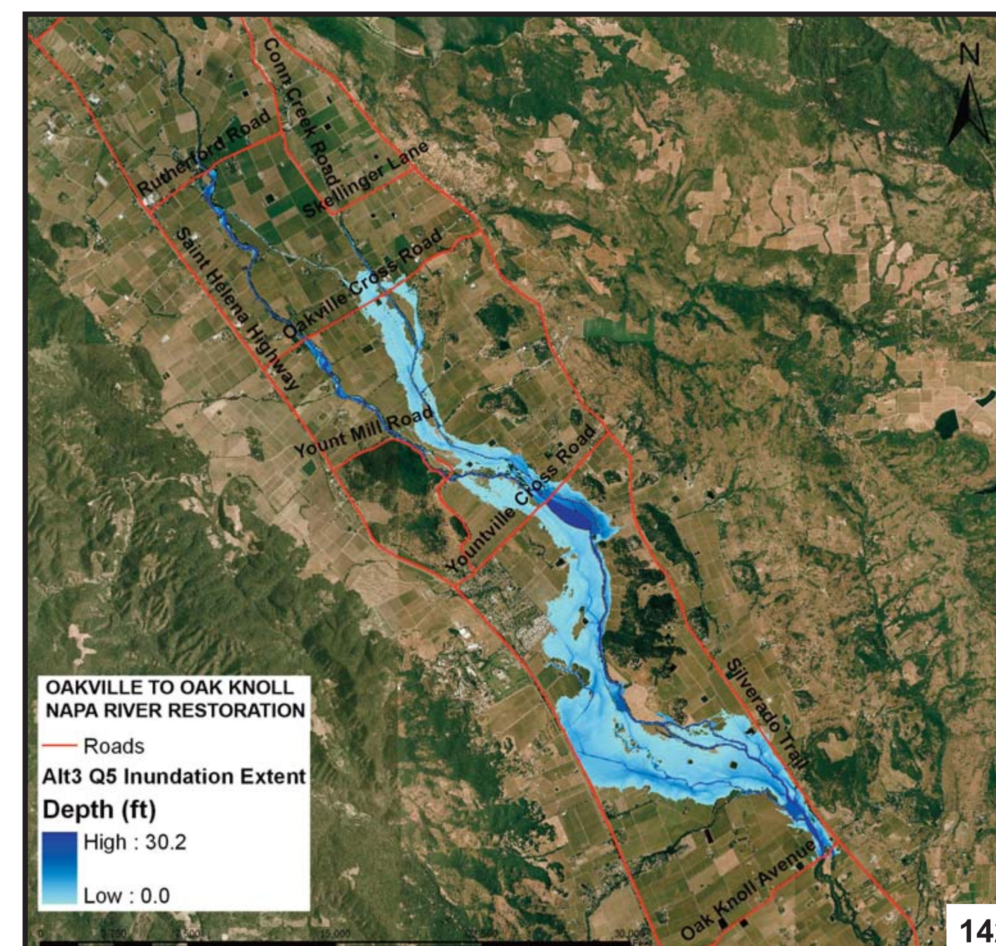
Alternative 2 – High and Medium Priority Restoration Areas

Flood benefits from Alternative 2 under the 2-, 5-, and 10-year flow conditions are similar to those realized in Alternative 1. In some locations Alternative 2 causes additional flooding such as additional ponding near Highway 29 under Q2, and increased flooding between the bypass and the main channel under Q5 and Q10. Relative to Alternative 1 the water surface profile is slightly lower downstream of Yountville Cross Road which produces moderately lower flood depths.









Alternative 3 – High, Medium and Low Priority Restoration Areas

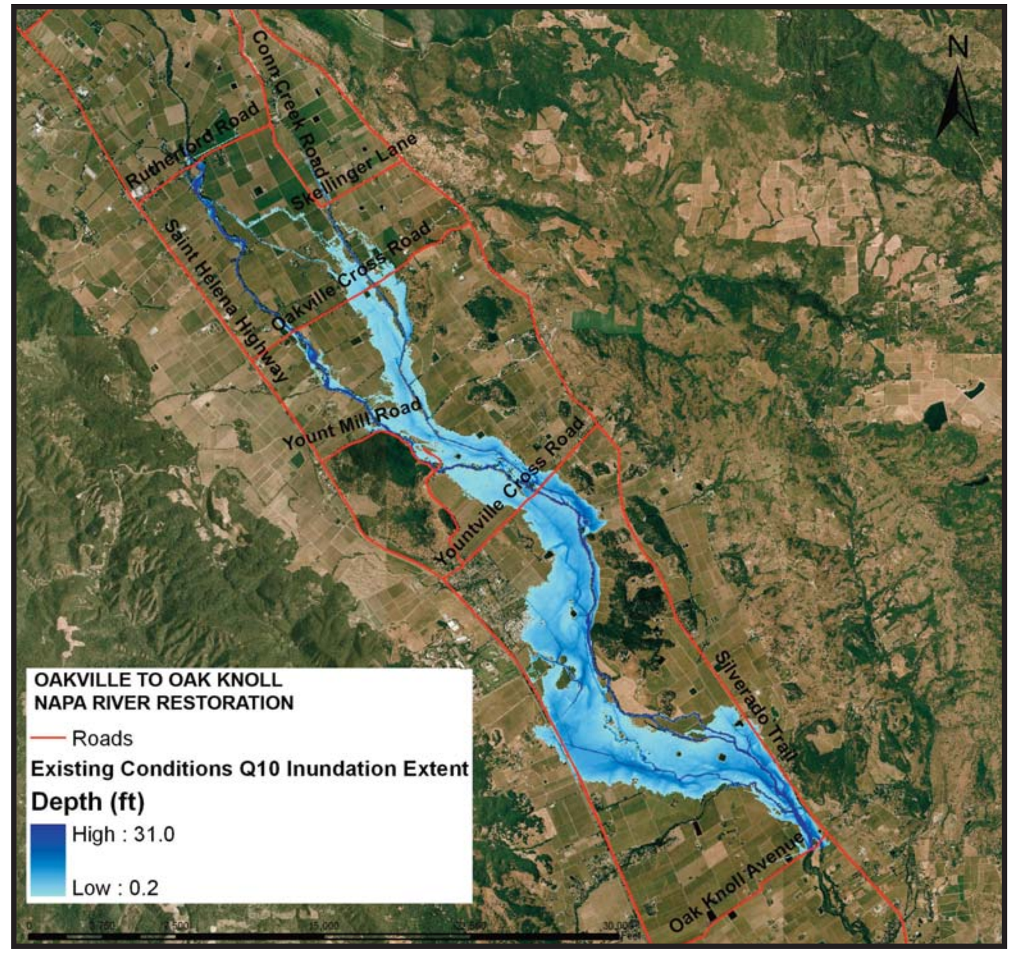
The 2-year flooding pattern for Alternative 3 exhibits reduction to flood extents similar to the other alternatives from breakouts in Reach 5. The flood basin provides moderate benefits to water levels and inundation. Minor reductions in water level are visible in the Reach 9. However the additional restoration areas included in this alternative do not appear to provide added flood benefit.

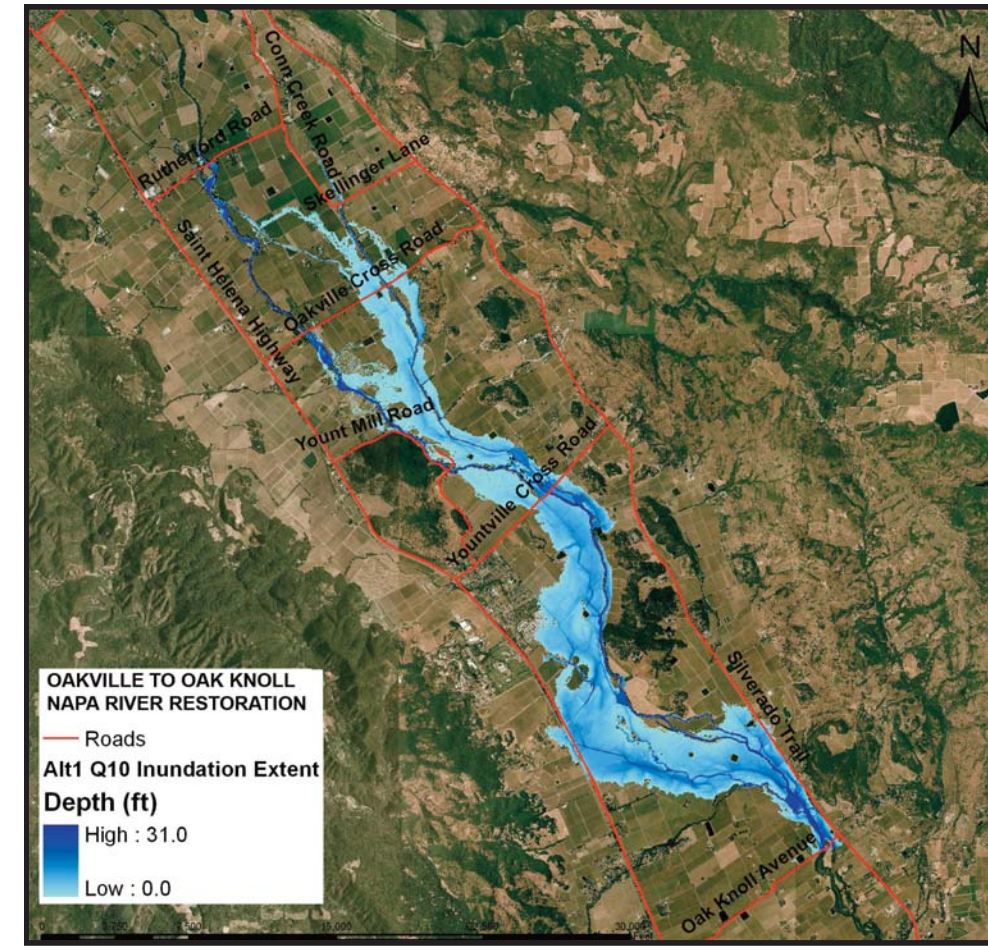
Model instability was encountered downstream of the large flood basin, Restoration Area 18b for the 5-, and 10-year model runs for Alternative 3 giving rise to a physically incompatible super-elevated water surface profile. Consultation with DHI—the software developer for the MIKE suite of modeling programs—did not provide resolution to this error in the modeling results. The water surface profile in this location should be considered erroneous. This water surface does not greatly impact the flooding extent which is similar to what is observed for Alternative 2 for the 5-, and 10-year flood events.

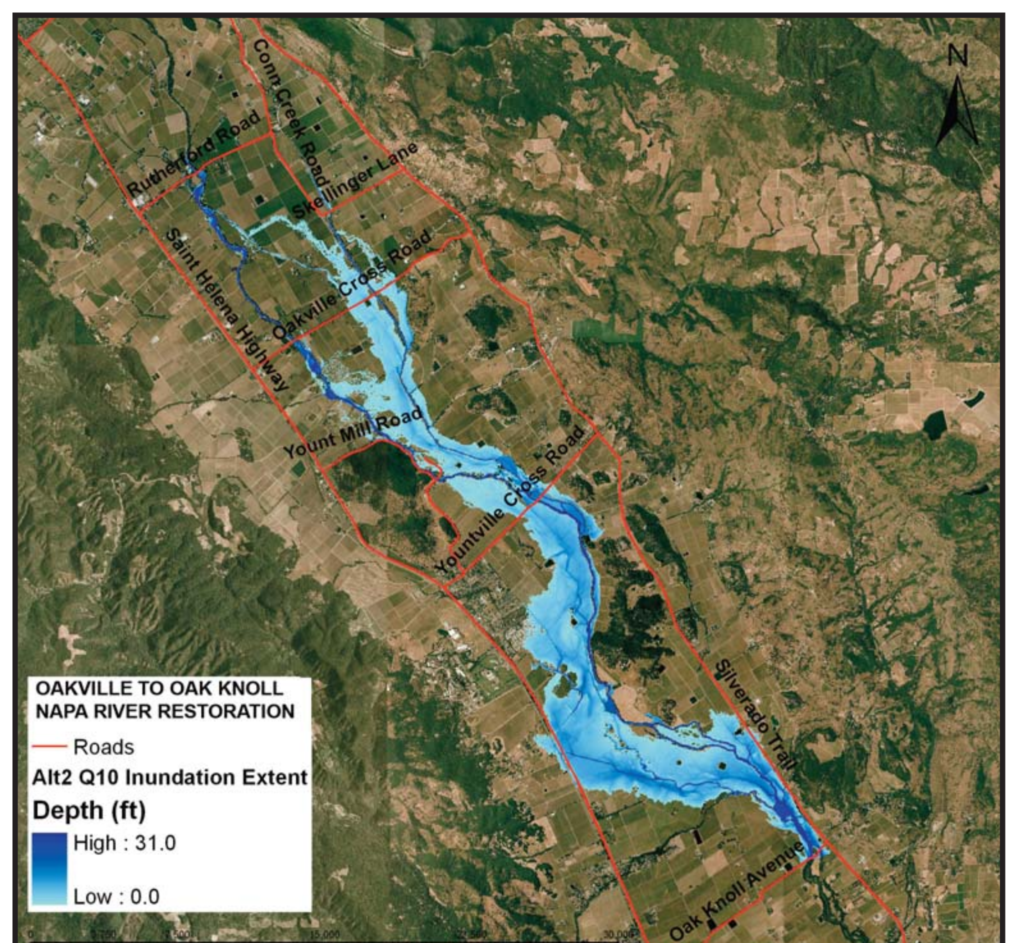
Summary

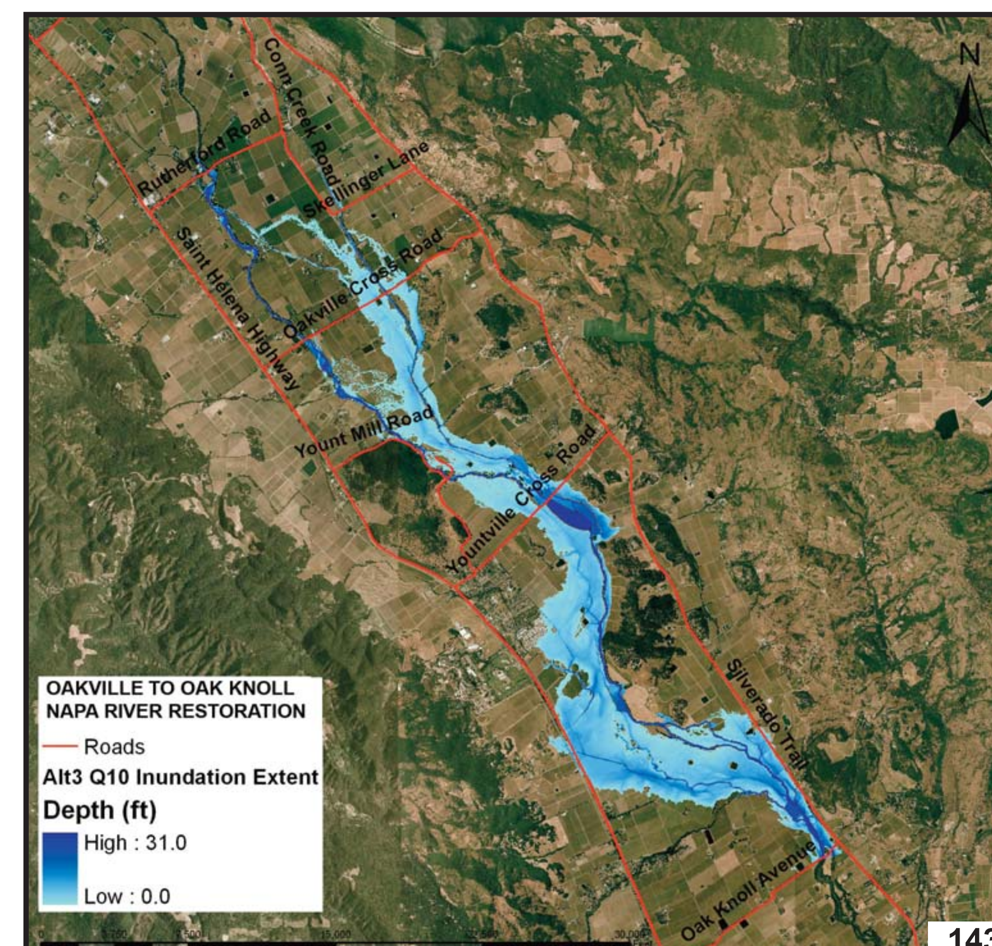
The calibrated MF model was adjusted to test the 2-, 5-, and 10-year flows for the three alternatives. Water levels and inundation extents are reduced in some locations for the 2-year flow but do not change significantly for the 5-, and 10-year events. For the 2-year event all three alternatives exhibit appreciable reductions in water surface elevations from approximately Yountville Cross Road to the downstream end of Restoration Area 8 spanning Reaches 4 through 7. These reaches see less of a reduction for the 5- and 10-year flow events. Additionally, the flood benefit achieved from Alternative 1 is approximately equal to that achieved under Alternatives 2 and 3

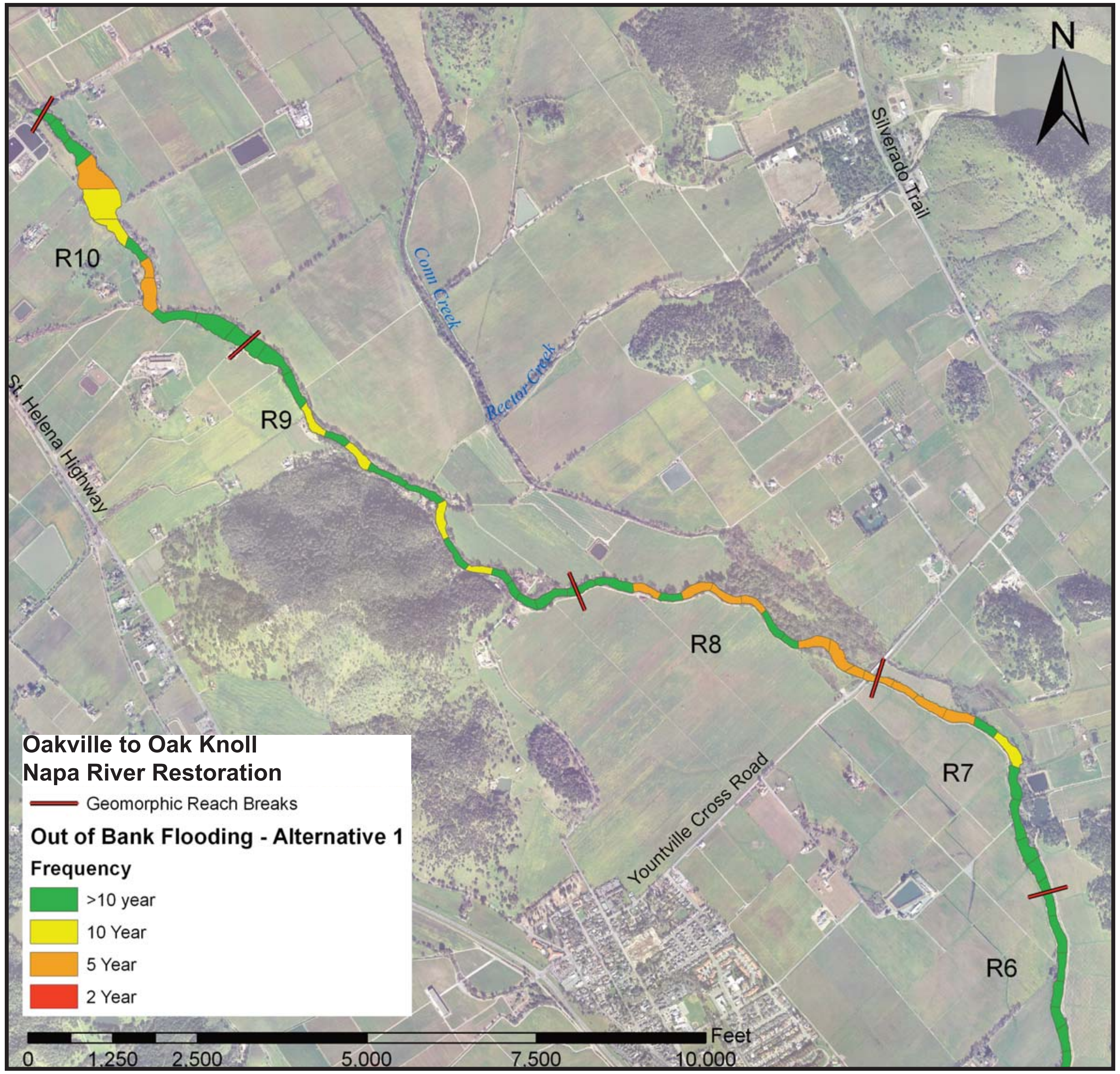
A larger watershed wide approach is needed to address flood management in the Napa Valley. Flood management is constrained by the need to not increase flood levels in the Napa River through the City of Napa flood control project. As a result flood water must be held on the Napa River floodplain, but done so in a way that causes less damage and inconvenience to the landowners and residents of the floodplain area. Dormant vineyards can hold water for a few hours but, debris and sediment would need to be filtered out before entangling the vineyard trellis or burying the vines. There are several ways that floodplain management could be enhanced, and a study is needed to assess the feasibility and determine the costs and benefits of different approaches.

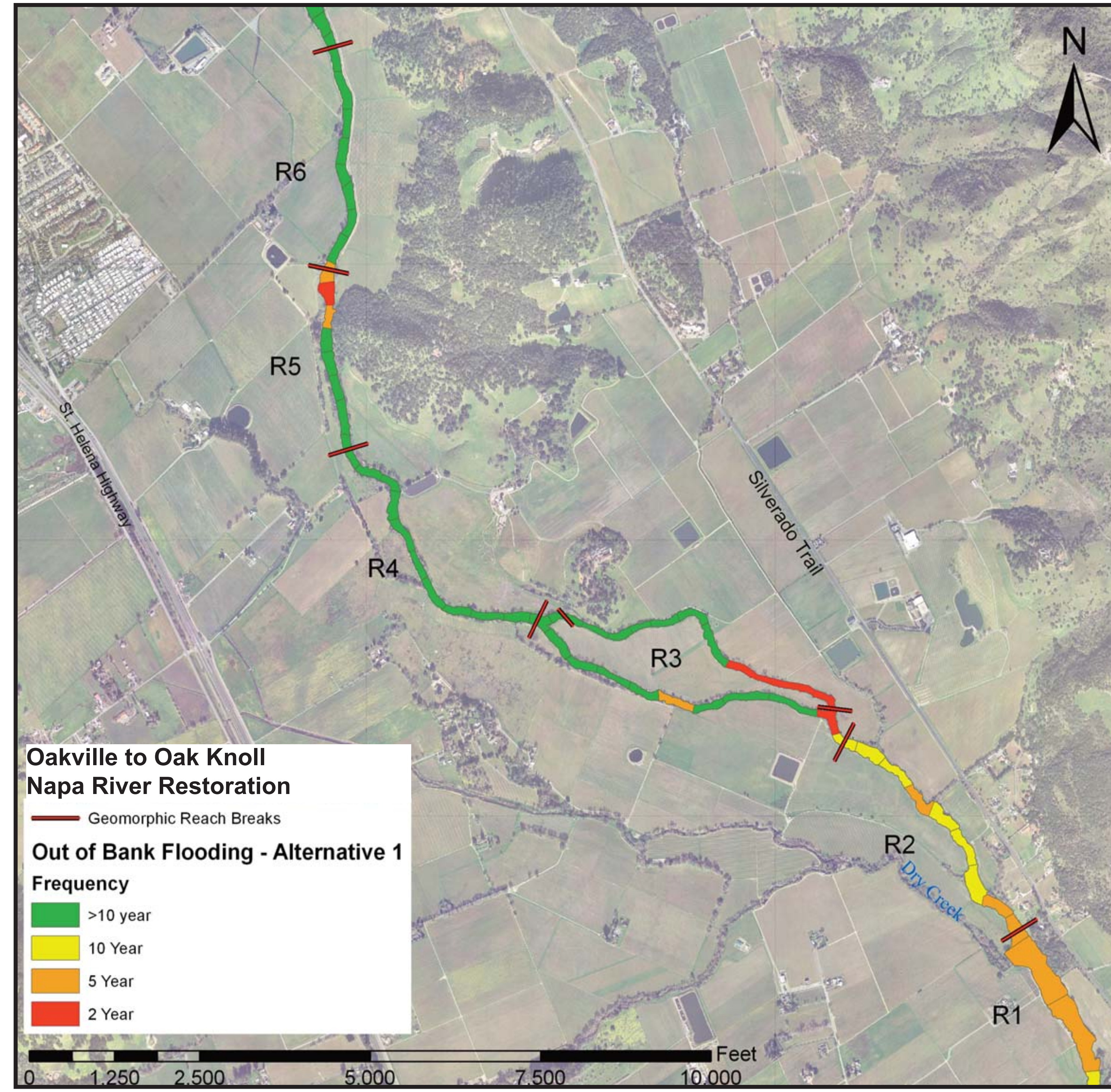




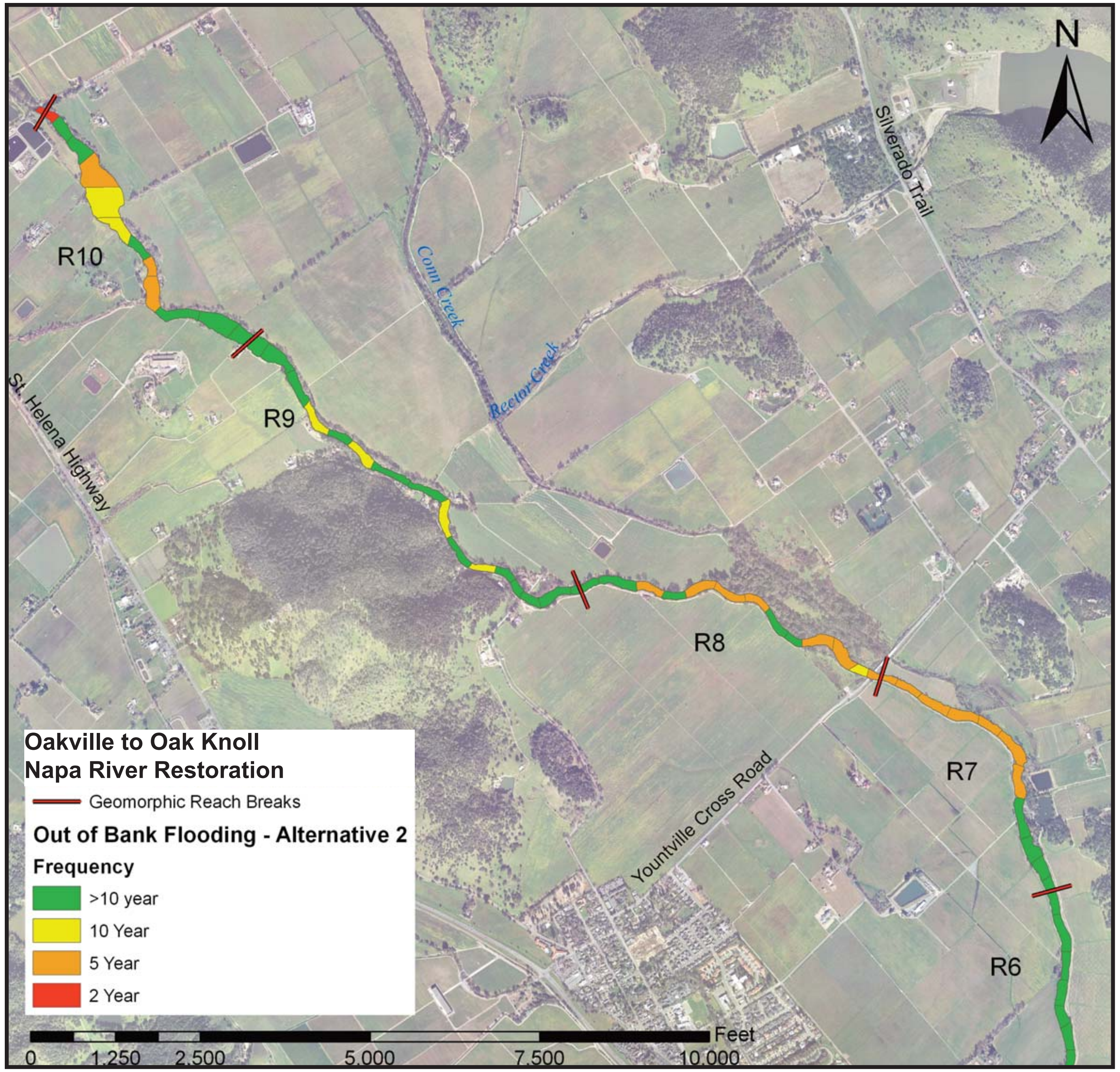


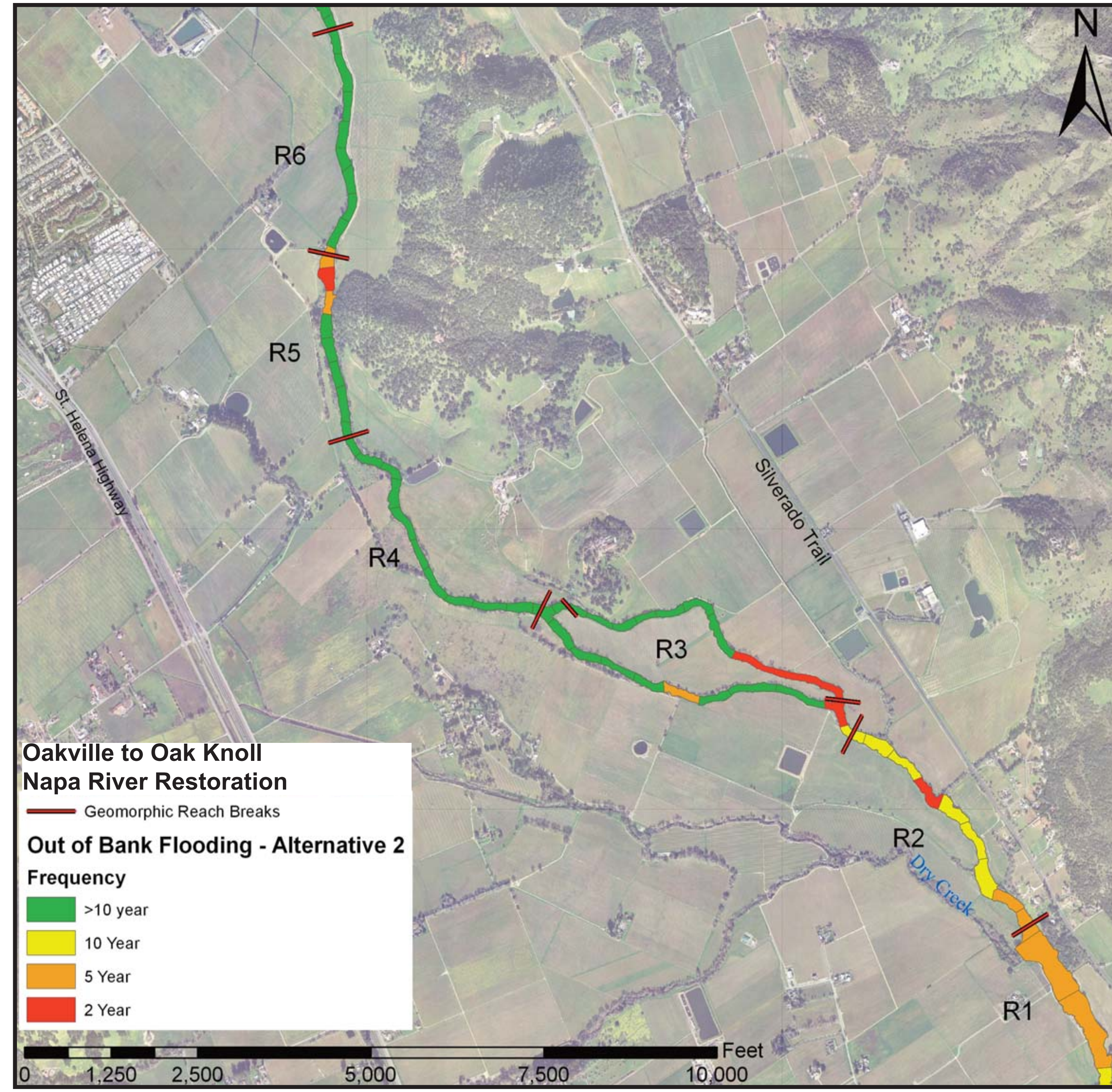




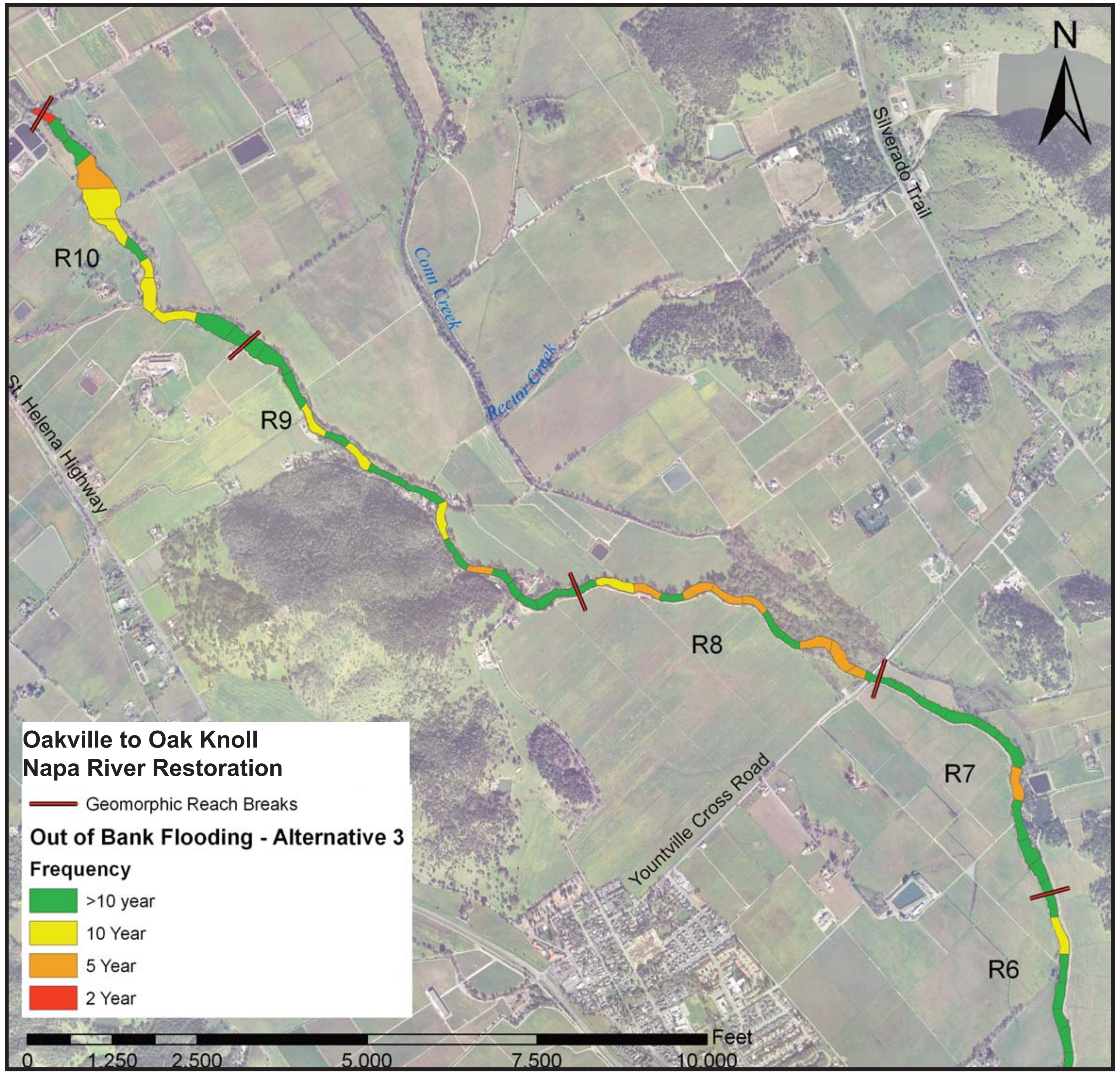


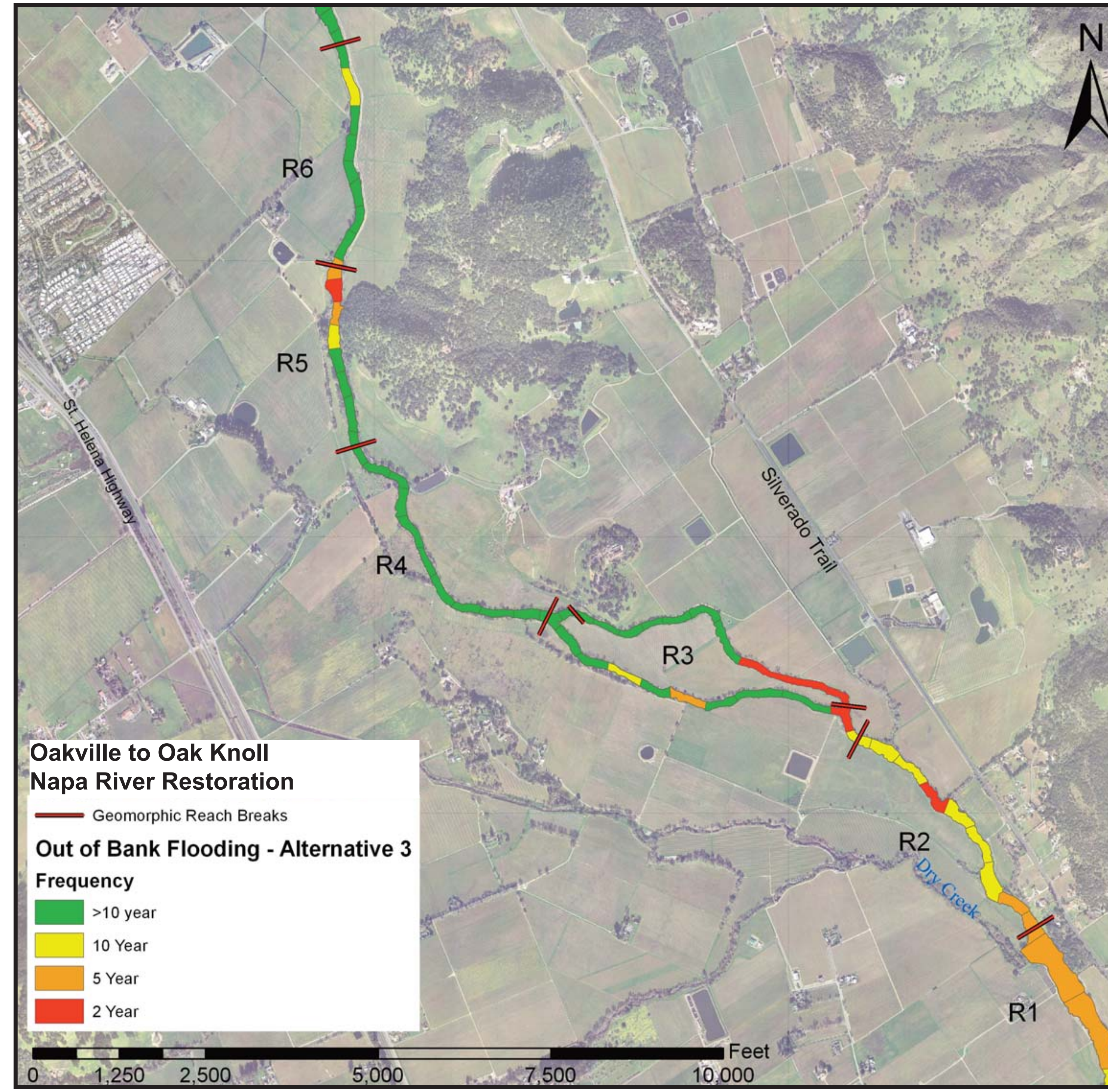
Alternative 1 will reduce out of bank flooding along parts of Reaches 10-7 from the 5-year flood frequency to the 10-year flood frequency. Reach 5 would see the greatest improvement from out of bank flooding changing from a 2-year event to the 10-year event for most of the reach. Reach 2 also shows an improvement from a 2-year to a 5-year event causing out of bank flooding.



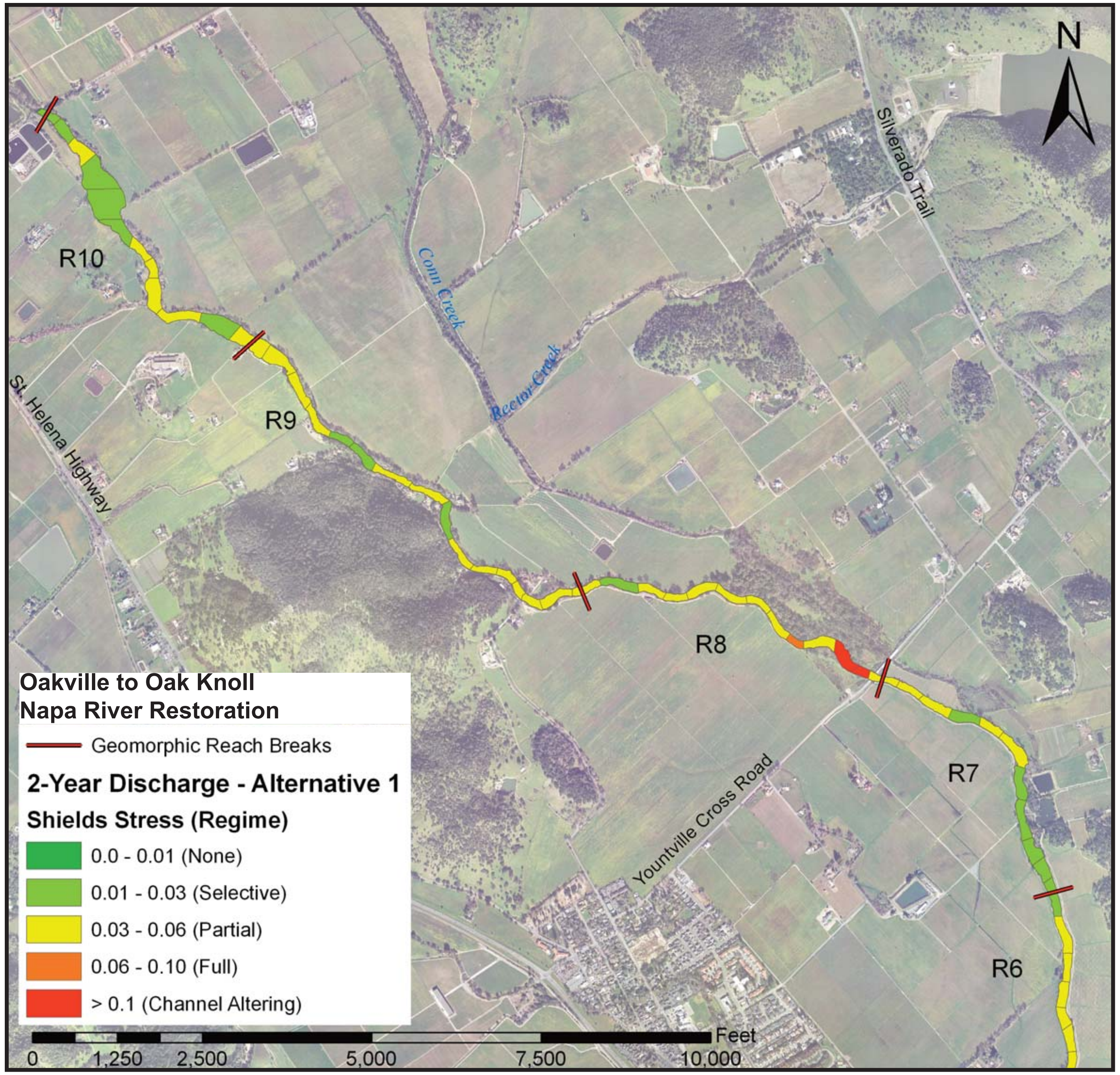


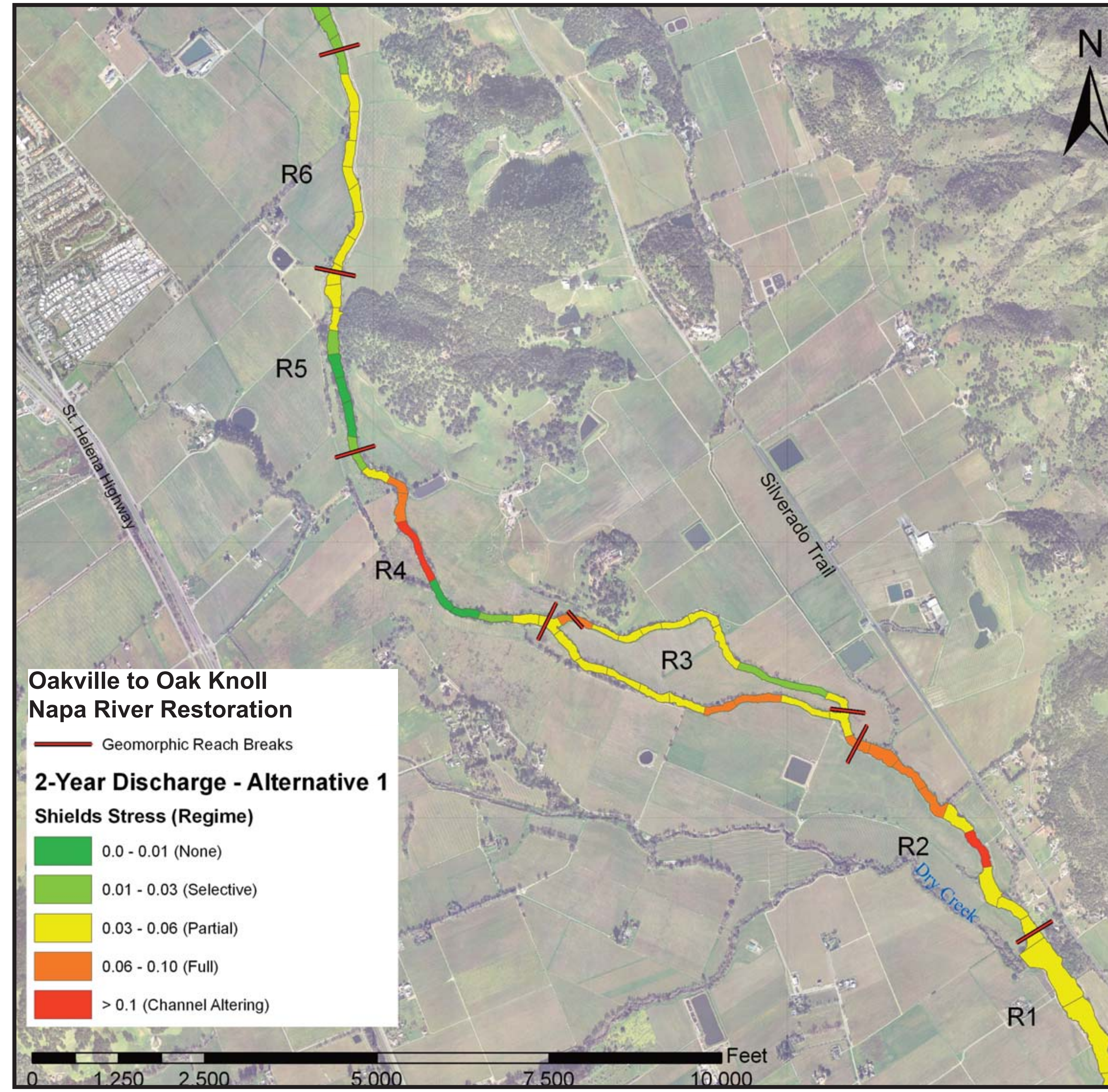
Alternative 2 has similar effects to Alternative 1, providing reduced frequency of out of bank flooding in Reaches 10-7, 5 and 2.



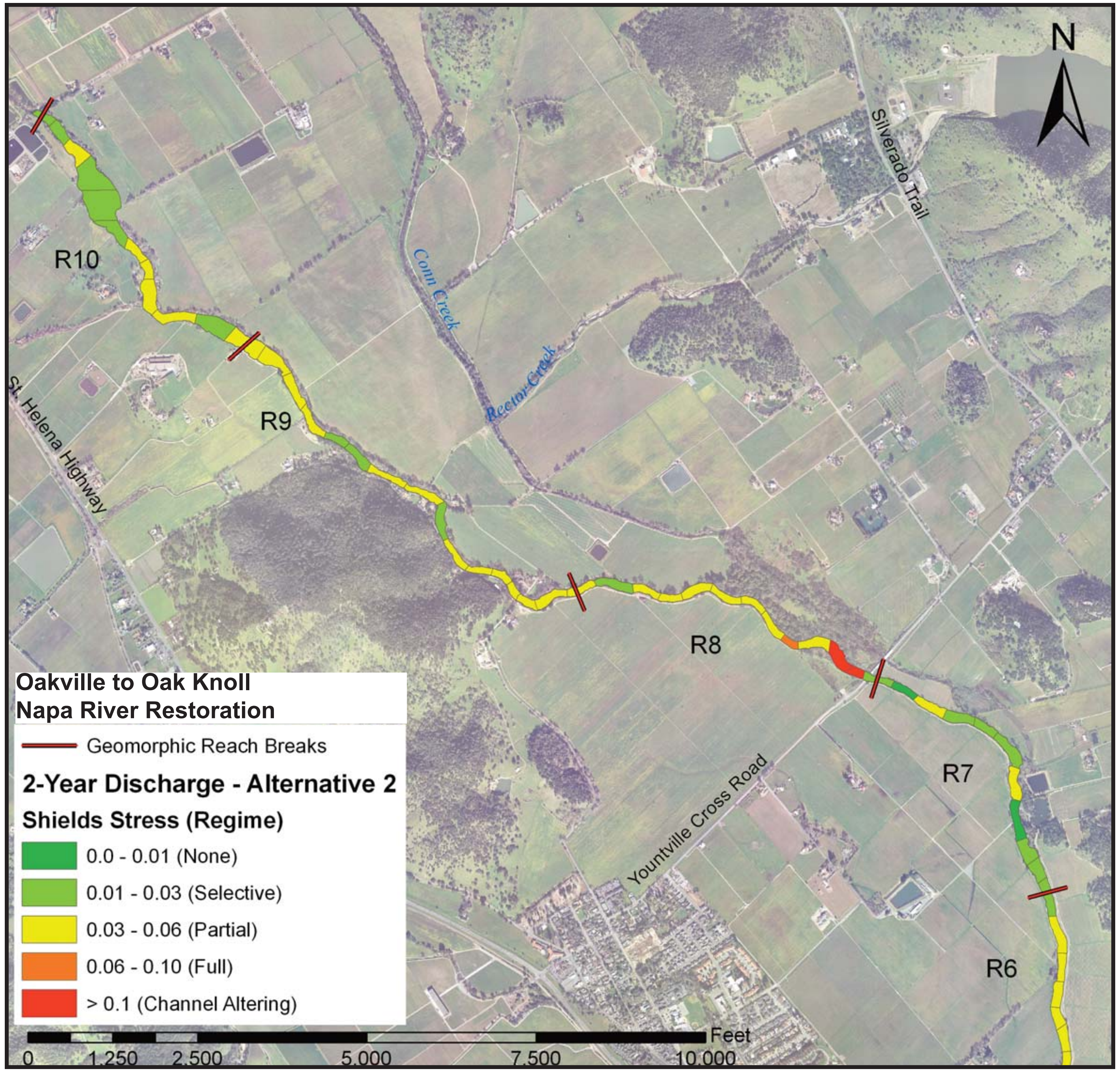


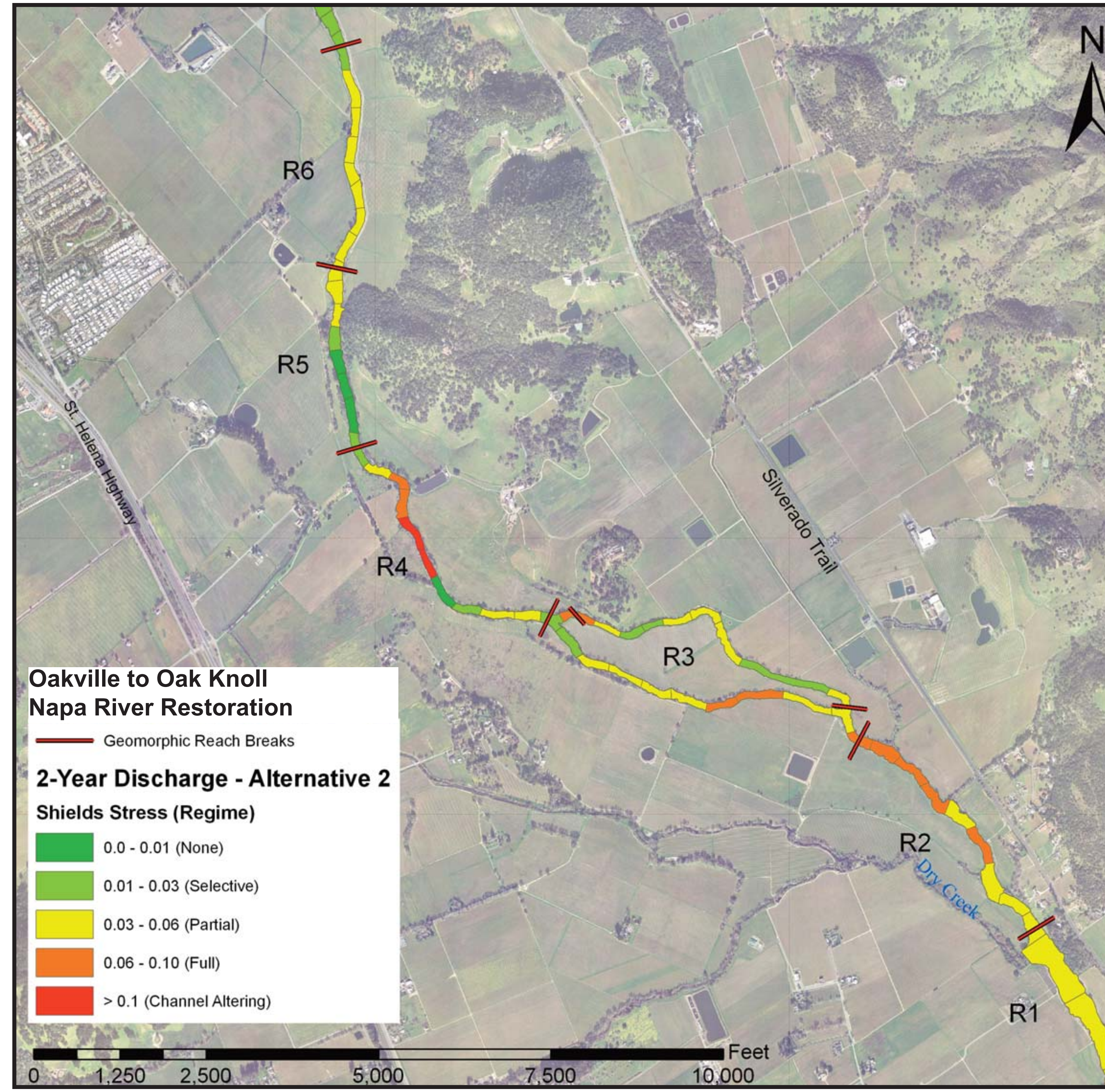
Alternative 3 does not differ substantially from Alternative 1 and 2 in the locations and level of change in the frequency of out of bank flooding. The exception is in Reach 7, which would have a large flood basin under Alternative 3 and see a local reduction in the frequency of out of bank flooding from a 2-year event to a greater than 10-year event.



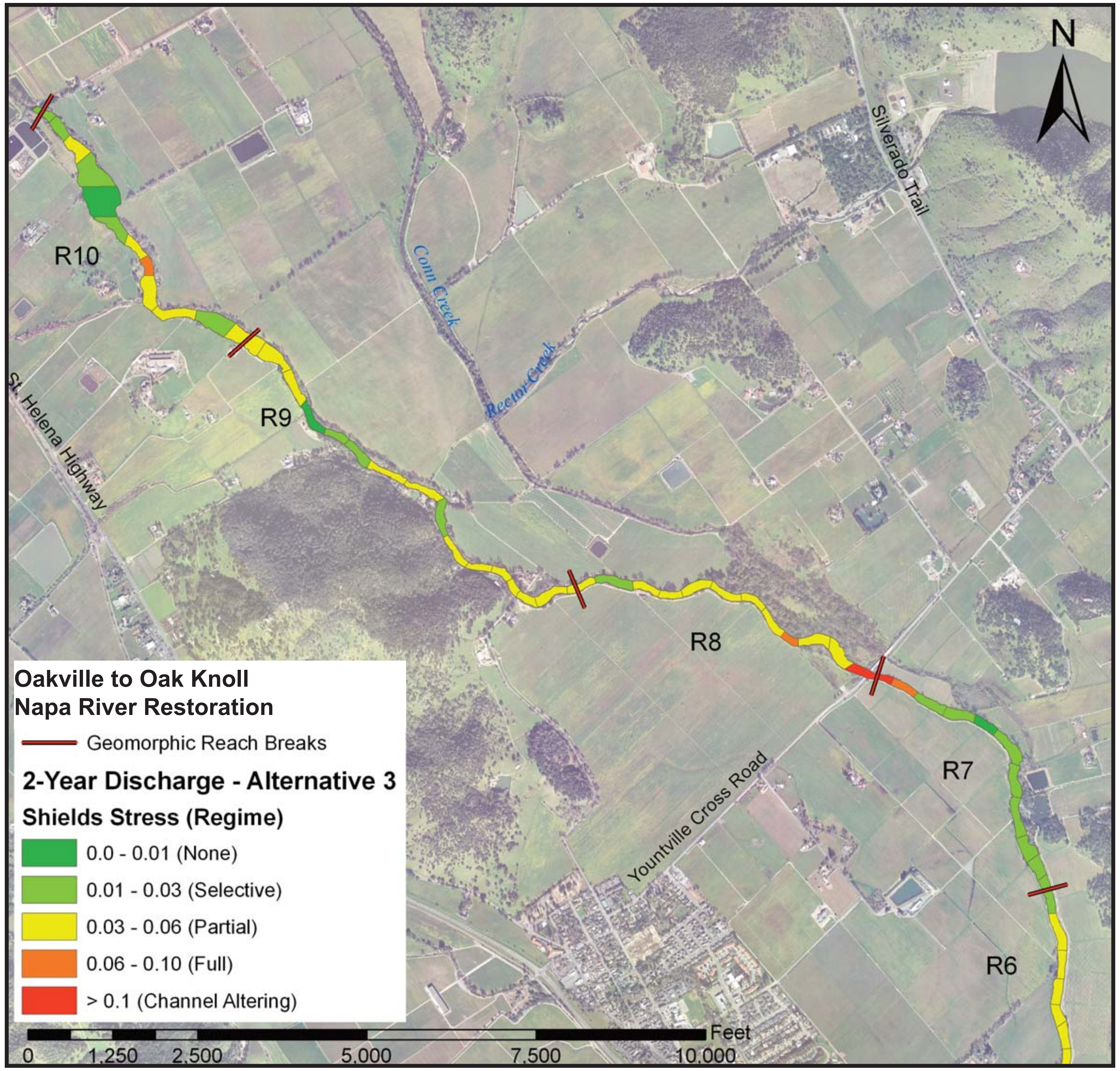


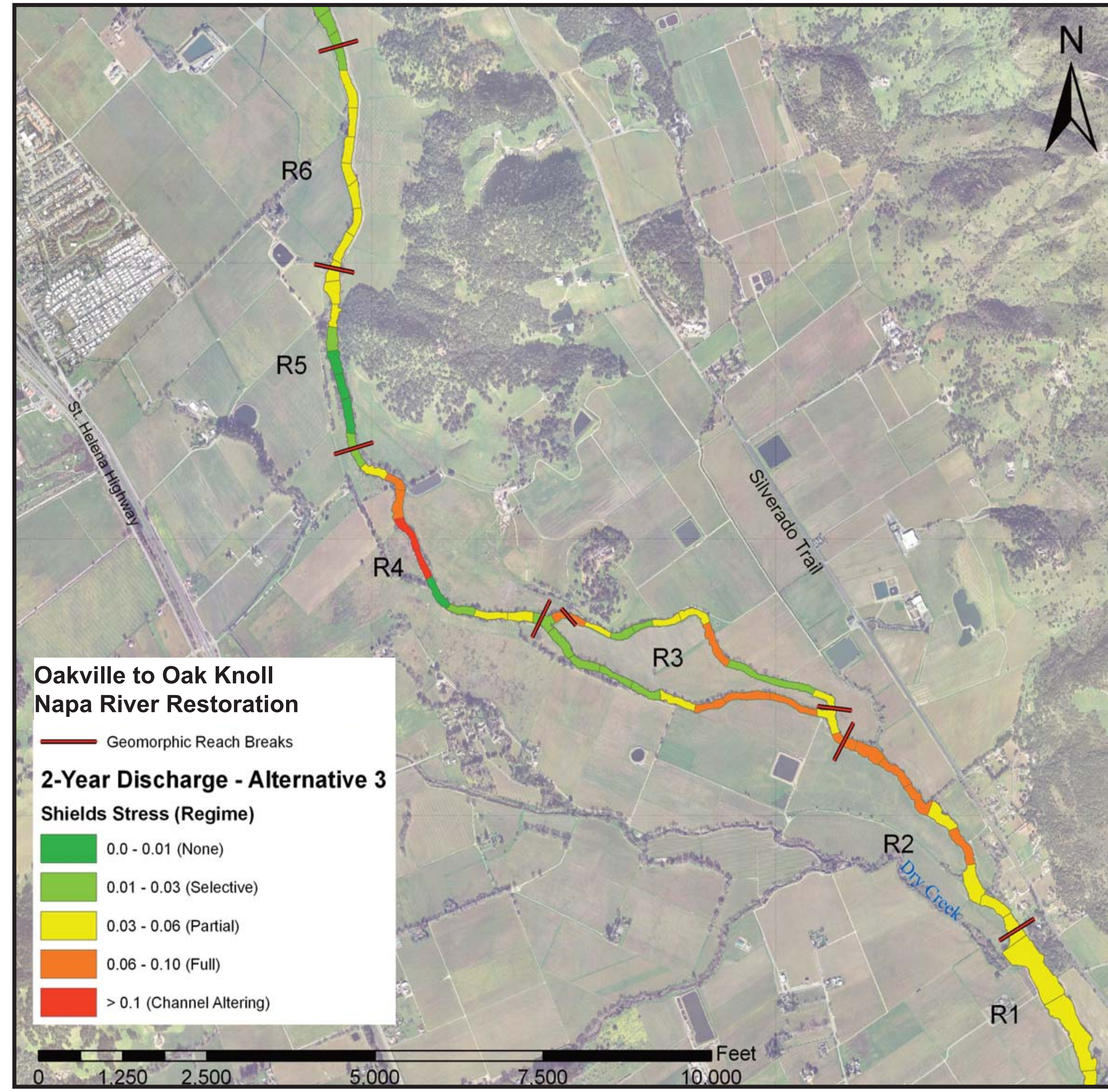
COLOR ON MAP	SHIELDS STRESS VALUE	EFFECTS ON RIVER AND BANKS
Green	0-0.01 None	No erosion of bed or banks likely
Pale green	0.01 - 0.03 Selective	A thin layer of spawning gravel or weaker unvegeted bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds.
Yellow	0.03 - 0.06 Partial	The upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.
Orange	0.06 - 0.1. Full mobilization	Gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features.
Red	>0.1. Channel altering flows	These flows will eliminate bed features (e.g. riffles and pools) and wash gravel out of the reach. Most unvegetated and some vegetated banks will experience severe erosion.



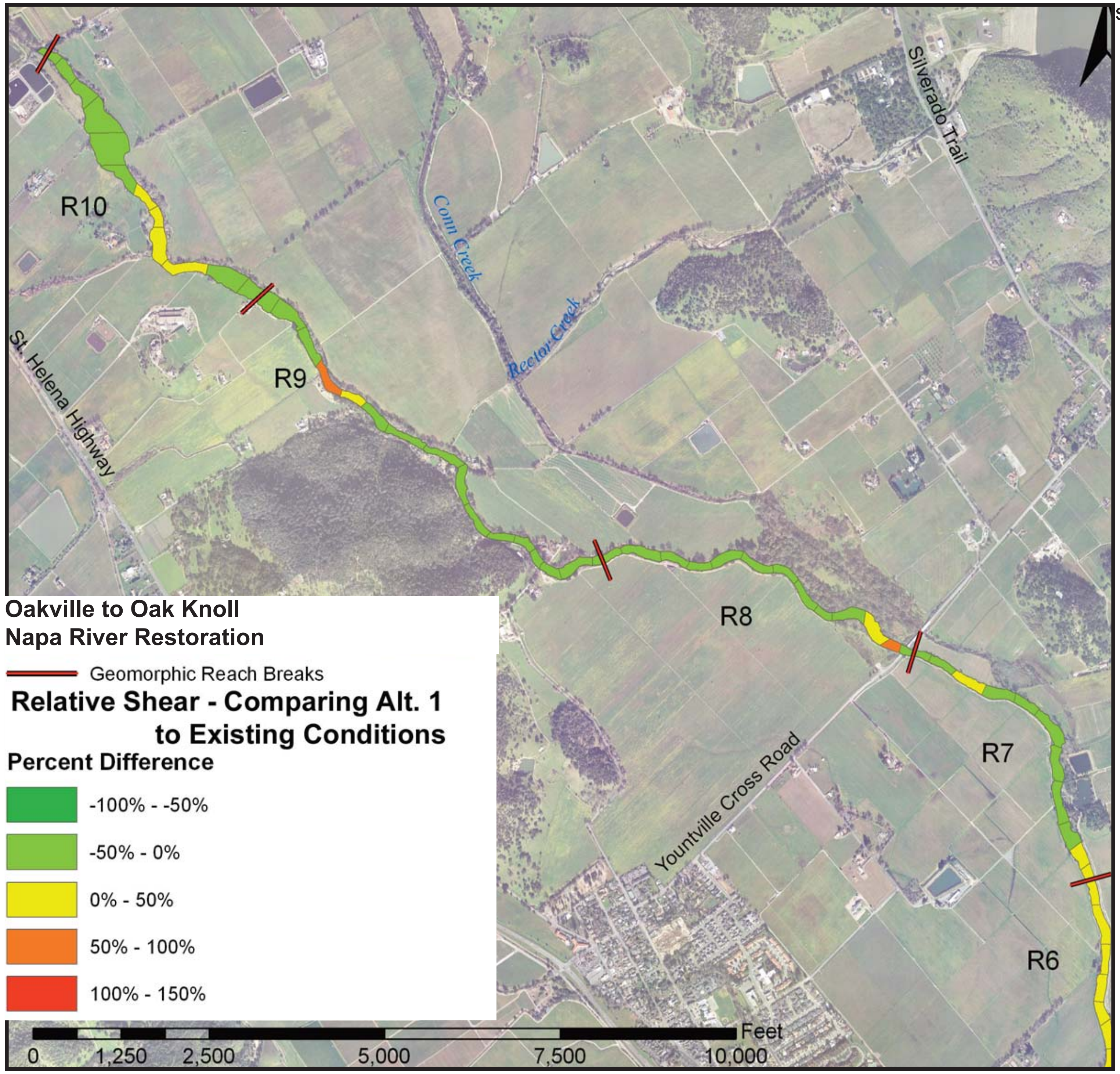


COLOR ON MAP	SHIELDS STRESS VALUE	EFFECTS ON RIVER AND BANKS
Green	0-0.01 None	No erosion of bed or banks likely
Pale green	0.01 - 0.03 Selective	A thin layer of spawning gravel or weaker unvegeted bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds.
Yellow	0.03 - 0.06 Partial	The upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.
Orange	0.06 - 0.1. Full mobilization	Gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegetated banks will experience erosion. After these flows gravel may reform bed features.
Red	>0.1. Channel altering flows	These flows will eliminate bed features (e.g. riffles and pools) and wash gravel out of the reach. Most unvegetated and some vegetated banks will experience severe erosion

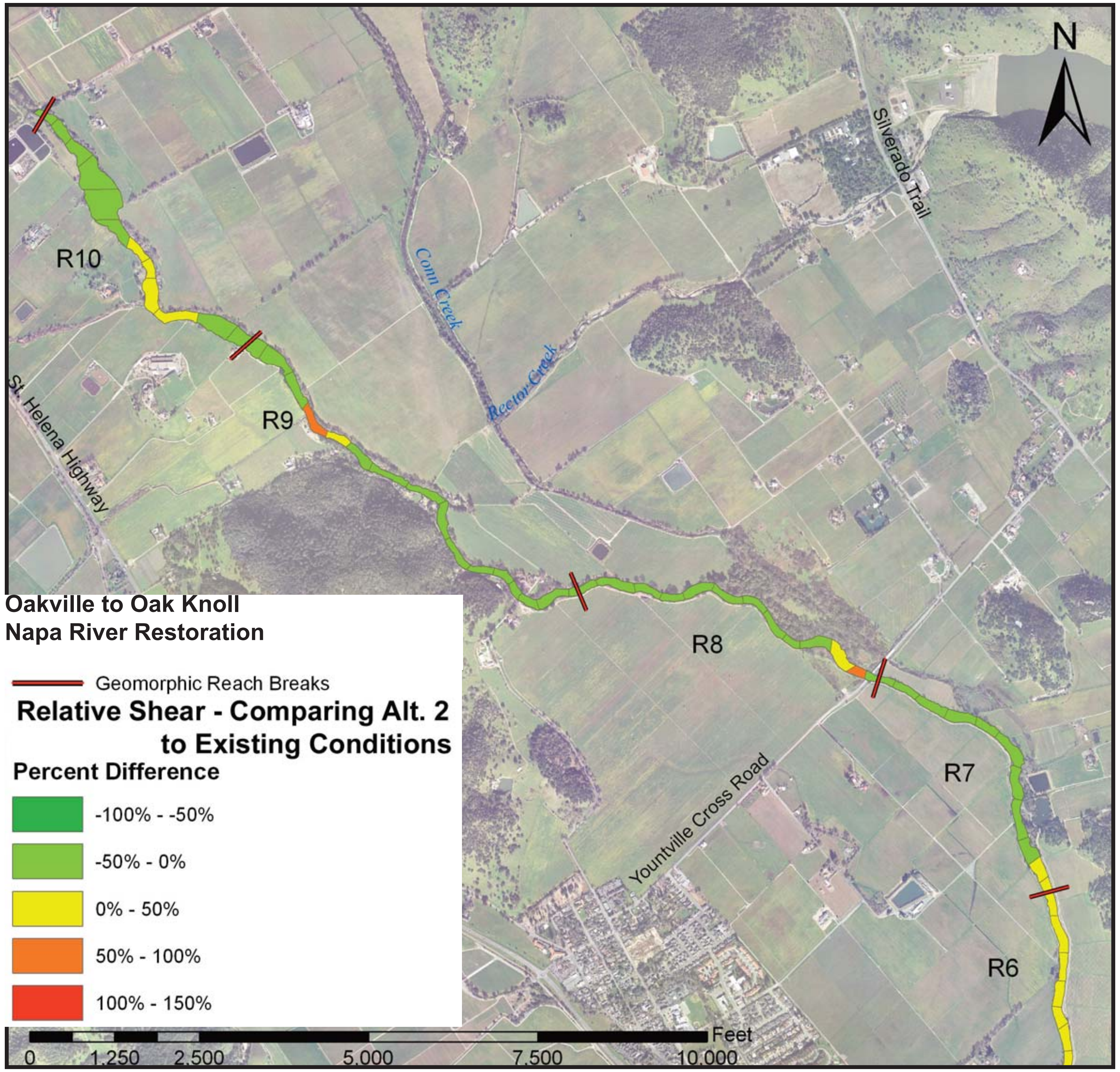


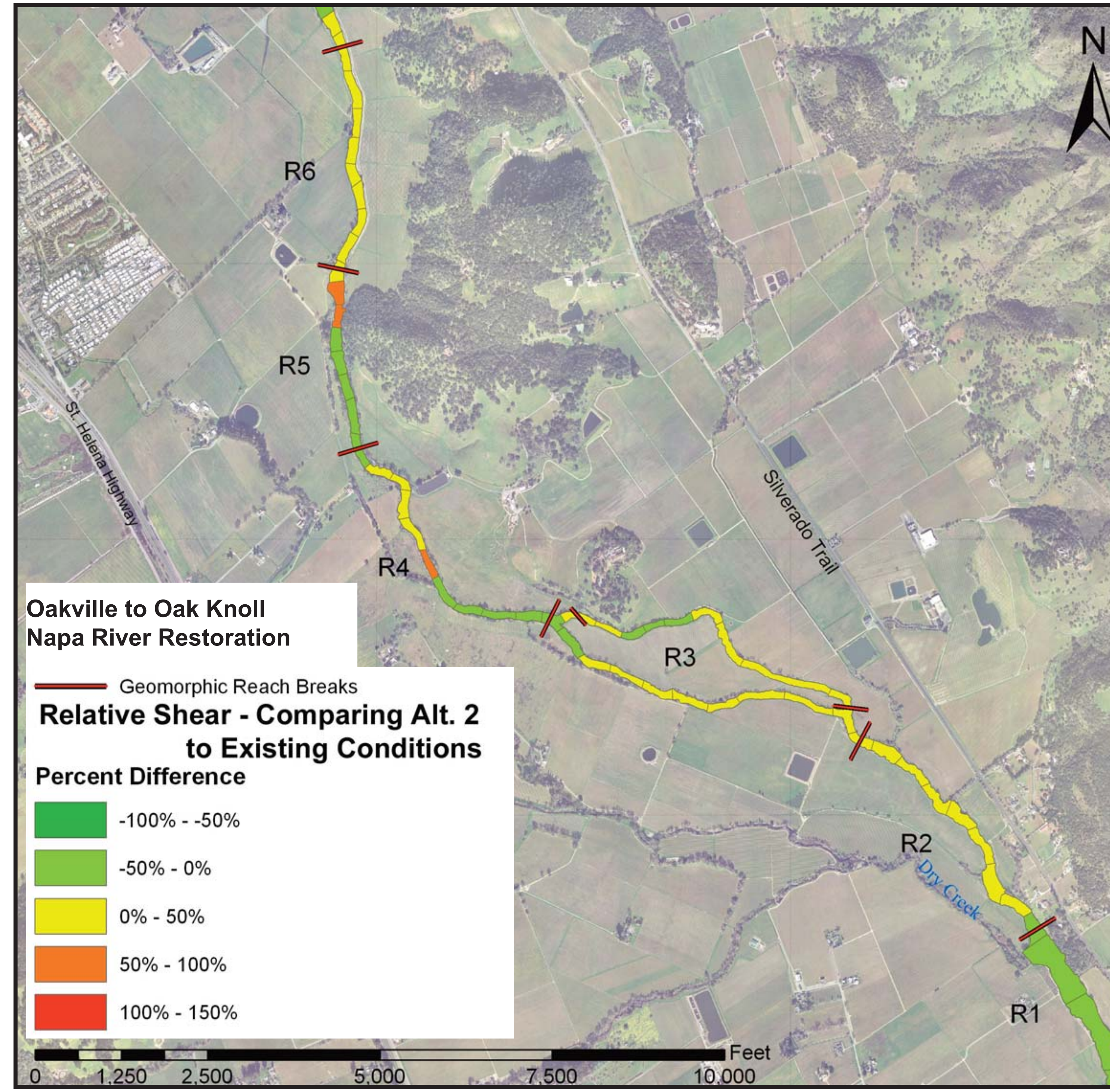


COLOR ON MAP	SHIELDS STRESS VALUE	EFFECTS ON RIVER AND BANKS
Green	0-0.01 None	No erosion of bed or banks likely
Pale green	0.01 - 0.03 Selective	A thin layer of spawning gravel or weaker unvegetated bank material may be eroded. Shallow redds may experience some scour, but occasional turnover of material can also be beneficial to promote cleaning of fines from the redds.
Yellow	0.03 - 0.06 Partial	The upper few inches of spawning gravel are eroded, and medium strength unvegetated bank material may start to erode. This level of erosion will cause some erosion of redds, and some loss of eggs.
Orange	0.06 - 0.1. Full mobilization	Gravel beds will fully mobilize, destroying all redds. Moderate to resistant unvegeted banks will experience erosion. After these flows gravel may reform bed features.
Red	>0.1. Channel altering flows	These flows will eliminate bed features (e.g. riffles and pools) and wash gravel out of the reach. Most unvegetated and some vegetated banks will experience severe erosion



Some care is needed in interpreting the results of the shear stress and Shields stress assessment. Note that some areas show an increase in relative shear stress under the proposed project alternatives. This may occur when an area downstream is widened. Widening the floodplain locally lowers the water surface elevation, creating a steeper gradient upstream. The steeper water surface gradient causes higher shear stresses. In many cases the actual value is still low, but the percent increase in shear stress is shown as high.





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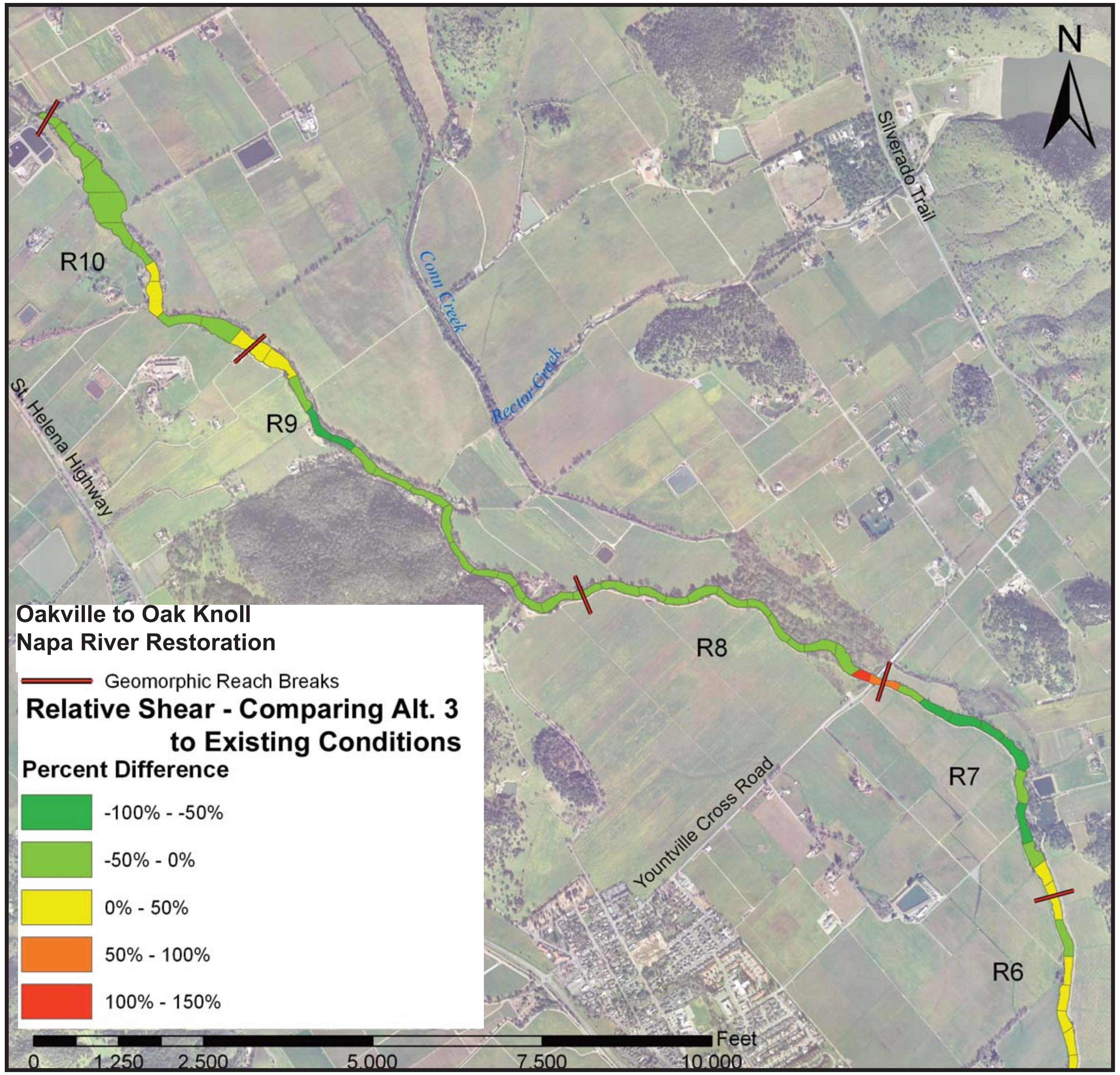

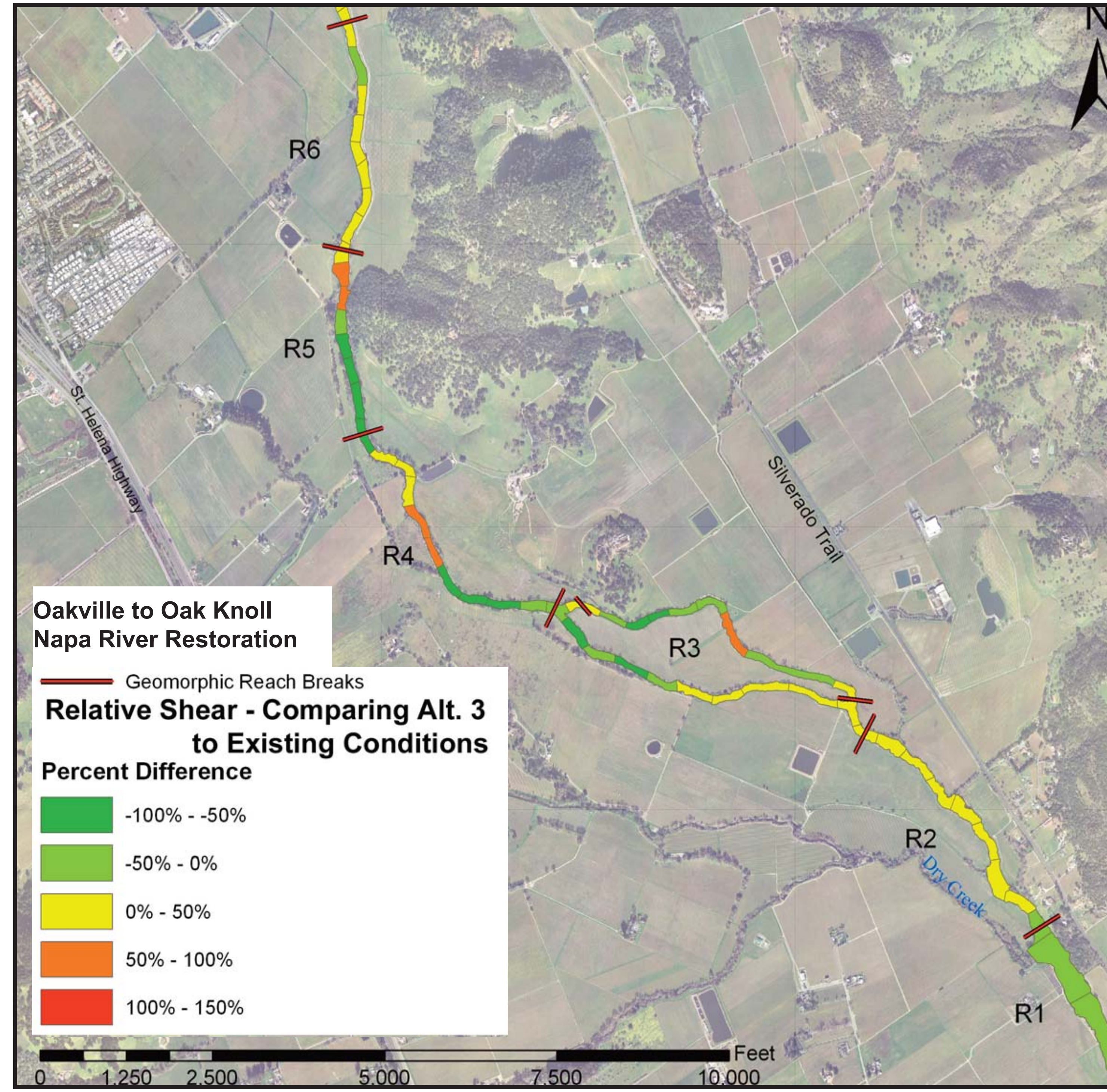

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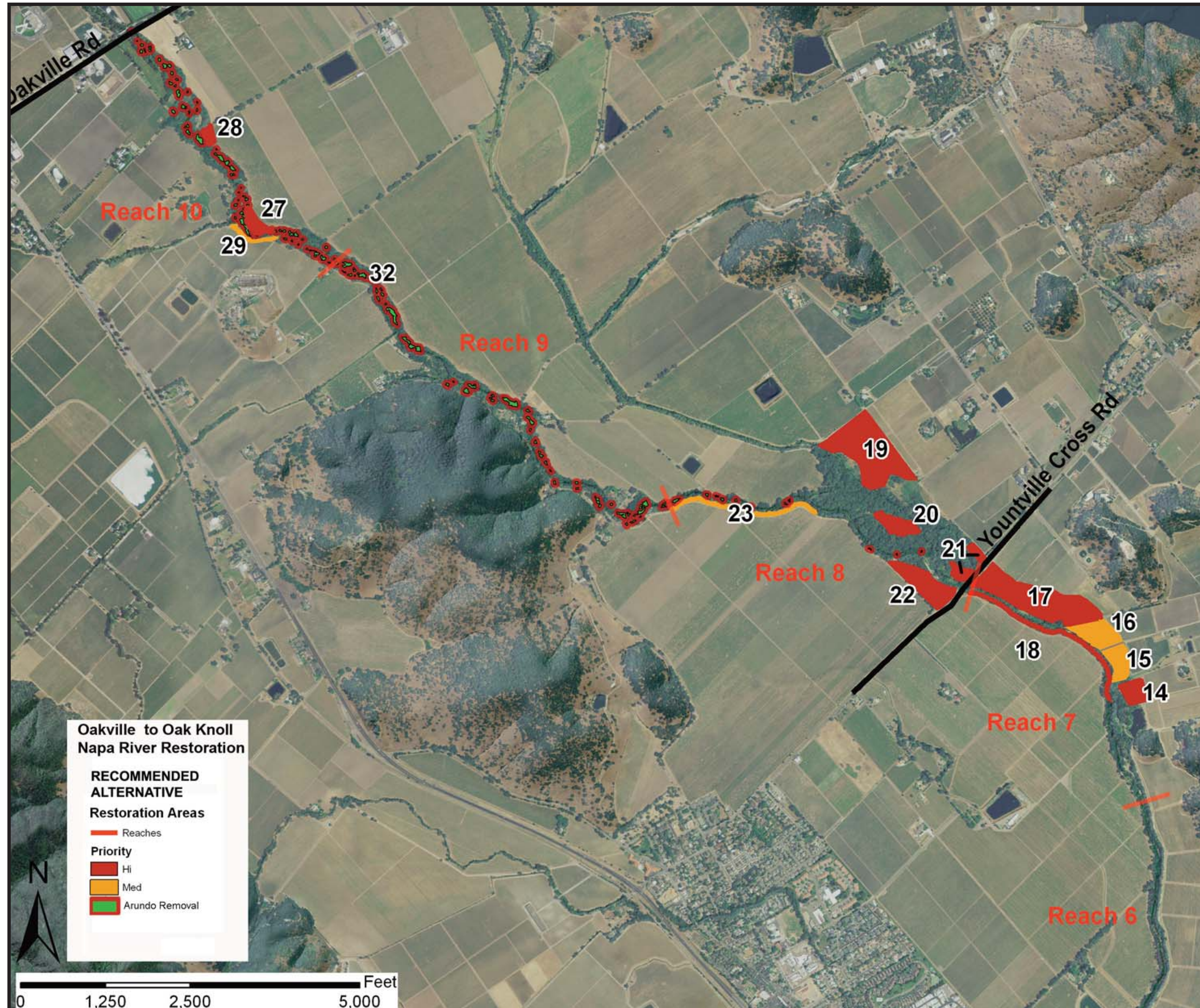
RECOMMENDATIONS

Under Alternative 1, only the high priority sites would be implemented. There are 12 restoration sites in three of the habitat nodes – Oakville, Yountville, and Oak Knoll. Alternative 1would affect 63.5-63.7 acres, of which 51.7 - 51.8 would be new riparian or channel habitat created from weedy upland, fallow land or vineyard. About 5.7 acres of existing riparian habitat would be graded in order to set back banks or create new floodplains and so would be transformed to channel and revegetated riparian habitat. In Restoration Area 17, the configuration of the restoration depends on whether two downstream sites, restoration areas 15 and 16 are included. These two areas are not included in Alternative 1, as the site owners have not yet approved of the restoration. Therefore, under Alternative 1, option 17b would be implemented. Restoration Area 1 also has two configurations which lead to a difference in acreages.

Alternative 1 provides some reductions in flood levels and inundation area over existing conditions. Alternative 1 will reduce out of bank flooding along parts of Reaches 10-7 from the 5-year flood frequency to the 10-year flood frequency. Reach 5 would see the greatest improvement from out of bank flooding changing from a 2-year event to the 10-year event for most of the reach. Reach 2 also shows an improvement from a 2-year to a 5-year event causing out of bank flooding. Alternative 1 would reduce sheer stress which causes channel erosion in Reaches 10, 9, 8, 7, 5 and part of 4.

Alternative 2 would include all of the restoration areas of Alternative 1 as well as all of the medium ranked sites and managed retreat sites. Alternative 2 would affect a total of 128.4-130.8 acres. Of this total 77.9-85.1 acres would be new riparian and channel habitats. Approximately 15.6-16.6 acres of existing riparian habitat would be graded to setback banks and create new channel and new riparian areas. Revegetation would re-create riparian habitat on this area. Including all of the high and medium restoration areas allows for major expansion of the Yountville and Old Hopper Creek habitat nodes. Alternative 2 has similar effects as to Alternative 1 on flood levels providing reduced frequency of out of bank flooding in Reaches 10-7, 5 and 2. For changes in sheer stress Alternative 2 produces improvements similar to Alternative 1. For Alternative 2, the landowners of several restoration areas will need to approve the restoration.

However, before restoration areas 13-1 can be considered for grading to set back banks or create floodplains, a study of the extent and properties of the highly resistant clay layer is needed. This layer dominates the bed and lower banks of the river channel from Reach 6 to Reach 1, inhibits vegetation growth, and represents a potential constraint to restoration. The suggested study would determine the depth and extent of this layer. A series of borehole investigations and geological logs would be conducted. Boreholes should be drilled along both banks of the Napa River from top of bank to the thalweg depth.



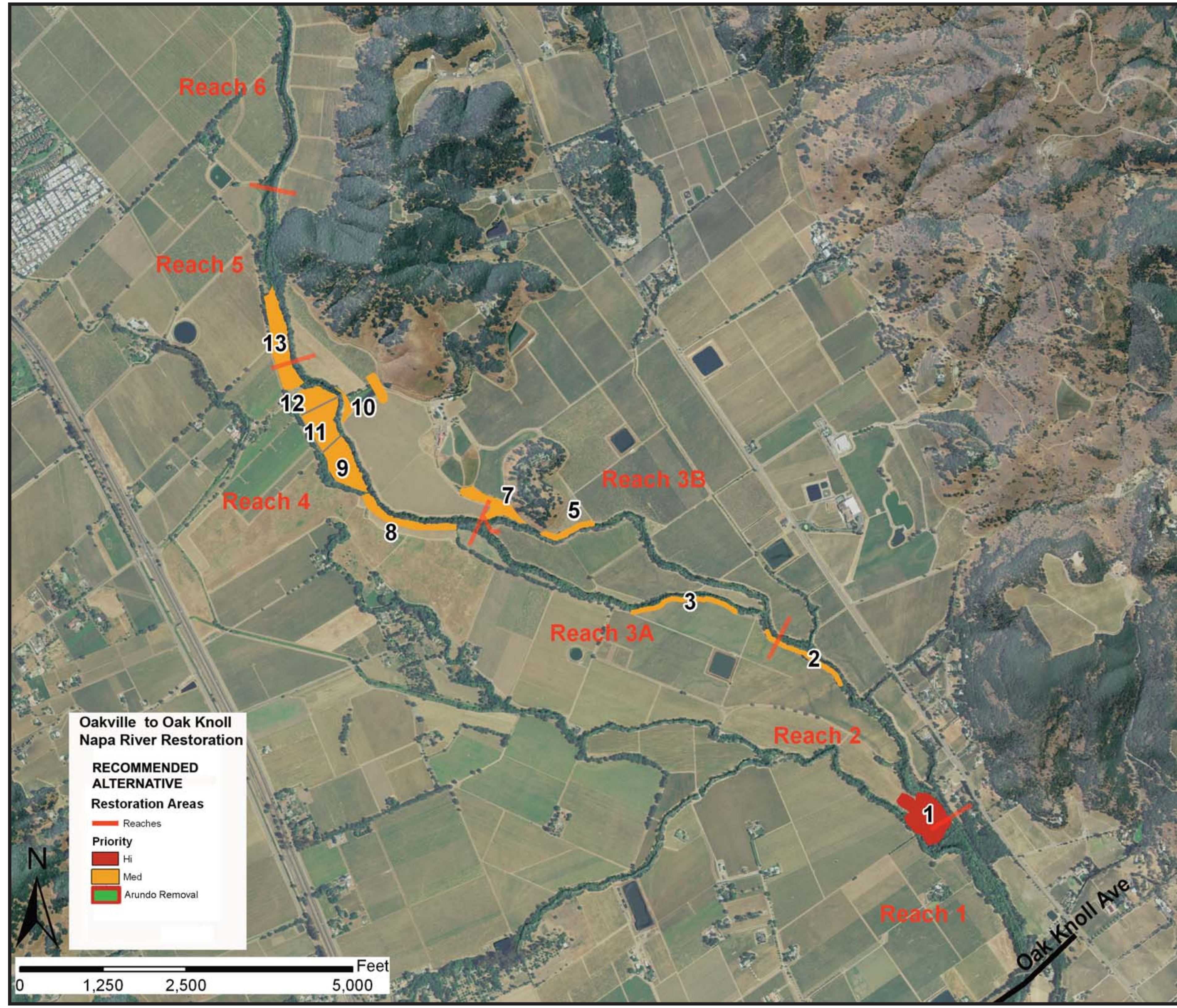
Several locations away from the channel but within a proposed restoration area would also be included. A soils log should be taken, noting the depth at which different soils are encountered. All boreholes should be georeferenced so that the true depth of the hardpan can be identified and mapped, allowing interpolation between sites. Approximately 20-30 boreholes should be completed.

System Wide Flood Study Needed

Another recommendation of this plan is for a watershed wide study of out of bank flooding and development of alternatives for the larger system. Flood management is constrained by the need to not increase flood levels in the the City of Napa flood control project. As a result flood water must be held on the Napa River floodplain in a way that causes less damage and inconvenience to the landowners and residents. Dormant vineyards can hold water for a few hours but, debris and sediment would need to be filtered out before entangling the vineyard trellis or burying the vines. Another idea is for many of the hillside vineyards to hold water in detention ponds to temporarily reduce peak flood levels and then release the water once the flood peak has passed. There are several ways that floodplain management could be enhanced, and a study could assess the feasibility and determine the costs and benefits of different approaches. These include (from upstream to downstream):

- Runoff source control on new development (e.g. low impact development);
- Runoff source control from existing urban and impermeable areas (e.g. downspout disconnection);
- Retrofits to stormwater system to increase infiltration;
- Localized flood detention where tributaries pass onto the Napa River floodplain;
- Creation of farmed bypasses to concentrate runoff in corridors and reduce flooding in adjacent areas;
- Additional setback levees along reaches of the Napa River that have either narrow or no levees.

The study will use existing County data such as the MIKE-SHE model to quantify the contribution to flooding coming from different sources (sub-watersheds) and conduct screening-level assessments of the contribution that different approaches can make to flood reduction (e.g. assess the volume of flood storage needed to reduce flooding by 10% in the valley flood and then conducting a screening level assessment of the area of detention required to achieve this reduction, as well as identifying potential sites.) Having identified the most likely candidate approaches hydrology and hydraulic modeling will be conducted to assess potential alternatives for flood management. The product will be a prioritized list of action items with approximate but quantified flood inundation reductions and costs



Implementation

Phasing

The first phase of the implementation of the Oakville to Oak Knoll Napa River Restoration will be to eradicate Arundo from Reach 10 through 1. Although there is a total of 5.59 acres of Arundo donax spread throughout most of the project area most of this is in Reaches 10-7. By removing this invasive plant as a first step in the restoration project the problem of reinfestation is minimized.

The next phase could focus on implementation of the restoration areas of either the Oakville or Yountville habitat nodes. Depending on available funding and landowner's agreements one or both of these projects could be undertaken as phase 2. Future phases after these 2 will require the completion of the extent and depth of the clay layer and a determination of the feasibility of restoration in those areas dominated by the clay.

Next Steps

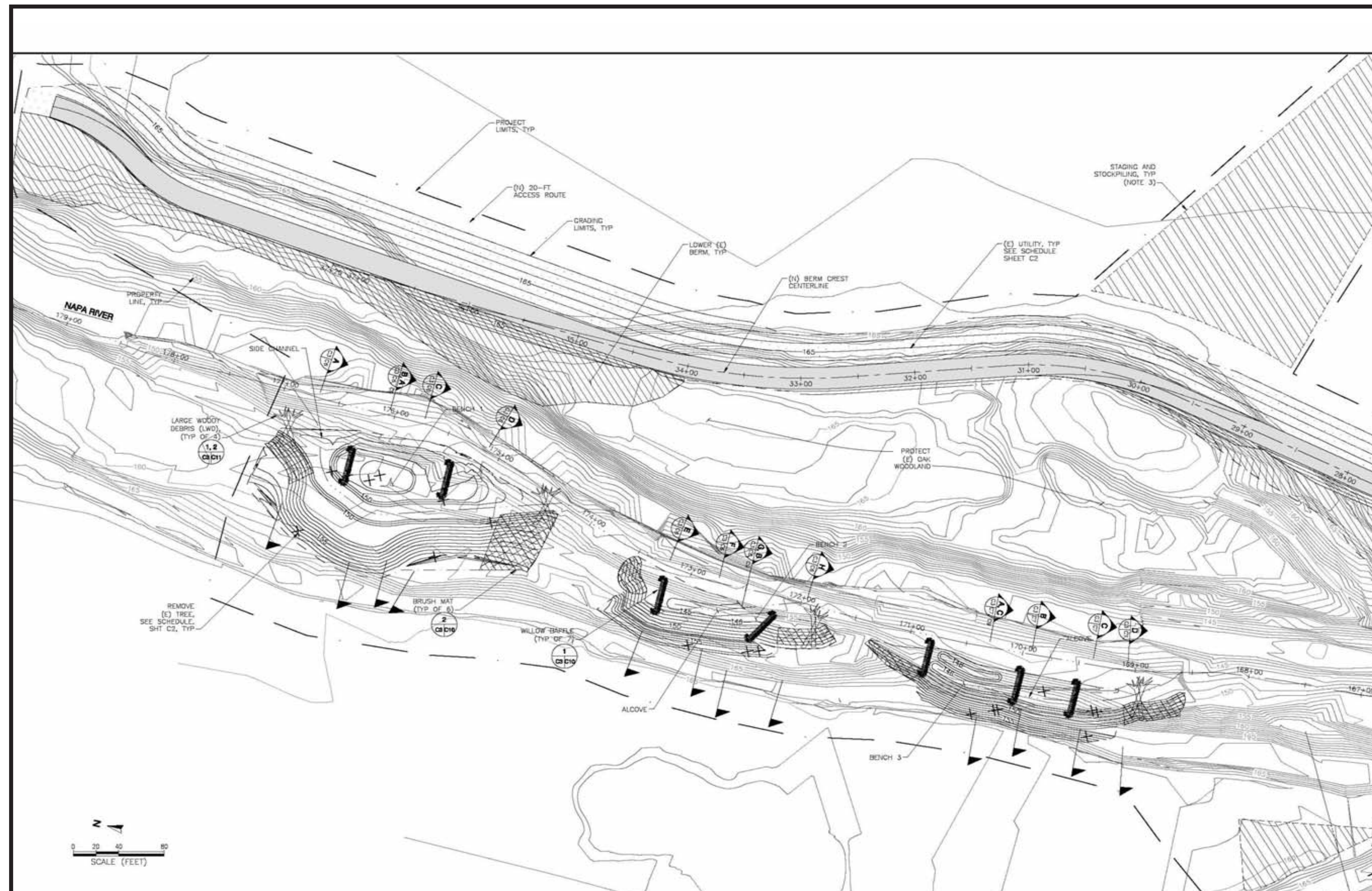
The California Land Stewardship Institute (CLSI) will work with Napa County to implement the next steps in the plan.

This progression of steps is envisioned as follows:

- Meet with landowners to outline the next steps and determine the willingness to proceed to project environmental review. Letters of intent providing approval for the design/study access should be signed by participating landowners.
- Complete CEQA review with Napa County acting as lead agency.
- Complete investigation of clay layer for Restoration Areas 1-13.
- Apply for Ca. Dept. of Fish and Game 1600 permit, Army Corps of Engineers 404 permit, Section 7 consultation with National Marine Fisheries Service, 401 certification from San Francisco Regional Water Quality Control Board.
- Apply for funding from various public and private grant agencies.
- Complete draft design incorporating changes from CEQA review, permits and landowners.

This process is expected to take 18-24 months and generate the needed approvals, landowner agreements, and funds to allow for final design and construction.

Restoration Area	Total Acres	New Acres of Riparian Habitat/Channel Area	Existing Riparian Acres Affected
Alternative 1 All sites ranked high	63.5-63.6	47.0-47.8 riparian 3.9-4.8 channel	5.7
Alternative 2 All sites ranked high and medium	128.4-130.8	70.4-76.2 riparian 7.5-8.9 channel	15.6-16.6
Alternative 3 All sites ranked high, medium and low	119.1-143.9	87.2-103.6 riparian 8.6-10.4 channel	22.5-23.5



EXAMPLE CONSTRUCTION DRAWING COMPLETED FOR THE RUTHERFORD REACH PROJECT

Institutional Analysis

As part of implementing the Oakville to Oak Knoll plan, we collected information on the types of organizations which could serve in an implementation and maintenance role. The primary responsibilities of the organization would be carrying out the project construction, determining a maintenance and monitoring plan which addresses any permit requirements and implementing a funding mechanism for long-term maintenance.

The Rutherford Reach Restoration project offers an example for this project. This 8-mile reach stretches from the Zinfandel Lane Bridge to the Oakville Bridge. The Rutherford Reach is private property. The only existing organization is an appellation group – The Rutherford Dust Society. The project was started by landowners working together through this appellation group.

The Rutherford restoration project is being implemented by the Napa County Flood Control and Water Conservation District. This special district covers Napa County and administers the Measure A funds, a county-wide sales tax which funds flood control and river restoration projects. The District has completed the design, CEQA review, permitting, construction bids, and construction oversight. The District also negotiated an agreement with each landowner; not all landowners participated in the project.

The District working with the Rutherford landowners formulated a benefit assessment district to carry out the long-term monitoring and maintenance of the river area. This district covers just the landowners along the river and assesses a per acre fee. This fee is restricted to the uses defined in the benefit assessment district and voted in by the landowners.

This arrangement came from a need for an agency experienced in hiring and overseeing construction projects. Neither the Rutherford Dust Society or the only other agency involved – the Napa County Resource Conservation District wanted to carry out the construction. The landowners also did not want to donate their land as part of the restoration, thus eliminating a park or open space district from being involved. The landowners wanted maintenance of the new restoration areas and the river channel in general, but had neither the staff nor the interest to carry this out. Instead they determined that a benefit assessment district would create a reliable but limited source of funds just for the purpose of maintaining and monitoring the river reach. The Napa Flood Control District is empowered to carry out the needed work and therefore the Benefit Assessment District moneys would be administered by them.

This type of management could also be evaluated by the Oakville to Oak Knoll landowners. However, additional options exist such as a private non-profit and mutual benefit organization which the county could contract with for the monitoring and maintenance if a benefit assessment district is approved by the landowners. The next phase of the Oakville to Oak Knoll project will involve discussion of these options by the reach landowners.

Type of Organization	Example	Purpose	Allowable Actions
PRIVATE			
Public benefit non-profit corporation 501(c)(3)	Red Cross, Salvation Army	Formed for public or charitable purposes	Donations are tax deductible. Board of Directors cannot be paid. No money or assets go to members if dissolved. Very limited lobbying allowed
Mutual benefit non-profit corporation 501(c)(4); 501(c)(6)	Homeowners Association, Country Club, fraternal organizations	Formed for the benefit of members	Can provide services and facilities to members. Members may own corporation and if it dissolves, assets and profits are distributed. Lobbying related to purpose of corporation allowed.
Mutual benefit non-profit corporation, agricultural organization 501(c)(5)	Ca. Farm Bureau	Formed to promote agricultural and horticultural activities	Can provide services and facilities to members. Lobbying related to purpose of corporation allowed.
Mutual benefit non-profit organization, cooperative associations 501(c)(12)	Mutual water company or association	Formed to provide a service to its members at the lowest possible cost	85% or greater of annual income must come from members and be used for services to members. Members hold shares which entitle them to a certain amount of water or other service.
Appellation Group - American Viticultural Area (AVA)	Yountville, Oak Knoll, Oakville Appellation Areas are sub areas within the Napa Valley AVA	An AVA must be approved by the Federal Alcohol and Tobacco Tax and Trade Bureau. AVAs are wine-growing regions defined by geographic features. Appellation groups are trade associations formed to promote the wines of the appellation	Most appellation groups are marketing organizations to promote the wines of the appellation. The Rutherford Dust Society has served as the organizer for a major restoration project on the Napa River in Rutherford.
PUBLIC			
County	Napa County	Counties are created through the state to carry out police powers and various state laws.	Counties have broad powers to regulate land uses, and implement public works and parks within thier boundaries.
Special Districts: Sanitation/wastewater irrigation, fire protection, flood control, water supply	Napa County Flood Control and Water Conservation District	Formed to provide a specific set of services within a defined geographic area	Can have independent elected board of directors or can be operated by County Board of Supervisors or City Council. State legislature must authorize each special district along with power to tax, issue bonds or set fees. The Special District receives new delegation of sovereign power from the state.
Benefit Assessment District, Community Facilities District	Parcel tax for park maintenance, fire prevention, landscaping and lighting	Formed to pay cost of providing specific capital improvements and/or other services within a defined geographic area. Properties included in the district must directly benefit.	Is not a unit of government but a revenue generation district. Agency which will receive the funds must provide written notice to all affected property owners, conduct a public hearing and conduct an assessment of vote. A majority (50% +1) of the affected property owners must approve for passage.
Joint Powers Agreement	Numerous examples in California - Cosumnes, American, Bear and Yuba Integrated Regional Water Management Plan	A Joint Powers Agreement is a contract among units of local government to carry out whatever anyone of these units of local government is authorized to do.	A JPA may have a governing board made up of representatives of the participating agencies.
Joint Power Authority	Transbay Joint Power Authority, SF Bay Area government agencies and transportation special districts; San Francisquito Creek JPA - three cities and two special districts	A Joint Powers Authority is a separate entity whereby two or more public entities operate collectively.	The Joint Powers Authority is distinct from member entities and has a separate Board of Directors. The authorizing agreement states the powers of the Joint Powers Authority which cannot exceed the shared authorities of the member agencies.
Memorandum of Understanding (MOU)	Very common type of agreement - MOU Regarding Urban Water Conservation in California; MOU on California's Coordinated Regional Strategy to Conserve Biological Diversity	A memorandum of understanding is a document that describes an agreement between parties and can outline how a specific project or program will be implemented, funded, or maintained.	MOU is similar to a letter of intent. An MOU is not as binding upon the signatories as a contract. An MOU can involve both public agencies and private parties.

Monitoring

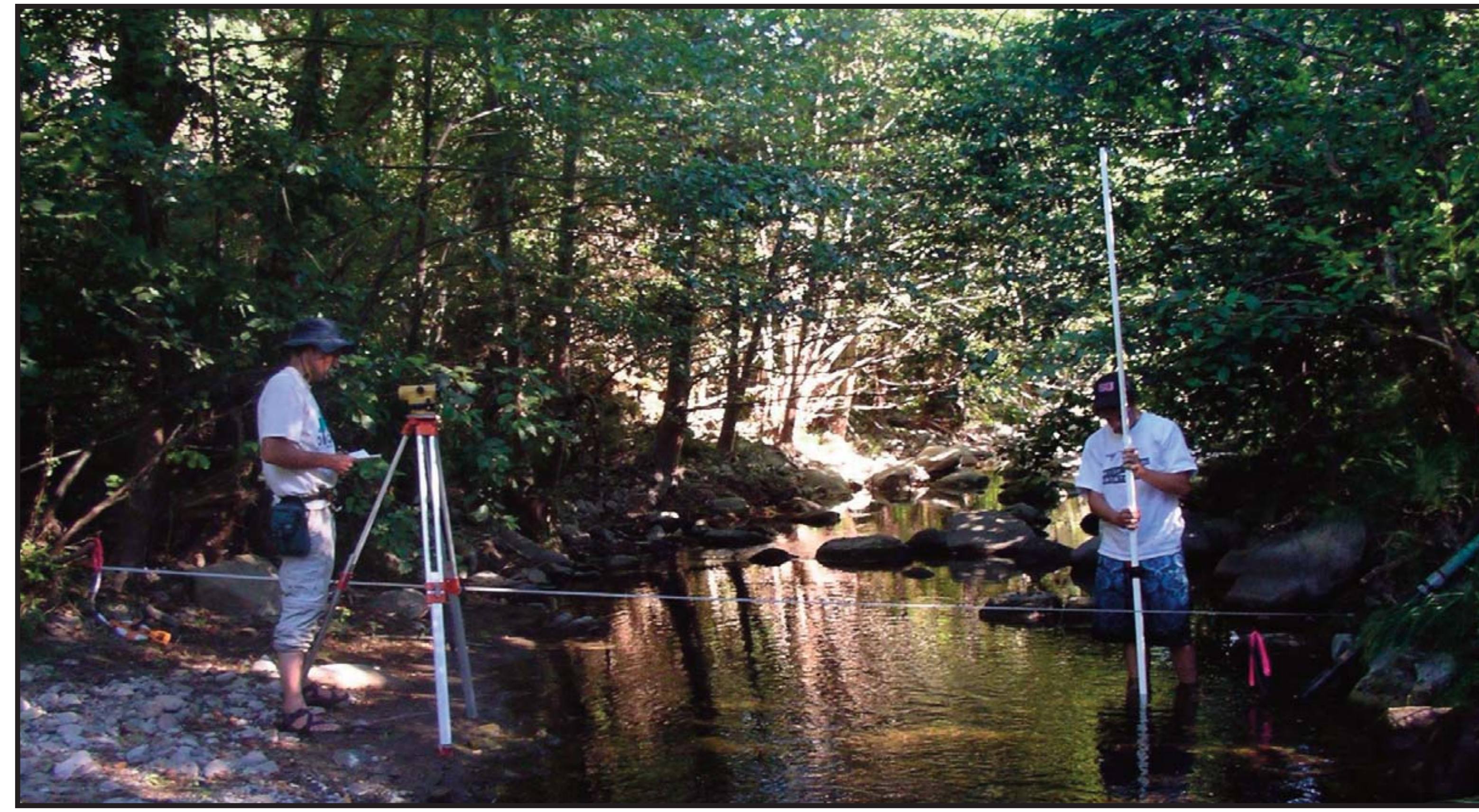
Two types of monitoring will be needed for the Oakville to Oak Knoll project once it is implemented. The first type of monitoring is project specific to make sure that each restoration area performs as designed and any problems can be addressed quickly. It is likely that the permits for the project will require monitoring to demonstrate that requirements have been met. Examples include mapping the planted areas to demonstrate that 90% percent cover was achieved in the planted riparian corridor after 5 years or newly graded and revegetated stream banks remained stable through a flood. This project specific monitoring will demonstrate that the restoration areas have created the acreage and type of habitat permitted.

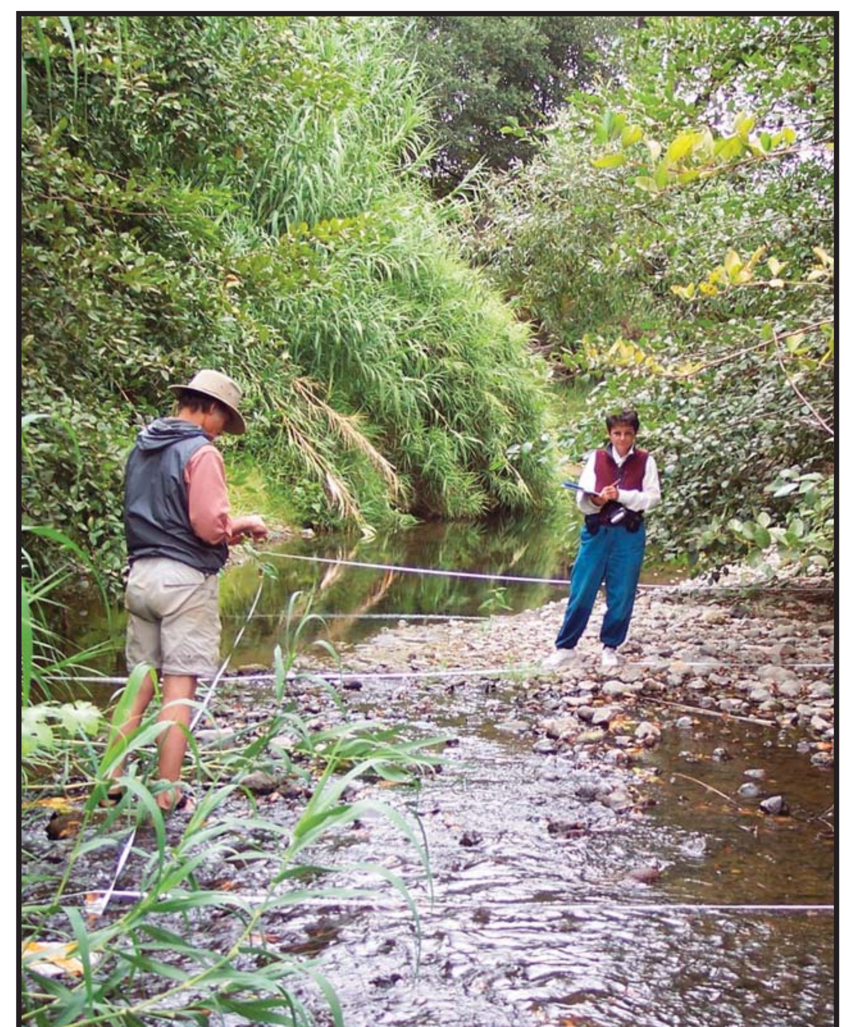
However there are a broader set of monitoring questions which address the dynamic nature of river processes and the fact that a change in one location may result in changes down or upstream of that location. To evaluate the success of the overall project in reducing channel scour and entrenchment of the river channel, additional monitoring will be needed on a regular basis over a longer time than the construction specific monitoring. For this longer term monitoring some basic measurements of the river channel need to be done every year there is a significant flood (2-5 year frequency) or every 3-5 years if there are no significant flow events. A longitudinal profile of the river channel and a selection of the cross sections used for this plan would be surveyed. The work needs to be performed by or under the direction of a fluvial geomorphologist. These measurements are completed at the same locations over time and allow for the comparison of data to document changes in the channel and the response of the system to project implementation. A new LIDAR flight and digital topographic layer would also be a useful activity as this provides detailed updated topographic information for the channel and the floodplain. Depending on the outcome of the study of the clay layer additional measurements may be needed.

For the riparian ecosystem the inventory completed for this plan should be repeated. The approach to evaluating riparian vegetation used in this plan allows for an analysis of ecological succession and links the vegetation size and species directly to channel/floodplain geomorphology. The degree to which successional processes are occurring along the Napa River indicates the health of the ecosystem. If the riparian corridor is not regenerating then it is not a sustainable system and will require constant effort to provide biodiversity and tree shade canopy. While this type of inventory is labor intensive it only needs to be completed every 5-7 years depending on flood events. Simply determining that the plantings at a restoration area are growing does not address the larger question of ecosystem health or the long term success of the restoration approach.

To evaluate the health of the aquatic system annual aquatic insect sampling should be done Samples should be collected in the fall at a series of stations whose locations coincide with the geomorphic survey and the riparian mapping. To interpret aquatic insect data the physical environment where the insects are collected needs to well understood, most particularly water velocity, scour and fine sediment loads as these features will affect the abundance and diversity of species. Basic water quality parameters of water temperature, measured as a continuous not instantaneous reading, nutrients, pH, specific conductance should all be monitored.

As the Oakville to Oak Knoll Plan is further evaluated through CEQA and permitting, additional types of monitoring may be identified. Funding for the monitoring should be part of the long term maintenance of the project. In addition academic studies should be encouraged.





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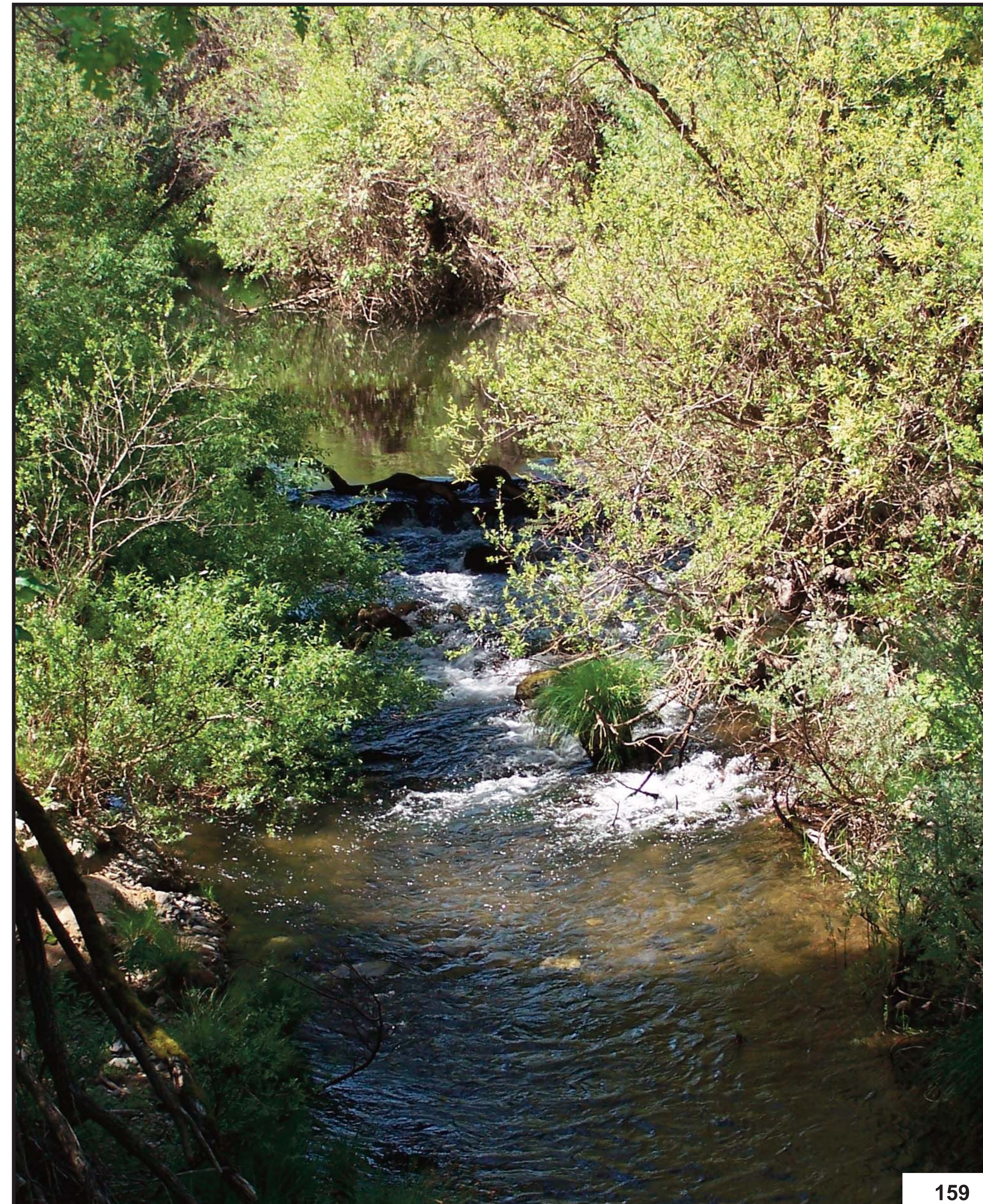

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Funding Sources

State Water Resources Control Board
Napa County (Measure A funds)

Funding for this project has been provided in full or in part through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.