Terwer Creek Riparian Restoration Project

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Abstract

These projects funded the continuation of a multi-phase riparian enhancement project in Lower Terwer Creek that was initiated in 2003. Restoration treatments conducted within the two project areas included: willow sprigging eroding banks, constructing willow siltation baffles, willow mattresses, planting native vegetation to provide long-term stability within the area, and removing exotic plant species. Objectives include stabilizing erosive streambanks, revegetating the project site with flood-resistant willow stands to reduce water velocities within this reach, increase localized deposition of fines (increase bar elevation and vegetative productivity) and aid in the long-term re-establishment of an unbraided stream reach.

A total of 20,000 bareroot Douglas fir (*Pseudotsuga menziesii*) and coastal redwoods (*Sequoia sempervirens*) were planted along floodplains and riparian areas throughout the Terwer Creek drainage.

YTFP mechanically removed ~50 pampas grass plants and sprouts and cut extensive back stands of Himalayan blackberries from the 2004-HR-04 project site. Approximately 1,500 willow sprigs and posts were then planted along 1,000 feet of streambank and 25 willow siltation baffles were constructed throughout the project reach. In addition to the willow planting, 250 bareroot Douglas fir trees and 100 cottonwood and big-leaf maple saplings were planted throughout all appropriate areas in the 2.5 acre treatment site.

Prior to willow and tree planting activities, YTFP mechanically removed ~20 pampas grass plants and cut back extensive stands of Himalayan blackberries growing along eroding streambanks throughout the 2005-HR-02 project area. A total of 16 willow siltation baffles and 15 willow mattresses were constructed along the active channel within the project reach. In addition, a total of 41 baffles were built on the adjoining flood terrace at the upper end of the reach. Crews also planted approximately 500 willow sprigs, as well as 30 big-leaf maple, 65 cottonwood, 41 red alder and 350 Douglas fir throughout the project site.

Vegetation transects and photographic monitoring points were established to track long-term changes in vegetation composition throughout both project site. In addition, topographic surveys were conducted before and after restoration activities to assess geomorphic changes throughout the lower (2005-HR-02) project site. YTFP will continue to repeat these surveys on a regular basis to provide a quantitative means to assess long-term project success.

Introduction

The Yurok People have inhabited the lands of and sustained themselves upon the resources of the Klamath River for centuries. The Yurok Tribe's entire culture is largely based upon the Klamath River and its associated fish populations. Today, only a fraction of historic anadromous fish runs return to spawn in the Klamath River and its tributaries. Although many factors have contributed to these declines in native fish runs, degradation of freshwater habitat has been pervasive in the Klamath River Basin. Kier and Associates (1991) note that "the fish habitats of the basin have been greatly diminished in extent and value in the past century by the construction of impassable dams and by stream diversions and sand and silt from mining, logging, grazing, road development, and floods." The declining health and productivity of the Klamath River's anadromous fisheries is of great cultural and economic concern to the Yurok Tribe.

To proactively address these declines, the Tribe initiated a large-scale, coordinated watershed restoration effort throughout the Lower Klamath sub-basin in conjunction with Green Diamond Resource Company (GDRC – formerly Simpson Resource Company) and the California Coastal Conservancy. This cooperative framework is intended to meet the mandates and objectives of tribal, state, and federal planning efforts, the Northwest Economic Adjustment Initiative and the state and federal ESA through innovative solutions to resource management issues between private landowners, Tribal interests, and public agencies.

In order to provide for meaningful restoration plans that truly address the limiting factors facing each salmonid species in a given drainage, the Yurok Tribe initiated the Lower Klamath River Watershed Assessment. This interdisciplinary effort, consisting of historical and current condition assessments throughout each of the Lower Klamath tributaries, resulted in the prioritization of restoration activities throughout the basin. The Lower Klamath Sub-Basin Watershed Restoration Plan (Gale and Randolph 2000) identifies chronic streambed sedimentation, heavily degraded instream and riparian habitat, and loss of habitat connectivity as the primary factors for salmonid decline. In order to address these problems, the Sub-Basin Plan prioritizes treatment of upslope sediment sources, in conjunction with instream and riparian restoration and fish barrier treatment.

The Yurok Tribal Fisheries Program (YTFP) initiated a multi-phase riparian enhancement project in Lower Terwer Creek beginning in 2003. Restoration treatments conducted within the two project areas included: willow sprigging eroding banks, constructing willow siltation baffles, willow mattresses, planting native vegetation to provide long-term stability within the area, and removing exotic plant species. Objectives include stabilizing erosive streambanks, revegetating the project site with flood-resistant willow stands to reduce water velocities within this reach, increase localized deposition of fines (increase bar elevation and vegetative productivity) and aid in the long-term re-establishment of an unbraided stream reach. The majority of work performed for this project was done with hand crews using hoedads, chainsaws, posthole diggers, and hand tools.

Project Area

The Lower Klamath sub-basin encompasses the lower 40 miles of the Klamath River and its tributaries, between the confluence with the Trinity River and the Pacific Ocean. There are 25 anadromous fish bearing tributaries within the sub-basin (Figure 1). The Yurok Indian Reservation extends one mile on either side of the mainstem throughout the lower 44 miles of the Klamath River. An aquatic and riparian habitat summary for the sub-basin is presented in Table 1. A summary of aquatic species presence by tributary is presented in Table 2. All project work occurred within Lower Terwer Creek.

Terwer Creek is a fourth order stream that drains approximately 31.8 sq. miles of coniferous-forested mountains. The headwaters originate at an elevation of 1,600 ft. and flows southerly 13.9 miles, through mostly steep, highly confined stream channels. Terwer Creek is moderately to highly confined throughout most of its course, with “B” and “C” channel types dominant throughout (see Rosgen 1994 for channel type descriptions). The lower portion of the creek flows through a broad floodplain past the community of Klamath Glen (Figures 2-3). The Terwer Creek watershed supports anadromous populations of chinook salmon, coho salmon, steelhead trout, coastal cutthroat trout and Pacific lamprey. The East Fork is the largest tributary in the drainage, supporting populations of coho salmon, steelhead and coastal cutthroat trout.

This project area is located on private property owned by Green Diamond Resource Company (GDRC – formerly Simpson Resource Company). The project area is located approximately 4,000 feet upstream from the Highway 169 Terwer Creek Bridge and encompasses two sites along the west side bank of Terwer Creek (Figures 2-3).

Methods & Materials

Willow Planting

Willow sprigs and posts were interplanted along erosive streambank and established LWD islands using methods outlined in Flosi et al. (1998). All willow used in this project was selectively harvested from densely populated stands located nearby and transported to the project site for use that same day. A portable water tank and pumps were used to continuously water and mist collected willow before, during and after planting. In addition, a drip irrigation system was set up to supply water to baffles, mattresses and sprig sites between the time of planting and the onset of substantial fall rain.

Willow siltation baffles and mattresses were installed using standard bioengineering methods (Engber 2005; Flosi et al. 1998). Baffles were constructed perpendicular to the stream with the most upstream baffle placed at an acute angle and the lower baffle placed at an obtuse angle. Each baffle is approximately 20 feet long and spaced at 20-30 feet intervals. Baffles constructed along the raw streambanks and other areas exposed to high stream velocities were armored with quarry rock tom minimize scour and increase riparian reestablishment success. The baffles constructed in the flood prone area where velocities and scour potential are lower were not armored with quarry rock. Instead we buried and surface-placed pieces of large woody debris (LWD) salvaged from nearby road-decommissioning projects into the baffles. This incorporated LWD provides necessary shade, protection and long-term nutrients to increase the survival and growth of these planting islands. Willow mattresses were constructed as needed on raw banks between the baffles to maximize bank stabilization and riparian revegetation. Willow mattresses were also constructed using standard methods (Engber 2005; Flosi et al. 1998).

Conifer & Deciduous Tree Planting

Bareroot Douglas fir, coastal redwood, big leaf maple and cottonwood were planted throughout the project site. All conifer, maple, and cottonwood planting was conducted in late winter through early spring using standard bareroot planting techniques. Crews properly stabilized the trees and took care when burying root systems to prevent "J-rooting". Each planted tree was enclosed in a biodegradable seedling protector tube where necessary to minimize damage from foraging wildlife. Conifers were local genetic stock donated by GDRC. All deciduous trees were provided from YTFP's Native Deciduous Tree Nursery. This facility is located at our office in Klamath, where we train staff members to collect and propagate local seed and cuttings and grow native deciduous trees for restoration project use.

Deciduous tree plantings occurred in sites rich in deposited organic material and protected from high flows (i.e. on downstream side of existing LWD deposits or existing willow clumps) to increase growth rates and survivability. YTFP selected sites on each flood terrace where existing riparian vegetation density is insufficient. All flood terrace planting occurred in late winter through early spring to maximize survival. Crews revisited the planting sites bi-weekly during the summer/dry periods following planting to water trees from a truck bed water tank. This aided in tree survival during the first year as the saplings establish root systems.

Exotic Vegetation Removal

Extensive clumps of exotic Himalayan blackberries and numerous pampas grass sprouts were mechanically removed from the restoration sites prior to native tree planting. The above ground portions of exotic blackberries were removed to allow hand crews to manually remove all root crowns. These areas were then planted with native willow, conifers, maples, and cottonwoods. Crews have revisited these locations annually to date to ensure eradication of pampas grass and thorough control of blackberries to allow for establishment and succession of planted tree species.

Riparian Vegetation and Photographic Monitoring

Restoration objectives include increasing the composition of native riparian plants, vegetative cover, structural diversity, and promoting bank and channel stability in lower Terwer Creek. To assess changes in riparian parameters, vegetation transect surveys and photographic monitoring was conducted in the project areas according to methods outlined in Collins (2003). Five permanent geo-referenced vegetation transects were established through the upper project area (2004-HR-04 site) and adjacent to the lower project area (2005-HR-02 site) in early August 2004 (Figure 8). Photograph stations were established at transect end points and at select distances along each transect. At each station, photographs were taken facing downstream, upstream, and facing both valley walls.

Vegetation surveys and photographic documentation were conducted in summer 2004 prior to restoration implementation to document baseline conditions. Surveys and photographic documentation were also conducted during summer 2005 following restoration implementation. Vegetation surveys and photographic monitoring will continue at select intervals in the future to quantitatively monitor riparian response to specific restoration treatments.

Channel and Bank Stability Monitoring

Detailed three-dimensional topographic surveys of the channel and adjacent land surfaces were conducted in the vicinity of the 2005-HR-02 site using a Total Station. Permanent geo-referenced benchmarks and three cross section locations were established in winter 2005 (Figure 9). Surveys were conducted in spring 2005 to document baseline channel and floodplain conditions. Surveys of the channel and the three cross sections were repeated in August and November 2006.

Results

All work commenced January 2004 and was completed during summer 2006. Below is a summary of completed tasks (see Figures 4-7 for project maps):

- **Riparian Conifer Planting**

A total of 20,000 bareroot Douglas fir (*Pseudotsuga menziesii*) and coastal redwoods (*Sequoia sempervirens*) were planted along floodplains and riparian areas throughout the Terwer Creek drainage. 4,000 Douglas fir and 3,000 coastal redwoods were planted in the lower five miles of Terwer Creek during January-March 2004. During winter 2005 and 2006, only Douglas fir were available from GDRC and hence no coastal redwood were plated during these years. 8,000 trees were planted during winter 2005 and an additional 5,000 trees were planted during winter 2006.

- **Upper project site (2004-HR-04 site)**

Prior to willow and tree planting activities, YTFP mechanically removed ~50 pampas grass plants and sprouts from the 2.5 acre treatment site Figure 33). In addition, YTFP cut back stands of Himalayan blackberries and mechanically removed root crowns to minimize regeneration of this invasive plant species.

Willow sprig revegetation was completed during late March 2004 through May 2004 (Figures 20-21). Approximately 1,500 willow sprigs and posts were planted along 1,000 feet of streambank on Terwer creek. Approximately 500 willow sprigs were planted along the steep left bank (looking downstream) to protect it from erosion. The floodplain located on the right bank was planted in selected areas that consisted of established vegetated plots and where soil was adequate for planting. Approximately eight willow planting sites were vegetated on the floodplain with 1,000 willow sprigs/posts.

YTFP constructed a total of 25 willow siltation baffles throughout the 2.5 acre flood plain bar between October 2004 and December 2004 (Figures 24-25, 27-32, 34). The baffles were constructed perpendicular to the active stream channel and averaged 20-25 feet in length, 5'-6' deep, and were spaced at 20 foot intervals. Each willow baffle is comprised of ~200 willow sprigs 10-12 feet in length.

In addition to the willow planting, 250 bareroot Douglas fir trees and 100 cottonwood and big-leaf maple saplings were planted throughout all appropriate areas in the 2.5 acre treatment site.

The 2.5 acre treatment site was visited bi-weekly during the dry summer months of 2004 and 2005 to water all planted willow sprigs and siltation baffles. In addition, YTFP revisited the site during this same time period to remove any additional pampas grass plants that were observed, as well as cut back any Himalayan blackberries that were encroaching on planted trees.

- **Lower project site (2005-HR-02 site)**

Prior to willow and tree planting activities, YTFP mechanically removed ~20 pampas grass plants and sprouts from two acres of riparian habitat adjacent to the restoration site. In addition, YTFP cut back stands of Himalayan blackberries growing along eroding streambanks throughout the project area and mechanically removed root crowns to minimize regeneration of this invasive plant species.

A total of 16 willow siltation baffles were constructed along the active channel within the project reach between August and October 2005 (Figures 39-45, 47-51). "Quarter-ton" quarry rock was used on each of these baffles to minimize baffle scouring due to high flows. The baffles were constructed perpendicular to the stream and averaged 25-35 feet in length, 5'-6' deep, and were spaced at 20-30 foot intervals. Each willow baffle is comprised of ~200-400 willow sprigs 10-12 feet in length.

A total of 15 willow mattresses were constructed in the same reach during the same time period. Each mattress was constructed parallel to the channel along the bank between each of the constructed baffles. The mattress trenches were dug 5'-6' deep and pieces of SWD and chunks of LWD were placed in the bottom of most mattress trenches before backfilling. Each willow baffle is comprised of ~200-400 willow sprigs 10-12 feet in length.

Crews installed a drip irrigation system throughout the willow baffle/mattress work area, with water being drawn from an adjacent perennially flowing and non-fish bearing tributary. Drip emitters and sprinklers were set up to water the planted willow brush and keep the backfilled trenches wet until fall rains and streamflow resumed in October. This drip system was reinstalled during the summer dry months in 2005 and 2006 to increase survival during these critical first two summers after planting.

Following the onset of fall rain and resumption of streamflow in the project reach, the crew moved away from the active channel and began work on constructing willow baffles on the adjoining flood terrace (Figure 50). These baffles were constructed similarly to the instream baffles, although the lack of any high-velocity flows in this area allowed us to avoid using armoring boulders. These baffles also incorporated a mixture of willow brush and posts, rather then strictly brush that is used for the instream baffles. A total of 41 baffles were built on the flood terrace at the upper end of the reach. Each terrace baffle is comprised of ~200-300 willow sprigs 12-15 feet in length.

Crews also planted approximately 500 willow sprigs, as well as 30 big-leaf maple, 65 cottonwood, 41 red alder and 350 Douglas fir. The deciduous trees are all stock started from seed (maples) or cuttings (cottonwood) at the YTFP tree nursery and grown out for over a year. The fir trees were bareroot trees provided by GDRC. All tree planting at this site occurred during January and February 2006.

- **Riparian Vegetation and Photographic Monitoring**

2004-HR-04 Site

Dominant vegetation types observed in the 2004-HR-04 site during both years were grasses and flowers, cottonwood and willow (Figure 13). The increase in willow cover in 2005 at the 2004-HR-04 site resulted from willow planting and construction of multiple willow baffles through the project area (Figure 34). The amount of bare ground observed in transects 4 through 5 was similar during both years (Figure 14). Construction of willow baffles resulted in a decrease in the amount of bare ground observed along transect 2. High flow events in 2005 scoured large portions of the stream bank and resulted in an increase in the amount of bare ground observed along transects 1 and 3 (Figures 14 and 35). Most of the riparian vegetation at the 2004-HR-04 site was in the first vegetation height class (1-3 ft) (Figure 15). The amount of vegetation cover increased in all three height classes during 2005. The increased vegetation cover at the 2004-HR-04 site, especially within the last height class, was in part a result of riparian planting and the construction of numerous willow baffles (Figures 15, 24-25).

2005-HR-02 Site

Dominant vegetation types observed in the 2005-HR-02 site during both years were grasses and flowers, blackberry and willow (Figure 10). The increase in willow cover in 2005 was due to the construction of several willow baffles through the project area. The Douglas fir category was populated at a very low level (0.02 percent) in 2005 due to planting efforts at the site (Figure 10). The amount of bare ground observed in transects 1 through 3 was similar for both years (Figure 11). Construction of willow baffles and willow planting resulted in the decrease in bare ground observed in transects 1, 2 and 4 (Figure 11). The increase in the amount of bare ground observed along transect 5 in 2005 resulted from high winter flows scouring existing riparian vegetation from the stream banks. Most of the riparian vegetation at the 2005-HR-02 site was in the first (1-3 ft) and last (>15 ft) height classes (Figure 12). The increase of vegetation in the last height class observed in 2005 was in part a result of the construction of numerous willow baffles (Figures 47-51). Restoration efforts at the 2005-HR-02 site included removing invasive plants such as pampas grass and exotic blackberries from riparian planting zones (Figures 33, 36-37).

- **Channel and Bank Stability Monitoring**

Approximately 3,000 feet of the primary and secondary channels and 20 acres of adjacent land were surveyed in spring 2005. Topographic data was brought into ArcView and rectified to the Klamath Glen USGS 1993 DOQ. Channel and land features were digitized to create GIS based maps of the project area pre- and post-restoration implementation (Figures 4-7). Cross section data collected in February 2005 and November 2006 for the 2005-HR-02 site are presented in Figures 16-18 and longitudinal profile data for this project reach is presented in Figure 19.

Restoration goals included the use of bioengineering techniques to decrease channel braiding and bank instability through the project reach. This included the desire to use bioengineering to decrease the channel width to depth ratio in this reach (i.e. deepen and narrow the channel), as well as shift the main thalweg further away from the west streambank to reduce sheer stress on this highly erosive bank. Once established, willow baffles placed in series are extremely effective at sorting bedload, trapping fines and dissipating energy to effectively protect erosive streambanks and aid in channel constriction.

Stream channel cross sections through the 2005-HR-02 project reach reveal that the main thalweg has shifted 30-50 feet away from the west (right) bank following the bioengineering work (Figures 16-17). In addition, the cross sections revel that deposition has occurred across the large floodplain on the east (left) side of the channel. This has resulted in a rise in bed elevation across this floodplain and a corresponding decrease in the number and flow frequency of braided secondary channels across this surface (Figures 16-17).

Thalweg longitudinal profiles surveyed through this reach before and after bioengineering implementation reveals a 4-5 foot lowering of the thalweg bed elevation throughout the project reach (Figure 19). In addition, the longitudinal profiles reveal a noticeable increase in pool depth and overall habitat diversity throughout the project reach.

YTFP plans to conduct annual topographic surveys throughout this project area and adjacent reaches to track geomorphic trends over time. This will provide the quantitative means to assess project success at achieving the above stated goals.

Literature Cited

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Table 1. Summary of physical habitat and riparian parameters by tributary, Lower Klamath River, California, 1996-1998

Tributary	Drainage Size (sq. mi.)	Stream Order	Dominant Channel Type	Pool:Flatwater:Riffle Ratio	% Pools >=3ft Max. Depth	Ave. Shelter Rating	Prim./Sec. Cover Type	Prim./Sec. Substrate Type	Ave. Embeddedness (%)	Ave. Canopy Closure (%)	% Conifers in Canopy	Existing LWD Density (# pieces/mile)	Total Future LWD Density (# pieces/mile)	% Future LWD Composed of Live Conifers	% Future LWD Composed of Deciduous Trees <2' Dia.	Sub-surface Flow Severity
High Prairie Creek	4.2	2	A-4	46:44:10	7.1	31.5	LWD/BL	GR/SC	25-50	80%	23%	N/S	N/S	N/S	N/S	M
Hunter Creek																
- Mainstem	23.8	4	C-4	43:50:07	48.4	20.0	BL/LWD	GR/SC	50-75	79%	10%	186	328	14.9%	55.5%	H
- East Fork		3	B-4	26:73:01	10.5	18.8	LWD/BL	GR/SL	50-75	88%	7%	351	456	13.0%	55.4%	M
- Mynot Creek	4.9	2	F-4	49:48:03	5.3	23.7	TV/BL	GR/SA	50-75	76%	15%	209	381	33.8%	32.7%	H
Hoppaw Creek																
- Mainstem	4.9	3	F-4	37:39:24	1.7	15.7	LWD/SWD	GR/SC	50-75	91%	11%	275	413	24.4%	28.4%	H
- North Fork		2	A-4	62:11:27	2.0	17.1	LWD/BL	GR/SC	50-75	95%	27%	537	556	41.8%	23.5%	L
Saugep Creek	1.7	2	F-4	38:56:06	2.5	11.4	TV/SWD	GR/SL	50-75	84%	0%	N/S	N/S	N/S	N/S	L
Terwer Creek																
- Mainstem	32.8	4	B-3	36:52:12	32.9	67.1	BL/WW	BL/GR	0-25	61%	18%	169	512	21.9%	12.3%	M
- East Fork		3	A-2	35:59:07	13.7	84.7	BL/WW	BL/GR	25-50	71%	5%	264	519	20.7%	11.8%	N/A
McGarvey Creek																
- Mainstem	8.6	3	C-4	70:26:04	18.5	27.8	LWD/SWD	GR/SC	50-75	89%	8%	359	907	7.4%	61.4%	M
- West Fork		2	C-4	74:20:06	11.4	30.2	LWD/SWD	SL/GR	50-75	94%	11%	445	1,129	6.4%	68.9%	N/A
Tarup Creek	4.9	3	C-4	71:19:10	25.8	20.5	LWD/SWD	GR/SC	50-75	97%	7%	228	515	12.1%	59.2%	H
Omagaar Creek	2.5	2	B-4	35:52:13	5.0	19.4	LWD/BL	GR/SC	25-50	95%	10%	233	641	14.7%	56.4%	H
Blue Creek																
- Mainstem (below barrier)	128.3	5	C-2	23:61:16	88.4	14.2	BL/WW	BL/LC	25-50	41%	34%	N/S	N/S	N/S	N/S	N/A
- Crescent City Fork	13.4	4	B-2	27:61:12	51.3	17.2	BL/WW	LC/BL	25-50	87%	42%	169	569	56.1%	16.6%	N/A
- Nickowitz Creek	12.4	3	B-2	25:66:09	22.0	14.8	BL/WW	GR/SC	25-50	90%	27%	135	567	39.8%	31.4%	N/A
- Slide Creek	5.7	2	A-2	19:65:16	42.4	18.5	BL/WW	LC/BL	25-50	38%	77%	94	538	69.3%	2.3%	N/A
- West Fork	9.7	3	B-2	30:62:08	44.3	17.5	BL/WW	LC/GR	50-75	86%	12%	216	590	12.7%	41.3%	N/A
Ah Pah Creek																
- Mainstem	16.3	4	B-3	33:61:06	3.8	16.2	LWD/SWD	GR/SA	25-50	84%	8%	394	778	19.9%	54.0%	M
- North Fork		3	B-4	40:54:06	11.1	15.9	LWD/SWD	GR/SC	25-50	82%	9%	262	777	27.7%	53.4%	M
- South Fork		2	A-2	34:63:03	5.4	12.7	SWD/LWD	GR/SA	25-50	89%	9%	400	890	21.0%	48.4%	M
Bear Creek																
- Mainstem	19.3	3	A-2	38:47:15	9.8	74.1	BL/WW	BL/LC	25-50	73%	8%	188	323	26.2%	16.6%	H
- North Fork		3	B-3	32:52:16	6.3	78.4	BL/WW	BL/GR	25-50	77%	7%	312	533	23.4%	10.8%	N/A
Surpur Creek	5.7	3	B-3	73:23:04	19.9	16.5	BL/SWD	GR/SC	50-75	89%	6%	321	677	21.5%	46.2%	L
Little Surpur Creek	2.7	2	A-2	64:35:01	19.7	13.2	SWD/BL	SC/GR	50-75	93%	10%	255	486	21.1%	59.9%	L
Tectah Creek	19.9	3	B-3	48:45:07	27.8	18.6	BL/LWD	LC/SC	25-50	86%	11%	131	559	23.0%	49.5%	M
Johnsons Creek	3.4	2	B-3	69:27:04	15.6	15.6	BL/UC	SC/GR	50-75	94%	3%	116	474	3.5%	73.9%	H
Pecwan Creek (Lower Mainstem)	27.7	4	B-2	24:62:14	45.0	22.2	WW/BL	GR/BL	50-75	74%	31%	N/S	N/S	N/S	N/S	L
Mettah Creek																
- Mainstem	10.7	3	B-2	40:51:09	11.2	30.0	BL/WW	GR/SC	50-75	86%	17%	112	150	14.5%	12.5%	L
- South Fork		2	B-2	24:64:12	7.1	29.1	WW/BL	GR/SC	50-75	89%	22%	181	143	4.6%	20.4%	N/A
Roaches Creek	29.5	4	B-2	46:49:05	37.7	31.0	BL/WW	GR/BL	50-75	78%	30%	34	112	35.5%	8.2%	L
Morek Creek	4.0	2	A-2	24:51:25	4.6	18.9	BL/WW	GR/BL	50-75	85%	34%	78	309	4.5%	80.6%	L
Cappell Creek	8.6	2	A-2	43:30:27	18.6	21.8	WW/BL	BL/GR	50-75	79%	41%	N/S	N/S	N/S	N/S	L
Tully Creek																
- Mainstem	17.3	3	B-3	24:71:05	34.7	14.8	BL/WW	BL/GR	25-50	79%	8%	106	254	12.9%	9.9%	L
- Robbers Gulch		2	B-3	39:52:09	12.5	13.5	BL/SWD	SC/BL	50-75	84%	8%	166	363	10.3%	3.1%	N/A

Cover Type Codes: LWD= Large Woody Debris SWD=Small Woody Debris BL=Boulder WW=Whitewater TV=Terrestrial Vegetation UC=Undercut Bank

Substrate Codes: SL=Silt/Clay SA=Sand GR=Gravel SC=Small Cobble LC=Large Cobble BL=Boulder

Table 2. Summary of aquatic species presence by tributary,
Lower Klamath River, California, 1996-2002.

Tributary	Chinook Salmon	Coho Salmon	Steelhead	Coastal Cutthroat Trout	Resident Rainbow Trout	Pacific/Brook Lamprey	Prickly/Coastrange Sculpin	Speckled Dace	Threespine Stickleback	Klamath Small Scale Sucke	Pacific Giant Salamander	Yellow Legged Frog	Tailed Frog
High Prairie Creek	n	y	y	y	n	y	y	y	y	y	y	y	y
Hunter Creek													
- Mainstem	y	y	y	y	n	y	y	y	y	y	y	y	y
- East Fork	y	y	y	y	n	n	y	n	n	n	y	n	y
- Mynot Creek	y	y	y	y	n	y	y	y	y	y	y	n	n
- Kurwitz Creek	n	n	y	y	n	n	y	n	n	y	y	n	y
Hoppaw Creek													
- Mainstem	y	y	y	y	n	y	y	y	y	y	y	n	y
- North Fork	n	y	y	y	n	n	y	y	y	y	y	n	y
Saugep Creek	y	y	y	y	n	y	y	y	y	y	y	n	n
Waukell Creek	n	y	n	y	n	y	y	y	n	n	n	n	n
Terwer Creek													
- Mainstem	y	y	y	y	n	y	y	y	y	n	y	y	y
- East Fork	n	y	y	y	n	n	y	n	n	n	y	n	y
McGarvey Creek													
- Mainstem	y	y	y	y	n	y	y	y	y	y	y	y	y
- West Fork	n	y	y	y	n	y	y	y	y	y	y	y	n
Tarup Creek	y	y	y	y	n	y	y	y	y	y	y	y	n
Omagaar Creek	n	y	y	y	n	n	y	y	n	n	y	y	y
Blue Creek													
- Mainstem (below barrier)	y	y	y	y	y	y	y	y	y	y	y	y	n
- Mainstem (above barrier)	n	n	n	n	y	n	n	n	n	n	y	n	n
- East Fork	n	n	n	n	y	n	n	n	n	n	y	n	n
- Crescent City Fork	y	y	y	y	y	n	y	n	n	n	y	n	n
- Nickowitz Creek	y	n	y	n	y	n	y	n	n	n	y	n	n
- Slide Creek	n	n	y	n	y	n	y	n	n	n	y	n	n
- West Fork	y	y	y	n	n	n	y	y	n	n	y	n	n
Ah Pah Creek													
- Mainstem	n	y	y	y	n	n	y	y	n	n	y	y	y
- North Fork	n	n	y	y	n	n	y	y	n	n	y	n	y
- South Fork	n	y	y	y	n	n	y	y	n	n	y	n	y
Bear Creek													
- Mainstem	y	y	y	y	n	n	y	y	y	y	y	y	y
- North Fork	n	n	y	y	n	n	y	n	n	n	y	y	y
Surpur Creek	n	n	y	y	n	n	y	y	n	n	y	y	n
Little Surpur Creek	n	y	y	y	n	n	y	y	n	n	y	y	n
Tectah Creek	y	y	y	y	n	y	y	y	y	n	y	y	y
Johnsons Creek	y	y	y	y	n	n	y	y	n	y	y	y	y
Pecwan Creek													
- Mainstem	y	y	y	y	n	n	y	y	n	y	y	y	n
- East Fork	n	n	n	n	y	n	n	n	n	n	y	n	n
- West Fork	n	n	n	n	y	n	n	n	n	n	y	n	y
Mettah Creek													
- Mainstem	y	n	y	y	n	n	y	y	n	n	y	y	n
- South Fork	n	n	y	y	n	n	n	n	n	n	y	y	y
Roaches Creek	y	y	y	n	y	y	y	y	y	n	y	y	n
Morek Creek	n	n	y	n	n	n	y	n	n	n	y	y	y
Cappell Creek	n	n	y	n	y	n	y	n	n	n	y	n	n
Tully Creek													
- Mainstem	n	n	y	n	n	n	y	n	n	n	y	y	n
- Robbers Gulch	n	n	y	n	n	n	n	n	n	n	y	n	n

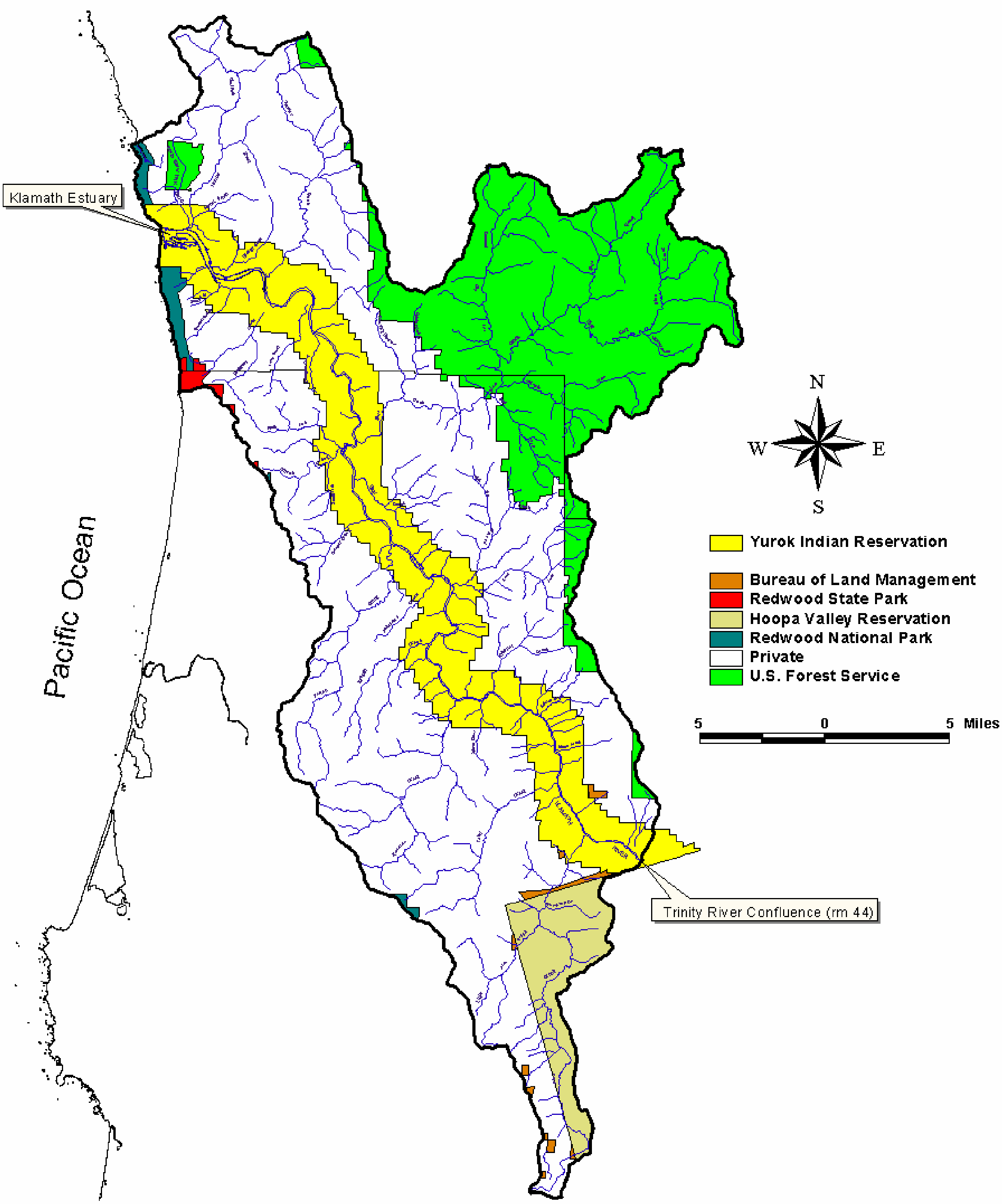

Figure 1. Lower Klamath River Sub-basin, California.

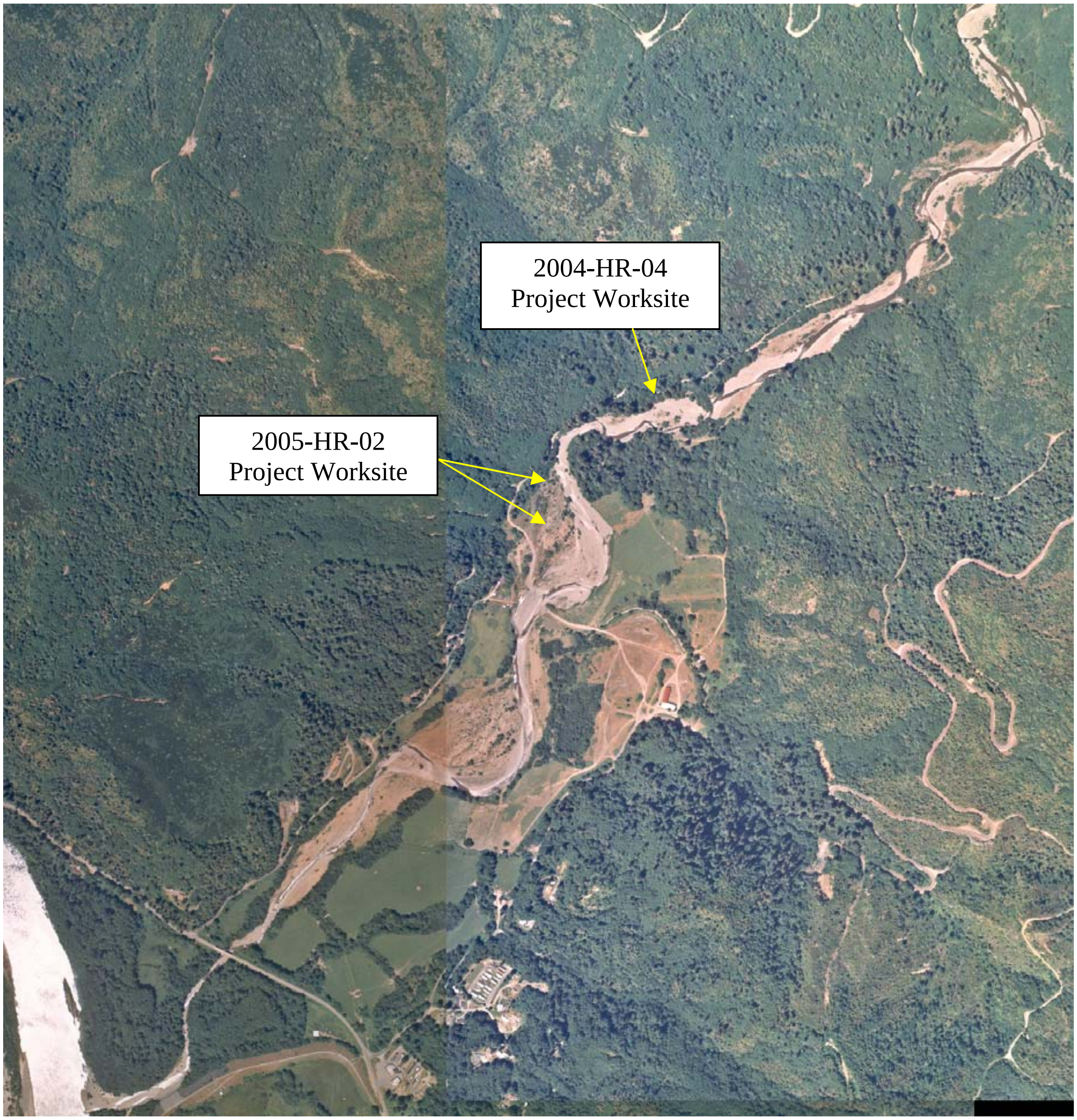

Figure 2. Aerial view of the lower 3.0 miles of Terwer Creek,
Lower Klamath River, California, 1997.

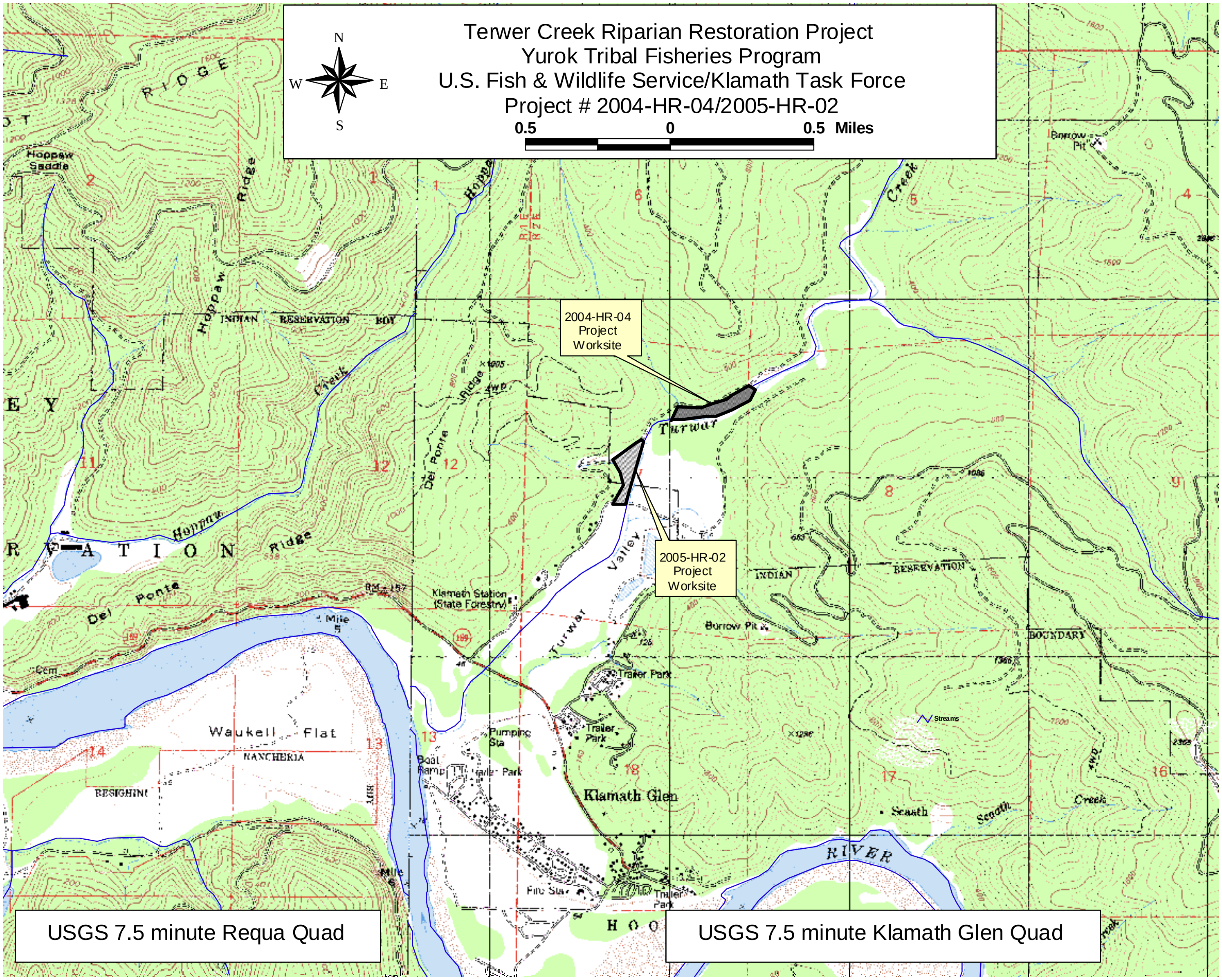

Figure 3. Project location map, Terwer Creek Riparian Restoration Project, Lower Klamath River, California, 2004-2006.

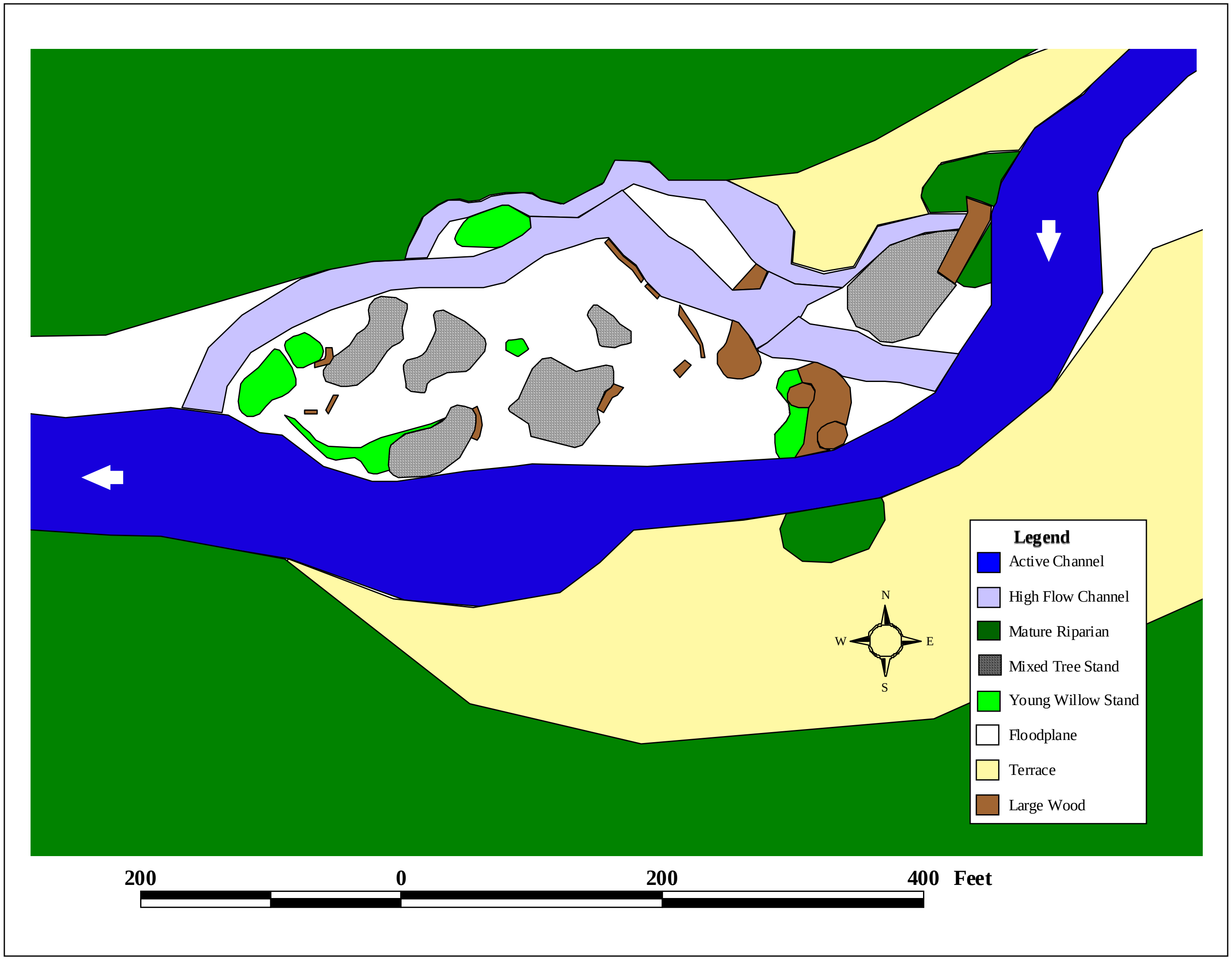

Figure 4. 2004-HR-04 project site map detailing pre-restoration conditions,
Lower Terwer Creek Riparian Restoration Project, Lower Klamath River, California, 2004.

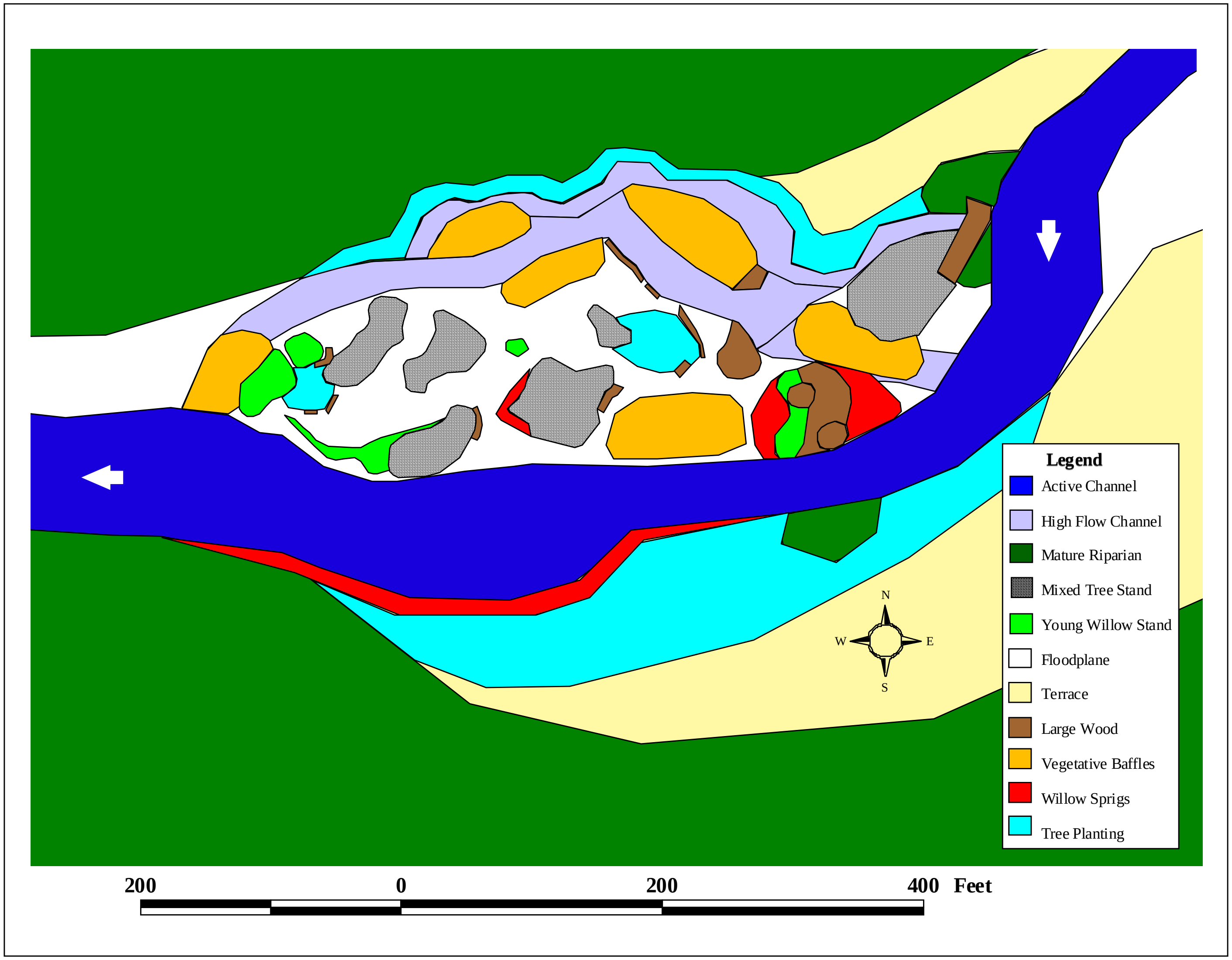

Figure 5. 2004-HR-04 project site map detailing post-restoration conditions,
Lower Terwer Creek Riparian Restoration Project, Lower Klamath River, California, 2006.

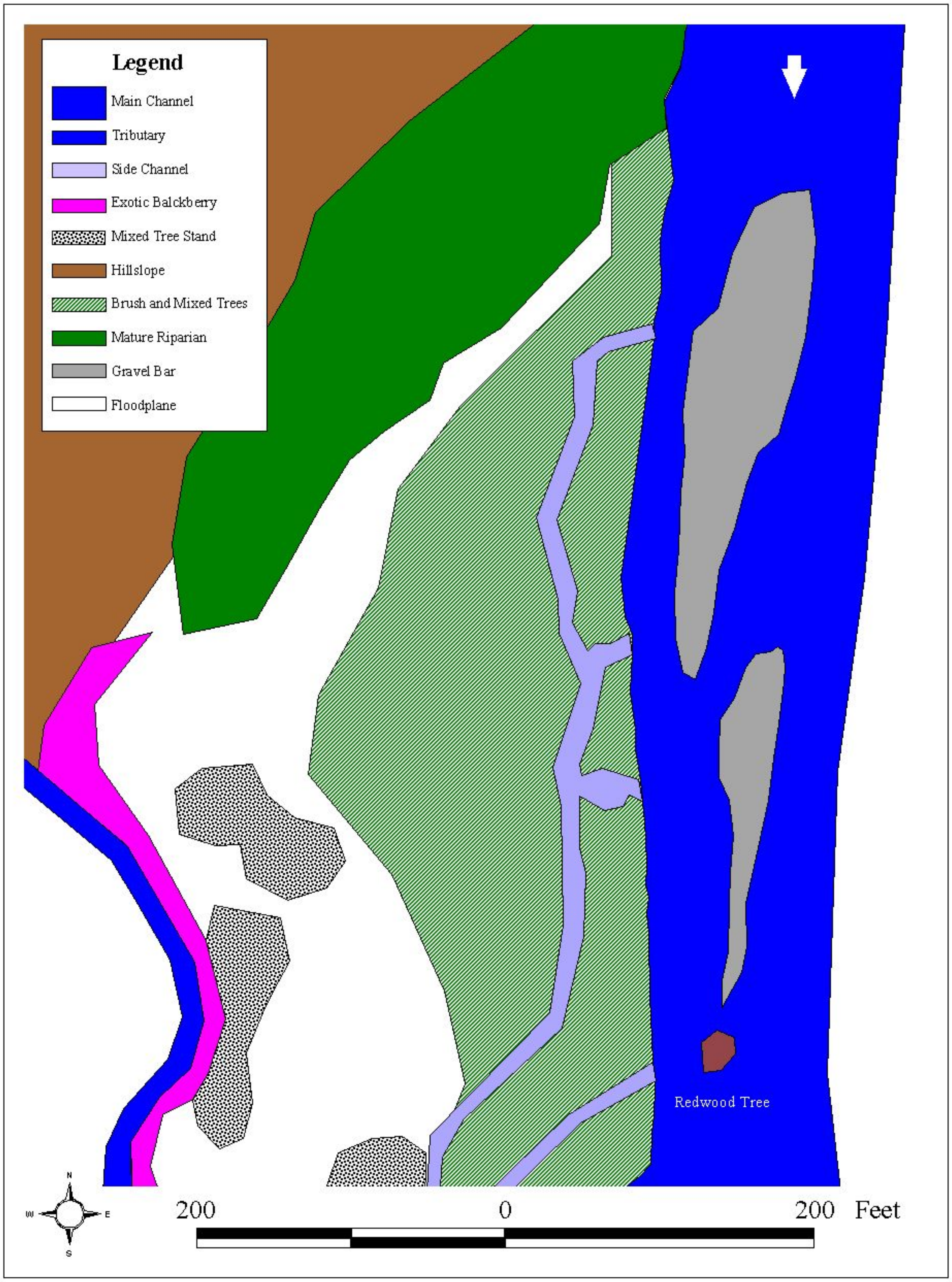

Figure 6. 2005-HR-02 project site map detailing pre-restoration conditions, Lower Terwer Creek Riparian Restoration Project, Lower Klamath River, California, 2005.

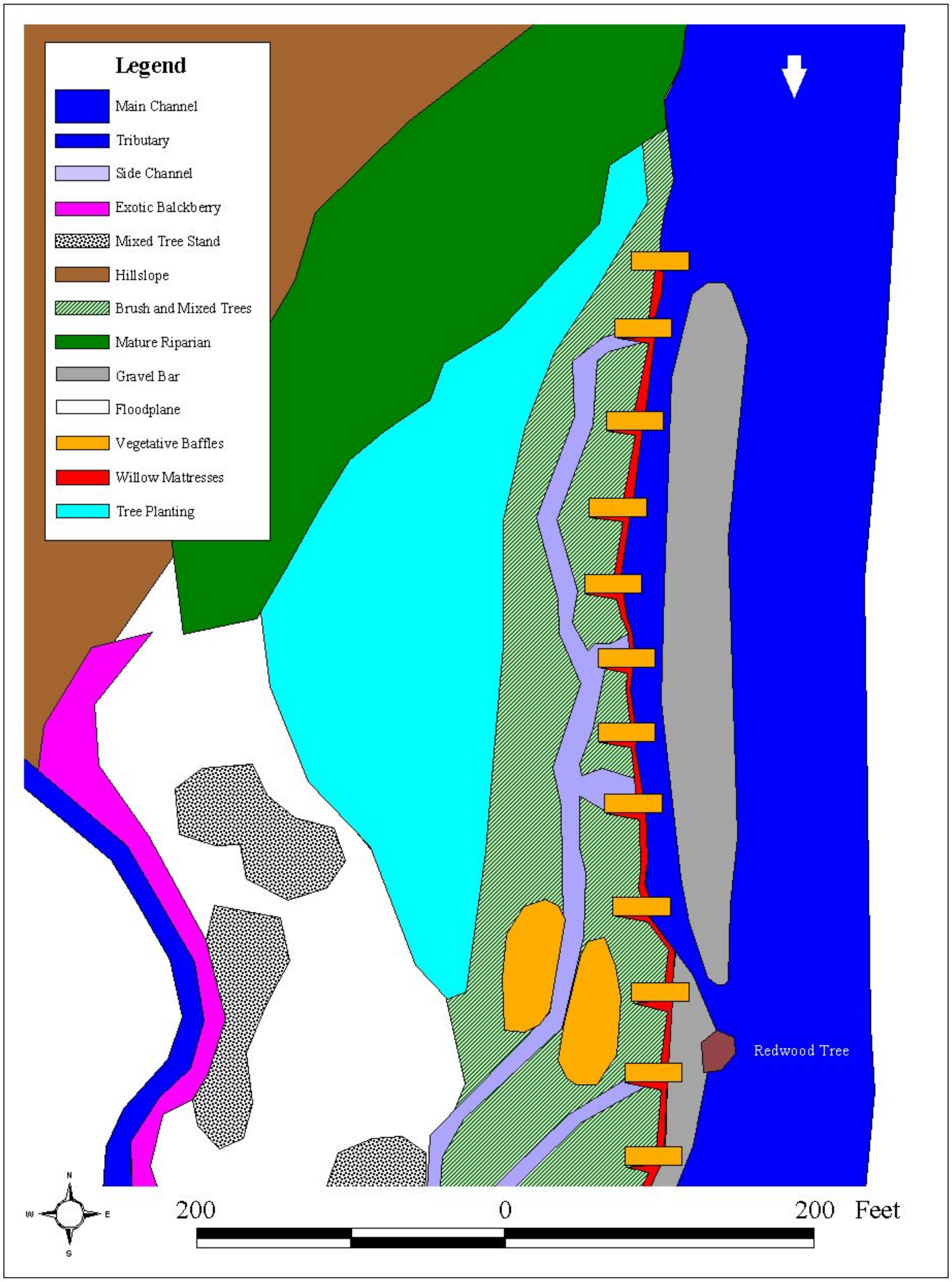

Figure 7. 2005-HR-02 project site map detailing post-restoration conditions, Lower Terwer Creek Riparian Restoration Project, Lower Klamath River, California, 2006.

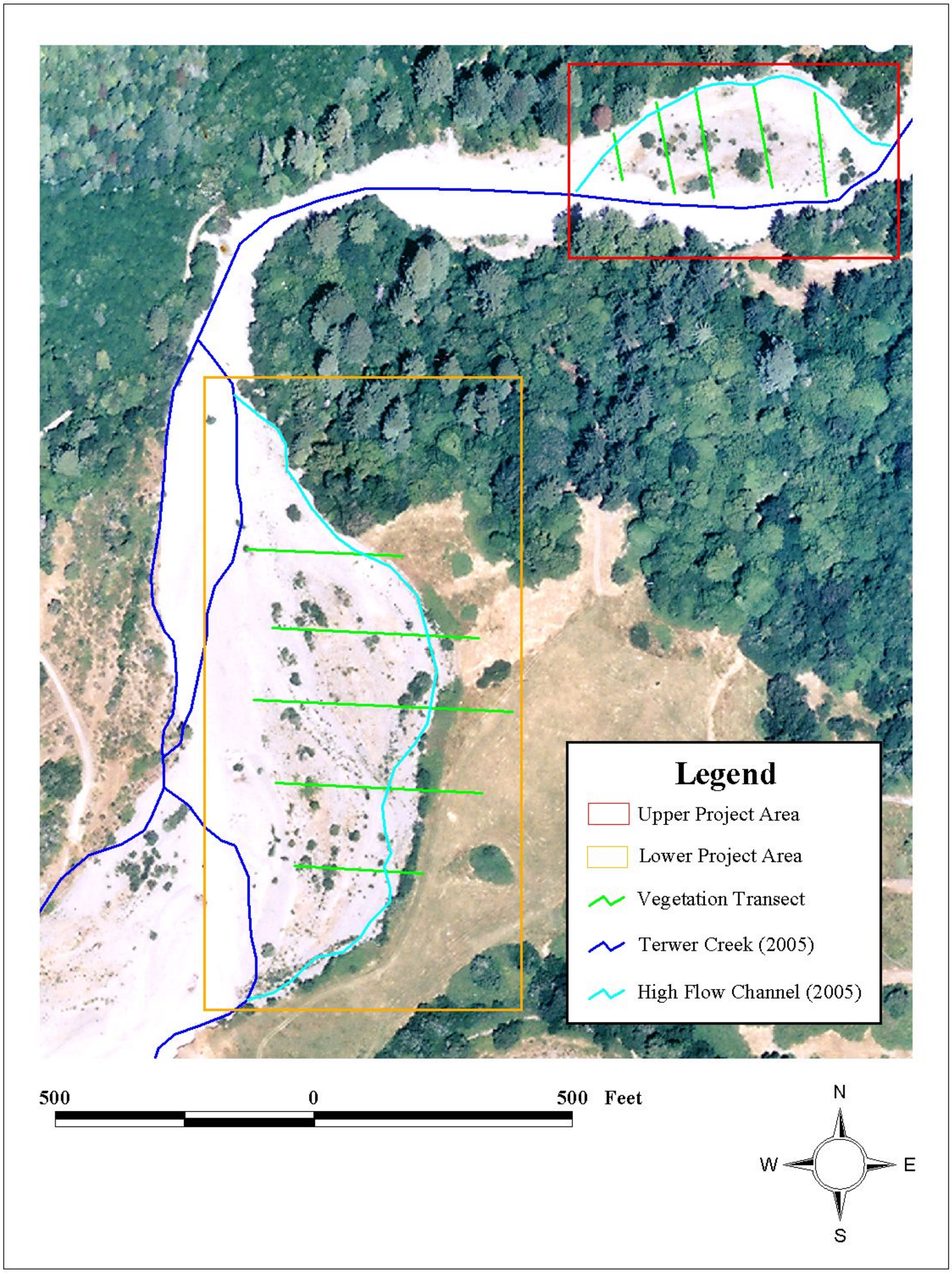

Figure 8. Site map depicting permanent vegetation monitoring transect locations established by the Yurok Tribal Fisheries Program in summer 2004 in Terwer Creek, Lower Klamath River. Map base image: 2004 Aerial Photograph.

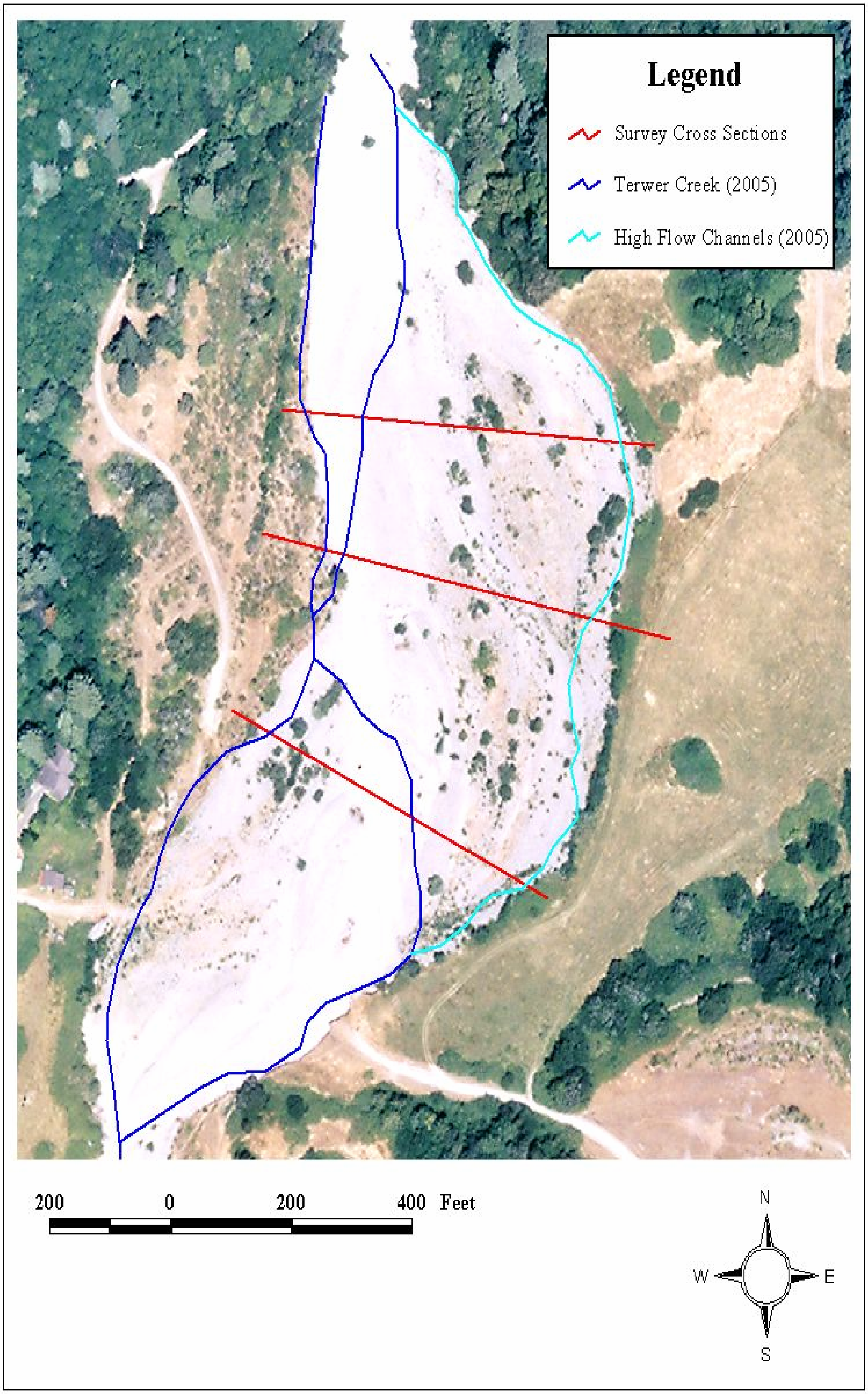

Figure 9. Site map depicting permanent cross section locations and channel survey data collected by the Yurok Tribal Fisheries Program in spring 2005 in Terwer Creek, Lower Klamath River. Map base image: 2004 Aerial Photograph.

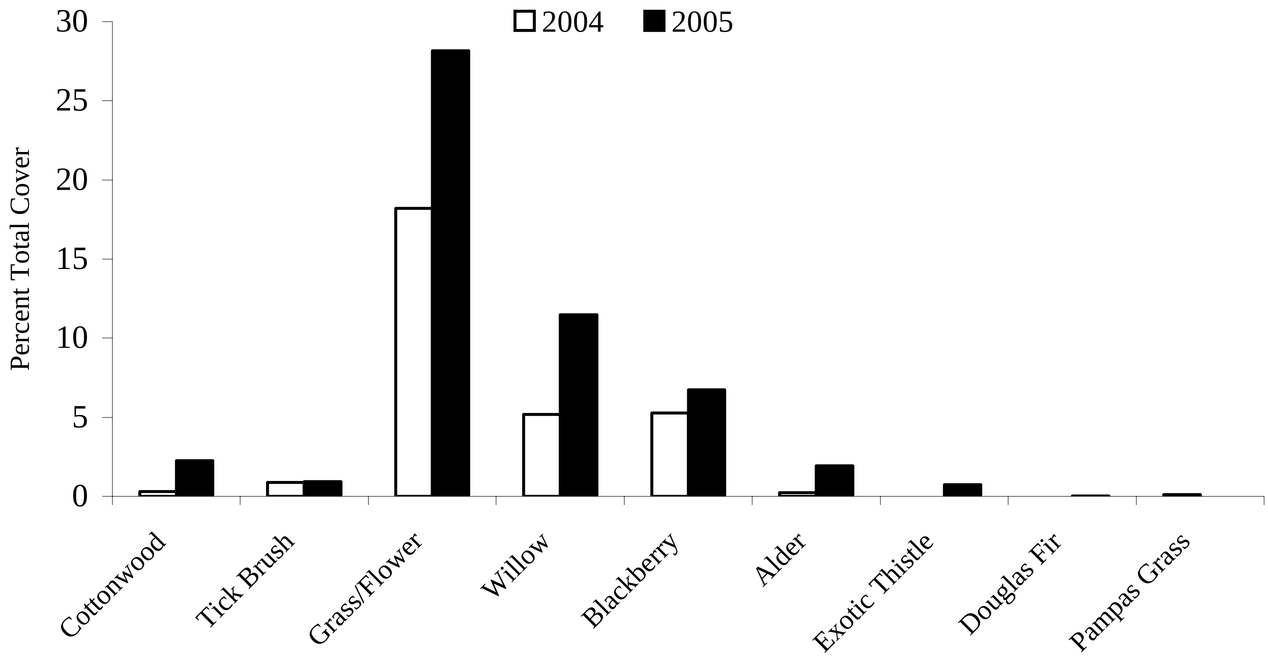

Figure 10. Vegetation types observed along vegetation transects located in a restoration site (2005-HR-02) located in Terwer Creek, Lower Klamath River. The 2004 data was collected prior to restoration implementation and the 2005 data was collected following phase 1 implementation.

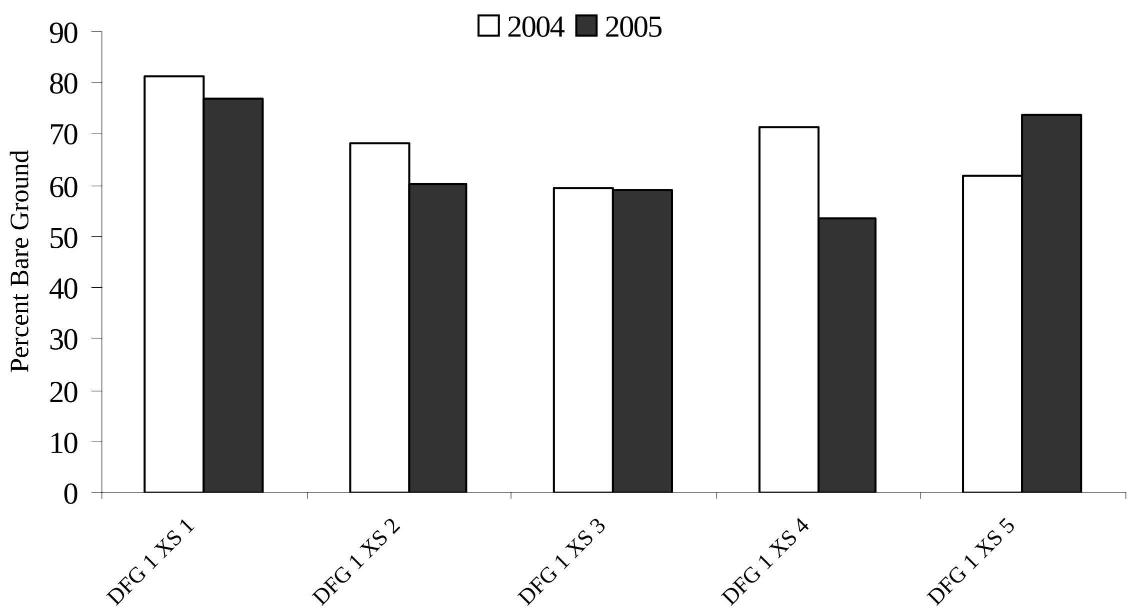

Figure 11. Percent bare ground observed along vegetation transects located adjacent to a restoration site (2005-HR-02) located in Terwer Creek, Lower Klamath River. The 2004 data was collected prior to restoration implementation and the 2005 data was collected following phase 1 implementation.

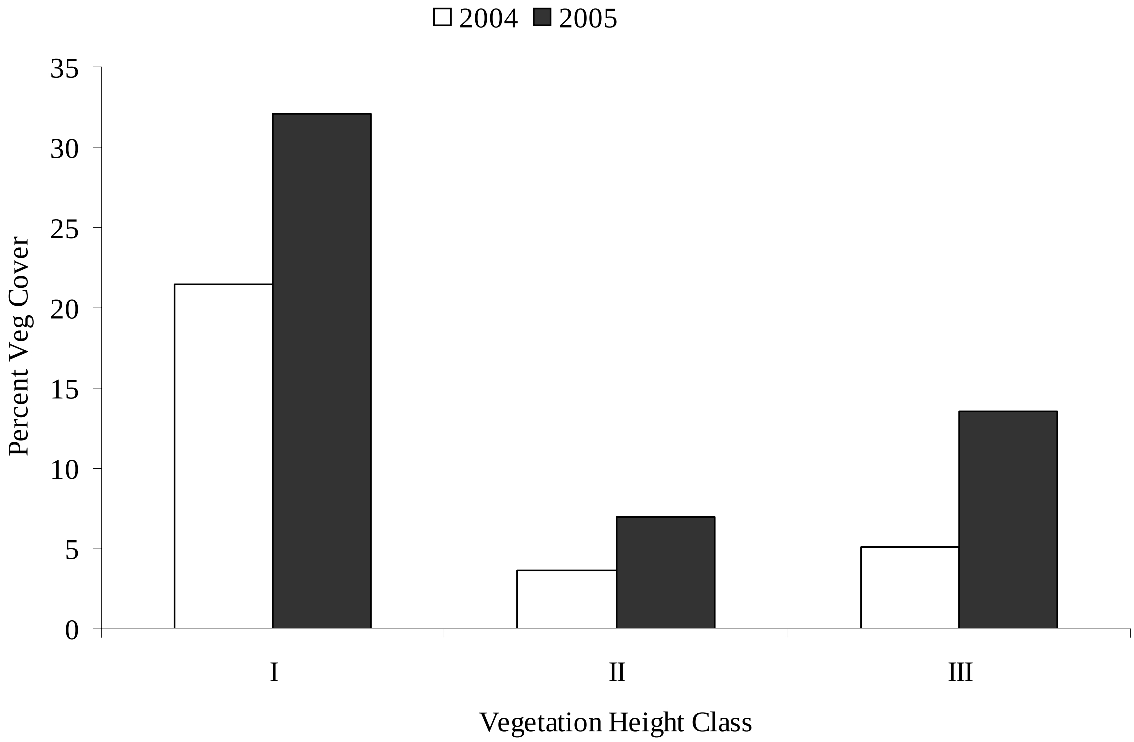

Figure 12. Amount of vegetation within three height classes (I = 0-3 ft; II = 3-15 ft; III = >15 ft) observed along vegetation transects located adjacent to a restoration site (2005-HR-02 site) located in Terwer Creek, Lower Klamath River. The 2004 data was collected prior to restoration implementation and the 2005 data was collected following phase 1 implementation.

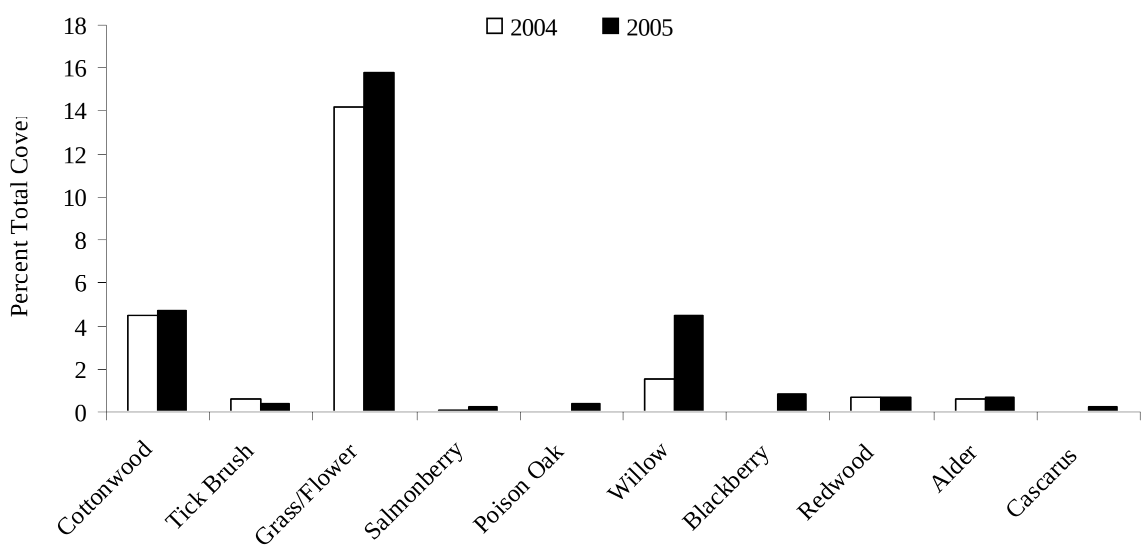

Figure 13. Vegetation types observed along vegetation transects located in a restoration site (2004-HR-04) located in Terwer Creek, Lower Klamath River. The 2004 data was collected prior to restoration implementation and the 2005 data was collected following phase 1 implementation.

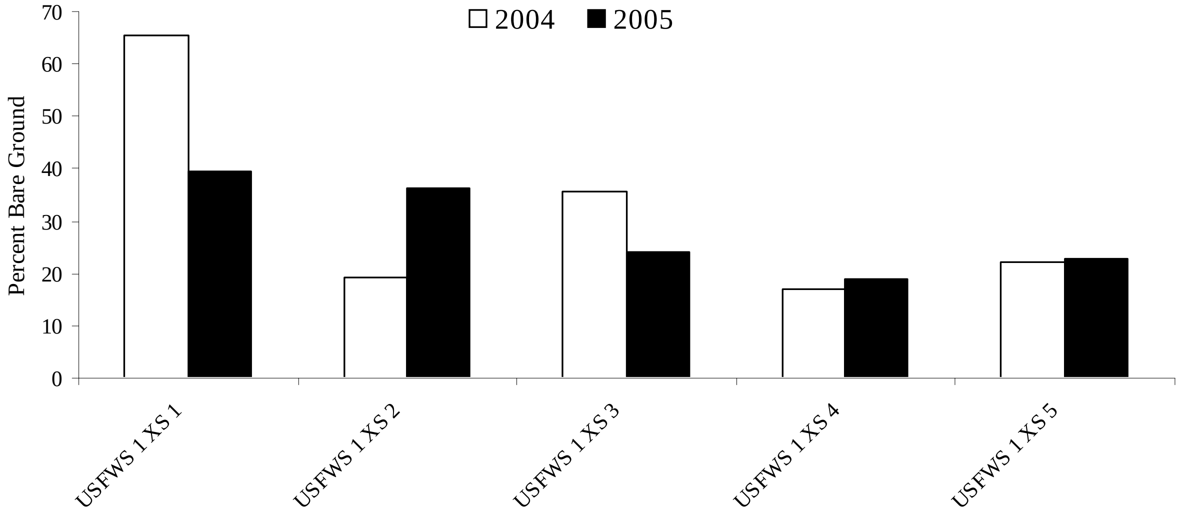

Figure 14. Percent bare ground observed along vegetation transects located in a restoration site (2004-HR-04) located in Terwer Creek, Lower Klamath River. The 2004 data was collected prior to restoration implementation and the 2005 data was collected following phase 1 implementation.

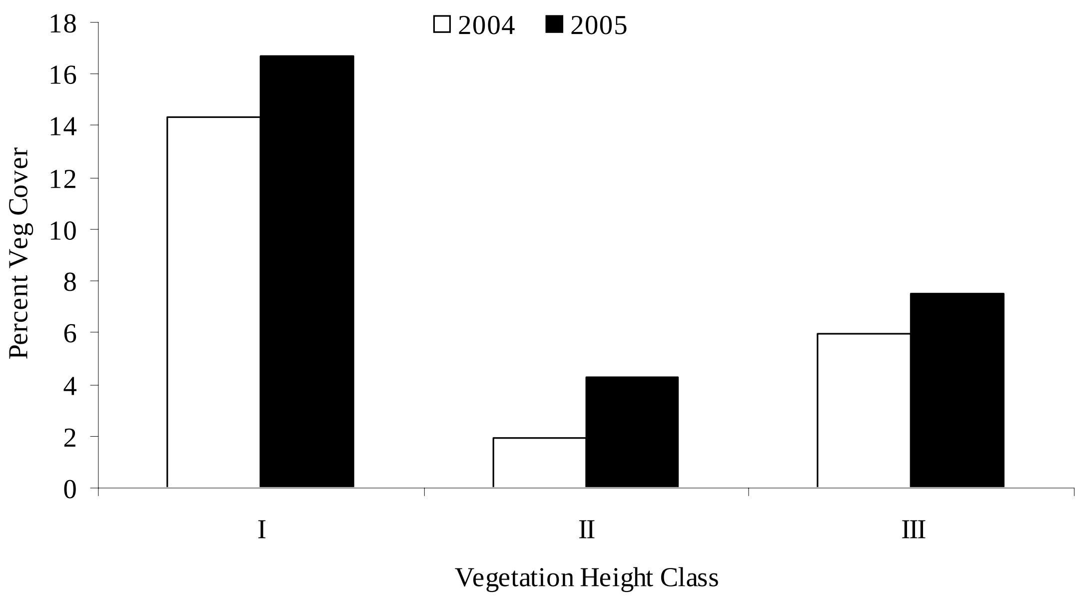

Figure 15. Amount of vegetation within three height classes (I = 0-3 ft; II = 3-15 ft; III = >15 ft) observed along vegetation transects located in a restoration site (2004-HR-04) located in Terwer Creek, Lower Klamath River. The 2004 data was collected prior to restoration implementation and the 2005 data was collected following phase 1 implementation.

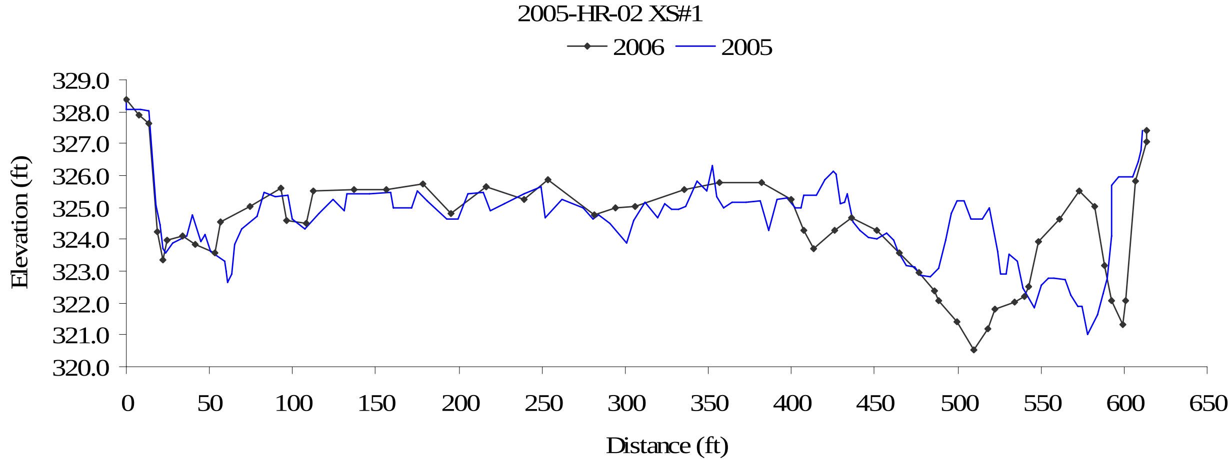

Figure 16. Stream channel cross-sectional profile before and after installation of willow baffles, 2005-HR-02 XS#1, Lower Terwer Creek, California, 2005-2006.

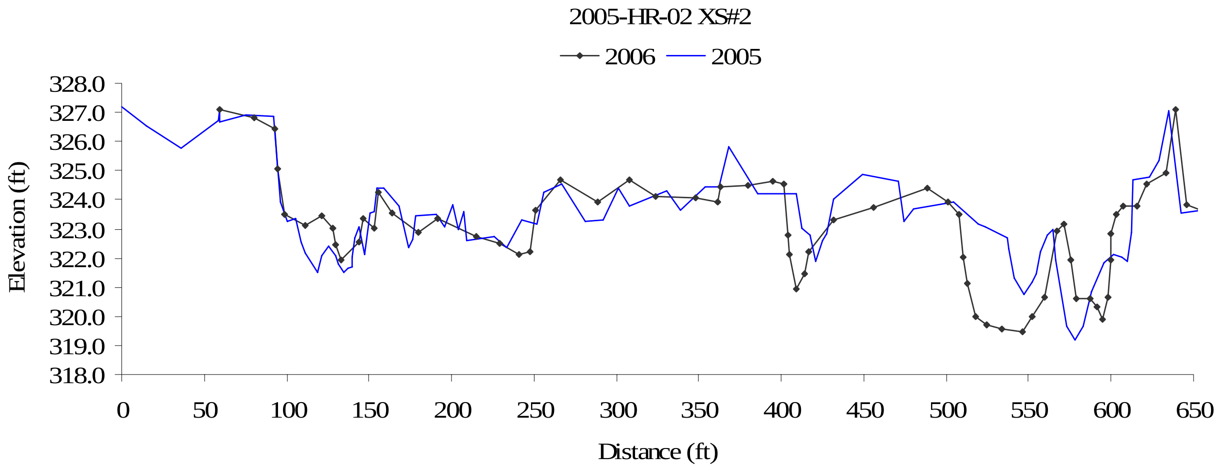

Figure 17. Stream channel cross-sectional profile before and after installation of willow baffles, 2005-HR-02 XS#2, Lower Terwer Creek, California, 2005-2006.

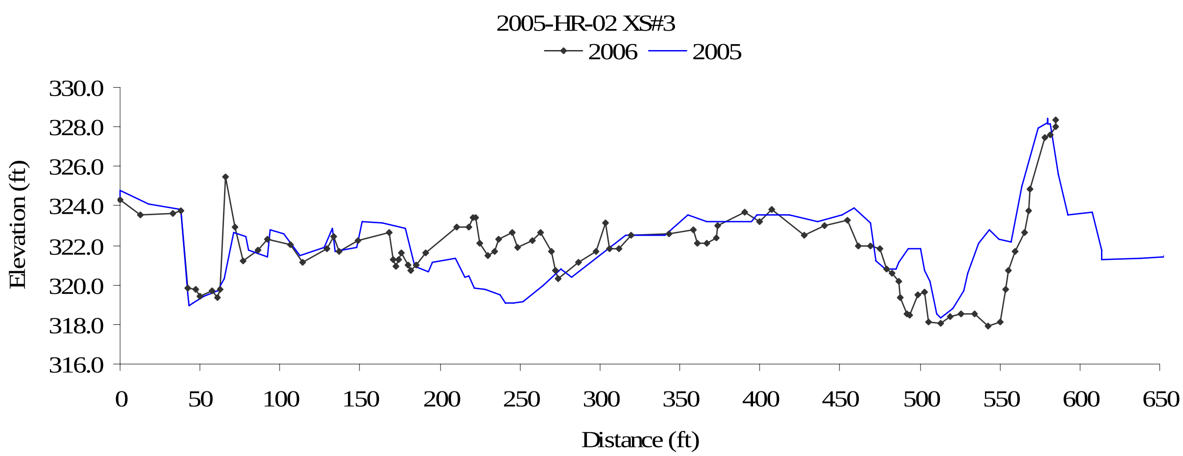

Figure 18. Stream channel cross-sectional profile before and after installation of willow baffles, 2005-HR-02 XS#3, Lower Terwer Creek, California, 2005-2006.

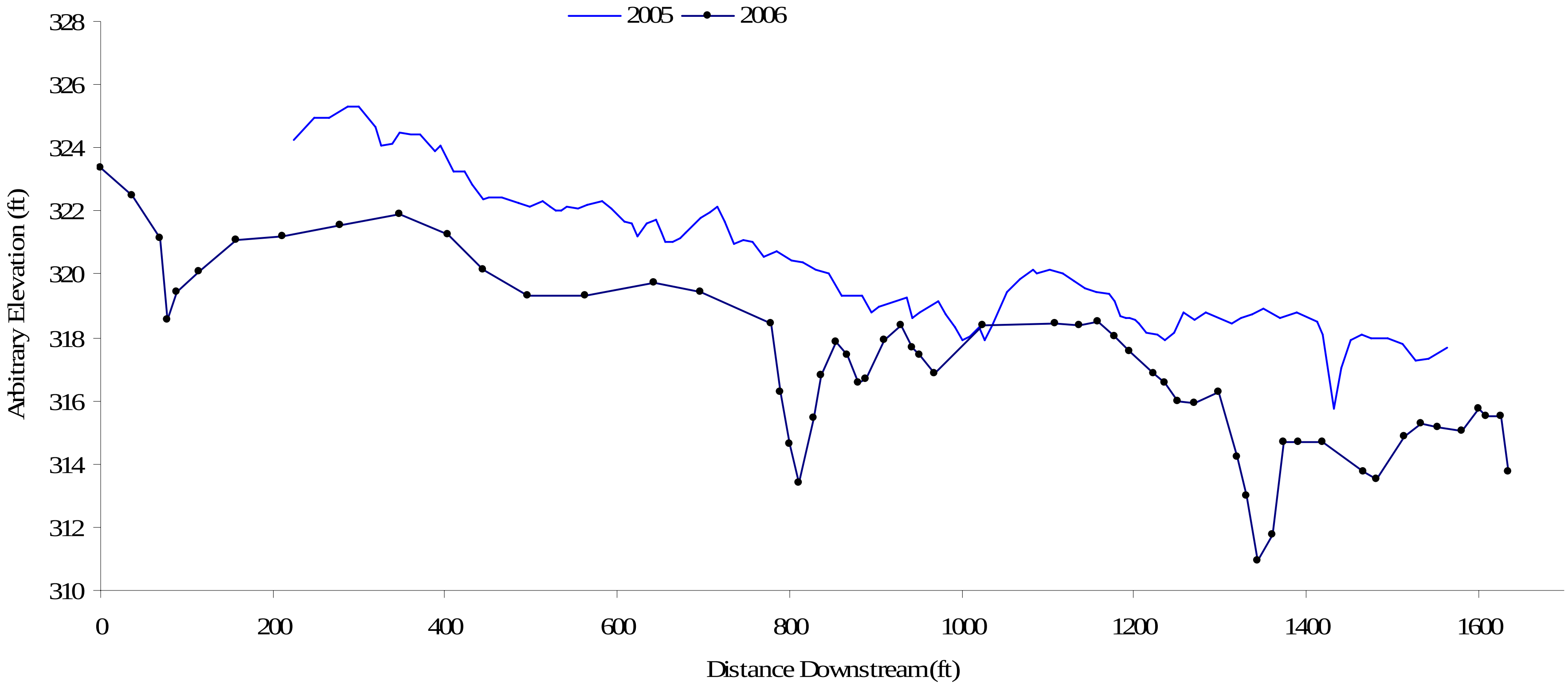

Figure 19. Stream channel longitudinal profile before and after installation of willow baffles at 2005-HR-02 XS#1 project site, Lower Terwer Creek, California, 2005-2006.

<u>**2004-HR-04 Project Site Photos**</u>

Figure 20. YTFP crew installing willow posts, Lower Terwer Creek, Lower Klamath River, California, 2004.

Figure 21. Willow posts installed along streambank, Lower Terwer Creek, Lower Klamath River, California, 2004.

Figure 22. Eroding streambank on east side of creek,
Lower Terwer Creek, Lower Klamath River, California, 2004.

Figure 23. Middle of willow baffle/mattress project site before construction, Lower Terwer Creek, Lower Klamath River, California, 2004.

Figure 24. Middle of willow baffle/mattress project site after construction, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 25. Middle of willow baffle/mattress project site after construction, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 26. Upper end of willow baffle/mattress project site before construction, Lower Terwer Creek, Lower Klamath River, California, 2004.

Figure 27. Willow baffles at upper end of site after installation, Lower Terwer Creek, Lower Klamath River, California, 2005

Figure 28. Willow baffles at upper end of site showing new growth, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 29. Willow baffles at lower end of site following high flow event, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 30. Willow baffles at lower end of site showing new growth, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 31. Willow baffles at lower end of site showing new growth, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 32. Willow baffles at lower end of site showing new growth,
Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 33. Pampas grass sprouts pulled from project site,
Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 34. Photographs taken from a permanent photographic monitoring point in Terwer Creek, Lower Klamath River. The upper photograph was taken in summer 2004 and the lower photograph was taken in summer 2005. Note the willow baffles in the back ground of the 2005 photograph.

Figure 35. Photographs taken from a permanent photographic monitoring point in Terwer Creek, Lower Klamath River. The upper photograph was taken in summer 2004 and the lower photograph was taken in summer 2005. Note the newly eroded stream bank in the 2005 photograph.

<u>**2005-HR-02 Project Site Photos**</u>

Figure 36. Lower end of willow baffle/mattress project site before construction, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 37. Upper end of willow baffle/mattress project site before construction, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 38. Upper end of willow baffle/mattress project site before construction, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 39. Excavating willow siltation baffle trench at lower end of baffle/mattress project site, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 40. YTFP staff constructing willow siltation baffle, Lower Terwer Creek, Lower Klamath River California, 2005.

Figure 41. YTFP staff constructing willow siltation baffle, Lower Terwer Creek, Lower Klamath River California, 2005.

Figure 42. Backfilling willow siltation baffle, Lower Terwer Creek, Lower Klamath River California, 2005.

Figure 43. Placing quarter-ton quarry rock on willow siltation baffle, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 44. Placing LWD in willow mattress trench, Lower Terwer Creek, Lower Klamath River California, 2005.

Figure 45. Backfilling willow mattress trench, Lower Terwer Creek, Lower Klamath River California, 2005.

Figure 46. Delivering water to willow siltation baffle installation site,
Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 47. Project site following installation of willow baffles/mattresses,
Lower Terwer Creek, Lower Klamath River, California, 2005

Figure 48. Project site following installation of willow baffles/mattresses, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 49. Project site following installation of willow baffles/mattresses, Lower Terwer Creek, Lower Klamath River, California, 2005.

Figure 50. YTFP staff installing willow baffles on adjoining flood terrace, Lower Terwer Creek, Lower Klamath River, 2005.

Figure 51. Willow baffles during >bankfull discharge flow event on 13-Dec-2006, Lower Terwer Creek, Lower Klamath River, 2006.

Appendix A

2004-HR-04 Project Budget

Personnel Costs:

Level of Staff	# of Hours	Hourly Rate	Total
Fisheries Biologist	504	$17.00	$8,568
Fisheries Technician	1,296	$12.00	$15,552
		Personnel Sub-total:	$24,120
		Staff Benefits @ 33%:	$7,960
		Total Personnel Costs:	**$32,080**

Materials and Supplies:

Program Supplies	$2,600

Total Materials and Supplies: $2,600

Operating Expenses:

Vehicle & Travel Expenses	$1,500
Total Operating Expenses:	**$1,500**
Project Subtotal:	$36,680
Administrative Overhead @ 29.7%:	$10,894
Total USFWS Funding:	**$47,574**

In-kind Contribution:

Yurok Tribe:

Level of Staff	# of Hours	Hourly Rate	Total
Senior Fisheries Biologist	120	$26.00	$3,120
Fisheries Biologist	120	$19.00	$2,280
		Personnel Sub-total:	$5,400
		Staff Benefits @ 33%:	$1,782
		Total Personnel Costs:	$7,182
		Administrative Overhead @28.19%:	$2,025
		Total:	$9,207

Simpson Timber Company:

10,000 Bareroot Redwood and Douglas Fir Trees	$3,300
Total In-Kind Contribution:	**$12,507**

2005-HR-02 Project Budget

Personnel Costs:

Level of Staff	# of Hours	Hourly Rate	Total
Fisheries Biologist	432	$18.00	$7,776
Fisheries Technician	893	$13.00	$11,610
		Personnel Sub-total:	$19,386
		Staff Benefits @ 33%:	$6,273
		Total Personnel Costs:	**$25,784**

Materials and Supplies:

Program Supplies	$3,200

Total Materials and Supplies: $3,200

Operating Expenses:

Vehicle & Travel Expenses	$1,500
Total Operating Expenses:	**$1,500**
Project Subtotal:	$30,484
Administrative Overhead @ 30.69%:	$9,355
Total USFWS Funding:	**$39,839**

In-kind Contribution:

Yurok Tribe:

Level of Staff	# of Hours	Hourly Rate	Total
Senior Fisheries Biologist	80	$26.00	$2,080
Fisheries Biologist	160	$19.00	$3,040
		Personnel Sub-total:	$5,120
		Staff Benefits @ 33%:	$1,690
		Total Personnel Costs:	$6,810
		Administrative Overhead @30.69%:	$2,090
		Total:	$8,890

Simpson Timber Company:

10,000 Bareroot Redwood and Douglas Fir Trees	$3,300
Total In-Kind Contribution:	$12,190