Lower Terwer Creek Streambank and Riparian Restoration - U.S. Fish and Wildlife Service – Tribal Landowner Incentive Program Project

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Yurok Fisheries Technician II, Steven Nova, giving a big "thumbs up" for the willow baffle construction in Terwer Creek

Introduction

The Yurok People have relied upon Klamath River for their subsistence, cultural, and economic livelihood since time immemorial. Central to Yurok culture is the harvest of anadromous fish, especially salmon and steelhead. Runs of anadromous fish currently returning to spawn in the Lower Klamath tributaries are depressed when compared with historical numbers. Extensive timber removal and road building activities has resulted in chronic sedimentation of streams and floodplains; a significant loss of channel-stored wood and riparian conifers; and a concomitant loss of habitat diversity and production potential in the sub-basin (Payne & Associates 1989; Gale and Randolph 2000; Beesley and Fiori 2007 and 2008; Voight and Gale 1998). The Yurok Tribe is dedicated to rehabilitating degraded river, tributary, and estuary habitats to levels that support robust, self-sustaining populations of native anadromous fish. To help address this need, the Yurok Tribe's Fisheries (YTFP), Watershed (YTWP), and Environmental Programs have been conducting fisheries and watershed assessments; and restoration in Lower Klamath habitats since the late 1990s.

Terwer Creek enters the Lower Klamath River 5.5 river miles upstream of the Pacific Ocean (Figures 1-2). Terwer Creek is a fourth order watershed draining approximately 31.8 square miles of steep, forested terrain (Figures 1-2). YTFP considers this a priority watershed for receiving upslope and fluvial rehabilitation activities (Gale and Beesley 2006, Gale and Randolph 2000; Gale 2007, 2008, and 2009; Beesley and Fiori 2008). Terwer Creek supports runs of late fall-run chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*), and multiple lamprey species (Voight and Gale 1998; YTFP Unpublished Data 1997-2010). Coho in the Klamath Basin are listed as threatened under the Endangered Species Act, while Klamath Basin runs of chinook, steelhead, and cutthroat have been previously petitioned for listing.

Lower Klamath River tributaries, especially coastal streams and those draining to the estuary, also provide critically important rearing and staging habitat for non-natal salmonids (Beesley and Fiori 2004; Hiner and Brown 2004; Beesley and Fiori 2007; Soto et al. 2008; YTFP 2009; Hiner 2009; Hillemeier et al. 2010; Silloway 2010). Off-estuary and coastal tributaries provide fish refuge from high water velocities or poor water quality occurring in the river; and offer diverse habitats for fish to forage or stage prior to initiating ocean entry or upriver migration. These areas are especially important to non-natal juvenile salmonids during winter - spring and directly influence fish growth just prior to ocean entry (Hillemeier et al 2010). Studies conducted in Oregon suggest ocean survival of juvenile chinook salmon was greatly increased when fish entered the ocean at larger sizes (120-160 mm) (Nicholas and Hankin 1989). YTFP recently documented overwinter use of off-channel habitats of lower Terwer Creek by natal and non-natal juvenile coho (YTFP Unpublished Data 1997-2010).

Historic logging and road building activities resulted in the removal of virtually all riparian conifers and loss of channel-stored wood and naturally formed wood jams. A moderate to severe forest fire occurred in the watershed in the late 1980s and the burn areas were then subjected to salvage logging. Aerial image analysis of Terwer Creek reveals numerous relic and active hillslope failures, substantial channel-stored sediment, and widespread riparian dysfunction (Fiori Unpublished Data). To help address upslope concerns, YTWP completed

a road system inventory in the watershed that prioritized treatment of all potential road-related sediment delivery sites; and they began treating priority road segments in 2007.

Riparian forest productivity and channel complexity in lower Terwer Creek has been further compromised as a result of cattle and timber mill operations occurring in the valley since the late 1800s. Currently, several actively managed cattle pastures exist in the valley (Figure 3); and at least one reproducing population of feral cattle resides in the lower watershed. Given the close proximity to the estuary and the potential to create a significant amount of quality overwinter rearing habitat in the valley for natal and non-natal salmonids; YTFP has worked with landowners and resource partners to begin rehabilitating relic riparian pastures and heavily impacted stream banks in 2005 (Gale and Beesley 2006, Gale 2007, 2008, and 2009; Beesley and Fiori 2008). YTFP has focused on using bioengineering techniques and constructing large wood and/or boulder structures to stabilize highly erosive stream banks; and building fences to exclude cattle from sensitive riparian areas of the Terwer valley.

This report focuses on stream and riparian enhancement work conducted for the U.S. Fish and Wildlife Service's (USFWS) Tribal Landowner Incentive Program (TLIP) grant (Federal Assistance # I-13-NA-1) (Figure 3). YTFP also obtained funds from California Department of Fish and Game's (CDFG) Fisheries Restoration Grant Program and USFWS Partner's for Fish and Wildlife funds to conduct this effort. Recently, YTFP obtained an American Recovery Act grant from the National Oceanic and Atmospheric Administration and additional USFWS funds to continue and expand our enhancement efforts in this critically important watershed. For report purposes the TLIP project area was divided into the upper and lower portions (Figure 4); and into individual project sites (Figure 5).

Project Objectives

The primary objectives of the TLIP project were to work with the landowners, which included Green Diamond Resource Company (GDRC) and a local cattle manager, to implement stream and riparian enhancement activities in the Terwer Creek valley that promote long-term channel stability and riparian resiliency. Specific activities included constructing willow mattresses and siltation baffles; propagating native seed, cuttings, and bareroot trees in the Yurok Tribal Native Plant Nursery (YTNPN); planting native conifers and deciduous trees in riparian habitats; and constructing large wood/boulder structures and engineered log jams (ELJs) to protect stream banks and riparian habitats. YTFP has worked hard to establish mutually beneficial partnerships with landowners in the Terwer Creek watershed. Stream and riparian enhancement conducted in the valley continues to demonstrate that habitat rehabilitation and working landscapes can operate in ways that result in long-term benefits to landowners and Tribal Trust fish and wildlife. Another primary objective was to provide quality employment opportunities to YTFP staff that involve improving conditions for local residents, the Yurok Tribe, and for native fish and wildlife.

Methods and Results

- Willow Baffle and Mattress Construction

A total of 112 willow siltation baffles and one 80 foot long willow mattress were constructed in the project area (Figures 5-6). Willow siltation baffles and the willow mattress were constructed using standard bioengineering methods (Engber 2005; Flosi et al. 1998). The willow mattress was constructed along an eroding bank located in the upper portion of the project reach (Site A) (Figures 5, 7-12). Exotic blackberry was removed from the site, the bank was outsloped to reduce erosion potential, and willow baffles were constructed behind the mattress to further promote improved riparian conditions in the reach (Figures 7-15).

Baffles were constructed at specific angles based on the direction of the main flow paths at each site to facilitate effective velocity reduction at each baffle. Willow baffles were constructed on several floodprone surfaces located within the project area to reduce stream velocities, promote fine sediment deposition and riparian growth, increase riparian forest function, and immediately improve conditions for native fish and wildlife (Figures 7-23).

Baffles were constructed by digging a 5-6 foot deep trench with a backhoe, lining the trench with a thick layer of vertically-placed willow cuttings (1-2 inch diameter) and posts (4-8 inch diameter), with the butt ends placed at the bottom of the trench (Figure 6). Baffles averaged ~ 20 feet in length and were spaced at various intervals depending on site conditions and objectives. Willows were angled slightly downstream in the trench and then a backhoe was used to backfill the trenches with the excavated material. Baffles were constructed to protect stream banks and riparian habitats from excessively high stream velocities. Some of the baffle sets were armored with quarry rock at their base in an attempt to minimize scour and increase willow survival. Large and small woody debris (LWD and SWD) salvaged from nearby road decommissioning projects were placed at the base of select baffle sets and into the bed between baffles to increase surface roughness. Buried and projecting wood provides increased soil moisture and nutrients to the willows, shade for willows, reduced stream velocities within the baffles, and promotes long-term riparian resilience and productivity.

- Log-Boulder Structure Construction

Eight log-boulder structures were constructed along an eroding bank located in the mid-portion of the project reach in 2007-2008; and an additional five were constructed in fall 2009 (Sites B - C) (Figures 5, 24-25). The log-boulder structures were constructed using an excavator according to methods detailed in Flosi et al. (1998) using both LWD and large quarry rocks (3+ ton) (Figure 25). Each log was placed in an excavated trench and angled upstream to deflect stream flows away from the bank (Figure 25). To increase bank stabilization, live willow posts and brush were incorporated into select structures where soil conditions were adequate to facilitate vegetation survival.

- Engineered Log Jams and Crib Wall Construction

YTFP worked with Rocco Fiori (Fiori GeoSciences (FGS)), a Licensed California Geologist, to implement more intensive bank protection techniques in the lower portion of the project reach (Site D) (Figures 5, 26-31). In fall 2009, FGS designed and constructed two ELJs according to methods outlined in Abbe et al. (2003). The ELJs were constructed in place of the proposed bioengineering approach based on recent channel changes (bank loss) and the resulting need to greatly reduce near bank shear stress along the left bank (looking downstream). YTFP worked with USFWS TLIP staff to change the scope of work to include the ELJs. A ~90 foot long crib wall ELJ was constructed along the highly impacted stream bank located in the lower reach (Figures 28-30). Recent channel shifts had forced flows directly into this bank and resulted in significant erosion at this site. Another ELJ was constructed upstream of the crib wall to deflect the main flow path away from the left bank and reduce the erosion potential downstream of the structure (Figures 26-27). The ELJs had live willow extensively incorporated into the structures to promote forest development and long-term channel and bank stability. These structure types were necessary to facilitate improved channel and riparian function and improve fisheries habitat at the in this reach.

In addition to providing significant bank protection, the ELJs have created valuable slow and deep water habitat for juvenile and adult salmonids during winter high flows (Figures 26-30). This was the first time that ELJs have been constructed in the Lower Klamath. YTFP plans to continue working with FGS to design and install more ELJs in lower Terwer Creek based on the performance of these structures during winter 2009-2010. Next summer, FGS and YTFP will construct two off-channel ponds in the lower portion of the project reach to increase overwinter rearing capacity for natal and non-natal salmonids. Additional ELJs will be constructed in the valley to promote multiple forested islands, further reduce stream velocities, protect the rearing ponds from erosion, and greatly improve conditions for fish.

- Conifer & Deciduous Tree Planting and Maintenance

Over 2,000 native conifers and a few hundred native deciduous trees were planted in the project area (Table 1; Figure 5). Species planted included Douglas fir (*Psuedotsuga menziesii*); Sitka spruce (*Picea sitchensis*); big leaf maple (*Acer macrophyllum*); and black cottonwood (*Populus balsamifera*) (Table 1). All conifer and deciduous planting was conducted in late winter through early spring using standard tree planting techniques. Crews properly stabilized the trees and took care when burying root systems to prevent "J-rooting" and to increase survival and productivity. Planting occurred in sites rich in deposited organic material and protected from high flows to increase growth rates and survivability. Hand tools were used to clear existing vegetation from each planting site and trees were planted using hoedads or tree planting spades. Extensive clumps of exotic (non-native) Himalayan blackberries were mechanically removed from throughout the project area prior to implementing bank protection activities and planting native trees. The above ground portions of the blackberries were removed with gas powered weed trimmers or heavy equipment and then hand crews removed root crowns using hand tools. Areas cleared of non-native plants were either treated with willow baffles and/or planted with native trees.

Crews watered select baffle sets and newly planted trees during summer months to aid survival while the plants established viable root systems. Areas were watered using a truckbed water tank and irrigation hose. Where tributary flow was available, YTFP constructed gravity fed water irrigation systems to transport water to the planting sites. YTFP plans to inspect planted areas in lower Terwer to assess annual survival and identify future planting sites. YTFP will continue watering activities and planting YTNPN trees over the next few years to ensure high tree survival and facilitate long-term riparian productivity in the area. YTFP will also continue monitoring riparian development and diversity in the project area to learn from past treatments and to guide future riparian enhancement activities.

- Yurok Tribal Native Plant Nursery

In 2005, YTFP began a native tree nursery at our office in Klamath, California (Figure 32). Since this time, the Yurok Tribal Native Plant Nursery (YTNPN) has provided an opportunity to train staff members in collection and propagation of local seed and cuttings, and nursery operation and maintenance. The YTNPN also allows YTFP to grow trees to larger sizes prior to planting to promote increased survival rates. For this project YTFP crews propagated over 2,000 big leaf maples, red alder (*Alnus rubra*), and black cottonwood. A total of 3,200 bareroot conifers were transplanted to 5-gallon pots to grow out at the YTNPN for future planting efforts in Terwer Creek and other priority Lower Klamath tributaries. YTFP crews received valuable training on all aspects of nursery operations and seed/cutting collection and propagation.

- Channel Monitoring and Evaluation

YTFP began conducting channel surveys in lower Terwer Creek in 2005. All surveying was conducted using an optical total station and the resultant topographic data was brought into Trimble Geomatics Office and exported to ArcView and Microsoft Excel for data analysis and to plot longitudinal profiles and cross sections. Permanent benchmarks were established in the reach to allow repeat surveying. Surveys were repeated in the project reach annually. Surveys conducted prior to 2007 were considered baseline surveys or pre-project surveys.

YTFP has established a total of eight permanent cross sections in the project reach since 2005 (Figures 33-34). A majority of these cross sections were established in 2006. Cross sections 9 - 10 were established in the lower portion of the project reach in late fall 2005; while cross sections 8 and 11 were added in 2007. Cross sections 9 - 11 were surveyed in October 2009 to document conditions in the lower portion of the project reach prior to constructing the ELJs (Figures 33). YTFP plans to conduct intensive channel surveys through lower Terwer Creek in summer 2010. Repeat surveys of this reach are critical for assessing effectiveness of enhancement activities and developing future treatment techniques.

Cross section data collected in the upper portion of the project reach showed gradual filling of the secondary channel along the right bank and a deepening of the main channel along the left bank (Figure 34). Data collected at cross section 6 showed erosion occurred along both banks and bar and right bank channel elevations increased (Figure 34). Data collected at cross sections 4 - 7 revealed channel migration from the right bank to the left, while cross

sections 8 - 9 showed another avulsion of the channel from the left bank to the right (Figure 34). Cross section 9 data revealed a loss of over 150 feet of the right bank, an increase in secondary channel and bar elevations, and an increase in the number of channels (Figure 34). Data collected in the lower portion of the project reach showed a huge loss of the left bank and continual channel development on the right bank (Figure 34).

Cross section 10 showed the loss of ~100 linear feet of bank from November 2005 to fall 2009 (Figure 34). Data collected at cross section 11 indicates similar lateral instability, with the loss of 35 linear feet of bank during winter 2007-2008 (Figure 34). The left bank in this reach is composed of layered beds of river gravels and silt, clay hardpan, and mill deposits (Figure 35). Based on channel surveys conducted in the lower portion of the project reach from 2005 – 2008, an estimated ~30,000 cubic yards of fine-grained sediment was delivered to the channel. Bank heights (distance above the channel bed) in this reach range from three to ten feet and pasture grass dominated this surface prior to initiating enhancement activities. Intensive treatment of this site (i.e. ELJ/willow baffle construction and riparian planting) was conducted in fall 2009 to provide increased protection of this productive floodprone surface.

- Vegetation Transect Assessment

GIS-based vegetation transects were created in the project area using ArcView and rectified aerial imagery. Five transect locations were randomly selected in the project reach to document short- and long-term changes in channel stability and riparian function (Figure 36). Cover types were mapped along each transect in ArcView using high resolution aerial imagery from 2005 (Pre-Project) and spring of 2009 (During Final Project Phases). Cover types identified included several vegetation classes and the active channel. The distance each cover type occupied along a given transect was digitized and calculated for 2005 and 2009. The amount of ground protected was estimated for every cover type identified in 2005 and 2009. Cover types were also classified by height: Class 0 (No Cover); Class I (0-15 feet); Class II (15-25 feet); and Class III (>25 feet). Field surveys were conducted in the project area pre-project (2007) and in early summer 2009 to verify the GIS-based mapping effort.

Seven cover types were identified during the vegetation transect mapping effort: Active Channel, Grass, Exotic Blackberry, Shrub, Shrub/Willow, Willow, Willow Mix (Figures 37-38). The Active Channel cover type was classified as a Class 0 (No Cover). Willow Mix was the only Class II (15-25 feet) cover type mapped in the reach; all other vegetation cover types were mapped as Class I (1-15 feet). There were no Class I Willow Mix cover types mapped. Dominant cover types for both years mapped were Grass and Active Channel. Bank erosion occurring in the project reach from 2005 to 2009 resulted in a decrease in Grass and Shrub cover types and a corresponding increase in the Active Channel cover type. The other differences to note included the elimination of Exotic Blackberry along the vegetation transects in 2009; and the addition of the Willow cover type in 2009 (Figures 37-38). The Willow cover type mapped in 2009 was comprised entirely of willow baffles constructed by YTFP (Figure X). YTFP plans to conduct field-based surveys of all vegetation transects in late summer 2010 and repeat them every two to five years to document long-term changes.

- Demonstration Project

Lower Terwer Creek is comprised mostly of small-scale ranches and industrial timberlands. This project was one of the first times YTFP coordinated with both Green Diamond Resource Company (GDRC) and a private landowner, Mr. Ken Farley, to conduct stream and riparian enhancement efforts in this watershed. GDRC owns a substantial portion of the Lower Klamath River Sub-basin. Therefore, the Yurok Tribe helped form the Lower Klamath Watershed Restoration Partnership in 1995 with GDRC, the California State Coastal Conservancy, and the Northern California Indian Development Council to address state and federal mandates by developing innovative solutions to resource management issues. The Yurok Tribe's Fisheries, Environmental, and Watershed Programs have since been coordinating with GDRC staff to conduct watershed monitoring; stream and riparian enhancement projects; and road decommissioning activities since 1997. GDRC continues to approve of our enhancement efforts in lower Terwer Creek and is currently working with us to develop future phases, and to generate the wood sources necessary to complete the work.

Mr. Farley's goals included protecting valuable infrastructure such as his well house and the pastures located along the creek (Figures 7-15). YTFP used willow baffles constructed upstream of Mr. Farley's well house to show local landowners, resource agency staff, and the community examples of bioengineering treatments and discuss how the treatments function to improve conditions for native fish and wildlife; while protecting valuable private property. This first "demonstration area" allowed Mr. Farley to see how the treatments looked and functioned and to gain confidence in the approach. During this project, YTFP and Mr. Farley have built a strong relationship that has resulted in significant fisheries and riparian habitat improvements. YTFP continues to use lower Terwer Creek as a "demonstration area" to promote the use of innovative ranch management techniques (i.e. using willow baffles to protect pastures, fencing cattle out of the creek). The success of this project has allowed YTFP to continue planning and implementing stream and riparian enhancement projects on Mr. Farley's property. FGS and YTFP are currently working with Mr. Farley to design and construct an off-channel pond on his property to increase the amount of overwinter habitat available to natal and non-natal juvenile salmonids. Mr. Farley is very supportive of using his property as a "demonstration area" and promoting the approach to other landowners.

In addition to the site being a "demonstration area", YTFP worked with Klamath River Early College of The Redwoods (KRECR) staff to develop and implement a fisheries management and restoration based curriculum for enrolled students. Several students participated in field visits to lower Terwer Creek during project implementation to learn about the project and discuss the importance of fisheries habitat rehabilitation in the Lower Klamath River. KRECR students were exposed to all the various stages of the project including project planning, monitoring, and implementation of several different enhancement techniques including tree planting, nursery management, willow harvesting, and baffle construction. YTFP continues to work closely with KRECR staff and students to promote a tribally based approach to fisheries science and native fish habitat restoration in the Klamath Basin.

Discussion and Recommendations

Enhancement treatments implemented during this project were designed to provide immediate and long-term benefits to Tribal Trust fish and wildlife. Objectives included increasing bank and channel stability, promoting diverse and resilient riparian habitats and forested islands, and improving water quality by reducing bank erosion through this reach. The use of willow bioengineering techniques in combination with ELJ construction resulted in significant bank protection and immediate aquatic and terrestrial habitat improvements. YTFP and FGS will continue and expand these efforts in the lower portion of the project reach this summer. In addition to promoting bank and channel stability, future enhancement activities will focus on increasing the amount of high quality, slow velocity overwinter rearing and staging habitat for natal and non-natal salmonids.

Future recommendations for lower Terwer Creek includes 1) maximizing the amount of high quality overwinter rearing and staging habitat for natal and non-natal salmonids; 2) constructing ELJs in the reach located upstream of the TLIP project reach to the Dandy Creek confluence; 3) continue tree planting activities within the lower valley and upstream of the Dandy Creek confluence; and 4) promoting forested islands in the Terwer Creek valley. Effectiveness monitoring should be continued and expanded in this watershed to facilitate an adaptive approach to habitat rehabilitation. This type of approach will ensure that techniques applied on-the-ground will be effective over short- and long-term timescales; and allows the information gained to be applied in other coastal watersheds of the Lower Klamath River.

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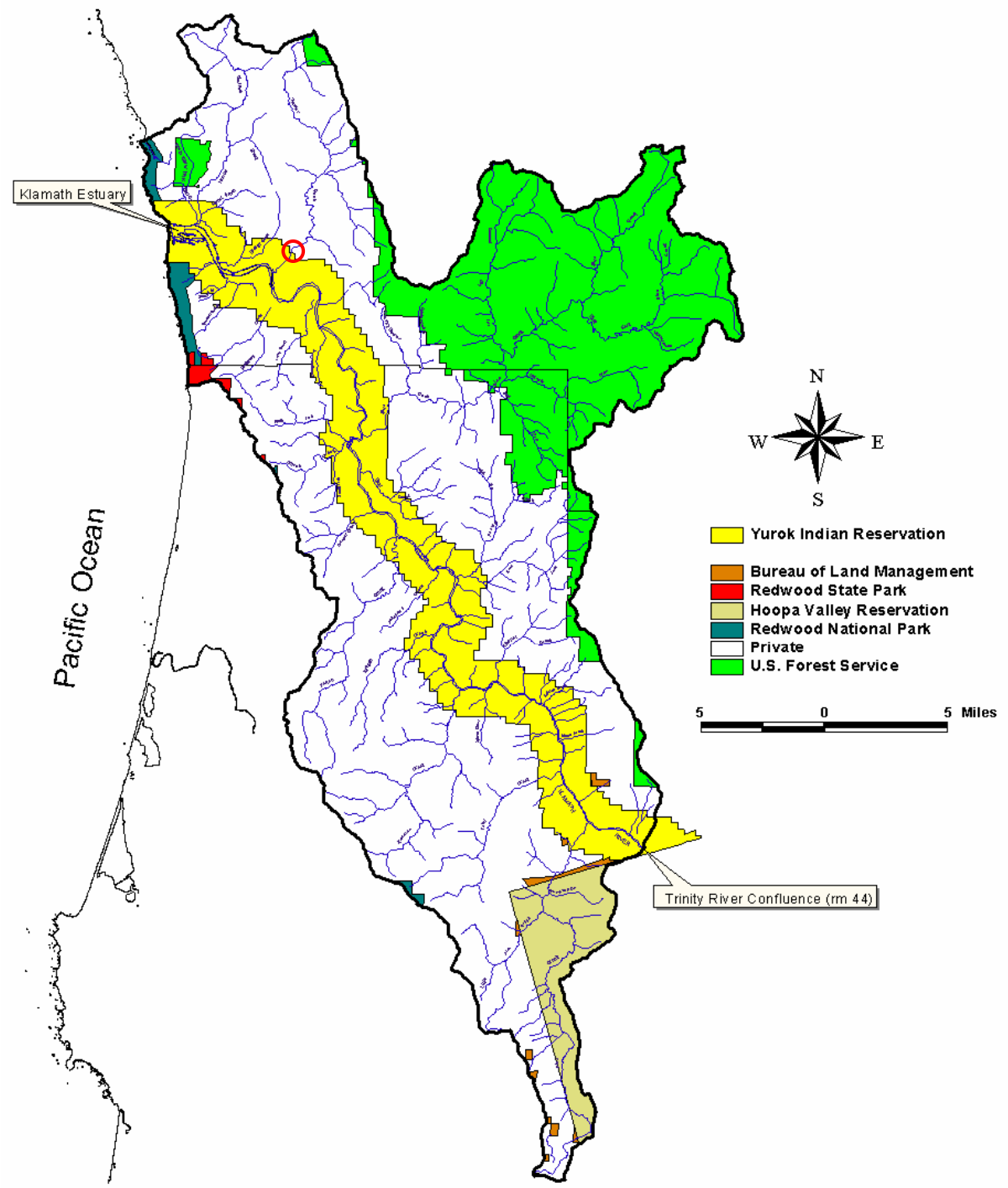


Figure 1. Map of the Lower Klamath River Sub-basin, California with the Terwer Creek project area circled in red.

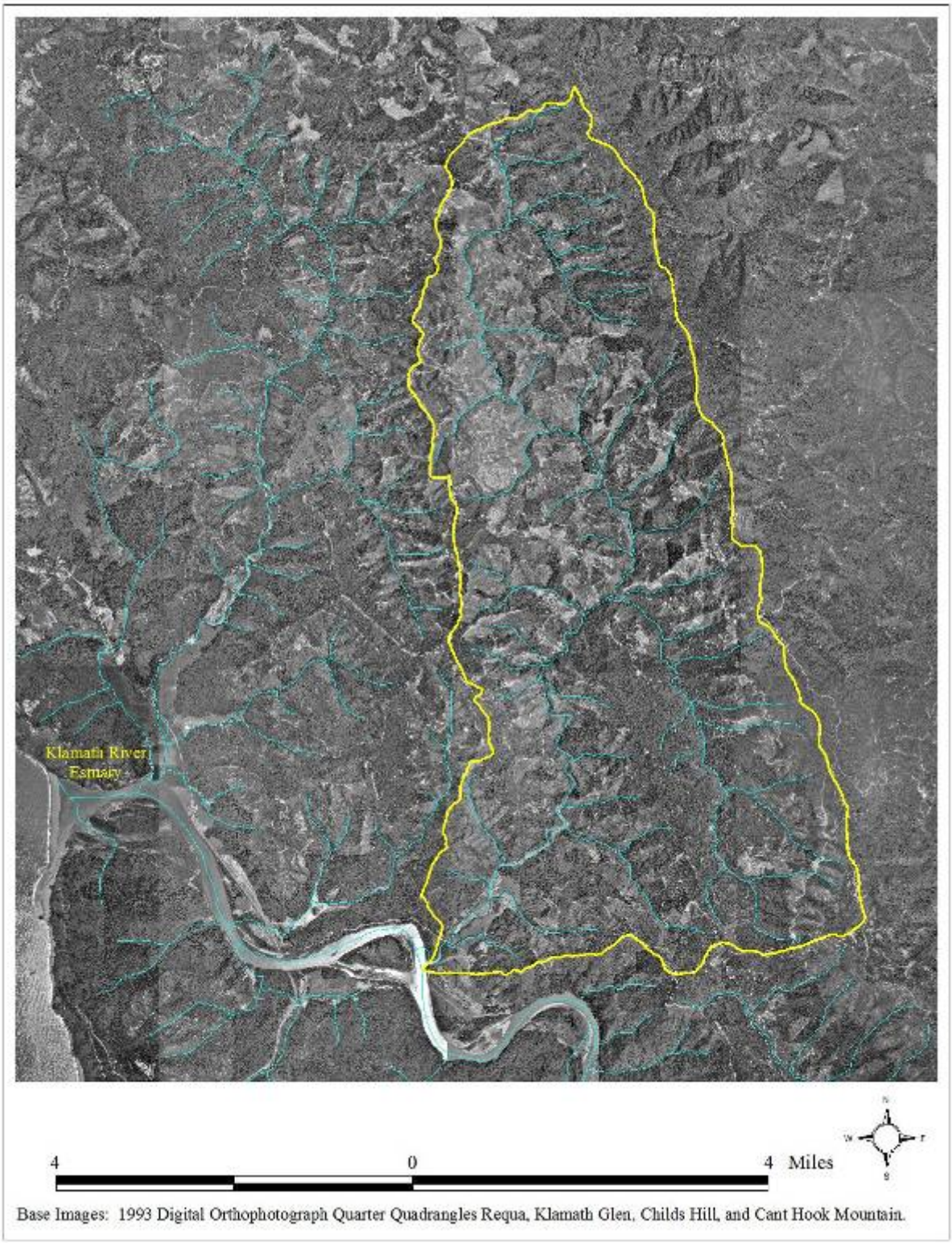


Figure 2. The Terwer Creek watershed, Lower Klamath River Sub-basin, California.

Figure 3. Map of the Terwer Creek valley with the "U" depicting the upper project boundary and the "D" depicting the downstream boundary of the project area (Base image: 2005 NAIP Aerial Imagery).

Figure 4. Map depicting the upper (outlined in red) and lower (outlined in light blue) project areas in the Terwer Creek valley (Base image: 2005 NAIP Aerial Imagery).

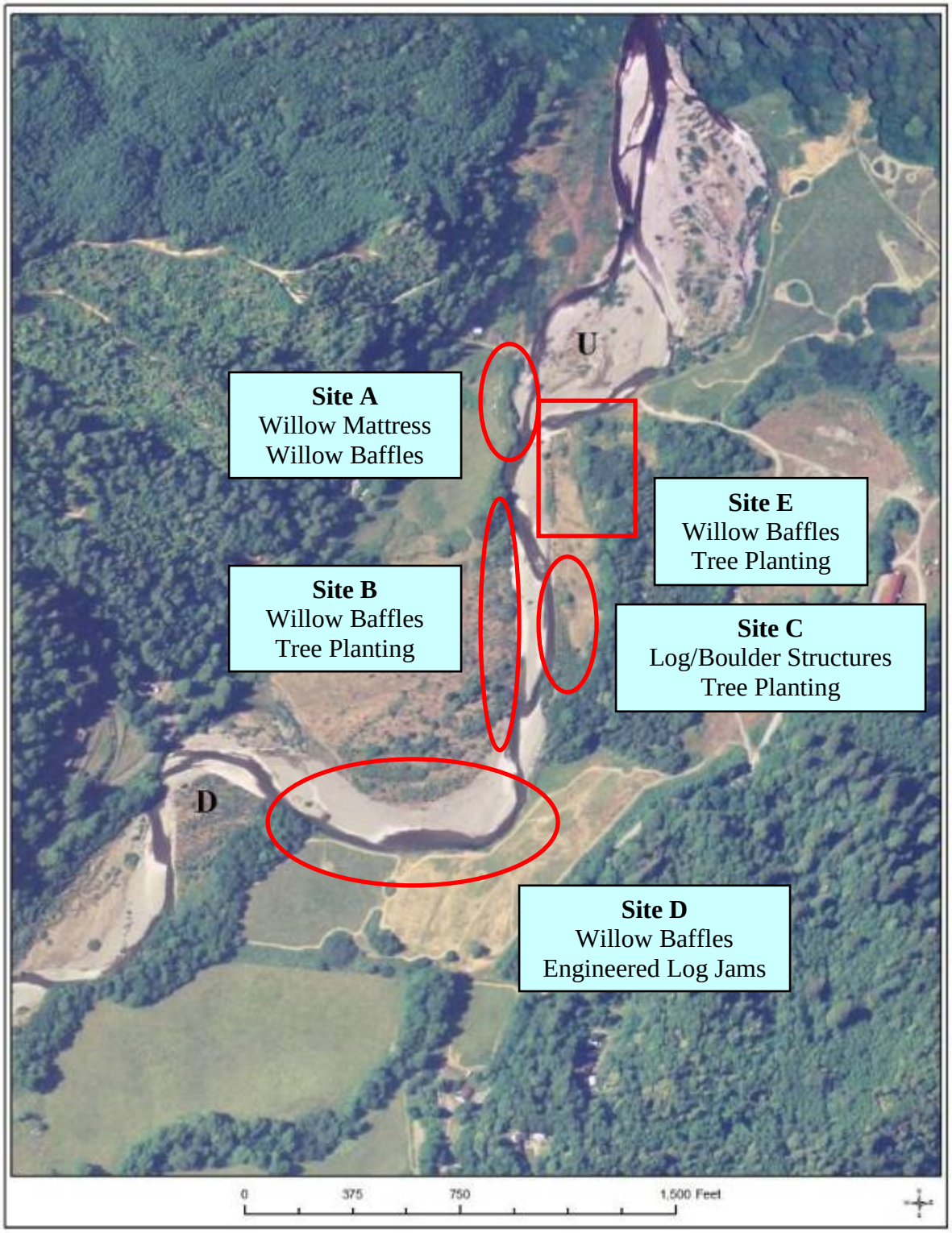


Figure 5. Map depicting several of the individual project sites located in the Terwer Creek valley (Base image: 2005 NAIP Aerial Imagery).

Figure 6. Yurok Fisheries staff constructing willow siltation baffles on a floodprone surface in lower Terwer Creek (Site D) (Top 2008 and Bottom 2009).

Figure 7. Looking upstream at an eroding bank (site A) dominated by Himalayan blackberry, Terwer Creek, Lower Klamath River, California, October 2005.

Figure 8. Looking upstream at an eroding bank (site A) during blackberry removal and outsloping activities, Terwer Creek, Lower Klamath River, California, September 2008.

Figure 9. Willow placed in the toe trench of the willow mattress (site A) prior to backfilling (Left), and Yurok Fisheries staff staking the willow mattress to the bank (Right) Terwer Creek, Lower Klamath River, California, October 2008.

Figure 10. Willow mattress (site A) being staked to bank following backfilling, Terwer Creek, Lower Klamath River, California, October 2008.

Figure 11. Looking upstream at the upper half of the willow mattress (site A) after it was staked and covered with soil, Terwer Creek, Lower Klamath River, California, October 2008.

Figure 12. Willow mattress (site A) following completion and mulching, Terwer Creek, Lower Klamath River, California, November 2008.

Figure 13. Removing Himalayan blackberries behind willow mattress (site A) prior to construction of willow baffles (Top - September 2008), and following removal of Himalayan blackberries (Bottom - December 2008), Terwer Creek, Lower Klamath River, California.

Figure 14. Willow terrace baffles being constructed behind willow mattress (site A), Terwer Creek, Lower Klamath River, California, December 2008.

Figure 15. Looking downstream at the willow mattress and terrace baffles (site A) following construction, Terwer Creek, Lower Klamath River, California, January 2009.

Figure 16. Looking upstream at an eroding bank (site B) prior to constructing willow baffles (Top - June 2006), and during construction (Bottom - October 2007), Terwer Creek, Lower Klamath River, California.

Figure 17. Looking downstream at an eroding bank (site B) prior to constructing willow baffles (Top - September 2007), and following construction (Bottom - October 2007), Terwer Creek, Lower Klamath River, California.

Figure 18. Looking downstream at an eroding bank (site D) prior to enhancement efforts (Top - October 2005), and during initial willow baffle construction (Bottom – March 2008), Terwer Creek, Lower Klamath River, California.

Figure 19. Looking upstream at an eroding bank (site D) prior to enhancement efforts (Top - December 2005), and following initial willow baffle construction on the left bank (Bottom – November 2008), Terwer Creek, Lower Klamath River, California.

Figure 20. Looking upstream at a floodplain surface (site D) following willow baffle construction, Terwer Creek, Lower Klamath River, California, December 2008.

Figure 21. Looking upstream at floodplain surfaces (site D) following willow baffle construction and a high flow event, Terwer Creek, Lower Klamath River, California, (Top - January 2009; Bottom - January 2010).

Figure 22. Looking downstream at the initial willow baffles (site D) (Top – December 2006), and the same area following more willow baffle construction and a high flow event (Middle and Bottom – January 2009), Terwer Creek, Lower Klamath River, California.

Figure 23. Photographs taken from an eroding bank (site D) looking towards Terwer Creek prior to enhancement efforts (Top - October 2005), and during tree planting (Bottom - January 2009), Lower Klamath River, California.

Figure 24. Looking upstream of an eroding bank (site C) prior to constructing log-boulder structures (Top - October 2005; Bottom - May 2006), Terwer Creek, Lower Klamath River, California.

Figure 25. Looking downstream at Yurok Fisheries staff positioning a log in an excavated trench (site C) (Left - October 2008), and following construction (Right - November 2008), Terwer Creek, Lower Klamath River, California.

Figure 26. An engineered log jam during construction (Site D) (Top – Fall 2009), and during a high flow event (Bottom – January 2010), Terwer Creek, Lower Klamath River, California.

Figure 27. An engineered log jam following construction (Site D) (Top – Fall 2009), and during a high flow event (Bottom – January 2010), Terwer Creek, Lower Klamath River, California.

Figure 28. Looking downstream at an engineered crib wall jam during construction (Site D) (Fall 2009), Terwer Creek, Lower Klamath River, California.

Figure 29. Looking downstream at an engineered crib wall jam during construction (Site D) (Top - Fall 2009), and during winter base flows (Bottom – Winter 2009-2010), Terwer Creek, Lower Klamath River, California.

Figure 30. Looking upstream at an engineered crib wall jam during a high flow event (January 2010), Terwer Creek, Lower Klamath River, California.

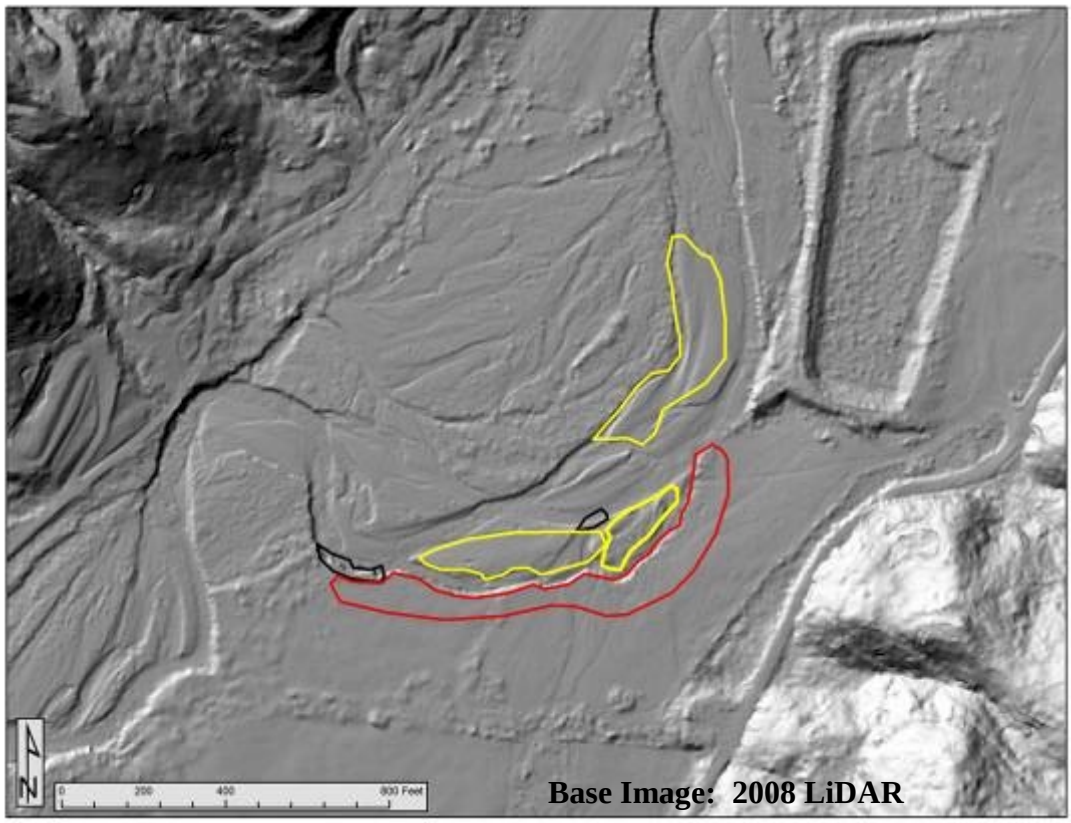


Figure 31. Map depicting enhancement techniques used in the lower portion of the project area (Site D), Terwer Creek, Lower Klamath River, California (Black = engineered log jams; Yellow = willow baffles and coarse wood; and Red = willow baffles and tree planting).

Table 1. Trees planted in riparian areas of lower Terwer Creek as part of the Tribal Landowner Incentive Program project (2007-2009), Lower Klamath River Sub-basin.

Species	Type	Quantity	Date Planted
Douglas Fir	Bareroot	1,350	Winter 2007-2008
Douglas Fir	Bareroot	500	Winter 2008-2009
Sitka Spruce	Bareroot	400	Winter 2007-2008
Sitka Spruce	Bareroot	150	Winter 2008-2009
Big Leaf Maple	2-gallon pots	94	Winter 2007-2008
Big Leaf Maple	2-gallon pots	70	Winter 2008-2009
Black Cottonwood	2-gallon pots	171	Winter 2007-2008
Black Cottonwood	2-gallon pots	72	Winter 2008-2009

Figure 32. Photographs of the Yurok Tribal Native Plant Nursery, and crews loading up native conifer saplings that were grown out at the nursery, Klamath, California.

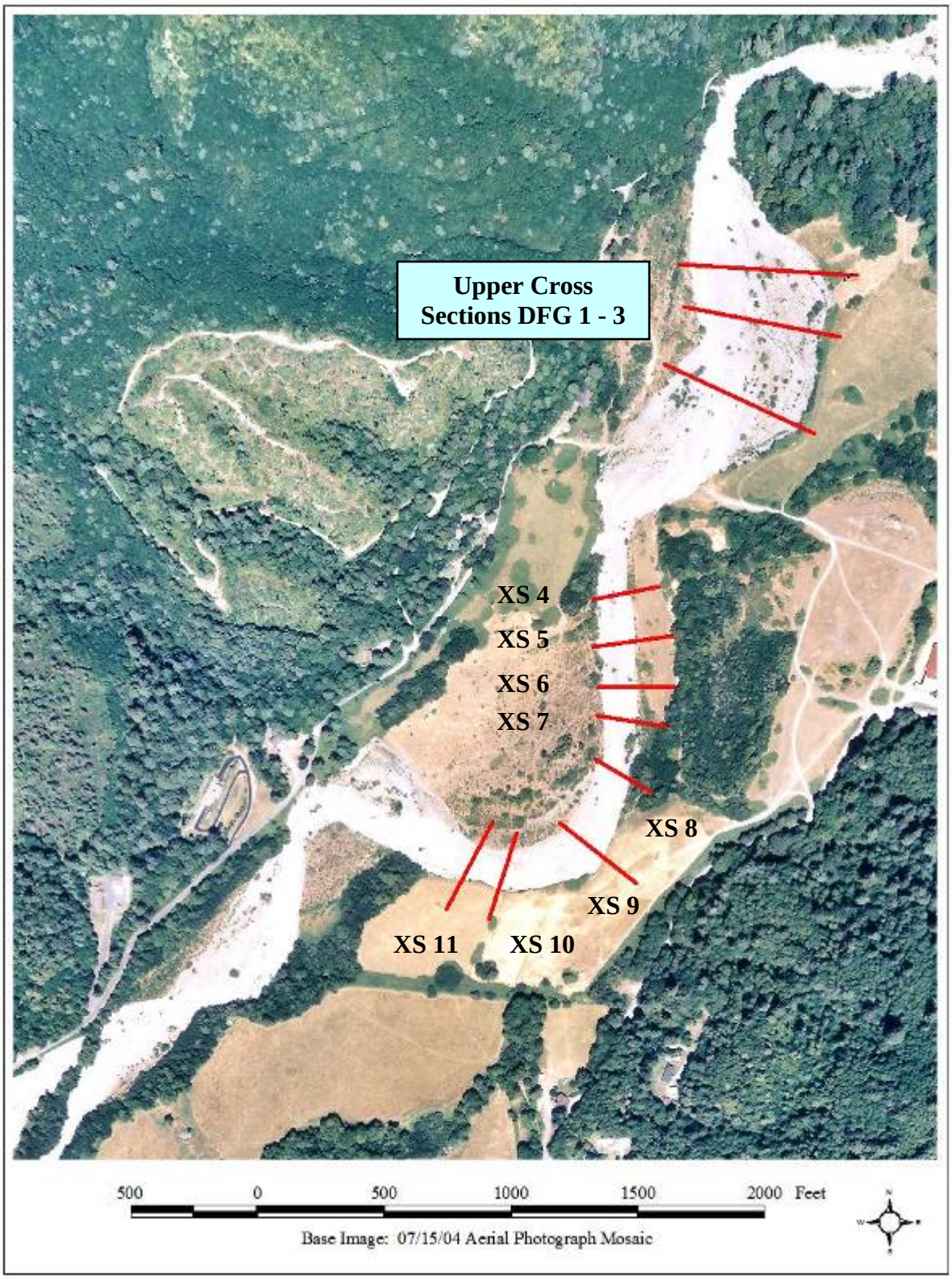


Figure 33. Map depicting permanent cross section locations in lower Terwer Creek.

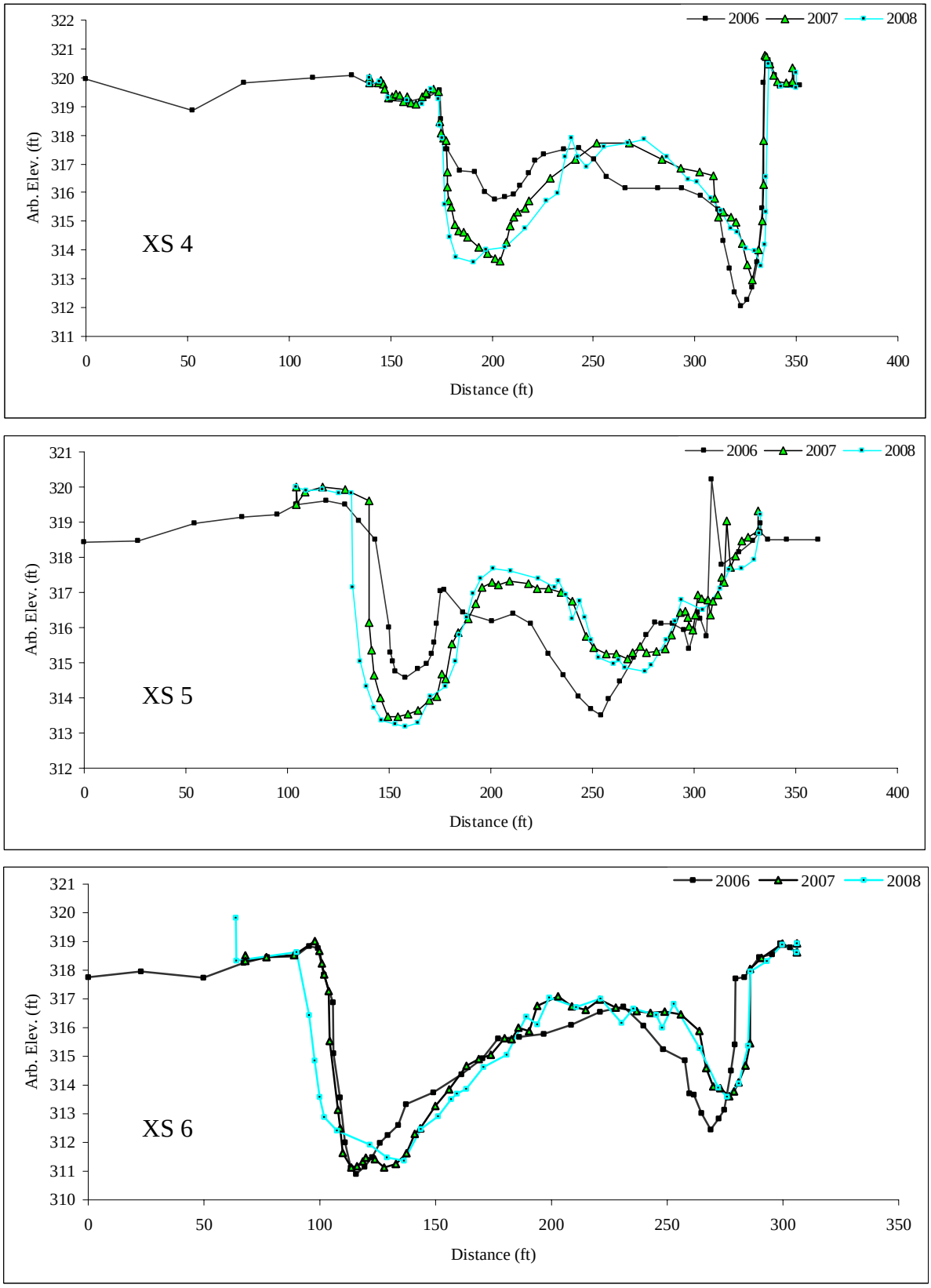
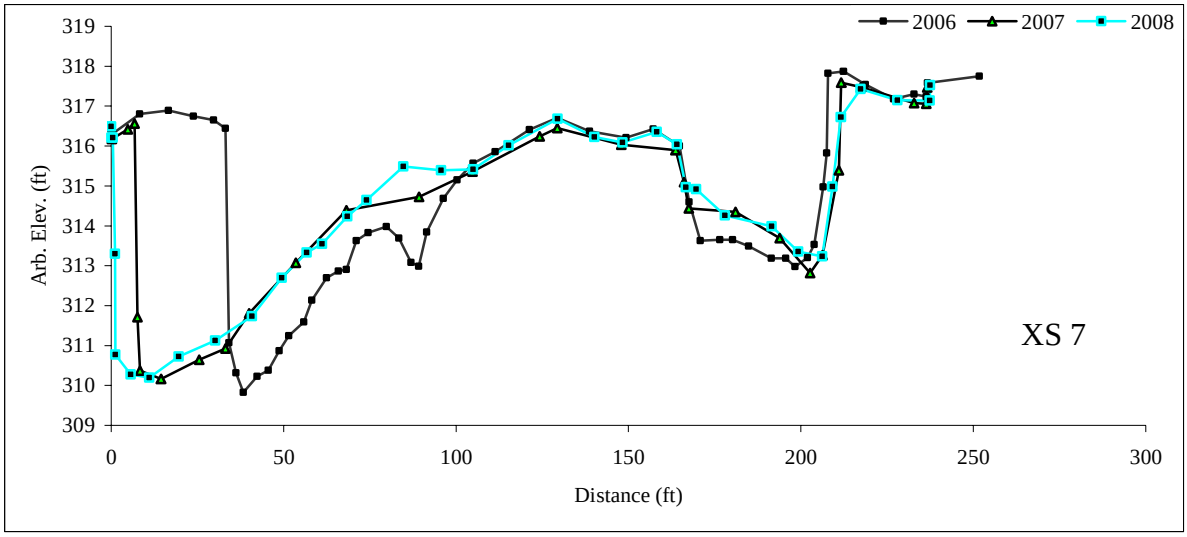
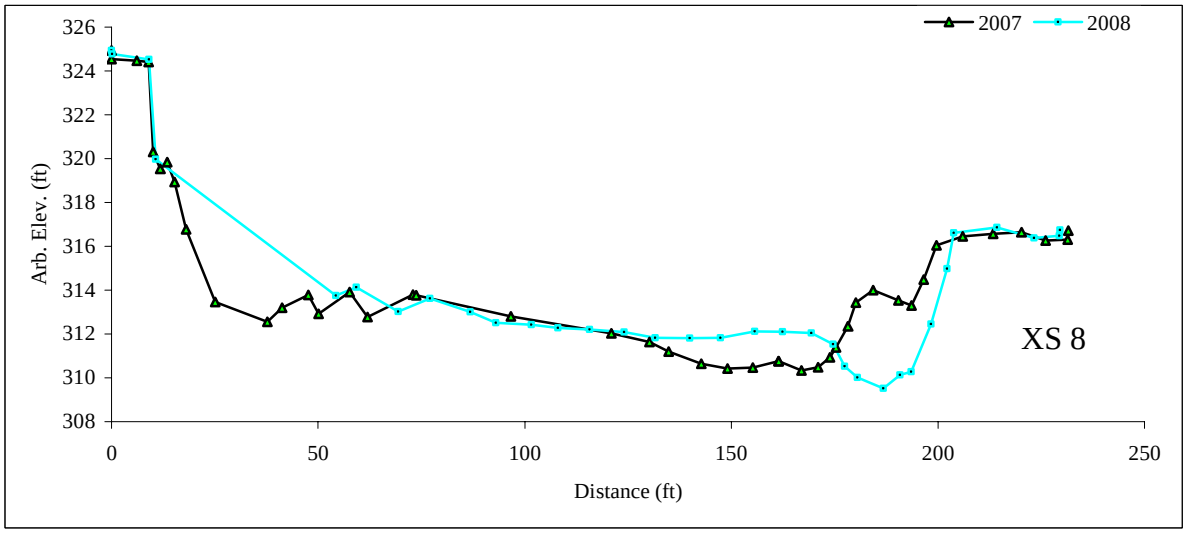


Figure 34. Topographic data collected at eight permanent cross sections located in lower Terwer Creek (2005 – 2008).





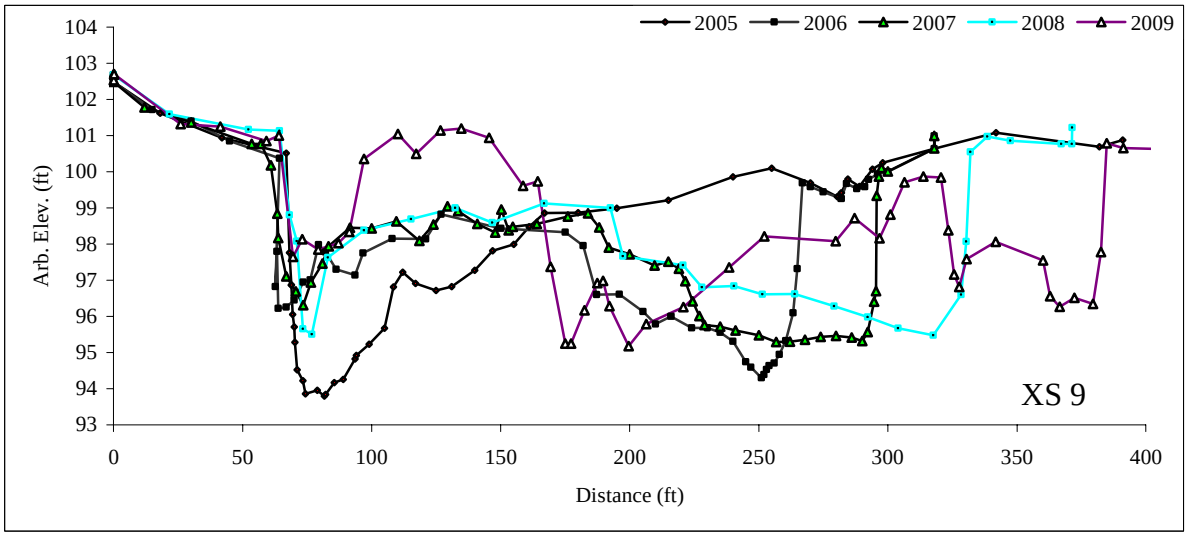
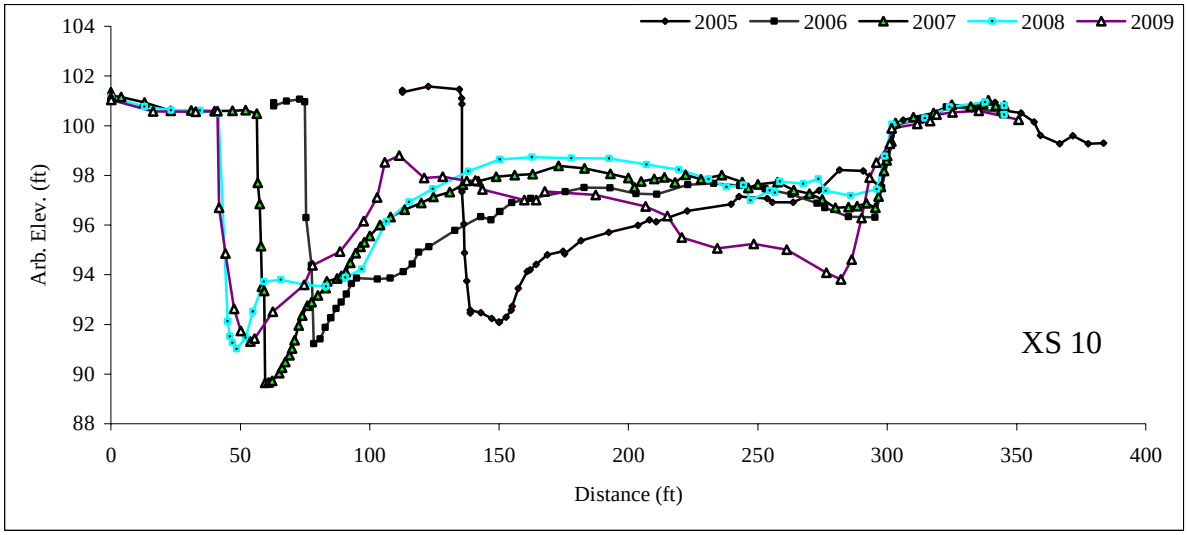


Figure 34. Continued.



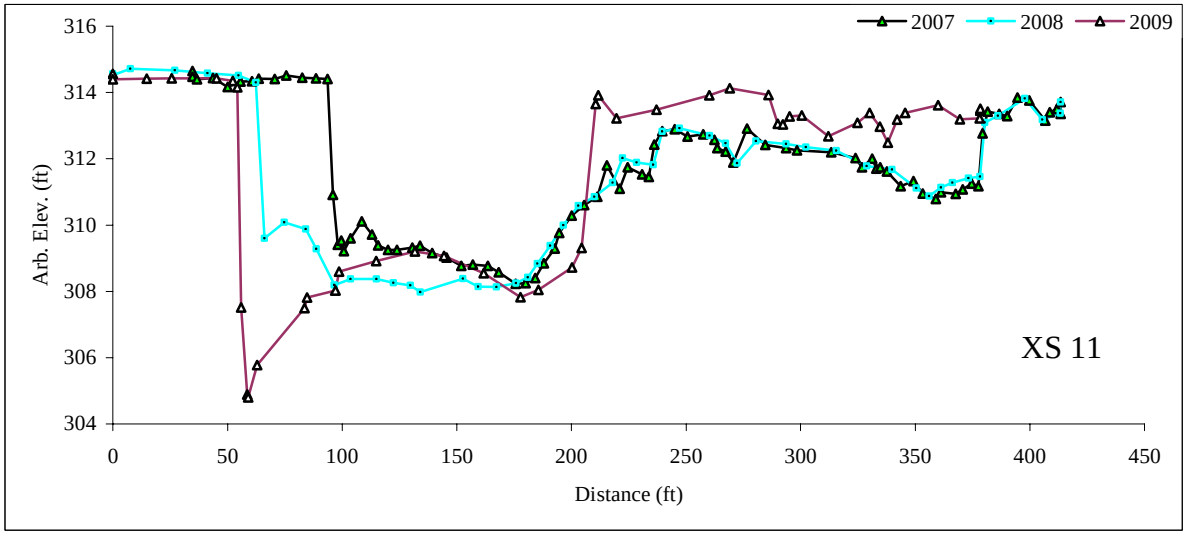


Figure 34. Continued.

Figure 35. Photographs of an eroding bank in the lower portion of the project reach (Site D), Terwer Creek, Lower Klamath River, California (Fall 2009).

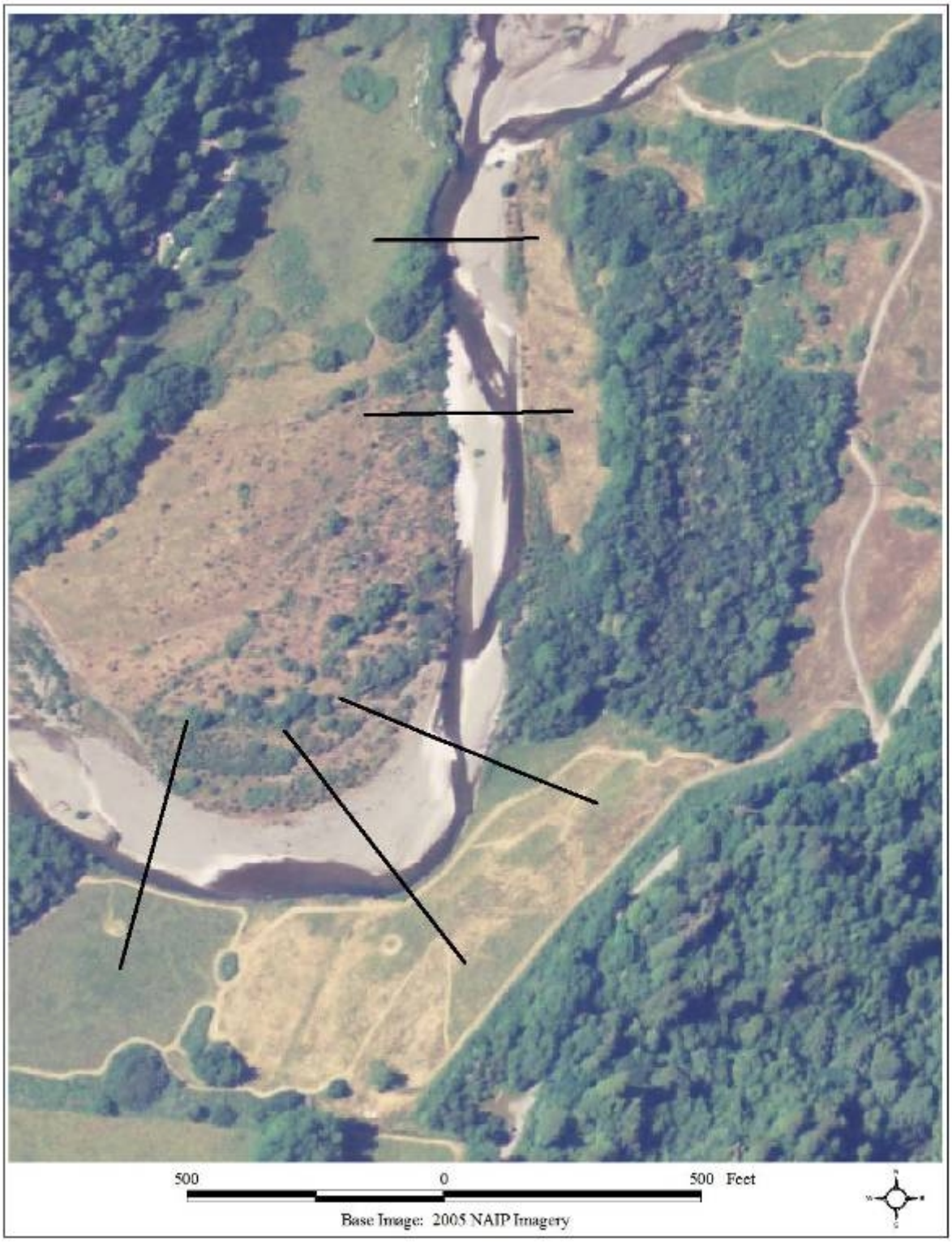


Figure 36. Map depicting permanent vegetation survey transects in lower Terwer Creek.

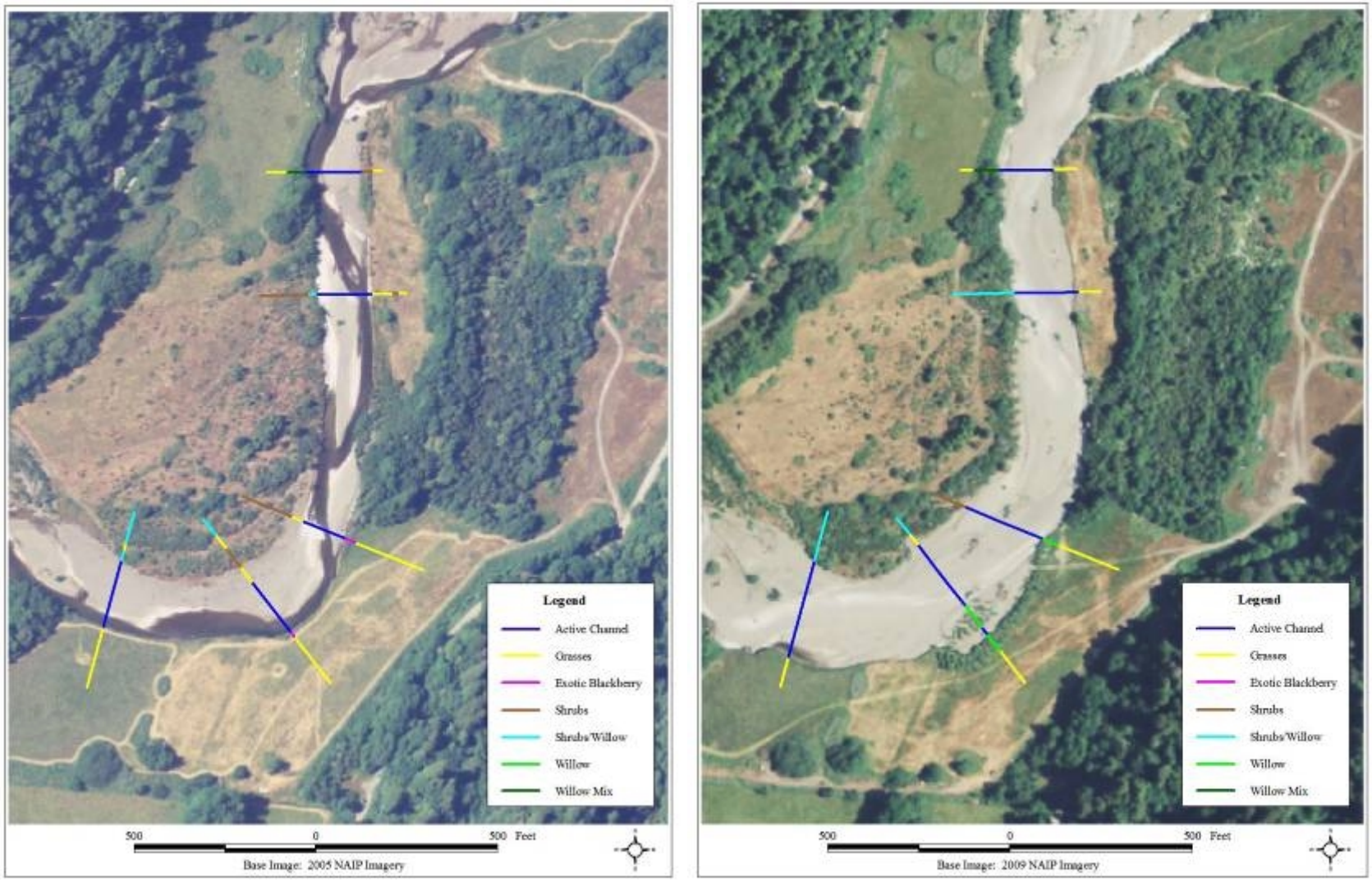


Figure 37. Maps depicting vegetation transect survey data for 2005 (Left) and for 2009 (Right) in lower Terwer Creek.

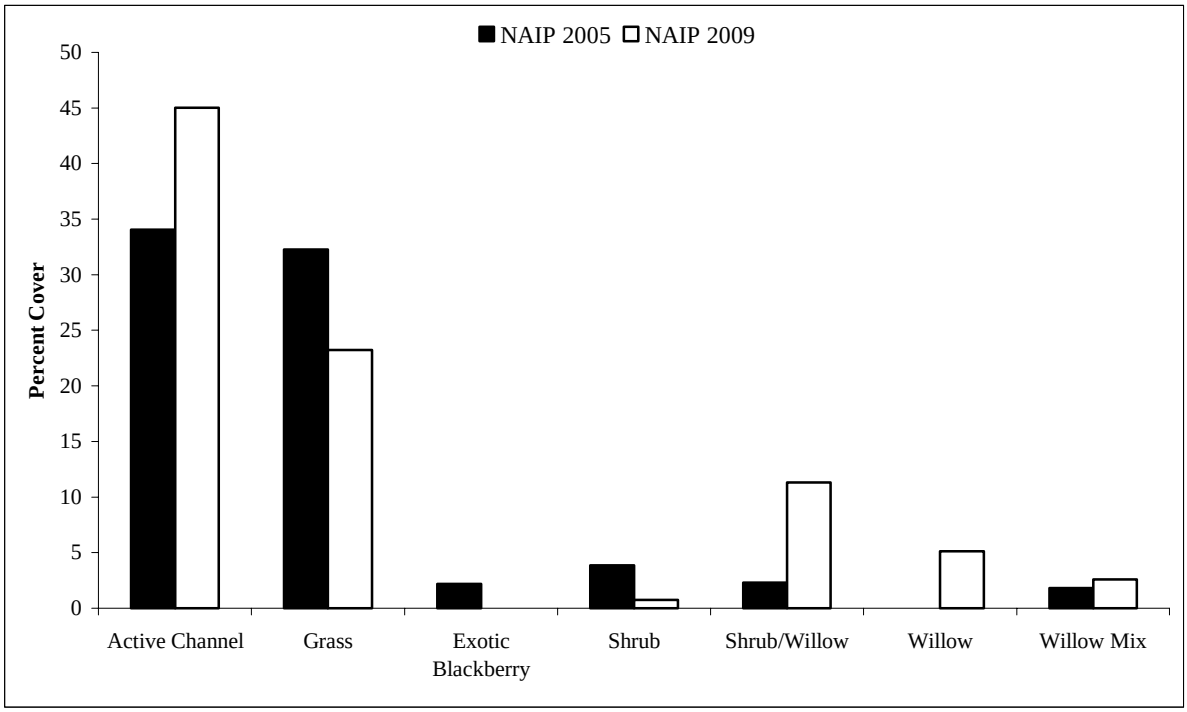


Figure 38. Vegetation cover data collected at five permanent transects located in lower Terwer Creek in 2005 and 2009.