Lower Klamath Tributaries Riparian Restoration Projects and Yurok Tribal Native Plant Nursery

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Acknowledgements

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Introduction

The Yurok People have relied upon Klamath River and coastal resources for their subsistence, cultural, and economic livelihood since time immemorial. Central to Yurok culture is the harvest of anadromous fish. Runs of anadromous fish currently returning to spawn in 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 & 2008; Gale and Beesley 2006; Voight and Gale 1998).

In the Klamath River, all runs of Chinook salmon (*Oncorhynchus tshawytscha*), green sturgeon (*Acipenser medirostris*), and Pacific lamprey (*Lampetra tridentata*)are on the decline and coho salmon (*O. kisutch*) are listed as "threatened" under the Endangered Species Act. The Yurok Tribe is dedicated to rehabilitating degraded 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 (YTWRD), and Environmental Programs have been conducting fisheries and watershed assessments; and implementing instream and upslope restoration activities in the Lower Klamath River Sub-basin since the late 1990s.

Initial restoration planning efforts included developing the Lower Klamath Sub-Basin Watershed Restoration Plan that prioritized upslope restoration and identified tributary specific restoration objectives for each Lower Klamath tributary (Gale and Randolph 2000). Sub-basin restoration objectives included: 1) reducing sediment inputs from upslope sources by treating high priority watershed road segments and stream crossings; 2) restoring native, conifer-dominated riparian forests; and 3) enhancing freshwater aquatic habitats. Since 2007, YTFP has been working with Rocco Fiori of Fiori GeoSciences to design and implement innovative stream and floodplain enhancement projects in priority Lower Klamath tributaries. Treatments have included installation of constructed and engineered wood jams (CWJs and ELJs) to facilitate formation and maintenance of productive fish habitats (e.g. spawning beds, deep pools, slow velocity rearing habitats), and enhancing off-channel habitats to increase salmonid rearing capacity (Gale 2008 and 2009; Beesley and Fiori 2009; YTFP 2010; Fiori et al. 2011a and 2011b).

Slow velocity habitats such as beaver ponds, pools associated with complex wood jams, and off-channel habitats (e.g. backwater pools, side channels) are important to both adult and juvenile salmonids. These types of habitats provide salmonids refuge from high water velocities or poor water quality occurring in the river, and offer diverse habitats for fish to rest, forage, and/or stage prior to initiating ocean entry or upriver migration. These areas are especially important to juvenile salmonids during winter - spring and directly influence fish growth just prior to ocean entry (Lestelle 2007). Overwinter growth and survival of juvenile salmonids is very important since it is well documented that ocean survival of juvenile salmonids is positively correlated to their size at ocean entry (Scrivener and Brown 1993; Quinn and Peteren 1994). Studies conducted in Oregon indicate that ocean survival of juvenile chinook was greatly increased when fish entered the ocean at sizes greater than 120 mm fork length (Nicholas and Hankin 1989).

In 2009, YTFP received grant funding through the National Oceanic and Atmospheric Administration's (NOAA) Coastal and Marine Habitat Restoration Program (American Recovery and Reinvestment Act Funds). The primary objectives of this project were to implement priority restoration measures in two coastal tributaries of the Lower Klamath River, expand and maintain the Yurok Tribal Native Plant Nursery to provide native plants for restoration and cultural purposes, and to provide critically valuable employment and educational opportunities for Tribal and local community members. Several other funding sources were used to accomplish coastal habitat restoration and project effectiveness monitoring project tasks. Project partners included private landowners including Green Diamond Resource Company and a small-scale rancher, NOAA, the U.S. Fish and Wildlife Service (Partners for Fish and Wildlife – Klamath River Program) (USFWS), the U.S. Department of Agriculture (USDA), Karuk Tribe and Larry Lestelle, the U.S. Bureau of Reclamation (BOR), and the U.S. Geological Society (USGS).

Project Objectives

The primary objectives of the NOAA coastal restoration project included:

- Reestablishing native conifers and deciduous trees in riparian habitats of two priority Lower Klamath River tributaries heavily impacted by historic logging and road building activities. These actions were implemented to facilitate increased recruitment of large wood to fluvial habitats, and to promote increased channel stability and riparian forest resiliency. This task was accomplished through coordinated use of NOAA and USFWS funding.
- Expanding and maintaining the Yurok Tribal Native Plant Nursery (YTNPN). YTFP propagates native plants for habitat restoration projects and to provide a source of medicinal and culturally significant plants for Yurok Tribal members. Nursery related tasks were accomplished through coordinated use of NOAA and USDA funding.
- Restoring habitat complexity and stream channel stability in lower Terwer Creek by installing willow siltation baffles, constructing tree planting islands, and enhancing two off-channel wetlands. These actions were implemented to provide immediate and long-term benefits for adult and juvenile salmonids and other aquatic dependent wildlife. These tasks were accomplished through coordinated use of NOAA and USFWS funding.
- Evaluating project effectiveness by conducting tree survival inventories within the riparian planting reaches, performing detailed topographic surveys of the lower Terwer Creek project area, and by monitoring salmonid use of the two off-channel wetlands in Terwer Creek. These tasks were accomplished through coordinated use of NOAA, USFWS, and BOR funding and with technical assistance from the USGS.
- Continuing a community-based habitat restoration curriculum in conjunction with the Klamath River Early College of the Redwoods (KRECR).
- Creating high quality, resource-based employment and educational opportunities.

Project Location

The Lower Klamath River Sub-basin encompasses the lower 40 miles of the Klamath River and its tributaries, from the confluence with the Trinity River to the Pacific Ocean (Figure 1). There are 25 anadromous fish bearing tributaries in the sub-basin (Gale and Randolph 2000). The Yurok Indian Reservation extends one mile on either side of the mainstem throughout the lower 44 miles of the Klamath River (Figure 1).

All restoration activities were implemented in Terwer Creek and McGarvey Creek (Figure 2). Terwer Creek enters the Lower Klamath River ~5.5 river miles upstream of the Pacific Ocean (Figures 1-3). Terwer Creek is a fourth order watershed draining approximately 31.8 square miles of steep, forested terrain (Figure 3). McGarvey Creek is a third order stream draining 8.6 square miles of forested hillslopes (Figures 2 & 4). McGarvey enters the Klamath River on the south side of the river approximately 6.3 river miles upstream of the ocean (Figure 2 & 4).

Both watersheds support anadromous populations of late fall-run chinook salmon, coho salmon, steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*), and Pacific lamprey (Voight and Gale 1998; Gale and Randolph 2000; YTFP 2009). Recent studies have revealed substantial use of the lower reaches of these watersheds by non-natal juvenile salmonids, especially juvenile coho salmon (YTFP 2009; Fiori et al. 2011a & 2011b; Pagliuco et al. 2011). Both of these coastal watersheds have been impacted by historic land use practices that resulted in the loss of old growth riparian forests and channel-stored wood, extensive sedimentation of fluvial habitats and channel instability, and a severe loss or simplification of once productive floodplain and slow velocity habitats (Gale and Randolph 2000; Gale and Beesley 2006; Beesley and Fiori 2007 & 2008; YTFP 2010).

The Yurok Tribal Native Plant Nursery (YTNPN) was started by YTFP in 2005 at our office in Klamath, California. The nursery consists of several plots and a recently constructed greenhouse facility (Figure 5). Crews worked on-site to maintain the nursery stock and to help construct the greenhouse. Crews also collected seed and live cuttings from native plants located in several Lower Klamath River Sub-basin watersheds to propagate new nursery stock.

Restoration and Effectiveness Monitoring Activities

Native Tree Planting

A total of 13,250 native conifer trees were planted in 5.3 miles of Terwer Creek (Table 1; Figure 6). An additional 9,987 native conifers were planted in 2.5 miles of McGarvey Creek (Table 1; Figure 7). All tree planting activities were conducted in late winter through early spring 2010 according to methods outlined in Flosi and others (1998). Crews took precaution when burying root systems to prevent "J-rooting". Trees were planted at a spacing of ~ 8-10 ft and crewmembers selected the most favorable microsites for planting (Figure 8). An estimated 200 acres of riparian habitat was planted within these two priority coastal watersheds (Figures 6-7).

Several hundred native conifer and deciduous trees were planted within 9.0 acres of Lower Terwer Creek, herein after referred to as the Lower Arrow Mills project area (Figure 9; Table 2).

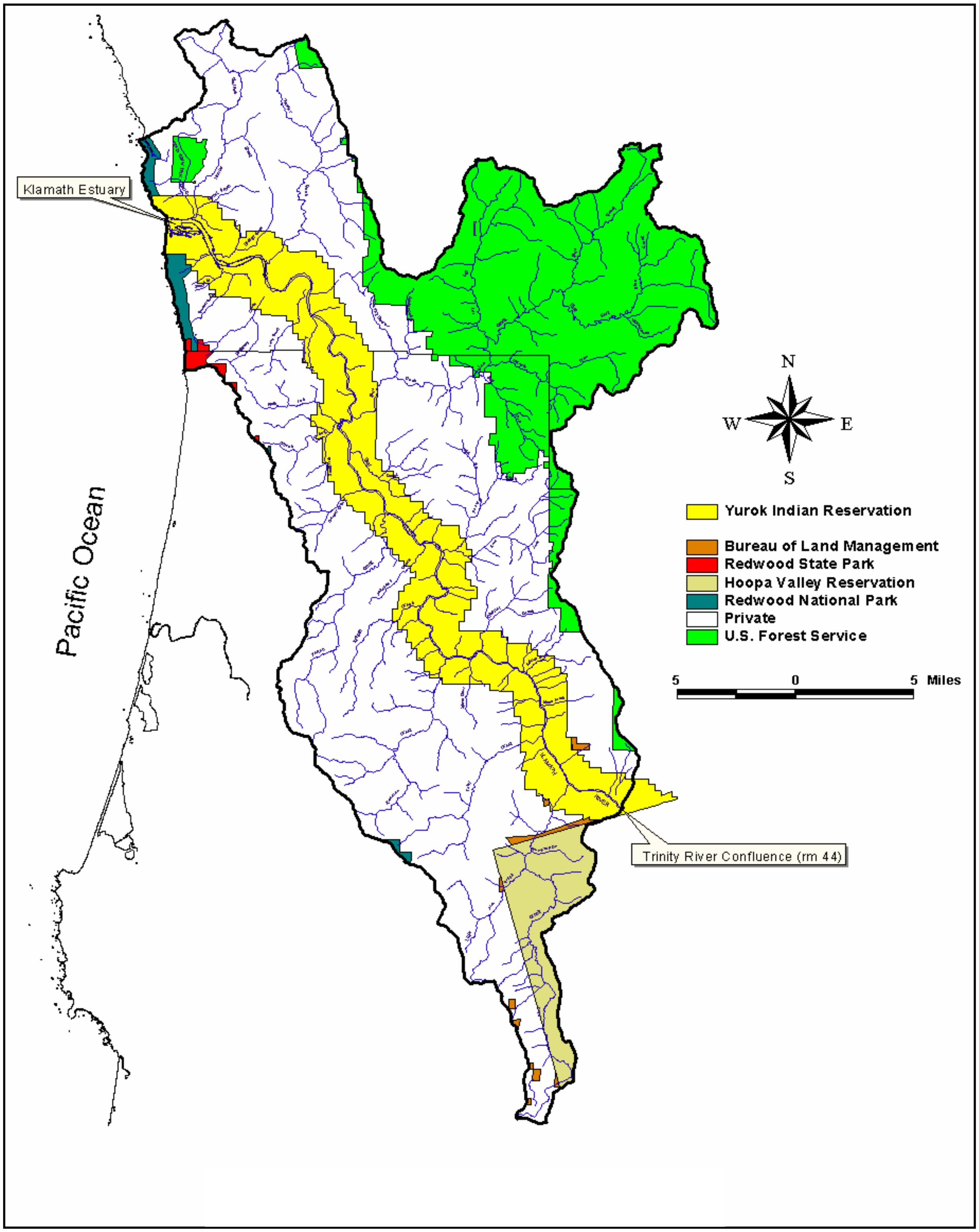


Figure 1. Map depicting landownership in the Lower Klamath River Sub-basin, California.

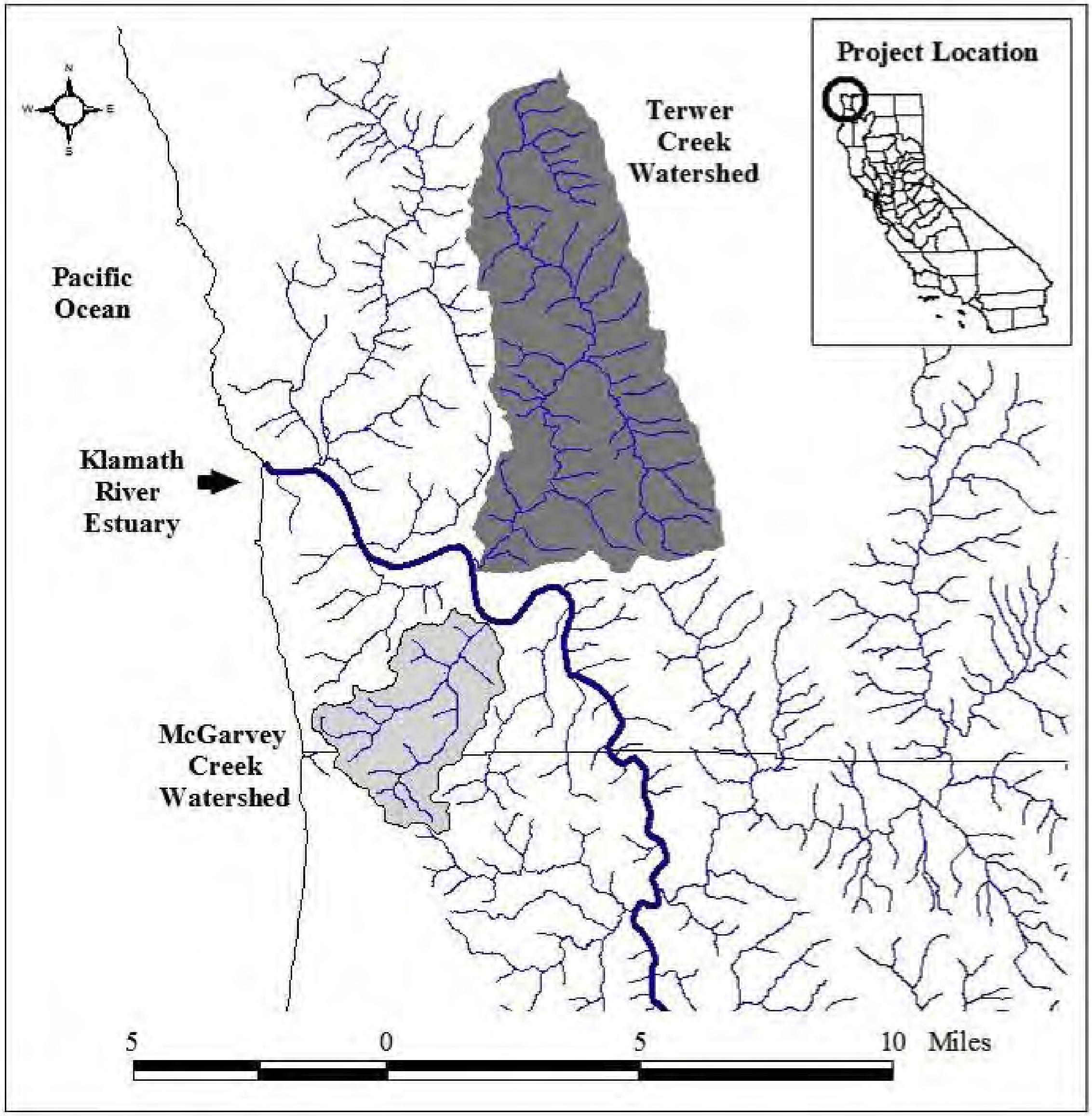


Figure 2. Map depicting two priority Lower Klamath River Sub-basin watersheds, California.

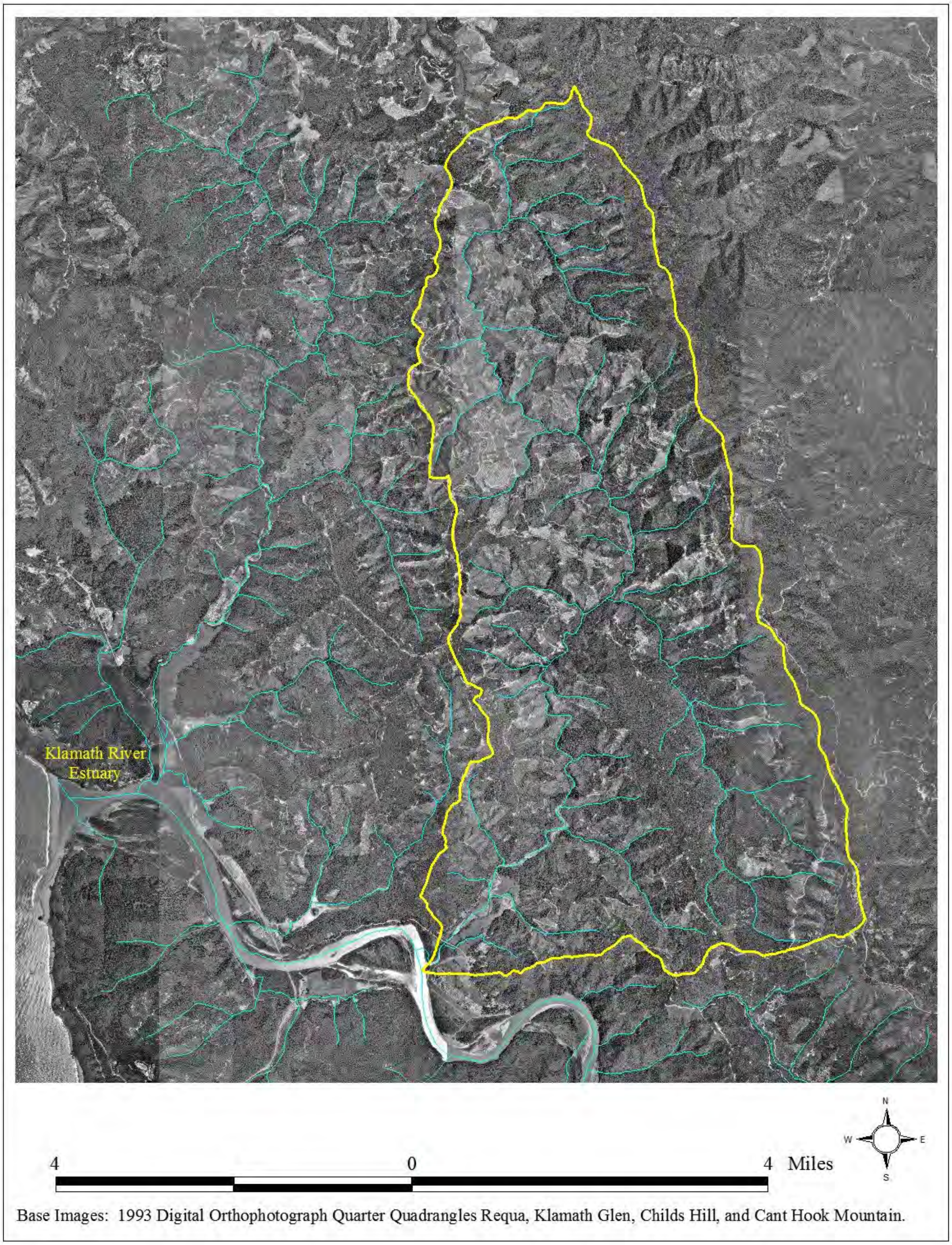


Figure 3. The Terwer Creek watershed, Lower Klamath River Sub-basin, California.

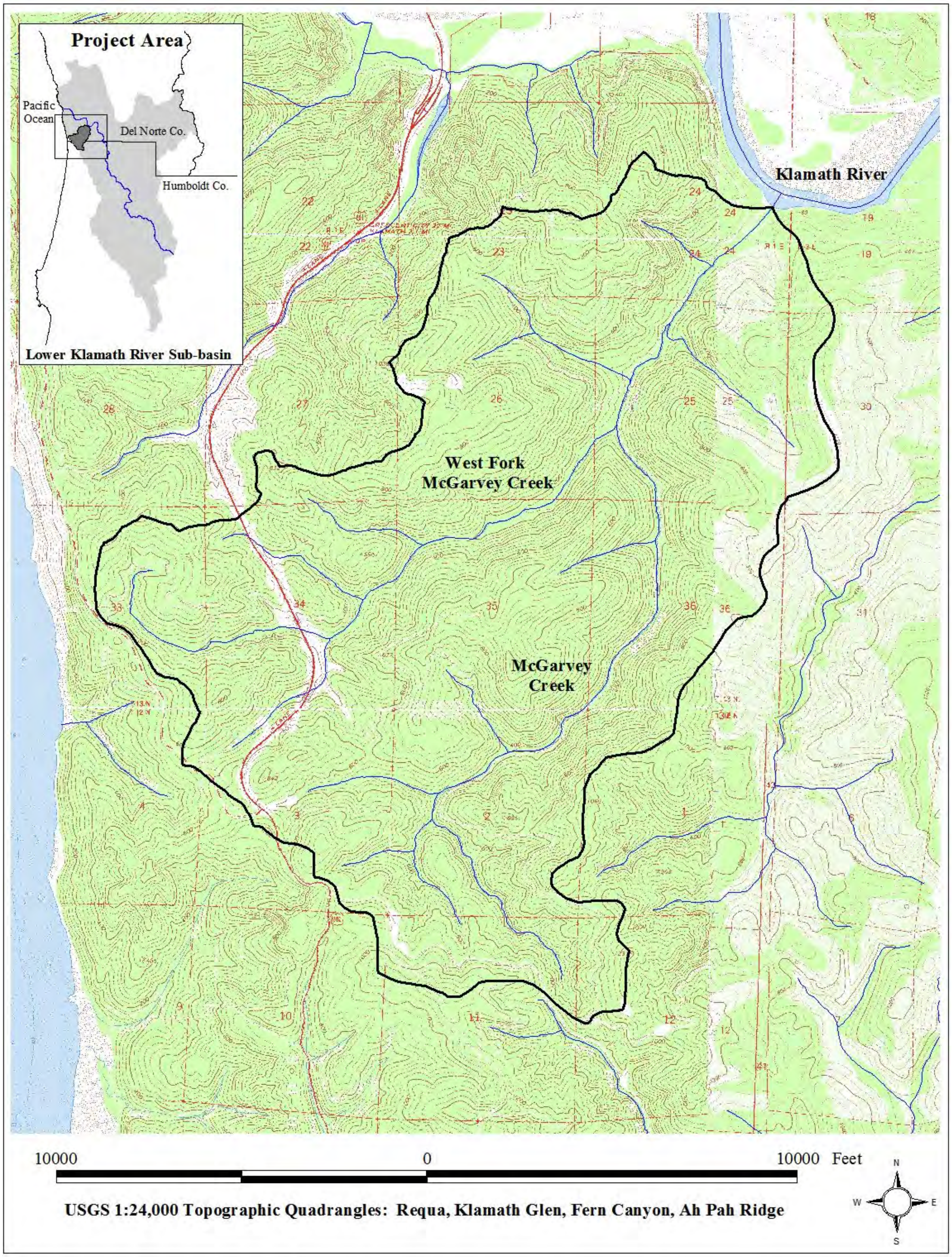


Figure 4. The McGarvey Creek watershed, Lower Klamath River Sub-basin, California.

Figure 5. Photographs of the recently constructed nursery greenhouse (Top) and native deciduous and conifer saplings at the Yurok Tribal Native Plant Nursery, Klamath, California.

Figure 5, continued. Photographs of the recently constructed nursery greenhouse (Top) and native deciduous and conifer saplings at the Yurok Tribal Native Plant Nursery, Klamath, California.

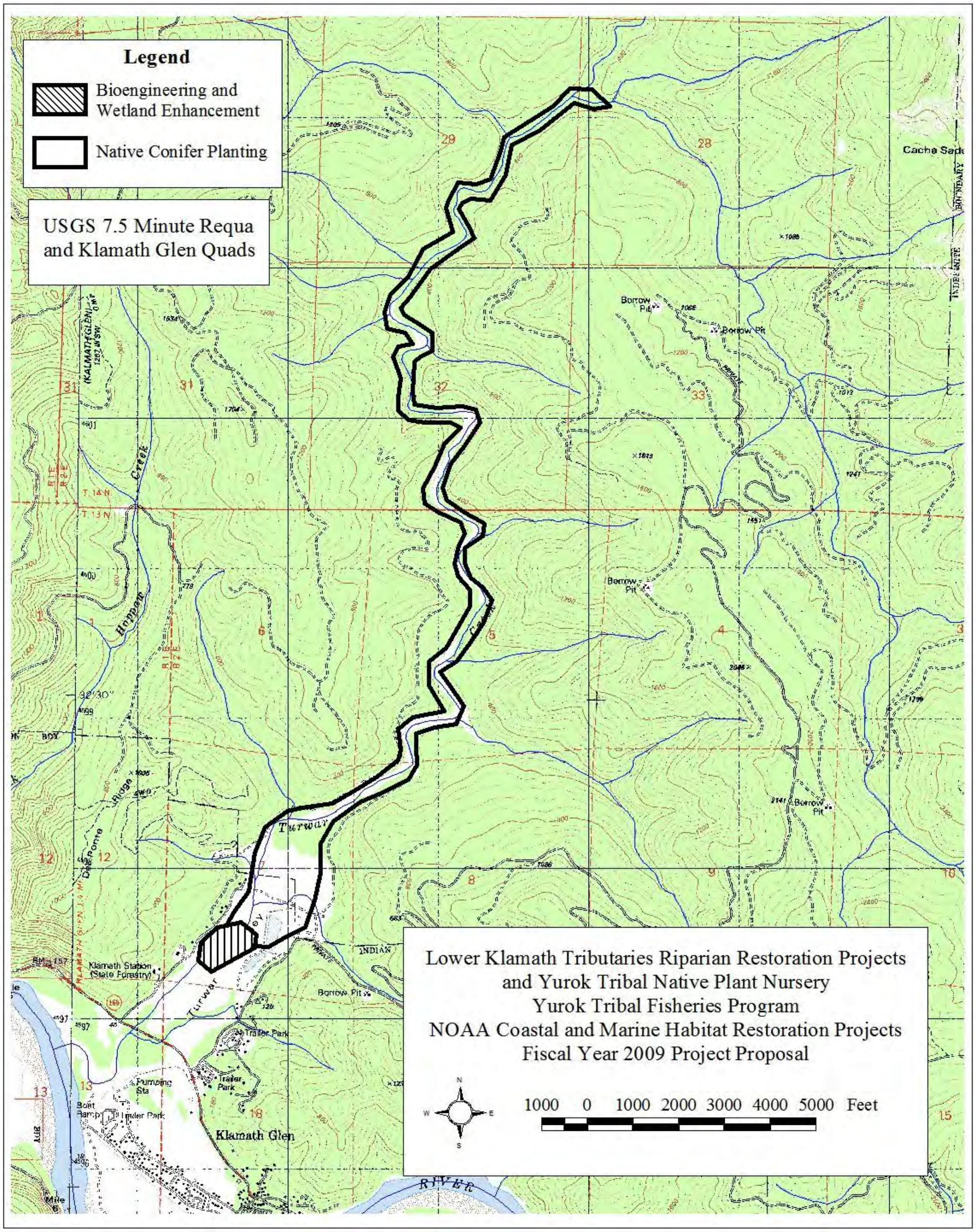


Figure 6. USGS map depicting the bioengineering and wetland enhancement project site and the native conifer tree planting area in Terwer Creek, Lower Klamath River.

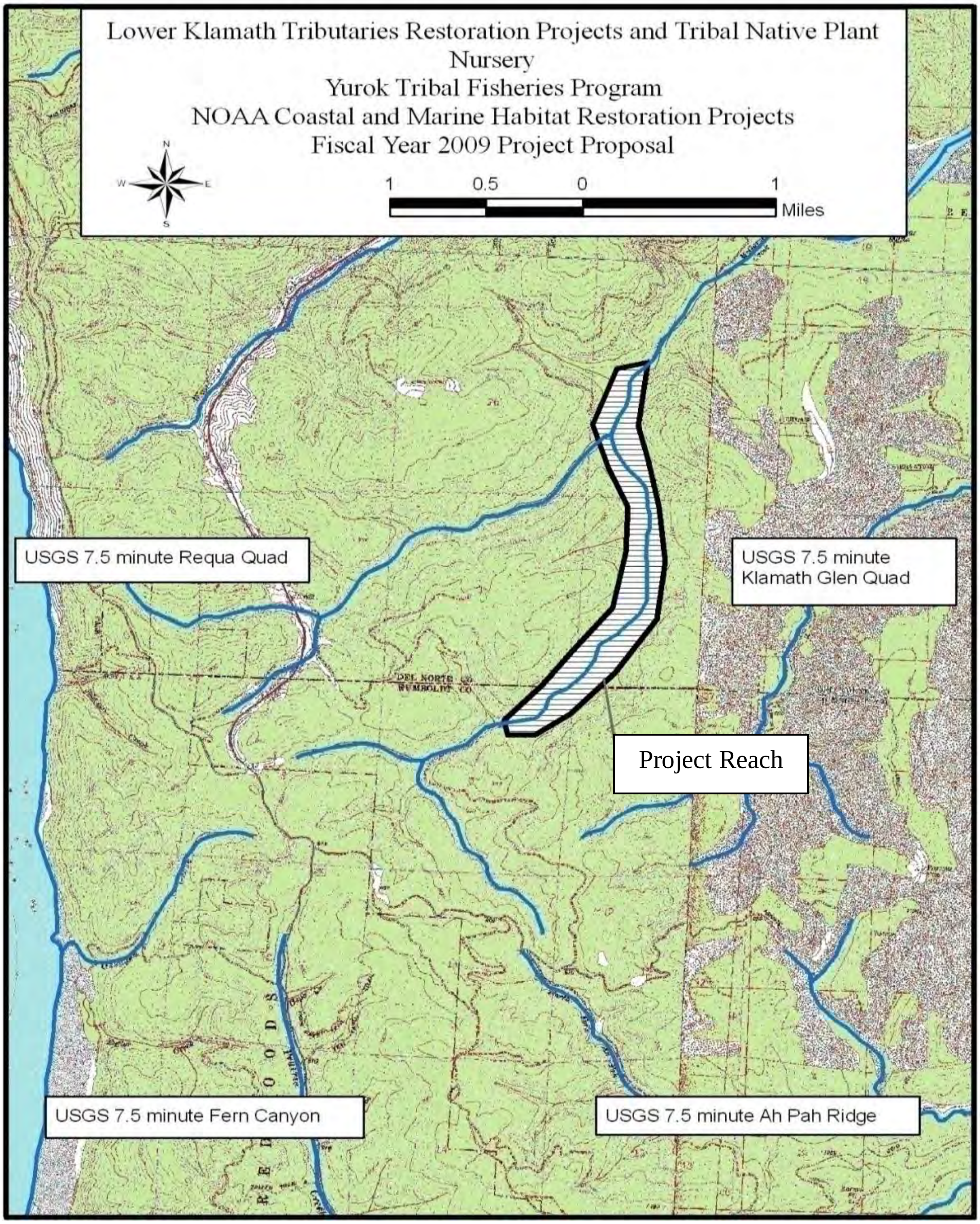


Figure 7. USGS map depicting native conifer tree planting area in McGarvey Creek, Lower Klamath River.

Figure 8. Photographs of YTFP crew members planting trees at the Terwer Creek Pond B Bioengineering site (Top) and in Terwer Creek, Lower Klamath River (Bottom).

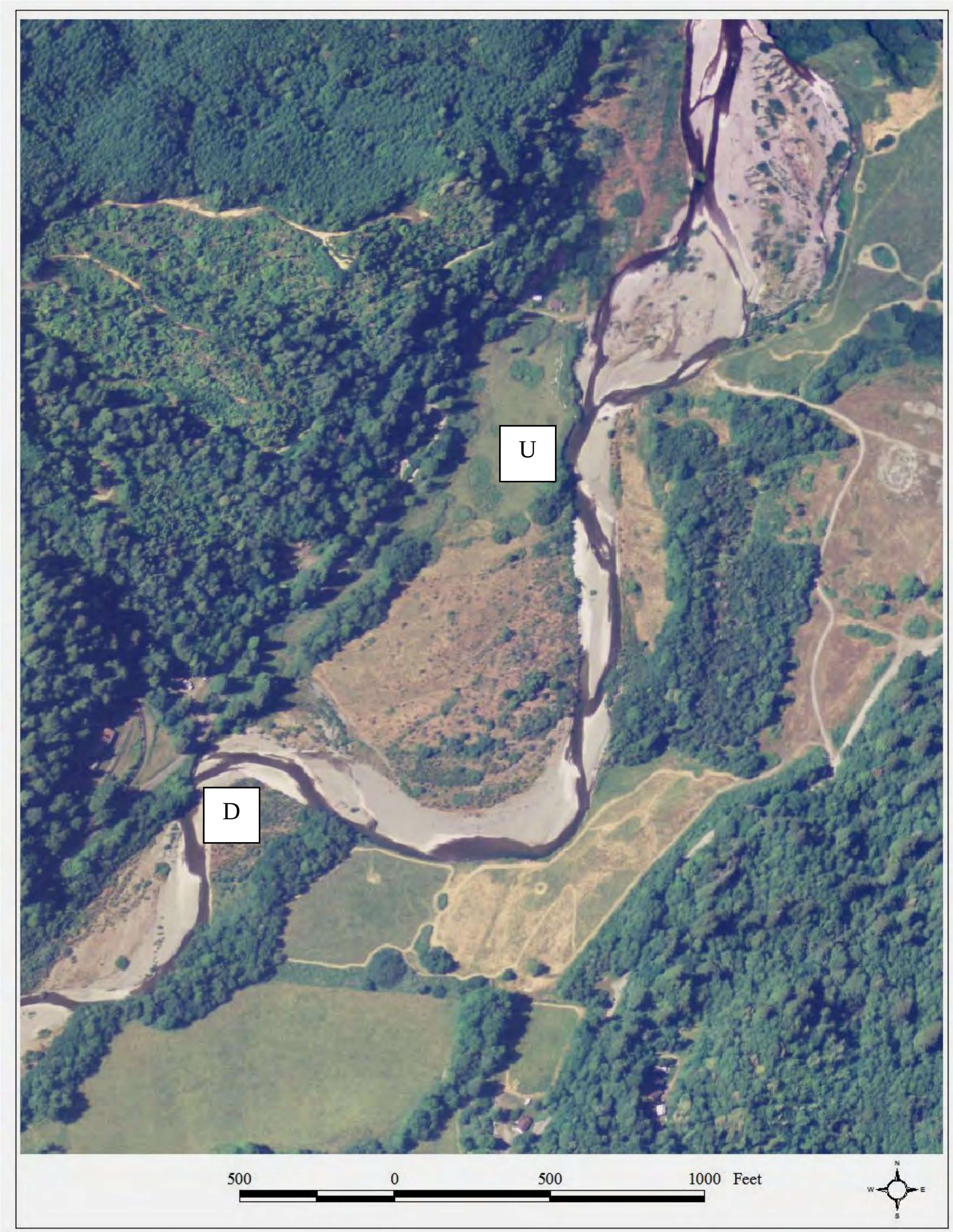


Figure 9. Map of the Terwer Creek valley with the “U” depicting the upper project boundary and the “D” depicting the downstream boundary of the Lower Arrow Mills project area (Base image: 2005 NAIP Aerial Imagery).

Table 1. Native trees planted in riparian habitats of Terwer Creek (exclusive of Bioengineering / Pond B site) and McGarvey Creek during winter – spring 2010, Lower Klamath River.

Tree Species Planted	**Terwer Creek Quantity**	**McGarvey Creek Quantity**
Douglas Fir	6,000	3,400
Coastal Redwood	6,250	5,437
Sitka Spruce	250	450
Western Red Cedar	750	700
Total	**13,250**	**9,987**

Table 2. Native trees planted at the Lower Arrow Mills project area (Bioengineering / Pond B) during winter – spring 2010, Terwer Creek.

Species	**Number Planted**
Coastal Redwood	34
Douglas Fir	64
Sitka Spruce	92
Western Red Cedar	22
Port Orford Cedar	21
Big Leaf Maple	6
Black Cottonwood	148
Red Alder	61
Tan Oak	0
Total	**448**

Planting in the Lower Arrow Mills project area was conducted by YTFP crews during winter through early spring 2010 according to methods outlined in Flosi and others (1998). In April 2010, YTFP staff and 35 volunteers planted an additional 250 native trees at the site as part of the annual Klamath River Clean Up (Table 2).

YTFP conducted tree survival surveys in Terwer Creek and McGarvey Creek to help assess the effectiveness of riparian planting efforts (Tables 3-4). In August 2010, crews conducted a 100% survey of the trees that were planted in the Lower Arrow Mills project area during winter – spring 2010 (Table 3). In summer 2011, crews established permanent vegetation transects in both the Terwer Creek (n=5) and McGarvey Creek (n=12) planting reaches to assess survival in these areas (Table 4). Transect boundary locations were documented using a hand-held GPS unit. All of the planted trees within a given transect or within the Lower Arrow Mills project area were surveyed to determine species and the condition of the tree. Crews recorded by species the total number of planted trees that were alive and relatively healthy, the total number of trees that were showing signs of stress, and the total number of dead trees. All surveys were conducted during late summer when the trees were assumed to be under the most stress. Survival estimates generated for the three areas planted were all above 80% (Tables 3-5).

Table 3. Tree planting survival data for the Terwer Creek Lower Arrow Mills project area (Bioengineering / Pond B), conducted during August 2010.

Species	**Healthy (live)**	**Moderate Health (stressed)**	**Dead**	**Survival (%)**
Coastal Redwood	34	3	2	95
Douglas Fir	64	8	4	95
Sitka Spruce	92	6	3	97
Western Red Cedar	22	14	5	88
Port Orford Cedar	21	5	4	87
Big Leaf Maple	6	12	4	82
Black Cottonwood	148	11	6	96
Red Alder	61	10	36	66
Tan Oak	0	0	1	0
Total	**448**	**69**	**65**	**89**

Table 4. Tree planting survival data for the Terwer Creek riparian tree planting reach, conducted during summer 2011.

Species	**Healthy (live)**	**Moderate Health (stressed)**	**Dead**	**Survival (%)**
Coastal Redwood	127	34	11	94
Douglas Fir	118	7	4	97
Sitka Spruce	5	0	3	63
Western Red Cedar	14	0	0	100
Total	**264**	**41**	**18**	**89**

Table 5. Tree planting survival data for the McGarvey Creek riparian tree planting reach, conducted during summer 2011.

Species	**Healthy (live)**	**Moderate Health (stressed)**	**Dead**	**Survival (%)**
Coastal Redwood	158	28	11	94
Douglas Fir	81	8	20	82
Sitka Spruce	77	6	19	81
Western Red Cedar	48	15	0	100
Total	**364**	**57**	**50**	**89**

Yurok Tribal Native Plant Nursery

The Yurok Tribal Native Plant Nursery (YTNPN) was developed in 2005 by the Yurok Tribal Fisheries Program to propagate trees and other plants to support out restoration efforts and provide Yurok Tribal members with culturally important plants (Figure 5). The Yurok Tribe is striving to continue and expand the YTNPN and native tree propagation to provide strong genetic diversity of riparian trees within the Lower Klamath Sub-Basin. For this project, crewmembers were provided quality training in nursery operations and native plant propagation and maintenance. Specific tasks included working at the YTNPN to maintain existing nursery stock (weeding, pruning, thinning, and fertilizing), assisting with greenhouse construction and operation, collecting native seed and live cuttings, and propagating new nursery stock from collected seed and live cuttings.

For this project, one of the primary goals was to increase production of deciduous trees and start propagation of native shrubs, conifers, and wetland species. Native trees and plants were to be grown out to the desirable size and planted in selected zones in the Lower Klamath Sub-Basin.

YTFP staff members collected native seed of Tan Oak, Red Alder, Coastal Redwood, Western Red Cedar, Sitka Spruce, Douglas Fir, Chinquapin, Big Leaf Maple, Vine Maple, and California Bay Laurel from the Lower Klamath Sub-Basin for propagation. Seeds were cleaned, processed, and stratified until the planting season began. Trees were transplanted into larger containers as needed during the project and have been sorted and inventoried for allocation to upcoming restoration projects. A total of 735 coastal redwoods, 133 Douglas fir, 200 cottonwood, 300 big leaf maple, 150 tan oak, and 60 California bay laurel were started from seed during the project period, and seed collecting and processing is currently ongoing to continue growing successive age classes of tree species native to our watershed.

In fall 2010, YTFP staff attended the Intertribal Nursery Council Annual Meeting and Workshop in Arlington, Washington. YTFP gave a formal presentation that described the operations and function of the YTNPN and highlighted the nursery work funded by NOAA and the USDA.

Lower Terwer Creek Restoration

In addition to tree planting, several other priority coastal habitat restoration and monitoring activities were implemented within the 9.0 acre Lower Arrow Mills project area (Figure 9).

- Willow Baffle and Planting Island Construction

A total of 194 willow siltation baffles were constructed in the 9.0 acre Lower Arrow Mills project area (Figures 10-13). Willow siltation baffles were constructed using standard bioengineering methods (Engber 2005; Flosi et al. 1998). 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 (Figure 10). 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. All willow was harvested locally, transported to the project site, and then immediately installed with heavy equipment (Figure 13). Large and small woody debris (LWD and SWD) was placed at the base of select baffle sets and into the bed between baffles to increase surface roughness (Figures 12-13). Buried and projecting wood provides increased soil moisture and nutrients to the willows, increased shade for the willows, reduced stream velocities within the baffles, and promotes long-term riparian resilience and productivity.

A total of 23 planting islands were constructed in the Lower Arrow Mills project area using an excavator (Figure 14-15). Planting islands consisted of a combination of large wood materials (e.g. nurse logs and/or rootwads), live willow, and native trees (Figure 14-15). Planting islands were configured to provide increased habitat complexity in the newly constructed off-channel ponds. In addition to baffle and island construction, YTFP also planted ~300 willow sprigs and constructed ~100 ft of willow revetment in association with the constructed off-channel habitats.

- Off-Channel Habitat Enhancement

In late summer 2010, YTFP and Rocco Fiori (Fiori GeoSciences – FGS) used heavy equipment to enhance two existing off-channel habitat features in the 9.0 acre Lower Arrow Mills project

Figure 10. Aerial photograph of lower Terwer Creek depicting recently constructed willow baffles and planting islands, Lower Klamath River (Summer 2011).

Figure 11. Looking upstream at a mid-channel bar in lower Terwer Creek prior to enhancement efforts (Top - December 2005), and following initial enhancement efforts (Bottom -November 2008), Lower Klamath River.

Figure 12. Looking upstream at willow baffles installed on the mid-channel bar to protect Holocene terrace soils and to create low velocity habitat in lower Terwer Creek, Lower Klamath River (01/01/10 – near bankfull event ~ 1,600 cfs).

Figure 13. Photographs of willow baffle construction in Lower Terwer Creek using LWD.

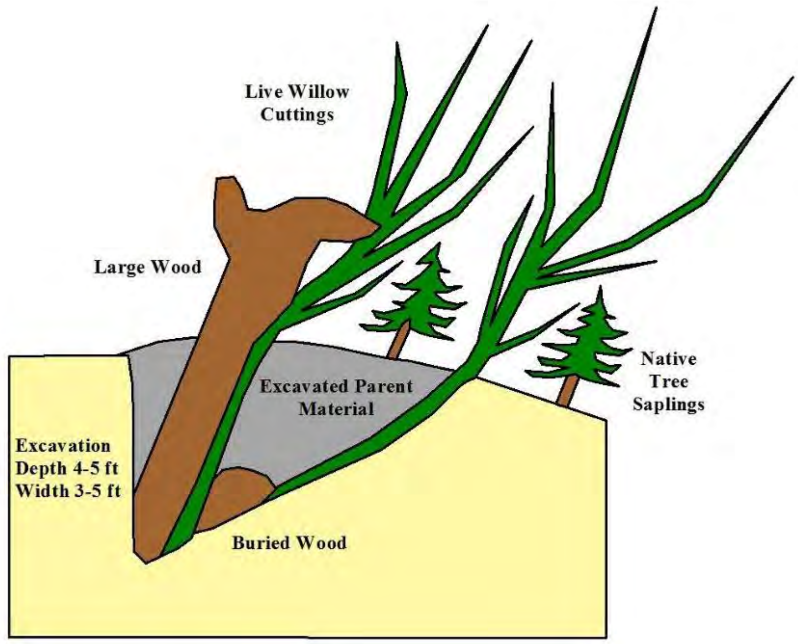


Figure 14. Cross section view of a typical planting island constructed in lower Terwer Creek.

Figure 15. Photograph of three planting islands constructed in lower Terwer Creek.

area (Figures 16-24). The off-channel habitat feature located on the west side of Terwer Creek was named Pond A, while the off-channel habitat feature constructed on the east side of the creek was named Pond B (Figures 16-18). The ponds were excavated to increase the size and depth of the features using an excavator and dozer (Figure 19). Excavated materials were loaded into 20-yard dump trucks and transported off-site to an approved disposal area (Figure 19).

Off-channel enhancement efforts of Pond A included enhancing the existing outlet channel, construction of a 700 ft side channel feature at the existing inlet, and adding large wood and vegetation (e.g. live willow) to increase habitat complexity (Figures 20-21). The volume excavated to form Pond A was approximately 1,200 cubic yards providing an inundated area of ~ 0.39 acres. The as-built design for Terwer Creek Pond A is presented in Figure 22.

Off-channel enhancement efforts of Pond B included construction of a ~300 ft outlet channel, enhancing the existing inlet channel, removing a relic levee to connect Pond B to an existing ~3.5 acre wetland, and adding large wood and vegetation (e.g. live willow and wetland plants) to increase habitat complexity (Figures 23-24). The volume excavated to form Pond B was approximately 5,200 cubic yards providing an inundated area of ~ 1.1 acres. The as-built design for Terwer Creek Pond B is presented in Figure 26.

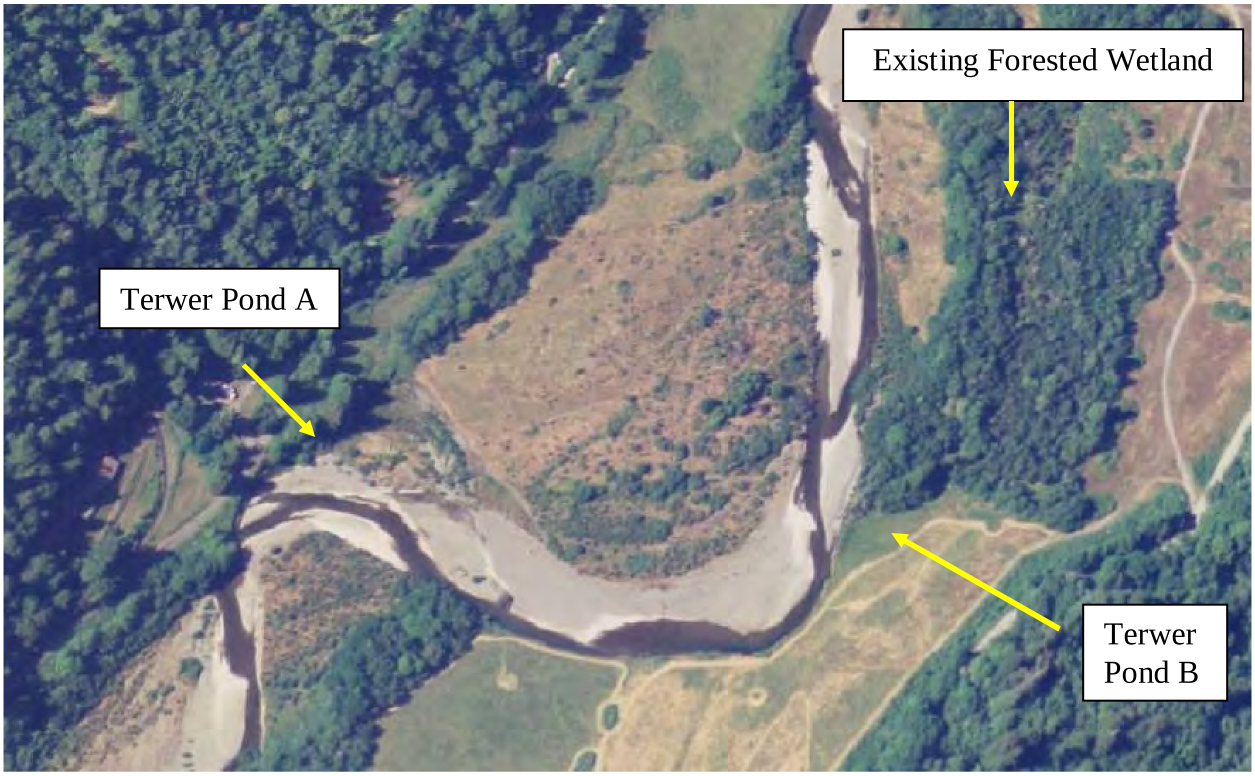


Figure 16. Aerial imagery of lower Terwer Creek depicting existing off-channel habitats prior to enhancement efforts, Lower Klamath River (Base image: 2005 NAIP Aerial Imagery).

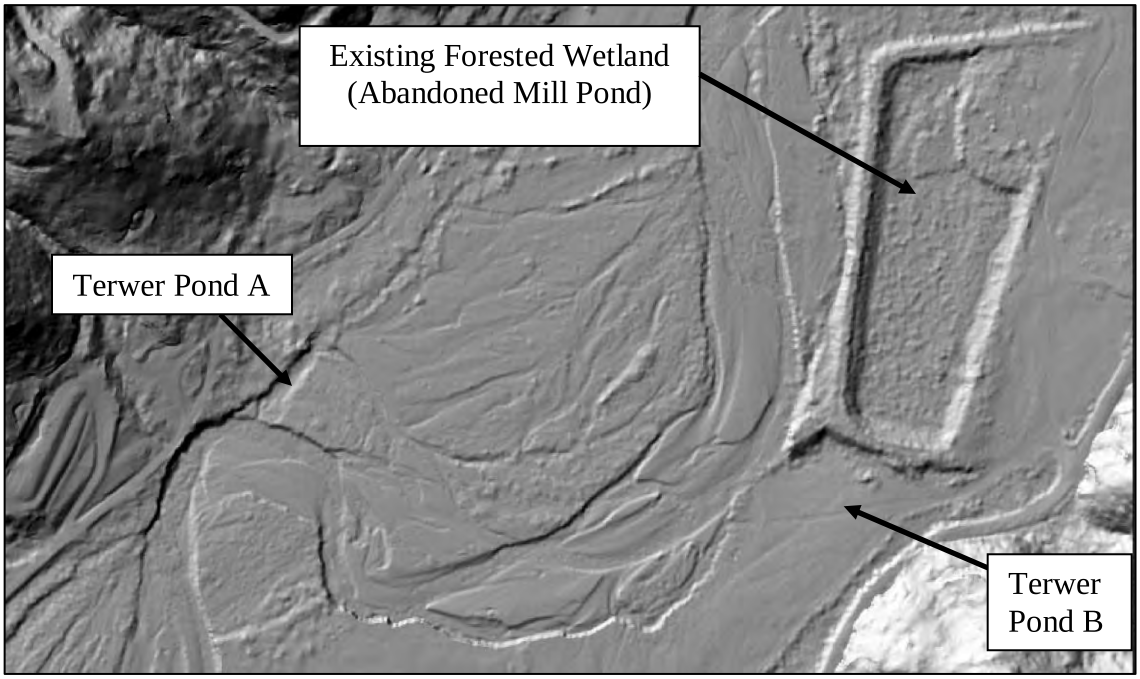


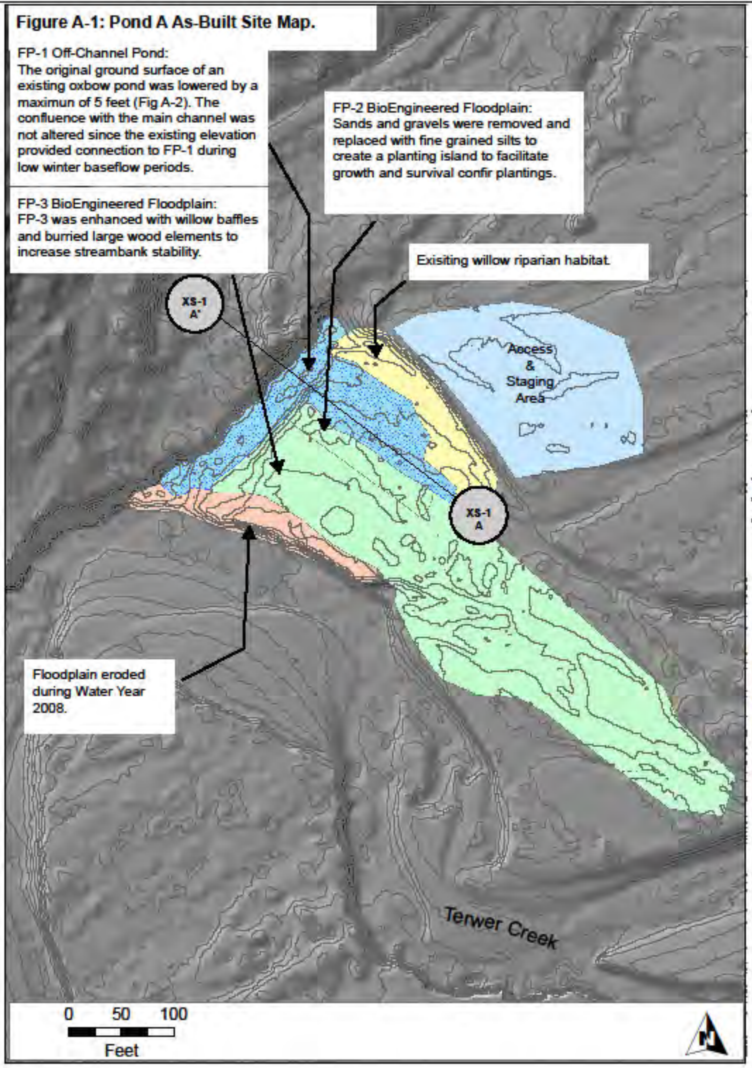
Figure 17. LiDAR imagery of lower Terwer Creek depicting existing off-channel habitats prior to enhancement efforts, Lower Klamath River (Base image: 2009 LiDAR Imagery).

Figure 18. Aerial photograph of lower Terwer Creek depicting recently enhanced off-channel wetland habitats, Lower Klamath River (Summer 2011).

Figure 19. Yurok Tribal Fisheries Program staff using heavy equipment to enhance off-channel habitats in lower Terwer Creek, Lower Klamath River (Summer 2010).

Figure 20. Time series photographs of Pond A constructed during 2010 in Terwer Creek, Lower Klamath River (Photo dates: a) July 15, 2010, b) July 28, 2010, and c) October 31, 2010).

Figure 21. Photographs of the outlet channel of Terwer Creek Pond A (Top) the PIT tag antenna arrays (Top and Bottom), and of the habitat structures constructed in the pond (Bottom).



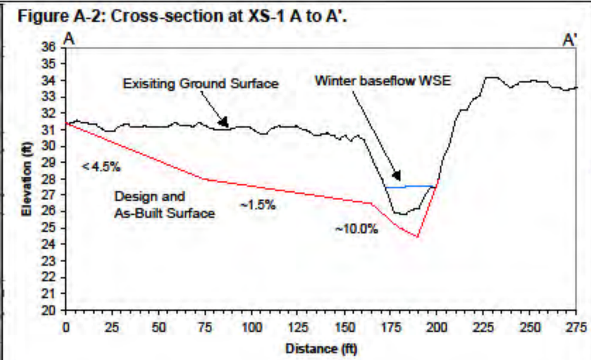


Table A- 1: Estimated Schedule of Quantities

Feature ID	Feature	Area (ft²)	Average Thickness (ft)	Maximum Estimated Volume (yds³)
FP-1	Off-Channel Pond	7,300	4.0	541
	Off-Site Disposal Total			541

Figure A- 3: Pond A post-construction photograph.
View to northwest along line A to A' (shown in Figure A-1).

EXHIBIT A

Terwer Creek - Pond A
As-Built Design

Prepared For:
Yurok Tribe Fisheries Program
Klamath, CA 95548

Prepared By:
Rocco Fiori, PG 8066
Fiori GeoSciences
Klamath, CA 95548

Notes:
Grading was conducted to maximize pond and wetland size within the delineated areas by working with existing topographic and hydrogeomorphic features and within available funding limits.

Ground water return flow and tributary inflows provide hydrologic connection to the main channel during the winter baseflow period.

Grading proceeded as follows:
1) The surface of FP-1 was excavated to create a deep water (>3') habitat that is inundated during winter and spring baseflow periods. FP-1 was over-excavated and silt materials were used as backfill to create a 2 to 3 foot deep soil layer in the bottom of the pond. The surface of FP-1 was sloped to drain towards the existing confluence with Terwer Creek.
2) Sand and gravels were excavated from FP-2. Fine grain silt deposits were imported to create a planting island to facilitate conifer growth and survival. In the long-term larger conifers grown within this planting island will provide shade cover for FP-1. Excavated sand and gravel deposits were re-located to existing gravel stockpiles and existing ranch roads.
3) Large wood elements and willow baffles were installed within FP-1, 2 and 3 to provide stability, improve summer moisture availability and shade, and increase habitat complexity.

Base layer:
2008 LiDAR hillshade and 1 ft contours.

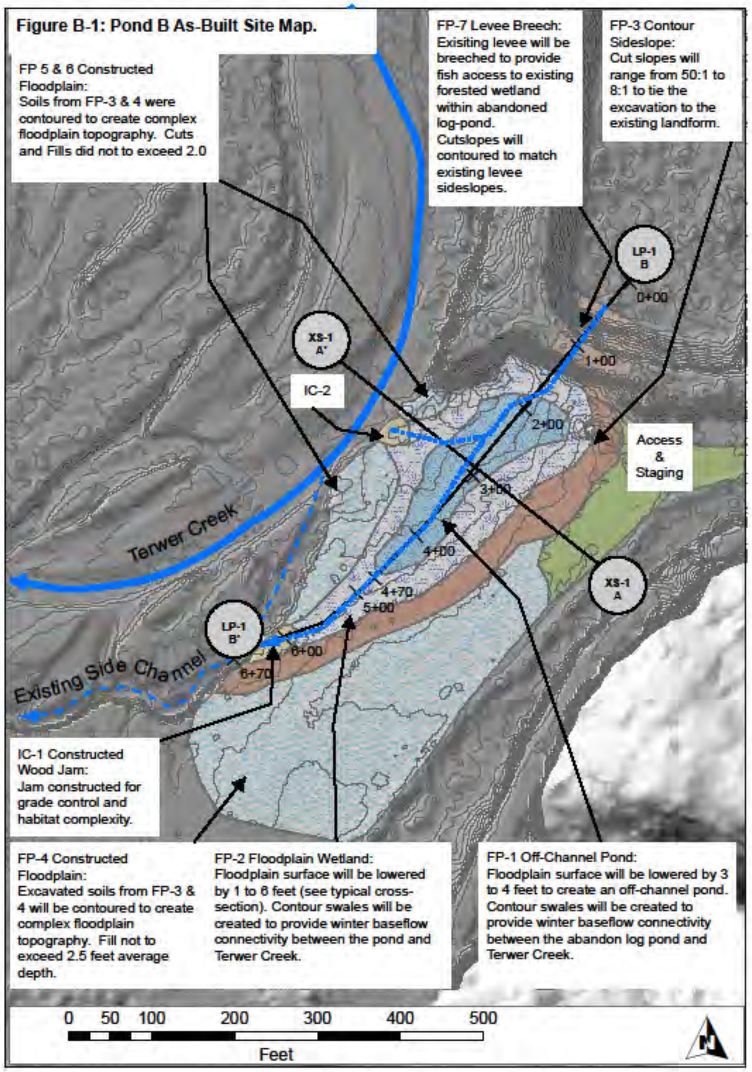
Sheet 1 of 1.

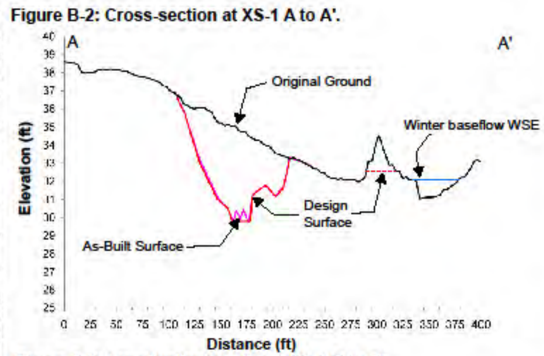
Figure 22. As-built design for Terwer Creek Pond A, constructed in summer 2010.

Figure 23. Photographs of Terwer Creek Pond B prior to enhancement efforts during summer (Top) and during winter flows (Middle and Bottom), Lower Klamath River (2009).

Figure 24. Time series photographs of Pond B constructed during 2010 in Terwer Creek, Lower Klamath River (Photo dates: a) July 15, 2010, b) July 28, 2010, and c) October 31, 2010).

Figure 25. Photographs looking upstream at the breached levee and existing wetland habitats (Top) and looking downstream through the breached levee during off-channel habitat enhancement of Terwer Creek Pond B, Lower Klamath River (summer 2010).





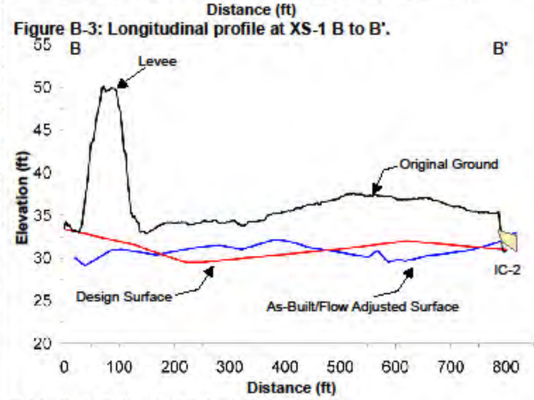


Table B- 1: Estimated Schedule of Quantities

Feature ID	Feature	Area (ft^2)	Average Thickness (ft)	Maximum Estimated Volume (yds^3)
FP-1	Pond	17,393	5.0	1610
FP-2	Wetland	31,963	3.0	3551
FP-3	Contour Slope	20,792	4.0	1540
			Cut Volume Total	5162
FP-4	Constructed Floodplain	69,578	2.0	5154
FP-5	Constructed Floodplain	11,438	1.5	635
FP-6	Constructed Floodplain	1,600	1.5	89
			Constructed Landform Volume Total	5878
			Cut & Fill Balance	-716
FP-7	Levee	10,096	17.0	2300
			Off-Site Disposal Total	2300

EXHIBIT B

Terwer Creek - Pond B As-Built Design

Prepared For:
Yurok Tribe Fisheries Program
Klamath, CA 95548

Prepared By:
Rocco Fiori, PG 8066
Fiori GeoSciences
Klamath, CA, 95548

Notes:
Grading was conducted to maximize pond and wetland size within the delineated areas by working with existing topographic and hydrogeomorphic features and within available funding limits.

The outlet at IC-1 was constructed as the primary ingress and egress point. Ground water return flow from the abandoned log pond and surface water within the pre-existing side channel provide hydrologic connection to the main channel during the winter baseflow period. The pre-existing floodplain elevation at IC-2 provides connection to the pond when Terwer Creek discharge is greater than winter base flow.

Grading proceeded as follows:
1) The floodplain surface at FP-1, 2 & 3 was lowered by an average of 2.5 feet. Fine grained floodplain deposits were contoured on to FP- 4 to create complex floodplain topography. Sand and gravel deposits encountered at depth were excavated separately and placed in an existing gravel stockpile.
2) The pond and connecting swales were excavated to provide deep water (>3') habitats that will be inudated during winter and spring baseflow periods (see Fig. B-2).
3) A portion of the existing levee (FP-7) was removed to provide fish access to

Base layer:
2008 LiDAR hillshade and 1 ft contours.

Sheet 1 of 1.

Figure 26. As-built design for Terwer Creek Pond B, constructed in summer 2010.

- Physical Monitoring

YTFP conducted detailed topographic surveys in the Lower Arrow Mills project area to document both baseline and post-project conditions. For these surveys, YTFP and FGS established a network of permanent bench marks and four cross sections in the project area using a real time kinematic GPS total station, an optical total station, and various survey related computer software. All of the topographic surveys were conducted using the GPS total station or the optical total station and a Recon data recorder. Baseline topographic surveys were conducted in the Lower Arrow Mills project area during fall 2009. Surveys were repeated to document conditions following enhancement efforts (summer 2010) and winter flows (summer 2011). Survey data was then imported into YTFP GIS and Microsoft Excel to create maps and to assess channel migration rates and the pool to riffle ratio (Figures 27-30).

Longitudinal profile survey data for 2010 and 2011 (Figures 27-29) was imported into Long Pro 2 software to analyze the pool to riffle ratio for the Lower Arrow Mills project reach. For this project, staff from NOAA and YTFP set the baseline pool to riffle ratio for the reach at 1:1 and set the target ratio at 1.5:1. The pool depth criteria used for the longitudinal profile analyses was $\geq$ 2.0 ft depth. Analysis of the 2010 longitudinal profile revealed a pool to riffle ratio of 1.3:1 for the project reach. Analysis of the 2011 longitudinal profile revealed an increased pool to riffle ratio of 1.5:1 for the project reach.

The cross section data collected in the Lower Arrow Mills project reach was used to assess channel migration (bank loss (ft) / year). For this project, the baseline channel migration rate was 100 ft/year based on 2009 data. One of the goals of the project was to increase channel stability and a goal of < 1.0 ft/year for channel migration was set by NOAA and YTFP. Negligible bank loss was observed at Terwer XS 8 and Terwer XS 10 from 2010 to 2011 (Figure 30). At Terwer XS 9, we observed negligible bank loss on the left bank and a loss of 14.86 ft of the right bank from 2010 to 2011 (Figure 30). At Terwer XS 11, we observed negligible bank loss on the left bank and a loss of 10.36 ft of the right bank from 2010 to 2011 (Figure 30). The 2011 data for Terwer XS 11 also shows the side channel that was constructed in 2010 on the right bank (Figure 30).

Although YTFP did not meet the pre-determined target established by YTFP and NOAA's for channel migration along the right bank, bank loss along the left bank was dramatically reduced relative to the baseline rate (Figure 30). The left bank is a Holocene terrace comprised mostly of fine grained soils capable of supporting native plants. In contrast, the right bank is a floodprone surface comprised mostly of gravels and sands that limit native plant colonization and survival. Protecting existing soils within fluvial corridors of Lower Klamath tributaries is a priority restoration measure of YTFP.

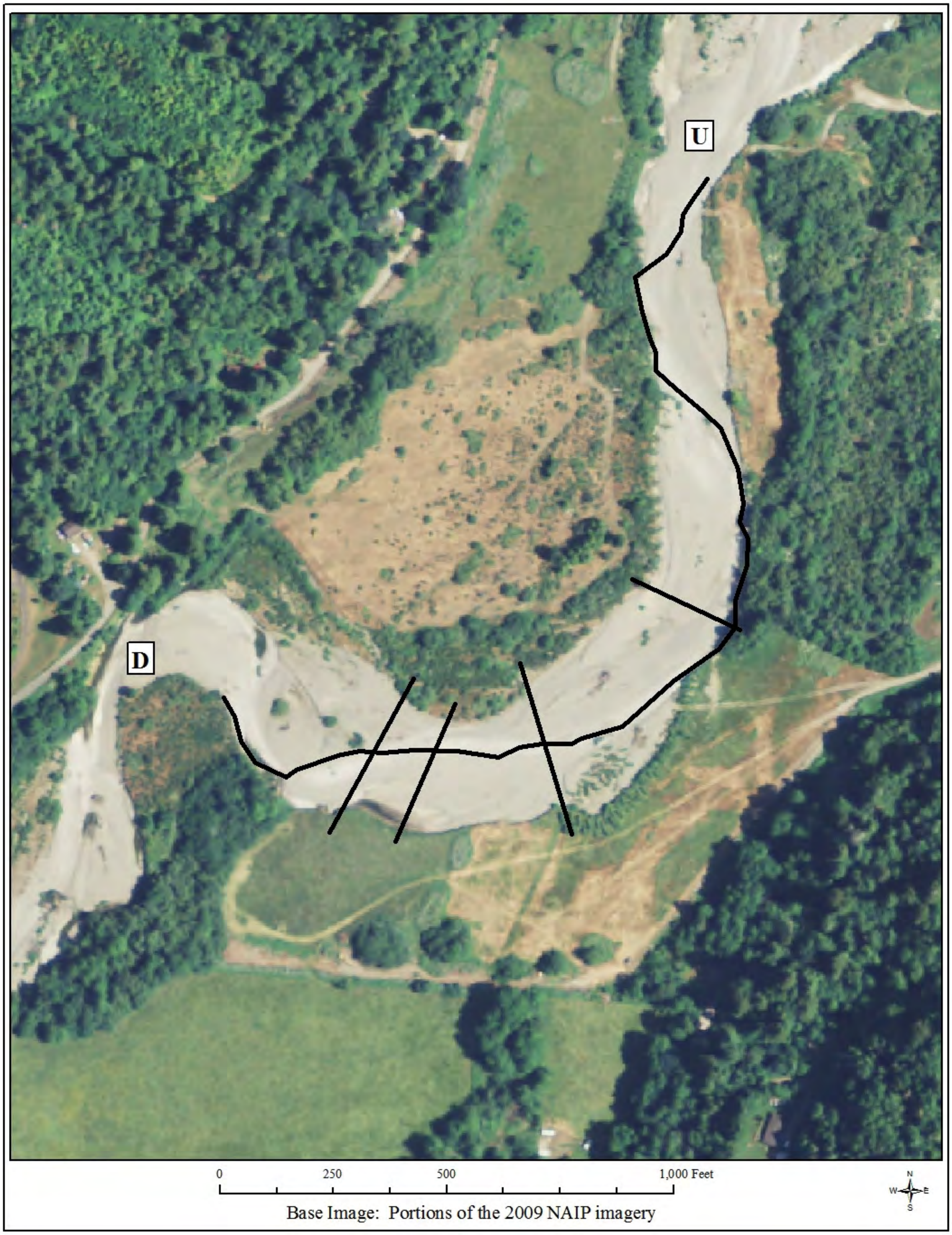


Figure 27. Longitudinal profile and cross sections surveyed during fall 2010 in the Lower Arrow Mills project reach in Terwer Creek, Lower Klamath River Sub-basin.

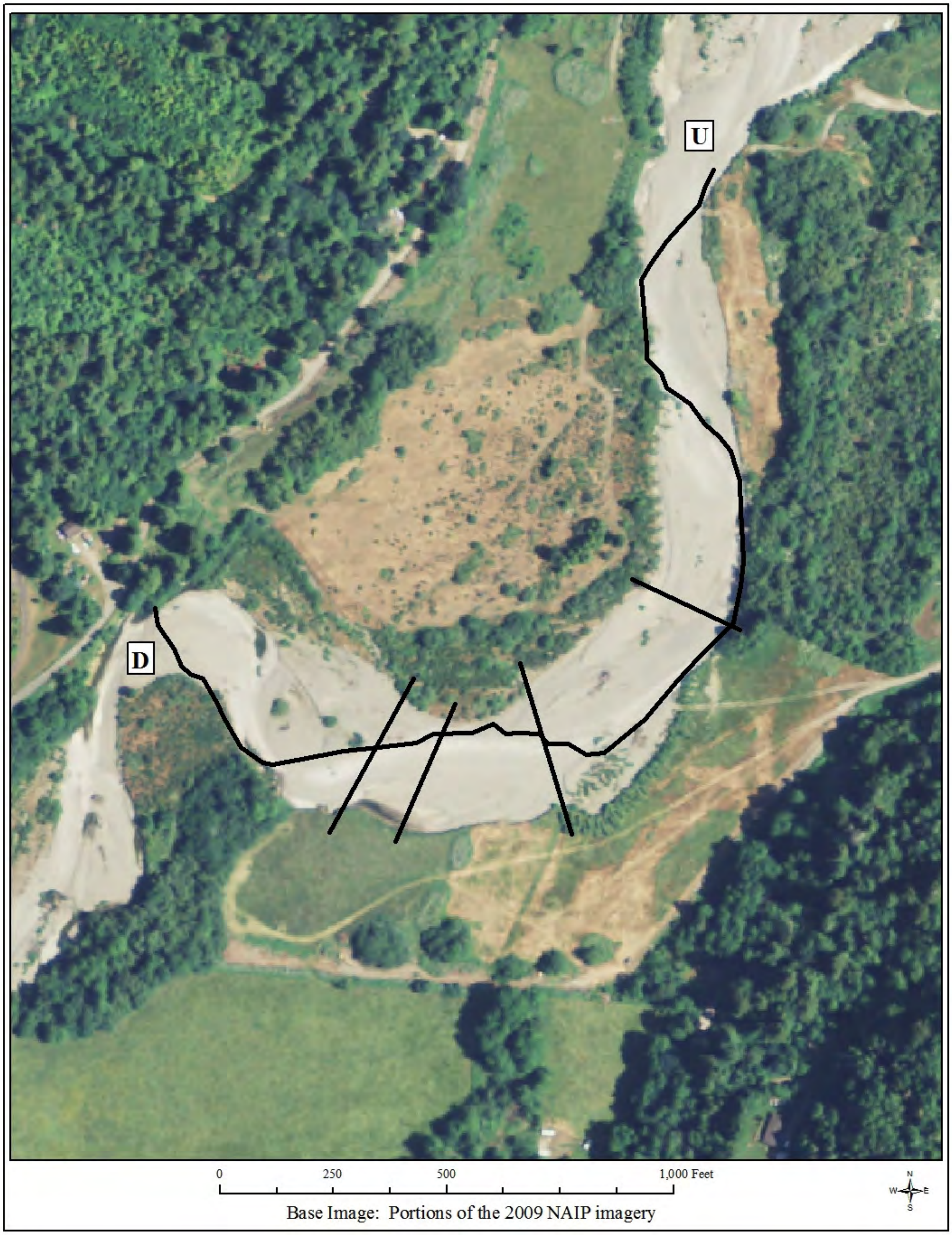


Figure 28. Longitudinal profile and cross sections surveyed during fall 2011 in the Lower Arrow Mills project reach in Terwer Creek, Lower Klamath River Sub-basin.

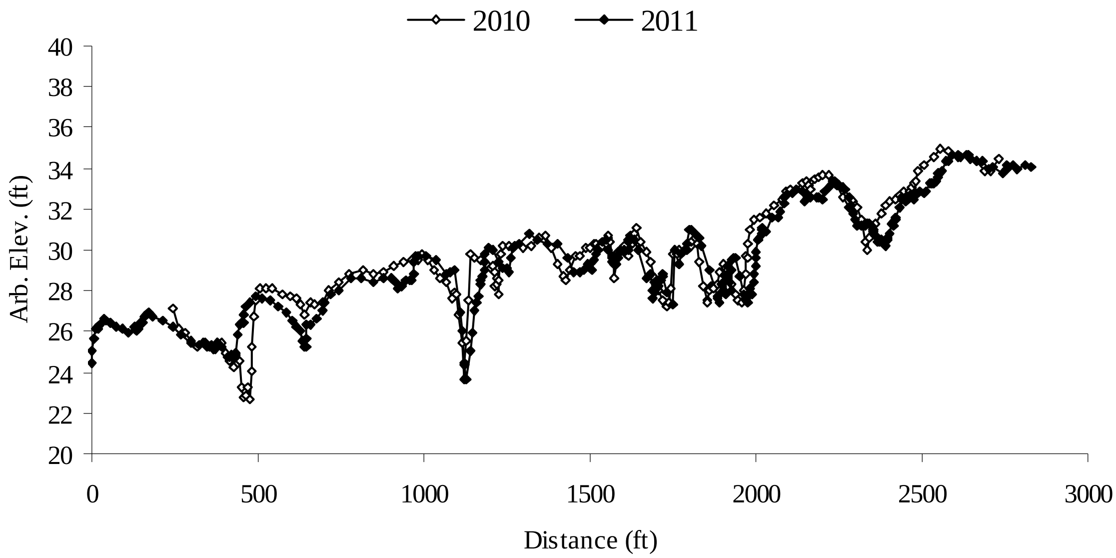
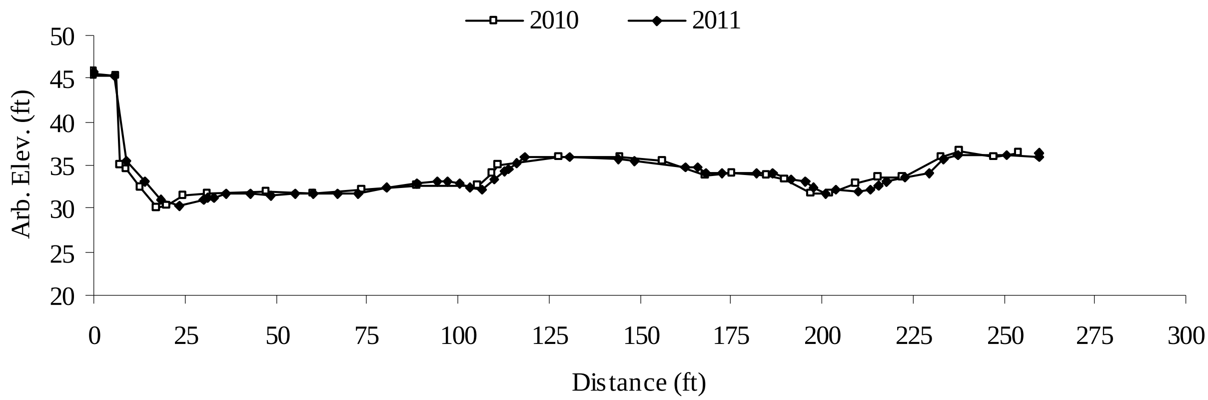


Figure 29. Longitudinal profile data collected in the Lower Arrow Mills project reach in Terwer Creek, Lower Klamath River Sub-basin (Fall 2010 & summer 2011).

Cross Section – Terwer XS 8



Cross Section – Terwer XS 9

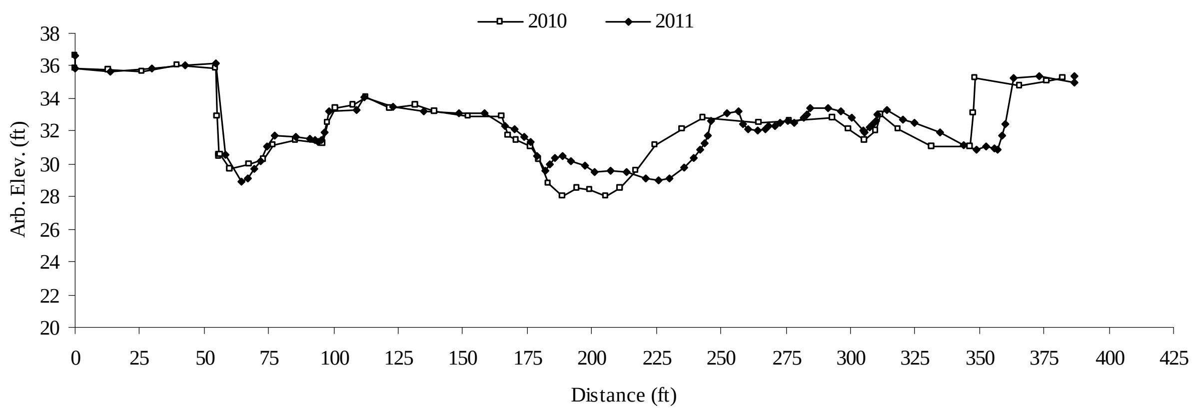
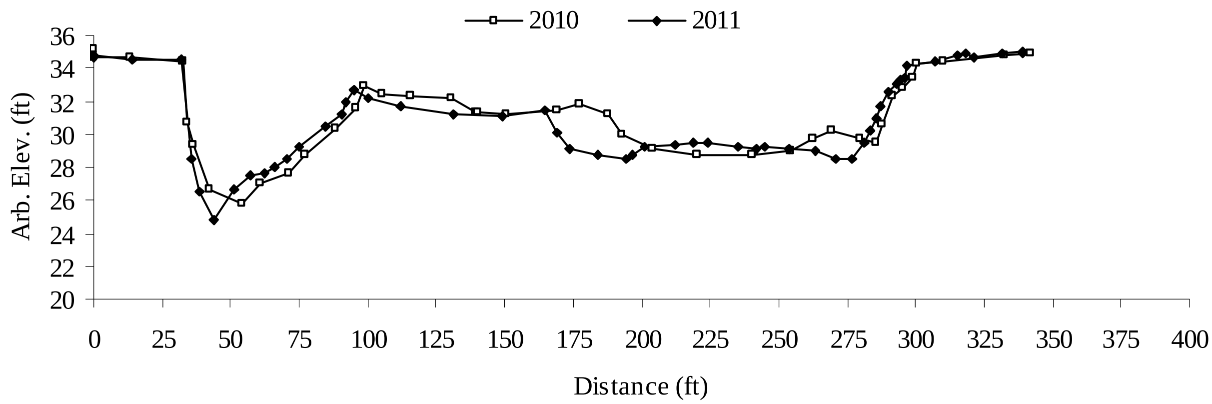


Figure 30. Cross section data collected in the Lower Arrow Mills project reach in Terwer Creek, Lower Klamath River Sub-basin (Fall 2010 & summer 2011).

Cross Section – Terwer XS 10



Cross Section – Terwer XS 11

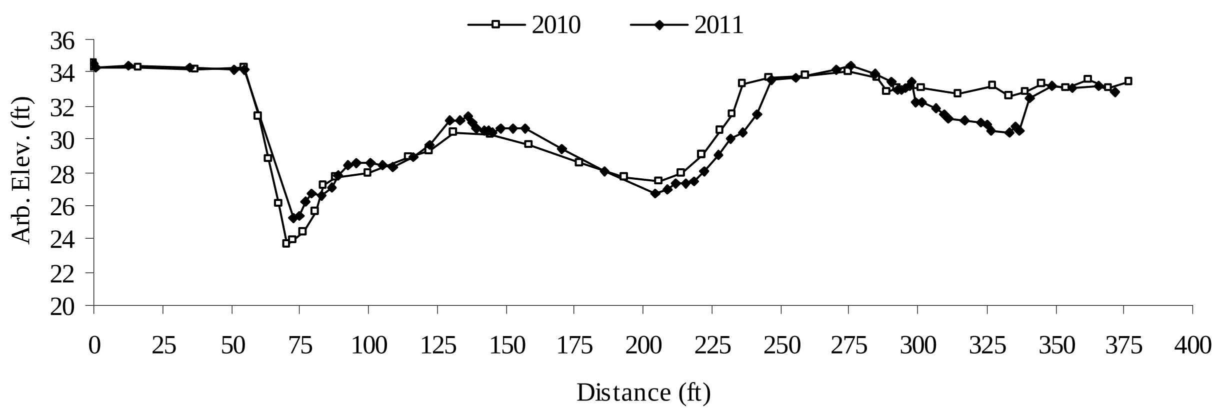


Figure 30. Continued.

Salmonid Use of Enhanced Off-Channel Ponds (Terwer Ponds A and B)

Fisheries sampling was performed throughout the available habitat in Terwer Creek Pond A using two 3 ft x 4 ft hooped fyke nets with a 50 ft lead block net extending from the entrance and center of the trap to the edge of the pond. Each fyke net was configured with 25 ft block nets extended from each side of the trap entrance, at or near a 45 – 80 degree angle to the trap entrance. The shape of Pond A is best characterized as "L" shaped. The upright section of the "L" is the original backwater area that existed before habitat enhancement and includes the outflow, or egress channel, to the off-channel habitat (Figure 31). The lower portion of the "L", or backcove, was enhanced in summer 2010 to increase the amount of off-channel habitat (Figure 32). The first fyke net was placed in the original backwater habitat in a downstream orientation to facilitate capturing fish swimming downstream (Figure 32). The second fyke net was set in the middle of the enhanced backcove. The orientation of this trap was changed after each trapping cycle to investigate whether fish preferred one area over another (Figure33).

Figure 31. Photograph depicting the typical configuration of hooped fyke net traps and block nets set in Terwer Creek Pond A during fisheries surveys.

Figure 32. Photograph of the original backwater area of Terwer Creek Pond A with hooped fyke net placed in a downstream orientation and the PIT Tag antenna arrays.

Figure 33. Photograph of the backcove area of Terwer Creek Pond A with a hooped fyke net with lead block nets extending from the trap entrance.

Fish sampling was performed throughout the available habitat in Terwer Creek Pond B using two 3 ft x 4 ft hooped fyke nets and one 2.5 ft x 3 ft fyke net. All fyke net setups had a 50 ft lead block net extending from the center of the trap opening to the edge of the pond. Each fyke net was configured with 25 ft block nets extended from each sides of the trap entrance, at or near a 45 – 80 degree angle to the trap entrance. For each population estimate, traps were set in three areas of the pond with different habitat characteristics. The first trap was placed in the south end of the pond near the south egress channel in shallow, open water habitat. The trap entrance was oriented facing west so that the trap was perpendicular to the outflow. The lead block net from the center of the trap entrance originated from the western edge of the pond and the end of the net was stretched near the eastern edge of the pond (Figure 34). The second trap was placed in the center of the pond with the trap entrance oriented to trap a deeper area with some willow baffle cover. The third trap was set near the second trap, but the trap entrance was oriented to the north instead of the east (Figure 35).

- Species Presence

YTFP conducted baseline fisheries studies and population estimates in Terwer Creek Pond A in 2009 prior to habitat enhancement. The only salmonid captured during sampling was juvenile coho, and other fish species observed were native species such as three spine stickleback (*Gasterosteus aculeatus*), speckled dace (*Rhinichthys osculus*), and Klamath smallscale sucker (*Catostomus rimiculus*) (Table 5). During the first winter - spring following the habitat enhancement activities implemented during summer 2010, YTFP observed juvenile coho, chinook, steelhead, and cutthroat utilizing the enhanced and enlarged pond habitat.

Baseline fisheries surveys in Terwer Pond B were conducted in March 2010 prior to habitat construction and enhancement during the summer of 2010. During those surveys, YTFP observed juvenile coho (both YOY and 1+), juvenile steelhead, speckled dace, three spine stickleback, Klamath smallscale suckers, and numerous amphibians such as Pacific tree frogs (*Pseudacris regilla*), rough-skinned newts (*Taricha granulosa*), and red legged frogs (*Rana draytonii*) (Table 5). After construction was complete and immediately following the first rainfall events during fall 2010 (following construction), juvenile salmonids were detected by the PIT (Passive Integrated Transponder) tag antennas and captured during fisheries surveys. Juvenile coho, chinook, steelhead, cutthroat, and other non-salmonid species were captured in Pond B during surveys in 2010 and 2011 (Table 5).

Figure 34. Photograph of the fyke net set in the southern area of Terwer Creek Pond B.

Figure 35. Photograph of fyke nets set at the eastern and northern edge of Terwer Creek Pond B.

Table 5. Aquatic species captured during fisheries monitoring activities in Terwer Creek ponds ("x" indicates species presence) prior to habitat enhancement and post-restoration, Lower Klamath River, California.

Species (Common Name)	Scientific Name	**Pond A**		**Pond B**	
Native Fish Species		Pre-Restoration	Post-Restoration	Pre-Restoration	Post-Restoration
Coho 1+	*Oncorhynchus kisutch*	X	X	X	X
Coho YOY	*Oncorhynchus kisutch*		X	X	X
Chinook YOY	*Oncorhynchus tshawytscha*		X		X
Steelhead	*Oncorhynchus mykiss*		X	X	X
Cutthroat	*Oncorhynchus clarkii*				X
Three Spine Stickleback	*Gasterosteus aculeatus*	X	X	X	X
Sculpin Spp.	*Cottus* spp.		X		X
Speckled Dace	*Rhinichthys osculus*	X	X	X	X
Klamath Smallscale Sucker	*Catostomus rimiculus*	X	X	X	X
Amphibians					
Rough-skinned Newt	*Taricha granulosa*		X	X	X
Northwestern Salamander	*Ambystoma gracile*	X	X	X	X
California Red-legged Frog	*Rana draytonii*		X	X	X
Pacific Tree Frog	*Pseudacris regilla*		X	X	X
Tadpoles (various unidentified spp.)			X	X	X
Common Garter Snake	*Thamnophis sirtalis*		X		
Invasive (Non-Native) Fish Species					
Green Sunfish	*Lepomis cyanellus*		X		X
Brown Trout	*Salmo trutta*		X		

- Population Estimates

Mark-recapture fish surveys were performed by YTFP in Terwer Creek Pond A and Pond B during January 2010, March 2010, January 2011, March 2011, and May 2011 to assess population abundance of juvenile salmonids, specifically coho. YTFP conducted mark-recapture sampling in both Terwer Pond A and B and applied the Lincoln-Peterson population estimator to quantify the trends and changes in the populations of the selected species. During sampling periods, there were two trapping events in the cycle for the Lincoln-Peterson model, a 'mark' event and a 'recapture' event. During each event, traps were set for a 24 hour period with a two to three day period between the marking and recapture event.

During the initial trapping (or 'marking') event, all captured salmonids were anesthetized with Tricane Methanesulfonate (MS-222), enumerated and identified by species, measured (FL), weighed (g), and scanned with an Allflex handheld scanner to detect PIT tags. If no PIT tag was detected, all fish greater than 64 mm and 2.9 g were marked with a 12 mm, 134.2 kHz, Super Tag 2 PIT tag. PIT tags were inserted into a small surgical incision made in the underside of the fish near the pelvic fin using a stainless steel sterile surgical blade. All PIT tags were sterilized in povidone/10% iodine hospital antiseptic solution before insertion into the body cavity. PIT tagged fish were scanned with an Allflex scanner and the individual tag numbers were recorded and the fish were identified as PIT tag marks (M). All fish less than or equal to 64 mm and 2.9 g were given a specific fin clip (e.g. upper or lower lobe of caudal fin) and noted as a mark (M). All marked fish were placed in holding pens to recover and then returned to the sampling area after they resumed a normal swimming pattern.

For the second trapping (or 'recapture') event, traps were deployed in the same areas as during the marking event. All target fish captured were anesthetized with MS-222, enumerated, measured, weighed, scanned for a PIT tag, and checked for a fin clip. All fish captured with the appropriate mark from the first trapping event were recorded as a recapture for the mark-recapture cycle. For juvenile coho captured and determined not to have a PIT tag already implanted, one was applied. All fish sampled were placed in holding pens to recover and then returned to the sampling area after they resumed a normal swimming pattern.

Population estimates for coho were calculated using the mark-recapture data and the Bailey (1951) equation of the Lincoln-Peterson estimator. This mark-recapture method assumes:

1. Marked animals (those marked during the first trapping event) had time to mix into the population so that each marked individual has "equal catchablity" as any unmarked individual.

2. Marked and unmarked animals have an equal probability of being caught.

3. All marking must be done at the same time and the population size must remain the same between captures.

4. The number of marked animals does not change between capture events (no loss of marks, no mortality of marked animals, and no migration of marked individuals).

The Bailey Equation:

$$\hat{N} = \frac{(C+1)M_1}{M_2 + 1}$$

Where $\mathbf{M_1}$ is the number of individuals marked in the first capture, $\mathbf{M_2}$ is the number of marked individuals caught in the second capture, **C** is the total second catch, and **N-hat** is the estimated population size (**N**).

The 95% confidence interval was estimated by first calculating the standard error of **N** using the equation:

$$s_N = \sqrt{\frac{N^2(C - M_2)}{(C+1)(M_2 + 2)}}$$

Then the following equation was used to calculate the 95% confidence interval:

$$CI_{95\%} = N \pm 1.96(s_N)$$

Fisheries surveys conducted during January 2010 (prior to habitat enhancement) in Terwer Pond A resulted in an estimate of 36 (95% +/-15) age 1+ coho salmon but no other age classes or species were observed (Figure 36). Population estimates were not conducted in Pond B during January 2010, but were conducted in March 2010 and resulted in the capture of two age 1+ coho and no standard deviation due to small sample size (Figure 36).

Population estimates were performed in Terwer Creek Pond A in January and March of 2011. In January 2011, YTFP estimated 33 juvenile coho salmon (age 1+) with a 95% confidence interval of ±14 fish (Figure 36). This estimate was performed during a period of low stream flows in Terwer Creek. The estimate conducted in March 2011 occurred during a period of higher stream flows. In March 2011, YTFP estimated 18 juvenile coho salmon (age 1+) with a 95% confidence interval of ± 7 fish (Figure 36). A third estimate was performed in mid-May 2011 to evaluate the abundance of coho juveniles using the pond at or near the end of the annual peak coho smolt migration, which occurs between early June and mid-May (Soto et al. 2008; YTFP 2009; Lestelle 2007; Silloway and Beesley 2011). The May 2011 trapping cycle resulted in an estimate of two juvenile (age 1+) coho (Figure 36). Due to the low numbers in the sample and no recaptures in the second trapping event, a 95% confidence interval could not be calculated for this population estimate. During this time of the year, young-of-the-year (YOY) coho and chinook salmon are in the process of redistributing throughout the watershed (Soto et al. 2008; Lestelle 2007). During May 2011, the number of YOY salmon estimated to be utilizing Pond A was 64 (95% +/- 37) coho and 761 (95% +/- 213) chinook (Figure 37).

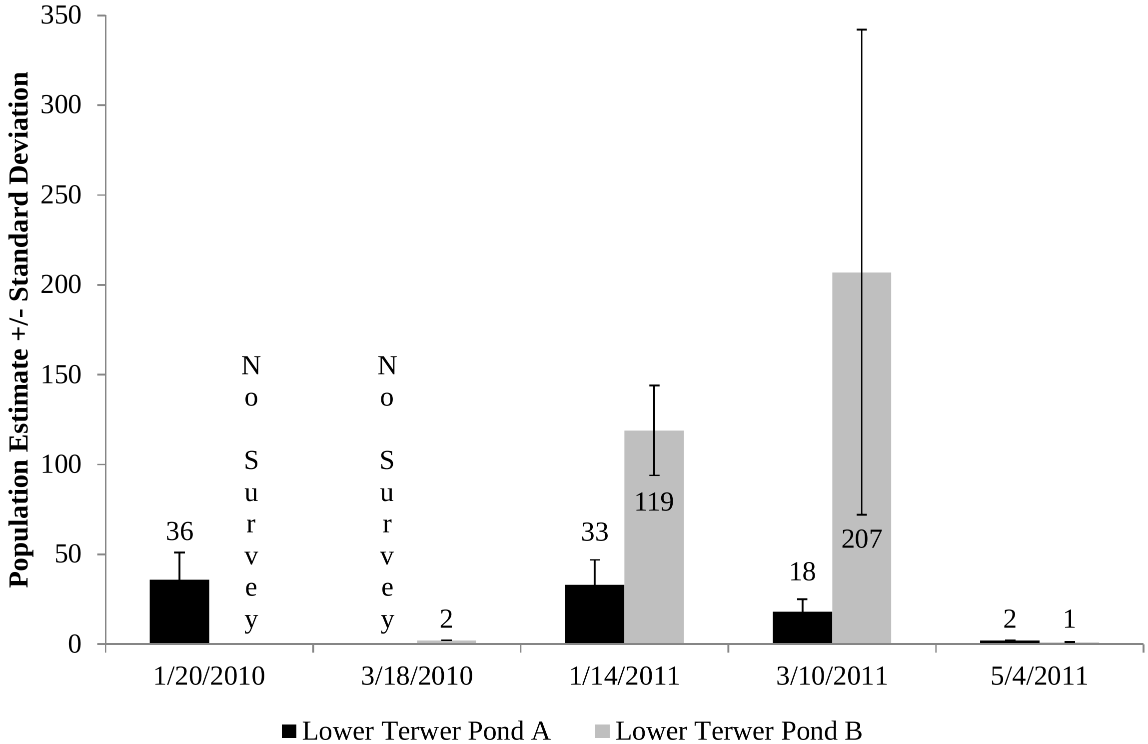


Figure 36. Mark-recapture population estimates for age 1+ coho in two off-channel ponds of Terwer Creek, Lower Klamath River, California.

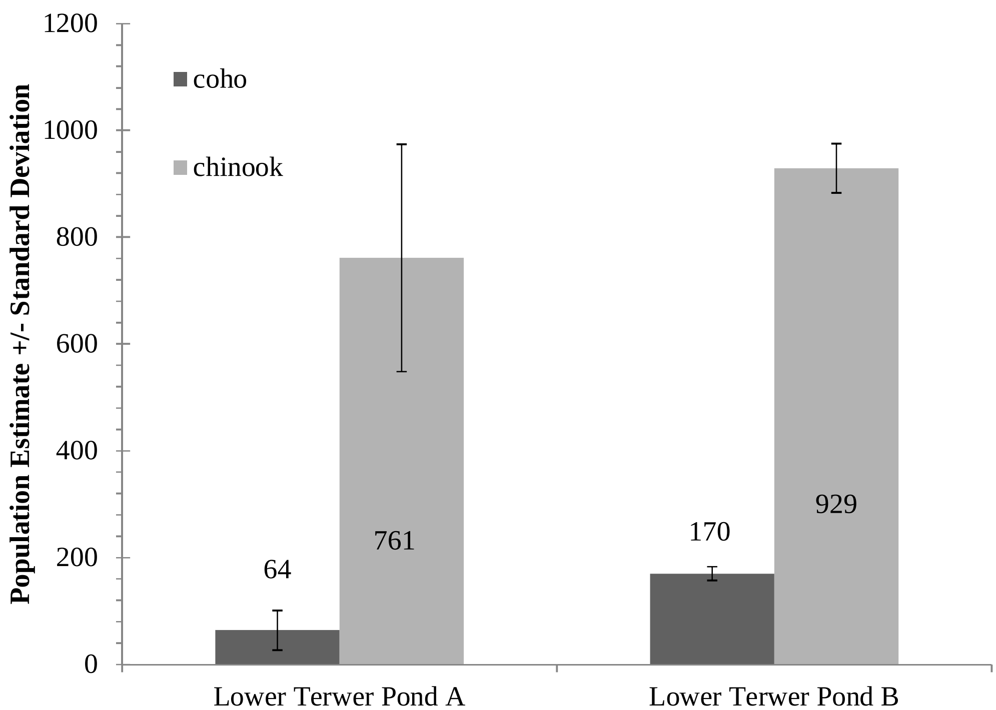


Figure 37. Mark-recapture population estimates for age 0+ coho and chinook salmon for May 2011 in two off-channel ponds of Terwer Creek, Lower Klamath River, California.

The pre-determined performance target for coho abundance in Pond A was an increase in abundance by 20%. Eight days of trapping during 2010 yielded 52 fish in the pre-enhanced pond (0.136 acre). NOAA and YTFP staff used the Modified Schnabel method to estimate pre-enhancement abundance in Pond A to be 382.4 fish/acre. However, subsequent fisheries surveys in Pond A during January 2010 yielded a population estimate for juvenile coho salmon (age 1+) of 36 fish with a 95% confidence interval of ± 15 fish (Figure 36). By extrapolating out the estimated population based on an increase in size from 0.136 acre to 1.0 acre, the baseline population would be 264.7 fish/acre. An increase in 20% would result in a target of 317.6 fish/acre.

The size of the enhanced Terwer Creek Pond A was approximately 0.5 acre. The highest population estimate from surveys that were conducted after restoration was during January 2011, which resulted in 33 (+/- 14) juvenile coho (66 fish/acre). Based on these metrics, we were unable to meet the targeted 20% increase in fish abundance. During all post-restoration population estimate sampling in Pond A (January 2011, March 2011, May 2011), the majority of juvenile coho (age 1+) were captured in the original backwater habitat that existed prior to restoration activities in 2010. Only 6.4% of the total catch of coho (age 1+) were captured in traps located in the newly created backcove habitat. Due to the recent excavation of the backcove, the habitat was not as complex as it was in the backwater area (Figures 32-33). As planted and existing vegetation matures in the newly excavated areas of Pond A we may see increased use of this habitat by juvenile salmonids.

The failure to meet the target goal of increased fish abundance in Pond A may also be attributed to changes in Terwer Creek's thalweg that occurred near Pond A's outlet channel. The thalweg shifted to the south during the first winter after enhancement of Pond A (winter 2010-2011), which produced a large backwater area (~ 40 ft long x 30 ft wide x 10 ft deep) near the entrance to the pond. This new backwater area was only inundated during periods of high flow, and was never sampled for fish presence or abundance.

Following enhancement of the ponds in summer 2010, YTFP conducted fisheries population estimates in Terwer Creek Pond B in conjunction with the Pond A surveys. The first population estimate was performed in January 2011 and resulted in a population estimate of 119 juvenile coho (age 1+) with a 95% confidence interval of ± 19 fish (Figure 36). March 2011 mark-recapture surveys resulted in an estimate of 207 juvenile coho (age 1+) with a 95% confidence interval of ± 135 fish (Figure 36). Populations estimates generated in May 2011 were one age 1+ coho, 170 (95% +/- 13) coho YOY, and 929 (95% +/- 46) chinook YOY (Figures 36-37).

Terwer Creek Pond B was approximately one acre after habitat enhancement activities were implemented in summer 2010. The pre-determined target for Pond B was to increase fish abundance by 200%. Prior to restoration activities, YTFP estimated a population of two age 1+ coho within the available off-channel habitat in March 2010 (Figure 36). Based on the March 2011 population estimate for age 1+ coho of 207 (Figure 36), the target of a 200% increase in abundance was met.

- Juvenile Coho Utilization and Movement Into Enhanced Habitats

YTFP assessed fisheries habitat utilization and movement into and out of both Pond A and B with the use of PIT tag technology, specifically stream-width PIT Tag Interrogation Systems (SPIs). Six antennas were placed in various habitats throughout each pond, including directional antennas in each inlet/outlet to monitor movement into and out of ponds (Figures 38-39). Antennas were also used to interpret fish preference of shoreline and deep water habitats, and to assess whether fish spent more time in habitats with woody debris cover.

On November 1, 2010, antennas were installed in Pond A at the following locations (Figure 38):

- Pond Inlet (Antennas 1 and 2)
- Mid-Pond (Antennas 3 and 4)
- Rear of Pond, Shoreline Habitat with Cover (Antenna 5)
- Rear of Pond, Deep Water Habitat with No Cover (Antenna 6)

On November 2, 2010 antennas were installed in Pond B at the following locations (Figure 39):

- Pond Inlet on North End (Antennas 1 and 2)
- Mid-Pond Habitat, Deep Water Habitat with Cover (Antenna 3)
- Mid-Pond Habitat, Shoreline Habitat (Antenna 4)
- Pond Inlet on South End (Antennas 5 and 6)

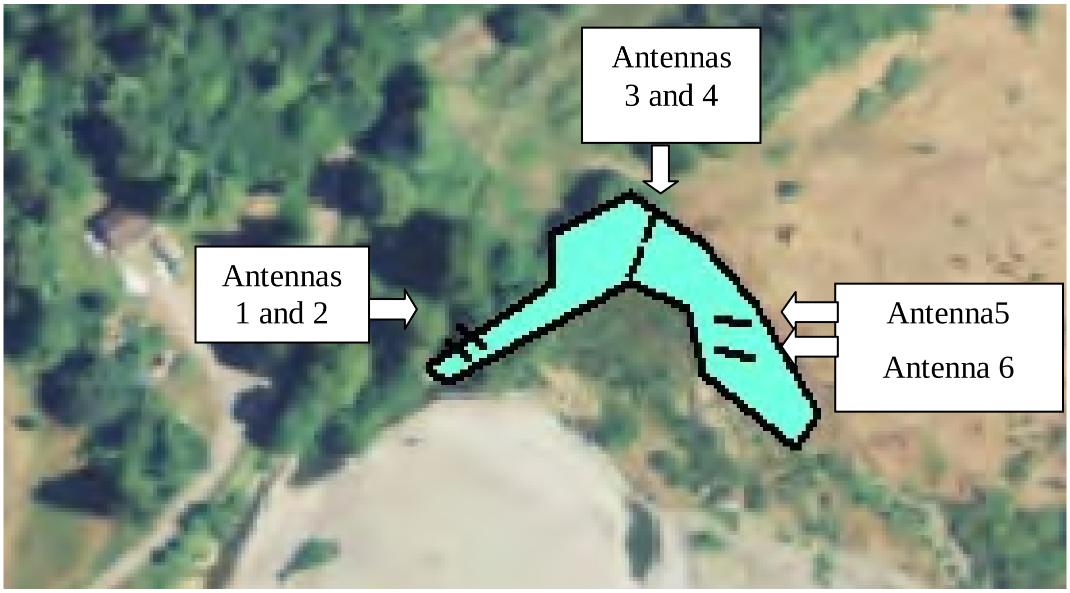


Figure 38. Location of PIT Tag antennas in Terwer Creek Pond A (11/01/2010 - July 2011).

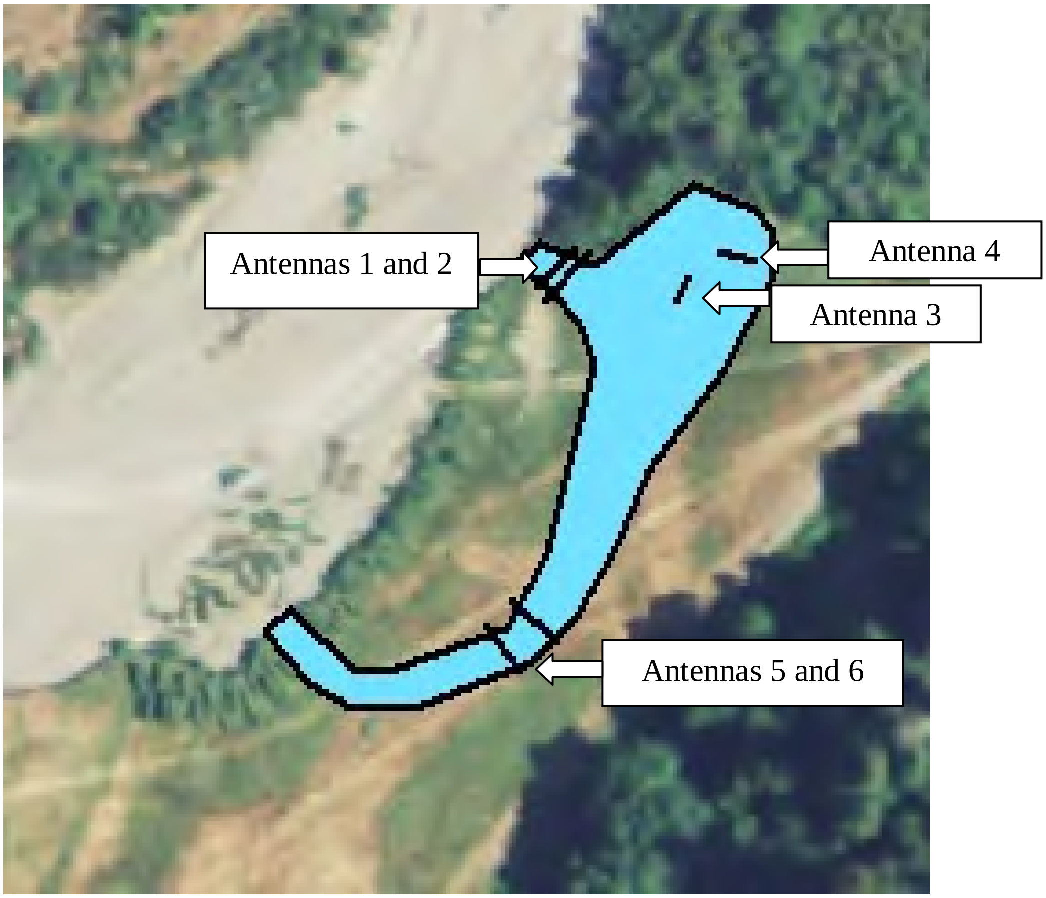


Figure 39. Location of PIT Tag antennas in Terwer Creek Pond B (11/02/2010 - July 2011).

PIT Tag Antenna Results for Pond A

The SPI antennas deployed in Terwer Creek Pond A detected 55 PIT tagged juvenile coho entering/exiting the pond between November 1, 2010 and July 2011. YTFP tagged 38 of these coho in Pond A during the abundance surveys. Two non-natal coho were detected entering/exiting Pond A. The first non-natal fish originated from the Crescent City Fork of Blue Creek and entered Pond A on November 20th and exited on November 23rd. The second non-natal fish was originally tagged by the Karuk Tribe in the Mid Klamath at Sandy Bar (RM 78)(Figure 41). This coho entered Pond A on January 6th and exited four days later. The remaining 15 coho that were detected in Pond A were either marked in the upper reaches of Terwer Creek or in Pond B.

Average residency time for non-natal PIT tagged coho entering Pond A was 3.5 days (n=2) (Figure 40). Juvenile coho originally marked in either Pond B or in upper Terwer had an average residency of 6.2 days, with a maximum length of stay of 46 days. The average residency time for coho tagged in Terwer Creek Pond A was 12 days, and the maximum duration that an individual stayed after marking was 67 days (Table 6). However, actual residency time and origin of coho marked in Pond A could not be determined.

Fish movement into the pond was related to flow events in the Klamath River and Terwer Creek, and it is not known whether fish moved in during the first freshet because it occurred prior to antenna installation on November 1, 2010 (Figure 42).

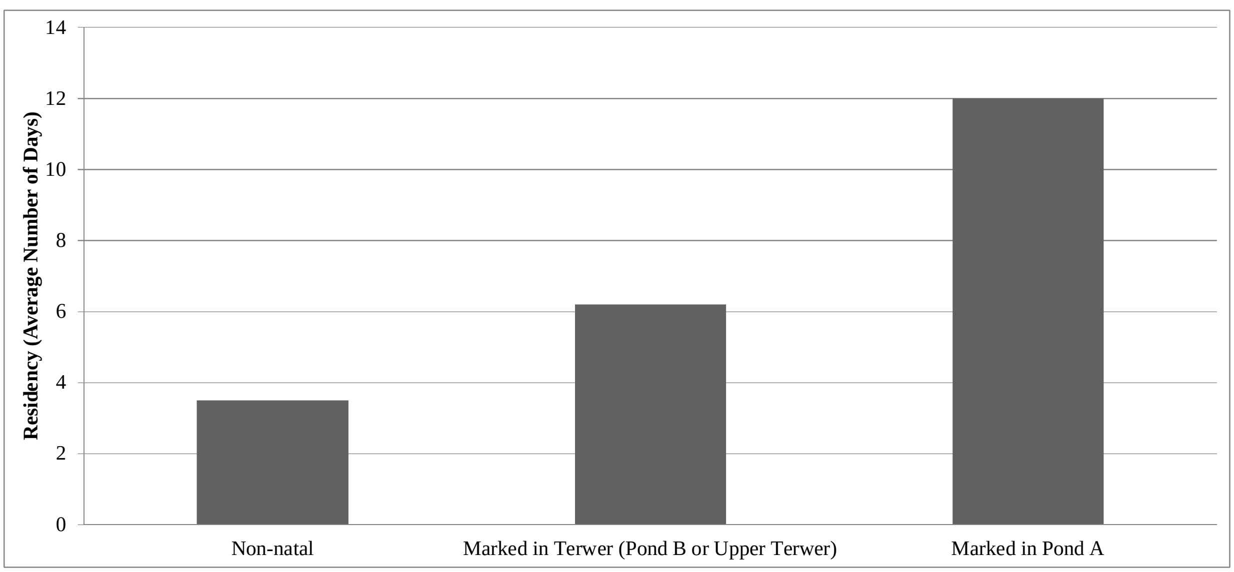


Figure 40. Average residency times for PIT tagged juvenile coho in Terwer Creek Pond A that were non-natal (n=2), marked in Terwer Creek at either Pond B or Upper Terwer (n=15) and marked in Pond A (n=38).

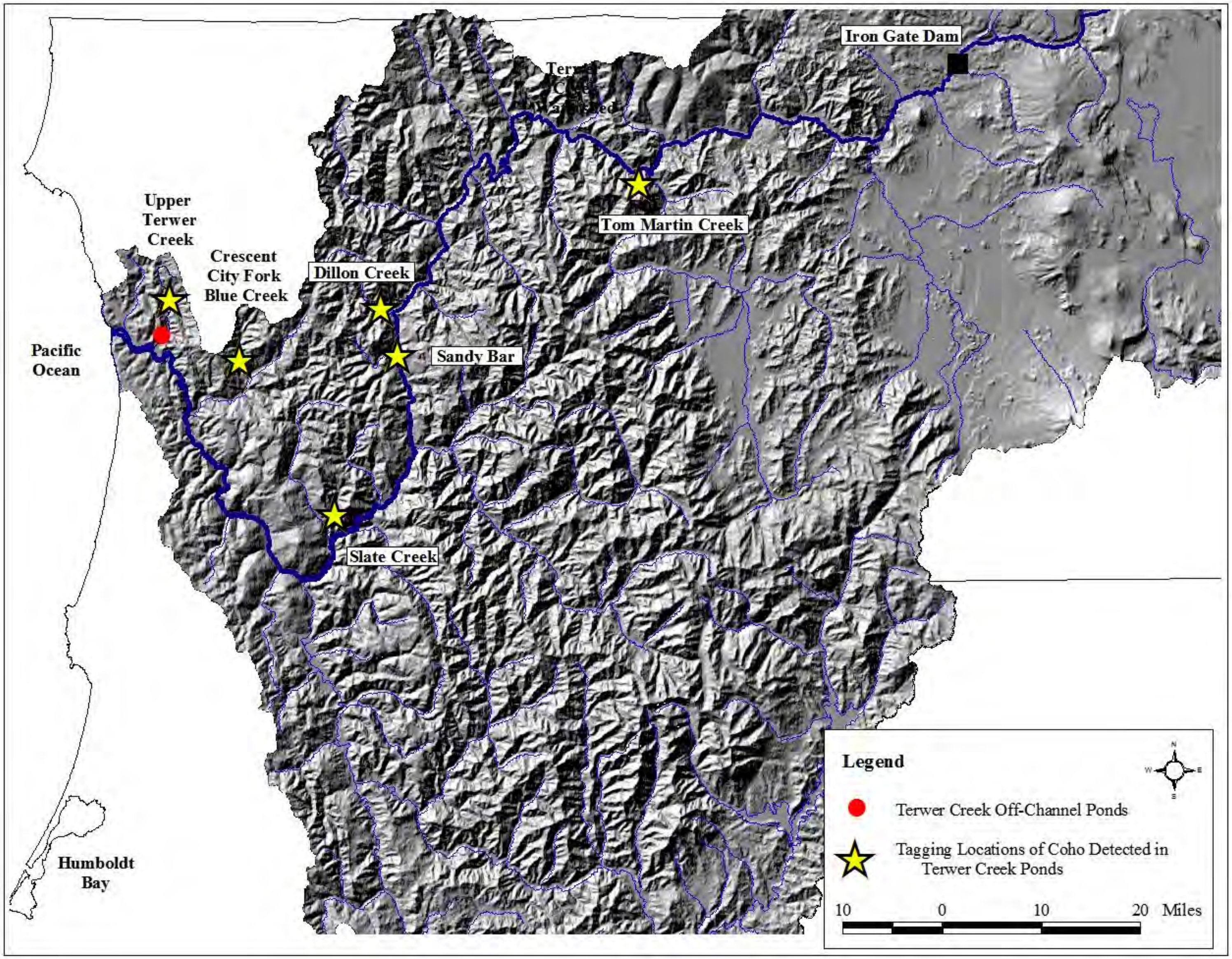
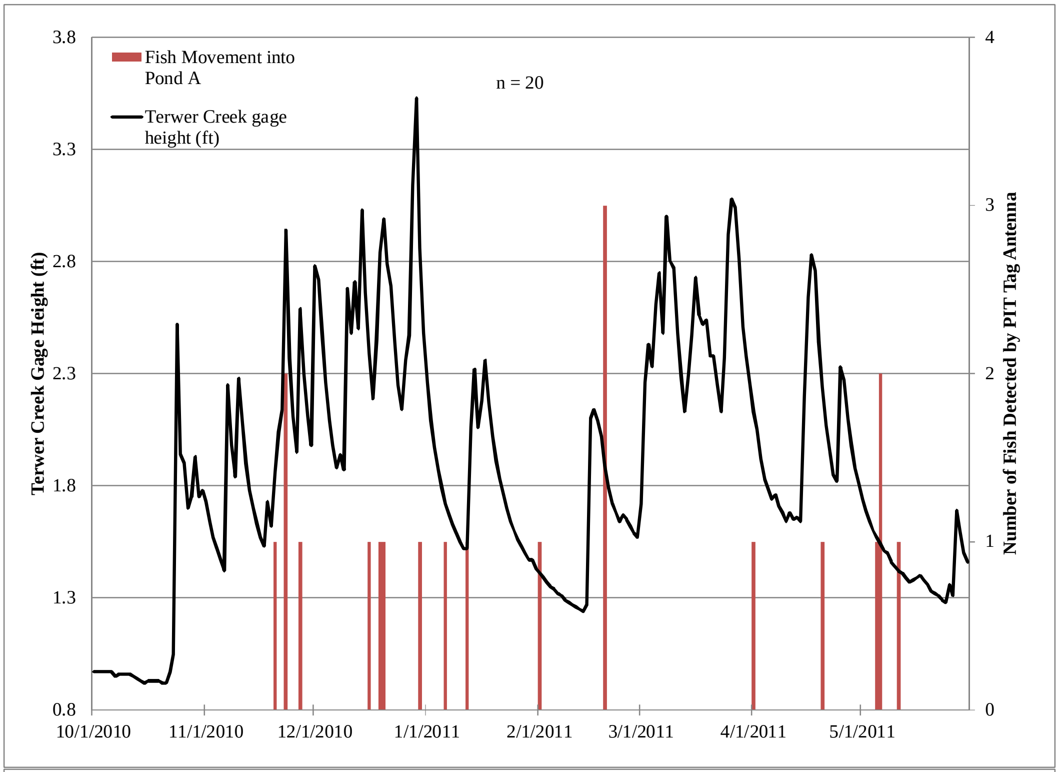


Figure 41. Map indicating tagging location of non-natal juvenile coho recaptured in Lower Terwer Creek Ponds A and B between November 2010 and July 2011.

Table 6. Minimum estimated residence time of juvenile coho marked outside of the two Terwer Creek ponds (Pond A & B) and for those juvenile coho marked within the ponds during winter 2010 – spring 2011.

Pond A			Pond B	
Number of Individuals Marked outside the pond	21		Number of Individuals Marked outside the pond	26
Minimum Days in the Pond	0.5		Minimum Days in the Pond	0.5
Maximum Days in the Pond	46		Maximum Days in the Pond	98
Average Days in the Pond	6.47619		Average Days in the Pond	18.8846
Number of Individuals Marked in the pond B	38		Number of Individuals Marked in the pond B	209
Minimum Days in the Pond	0.5		Minimum Days in the Pond	0.5
Maximum Days in the Pond	67		Maximum Days in the Pond	126
Average Days in the Pond	12.0395		Average Days in the Pond	25.7436



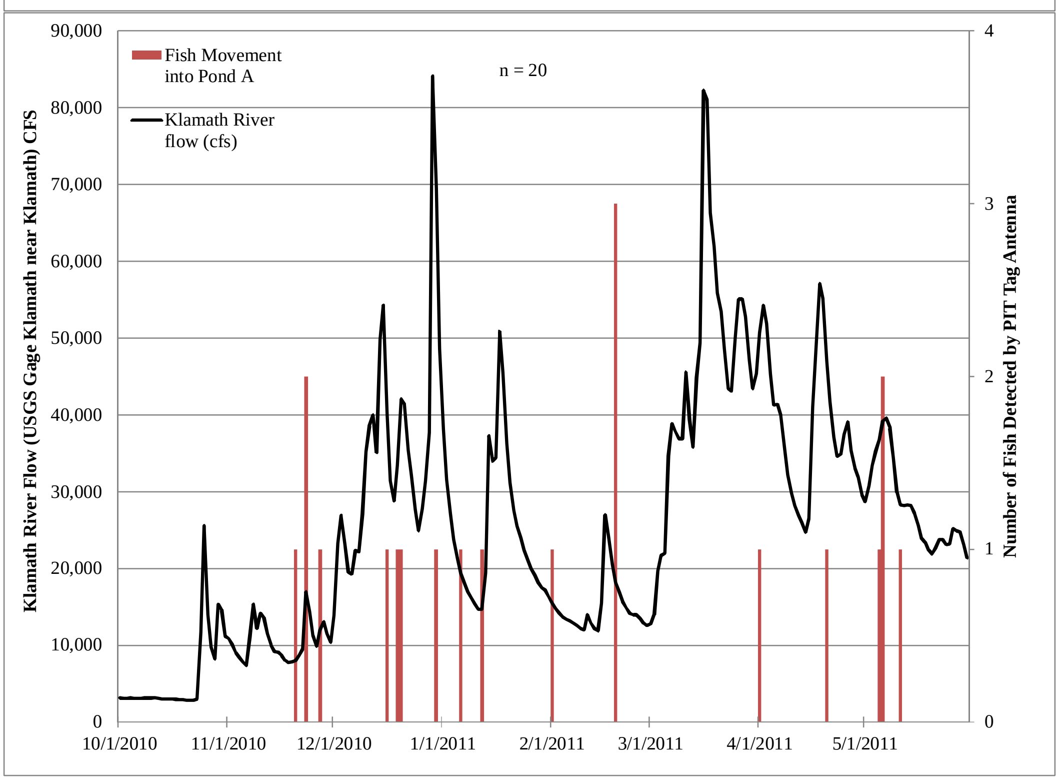


Figure 42. Non-natal juvenile coho movement into Terwer Creek Pond A plotted with Terwer Creek gage height (Yurok Tribal Environmental Program unpublished data, top graph) and flow for the Klamath River as reported by the U.S. Geological Survey for the Klamath River near Klamath gage (Water Year 2011, bottom graph).

PIT Tag Antenna Results for Pond B

PIT tag results from Terwer Creek Pond B indicated that fish use of the newly constructed pond began with the initiation of fall rainfall events and was utilized extensively by both natal and non-natal coho. From November 2010 through May 2011, the SPI antennas detected 235 PIT tagged coho (age 1+ and YOY) entering/exiting Pond B. The majority of these coho (n=209) were captured and tagged in Pond B during the abundance surveys. The remaining PIT tagged coho were marked in other areas of Terwer Creek (n=16) or were non-natal fish (n=10).

Ten non-natal juvenile coho were detected in Terwer Creek Pond B. Five of these non-natal coho fish were marked by the Karuk Tribe in the Mid Klamath at Slate Creek (RM 51.0), Sandy Bar (RM 77.6), Dillon Creek (RM 84.1), and Tom Martin Creek (RM 142.9). The other five non-natal coho were tagged by YTFP in the Crescent City Fork of Blue Creek (n=4) and in McGarvey Creek (n=1). Non-natal coho using Pond B had a higher average residency time of 34.9 days (Figure 43), compared with natal fish marked within the Terwer watershed and with the fish marked in Pond B. The maximum duration of residency detected by the SPI stations in Pond B was 92 days (Table 6). This coho was marked in the Crescent City Fork of Blue Creek on 10/06/10 and was detected entering Pond B on 11/23/11 (Antenna 6) and exiting on 01/01/11 (Antenna 1). This coho then reentered the pond through the lower-most egress channel (Antenna 6) on 03/02/11 and finally exited through the same egress channel on 04/26/11 (Antenna 6).

Natal coho marked in upper Terwer Creek displayed the lowest residency time with an average of 9.5 days in Pond B. Eighty one percent of the juvenile coho marked in upper Terwer Creek prior to entry in Pond B (natal fish) spent less than five days in the pond. Maximum residency time in Pond B for natal coho was 98 days (December 22, 2010 - March 30, 2011). Coho marked in Pond B spent an average of 25.74 days in the pond after being marked, with a minimum of 0.5 days and a maximum of 126 days (Table 6). One third of the coho marked in Pond B exited the pond either the same day or the day after being marked; however, actual residency time for fish marked in Pond B could not be determined.

Fish movement into the pond was related to flow events in the Klamath River and Terwer Creek, and it is not known whether fish moved in during the first freshet because it occurred prior to antenna installation on November 2, 2010 (Figure 44).

Residency Targets for Enhanced Ponds

We used non-natal residency time of coho in enhanced areas when measuring whether or not results had met pre-determined targets set up by NOAA and YTFP staff. Non-natal fish were used because there was no way to determine how long unmarked fish had resided in either pond prior to being PIT tagged during the abundance surveys. Non-natal coho utilizing Terwer Pond B had an average residency time of 34.9 days (n = 11, minimum = 0.5 days, maximum = 92 days), which met our target of 33 days. However, non-natal fish utilizing Terwer Pond A did not meet the target residency of 54 days. Only two non-natal coho utilized Pond B and they had an average residency of 3.5 days (minimum = 0.5 days, maximum 4.0 days). We have not determined why there was such a difference in utilization between the two ponds, and further monitoring may help us determine whether more fish prefer Pond A over time.

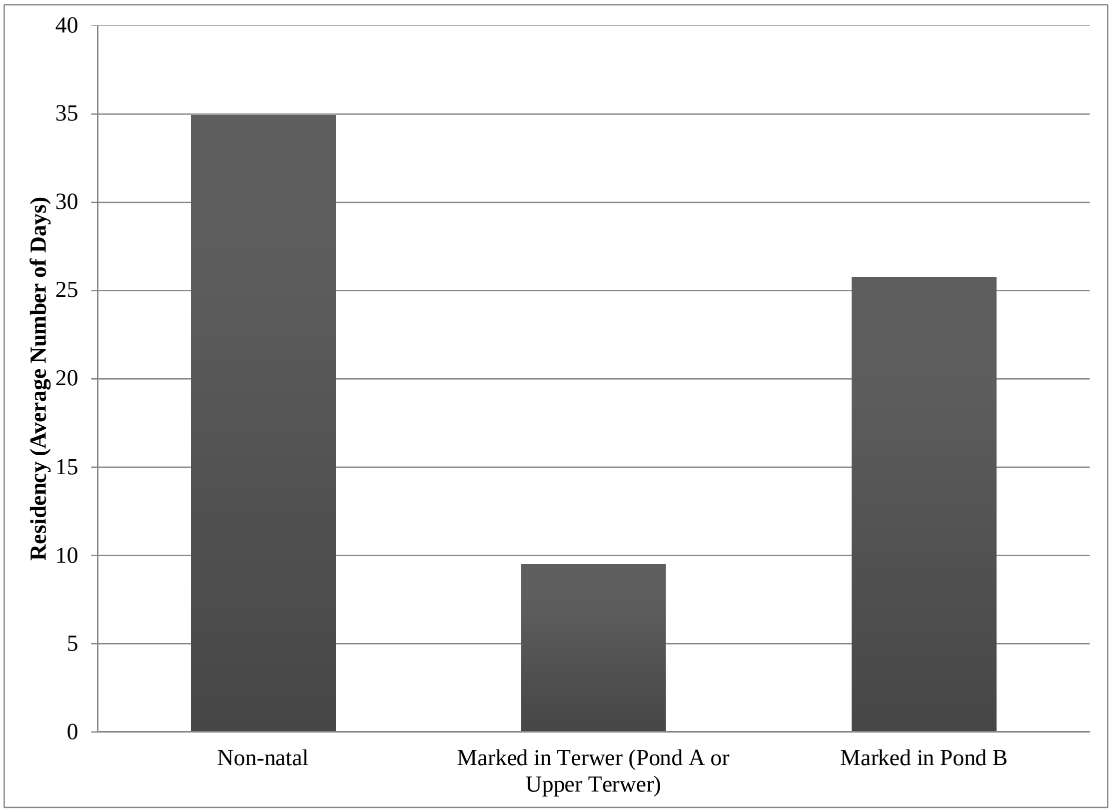


Figure 43. Average residency times for PIT tagged juvenile coho in Pond B that were non-natal (n = 10), marked in Terwer Creek at either Pond B or Upper Terwer (n = 16) and marked in Pond A (n = 209).

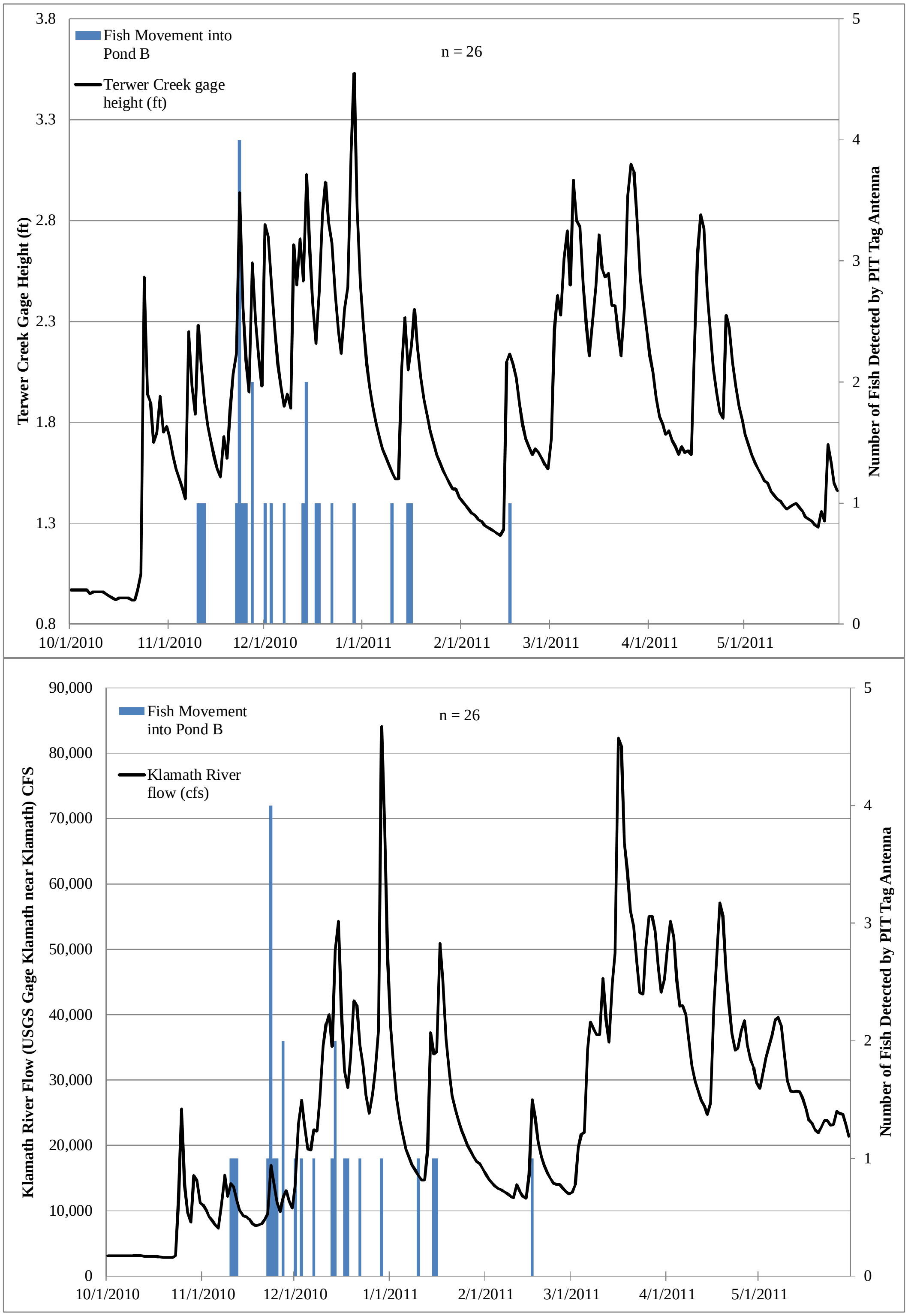


Figure 44. Non-natal juvenile coho movement into Terwer Creek Pond B plotted with Terwer Creek gage height (Yurok Tribal Environmental Program unpublished data, top graph) and flow for the Klamath River as reported by the U.S. Geological Survey for the Klamath River near Klamath gage (Water Year 2011, bottom graph).

- Habitat Preference

SPI antennas were deployed in specific habitat types in Terwer Creek Pond A and B to assess habitat preference by juvenile coho within the recently enhanced ponds (Figures 38-39). Four antennas were deployed, two in each pond, to monitor fish use: 1) deep water with woody debris cover, 2) deep water without cover (open water), 3) shoreline habitat without cover (open water), and 4) shoreline habitat with woody debris cover. Overall, more juvenile coho utilized Terwer Creek Pond B for longer periods of time than Pond A.

Within Pond A, two habitat features were monitored with PIT tag antennas: shoreline with cover (Antenna 5), and deep water without cover (Antenna 6) (Figure 38). There were more total detections and individual juvenile coho utilizing the deep water habitat compared to shoreline habitat use. The average, maximum, and median number of detections per fish were also greater for deep water than for shoreline habitat in Pond A (Table 7).

The SPI antennas in Terwer Creek Pond B were placed in deep water habitat with cover (Antenna 3), and shoreline habitat without cover (Antenna 4) (Figure 39). The total number of coho utilizing the shoreline habitat was higher than deep water habitat; however, the number of detections in the deep water habitat was nearly twice that of shoreline habitat detections. The average, maximum, and median number of detections per fish were also greater for deep water than shoreline habitat in Pond B (Table 7).

Table 7. Habitat use by juvenile coho in Terwer Creek Pond A (11/01/2010 – 7/20/2011) and in Pond B (11/02/2010 – 6/27/2011).

Antenna Number	Pond	Habitat Type	Total Number of Records	Number of Coho Utilizing	Minimum Number of Records/Individual Coho	Maximum Number of Records/Individual Coho	Average Number of Records/Individual Coho	Median Number of Records/Individual Coho
3	B	Deep Water/Cover	11,091	136	1	1020	81.6	19.5
4	B	Shoreline Habitat	5,778	150	1	596	39.6	9.5
5	A	Shoreline Habitat/Cover	179	20	1	61	9	2
6	A	Deep Water/No Cover	287	26	1	83	11	2.5

- Fish Rescue

Terwer Creek Pond B became disconnected from Terwer Creek on May 6, 2011 when flows went subsurface within the side channel that connects the pond to Terwer Creek. After this date, YTFP removed a total of one coho yearling, three age 1+ steelhead, 191 YOY coho, and 1,376 YOY chinook from the pond and relocated them into flowing reaches of Terwer Creek. Fish rescue activities began on May 6th when YTFP conducted a population estimate. Results from the population estimate were one coho yearling (age 1+), and population estimates of 929 YOY chinook and 170 YOY coho (Figure 37). All the fish captured at the end of this trapping cycle (736 chinook YOY, 145 coho YOY, two juvenile steelhead, and one coho 1+) were relocated to the Terwer Creek mainstem so that they would not remain stranded in the pond. An additional 495 chinook YOY, 39 coho YOY, and one steelhead YOY were captured and relocated between May 20th and May 27th (Figure 45). On May 26, the project area received enough precipitation to reconnect Pond B to the side channel. While there was not enough rainfall to reconnect the side channel with mainstem Terwer Creek, it did allow fish previously stranded in the side channel to move into the pond. Additional fish rescue efforts were conducted between June 8th - 16th, and seven YOY coho and 145 YOY chinook were relocated to Terwer Creek.

Terwer Creek Pond A stayed wetted and connected by surface flows to mainstem Terwer Creek into early July 2011. On July 14th and 15th, with the pond disconnected from Terwer Creek, the YTFP trapped the off-channel habitat in Pond A to assess stranding. During these surveys, only young-of-the-year coho (4) and chinook (7) were captured and relocated into Terwer Creek. The ability of this site to stay wetted late into the water year, well beyond the peak smolt migration period, may result in a lower stranding rate than Pond B (Soto et al. 2008; YTFP 2009; Lestelle 2007; Silloway and Beesley 2011).

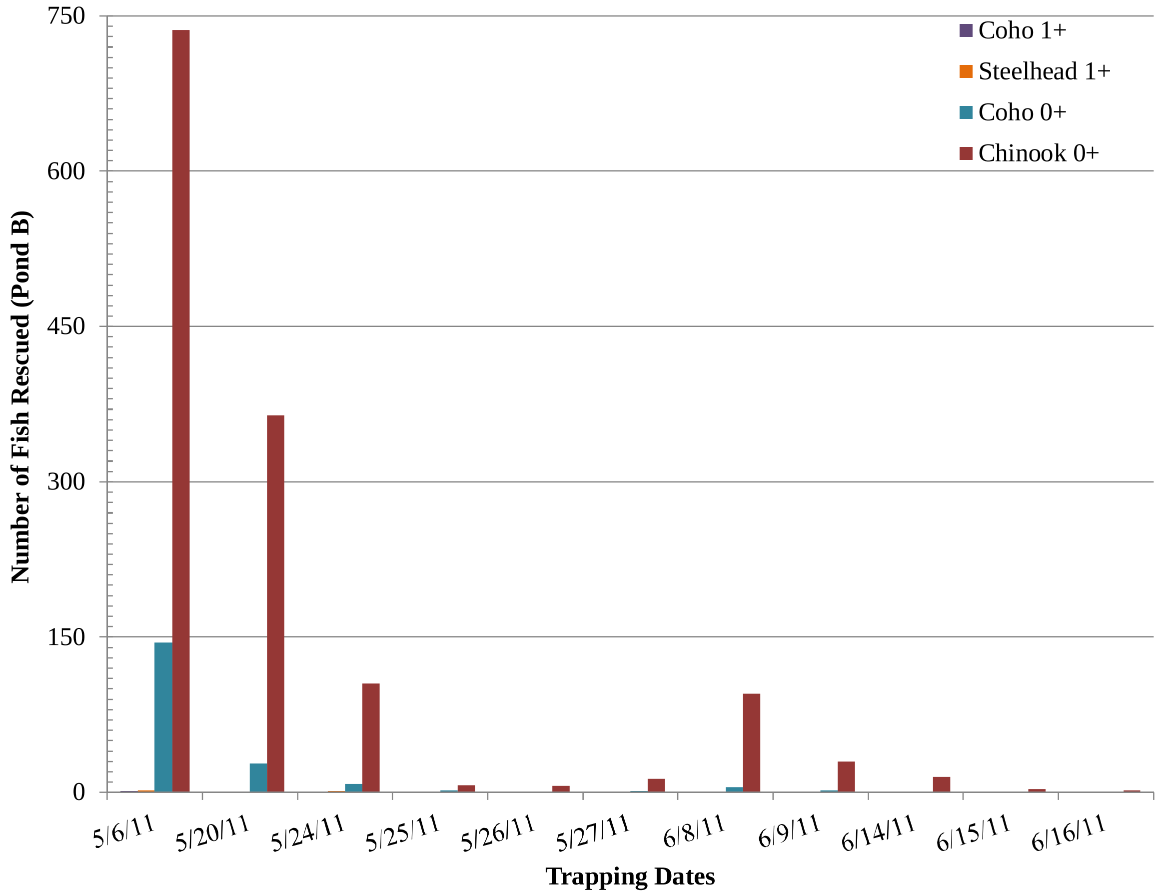


Figure 45. Results of fish rescue efforts performed in Lower Terwer Creek Pond B, Lower Klamath River, California.

- Fish Growth

Fish growth performance targets were based on data collected during pre-enhancement fisheries surveys and publications documenting fish growth. Baseline surveys in Lower Terwer Pond A documented growth of individual fish between surveys ranging from 0.12 – 0.51 mm/day. NOAA and YTFP staff set a target of 0.47 mm/day for fish growth of individuals residing in Pond A after habitat enhancement, which was not met. Only three individuals were recaptured during two separate population estimates, and one of the individuals had left Pond A for a period of time between captures. Average growth for the two individuals remaining in Pond A between trapping events was 0.22 mm/day and 0.039 g/day for weight. Growth of the fish that left Pond A between trapping events was 0.33 mm/day and 0.099 g/day (Table 8).

Due to a lack of baseline data for Pond B, the performance target was based on results from Wood Creek and was set at 0.20 mm/day. PIT tag antennas at the inlets of Pond B allowed YTFP to calculate fish growth for individuals that remained in Pond B compared with individuals that moved into and out of Pond B at least one time between recaptures. The general trend showed that coho that remained in Pond B grew more than fish that left the habitat (Figure 46). Average growth of coho was 0.35 mm/day and 0.139 g/day for weight, which exceeded performance targets (Table 9). Growth rates were highest for fish that remained in Pond B (0.35 mm/day), followed by fish that remained in Pond A (0.22 mm/day). Fish that moved out of Pond B had the lowest growth rate of 0.15mm/day and 0.053 g/day (Figure 47).

Table 8. Average growth of juvenile coho utilizing Terwer Creek Pond A.

Fish that stayed in the Pond A	n = 2		
Avg. Days in the Pond			35.5
Avg. Length Growth Rate (mm/day)			0.21958
Avg. Weigth Growth Rate (g/day)			0.03829
Fish that moved in & out of the Pond A		n = 1	
Avg. Days in the Pond			67
Avg. Length Growth Rate (mm/day)			0.32653
Avg. Weigth Growth Rate (g/day)			0.09898

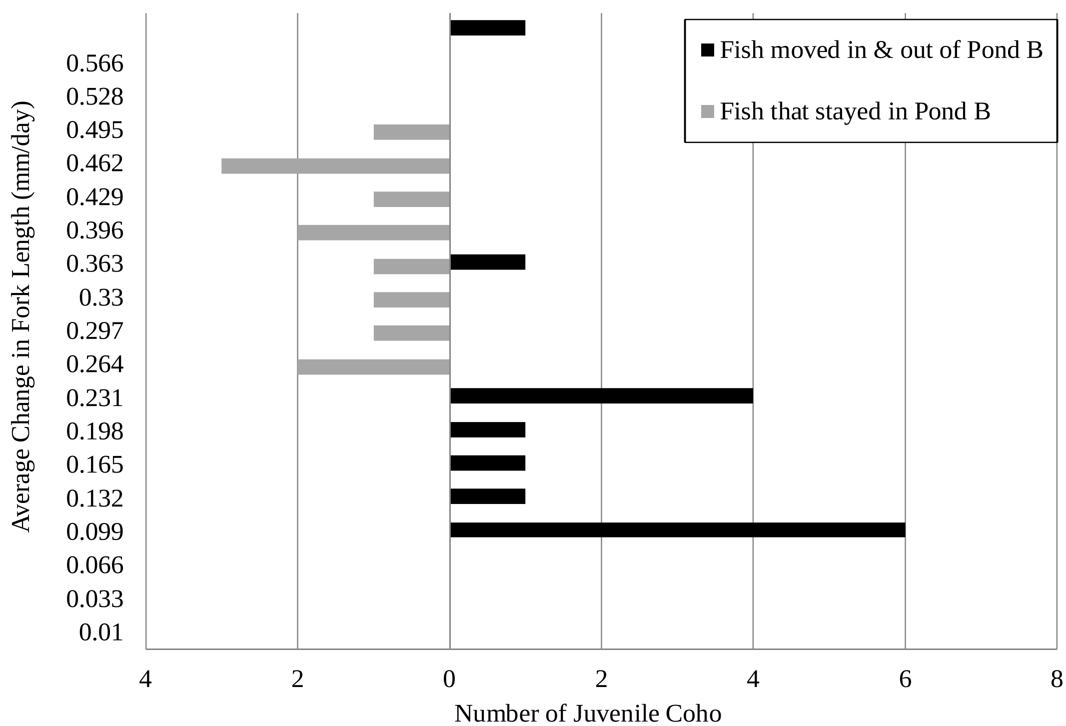


Figure 46. Average growth (change in fork length) of individual coho that remained in Pond B compared to fish that left Pond B at least one time between recaptures.

Table 8. Average growth of individual juvenile coho utilizing Terwer Creek Pond B, separated into groups that remained in the pond between recaptures and fish that left at least once between recaptures.

Fish that stayed in the Pond	n = 12		Fish that moved in & out of the Pond	n = 16
Avg Days (per/day) in the Pond	72.9167		Avg Days in the Pond	55.3125
Avg. Length Growth Rate (mm/day)	0.35139		Avg. Length Growth Rate (mm/day)	0.15549
Avg. Weigth Growth Rate (g/day)	0.13839		Avg. Weigth Growth Rate (g/day)	0.05327
Max. Length Growth Rate (mm/day)	0.46296		Max. Length Growth Rate (mm/day)	0.55556
Min. Length Growth Rate (mm/day)	0.21622		Min. Length Growth Rate (mm/day)	0.05357

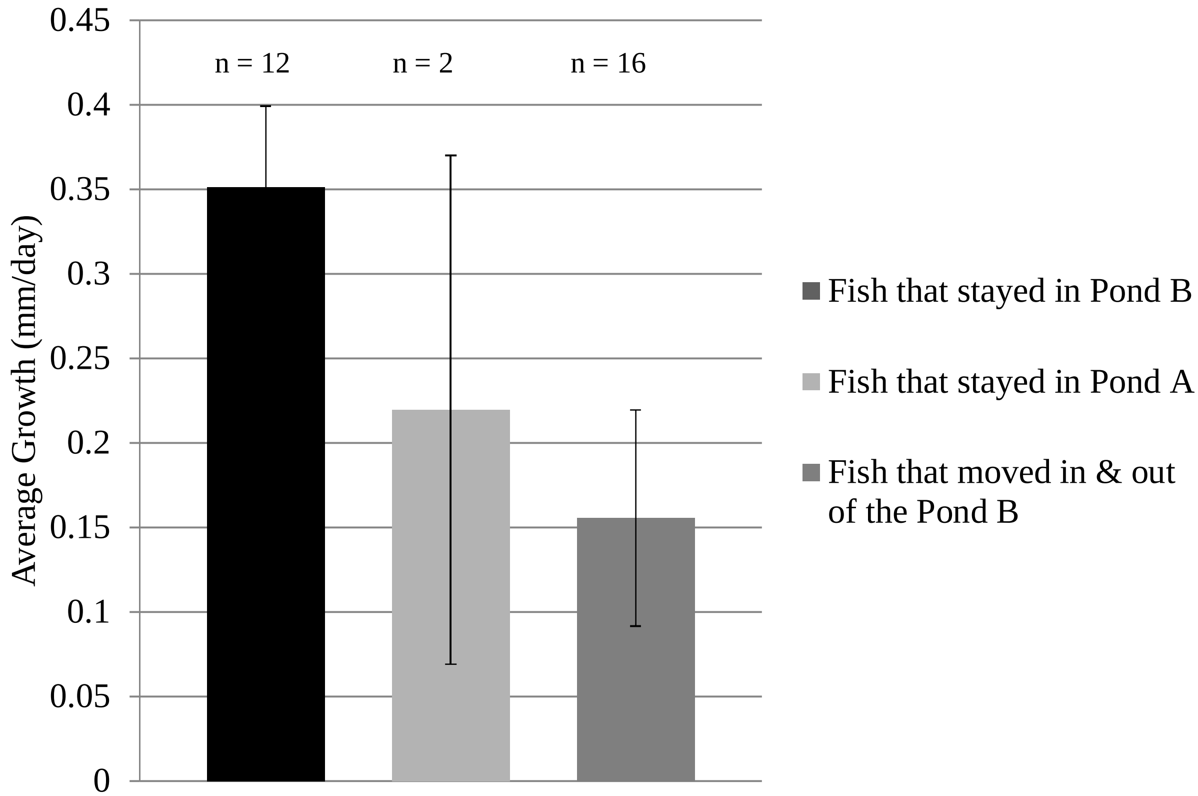


Figure 47. Average growth of coho remaining in Terwer Creek Pond B between recaptures, remaining in Pond A between recaptures, and fish that moved outside of Pond B at least one time between recaptures.

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