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Trinity River Biological Monitoring of Channel Rehabilitation Sites: A Pre-Construction Baseline Habitat Evaluation

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Trinity River biological monitoring of channel rehabilitation sites: A pre-construction baseline habitat evaluation

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Abstract. Alluvial river function has been severely limited in the Trinity River downstream of Lewiston Dam following construction of the dam. An encroaching riparian berm dominates the river and reduces channel complexity to a confined U-shape. The confined channel reduces available salmonid habitat at moderate flows, conditions that occur most frequently during late winter and early spring when seasonal salmonid fry densities and demand for fry habitat are often high. To increase habitat for fish and wildlife in the Trinity River corridor, the Trinity River Restoration Program is attempting to facilitate alluvial function in the River through mechanical removal of the armored riparian berm and re-structuring the channel and floodplain to function under the hydrographs proposed in the Trinity River Mainstem Fishery Restoration Record of Decision. This project characterizes baseline habitat to flow relationships for Chinook salmon, coho salmon, and steelhead over a range of low to moderate discharge (500 to as high as 4,500 cubic feet per second) for select proposed Trinity River rehabilitation and control sites. Habitat to flow relationships show an initial reduction in habitat area for fry (fish less than 50 mm fork length) and juvenile (50 to 120 mm) as flows increase over summer base flow (500 to 600 cubic feet per second depending on tributary input), and show eventual gains in habitat at all study sites as flows continue to increase through moderate discharges (2,800 to 4,500 cubic feet per second). After mechanical alterations have occurred and these sites have undergone significant channel evolution in response to rehabilitation flows, comparison to these baseline relationships will inform Trinity River Restoration Program managers as to the effectiveness of the rehabilitation actions in improving fry habitat over currently degraded channel conditions.

Introduction

Completion of the Trinity River Division (TRD) of the Central Valley Project in 1963 and the subsequent diversion of Trinity River water to the Sacramento Basin resulted in dramatic alteration of the Trinity River channel downstream of Lewiston Dam. A once dynamic hydrograph that included flood events that sometimes exceeded 70,000 cubic feet per second (cfs) and a pronounced spring snowmelt signature was changed to static, low flow tailwater release (USFWS and Hoopa Valley Tribe 1999). For nearly two decades roughly 90 percent of the mean annual discharge at Lewiston Dam was diverted to the Sacramento Basin, leaving behind a nearly constant 100 to 150 cfs to wet a channel topography that had been shaped by floods magnitudes higher (Figure 1). The static low-flow conditions were conducive to germination and maturation of a woody riparian community along this now narrower water's edge (McBain and Trush 1997).

Fine sediment from tributary or other sources is suspended in the water column during moderate flow events. As rising waters flow into the encroaching riparian community, energy is dissipated by woody plants and sediments fall out of suspension and

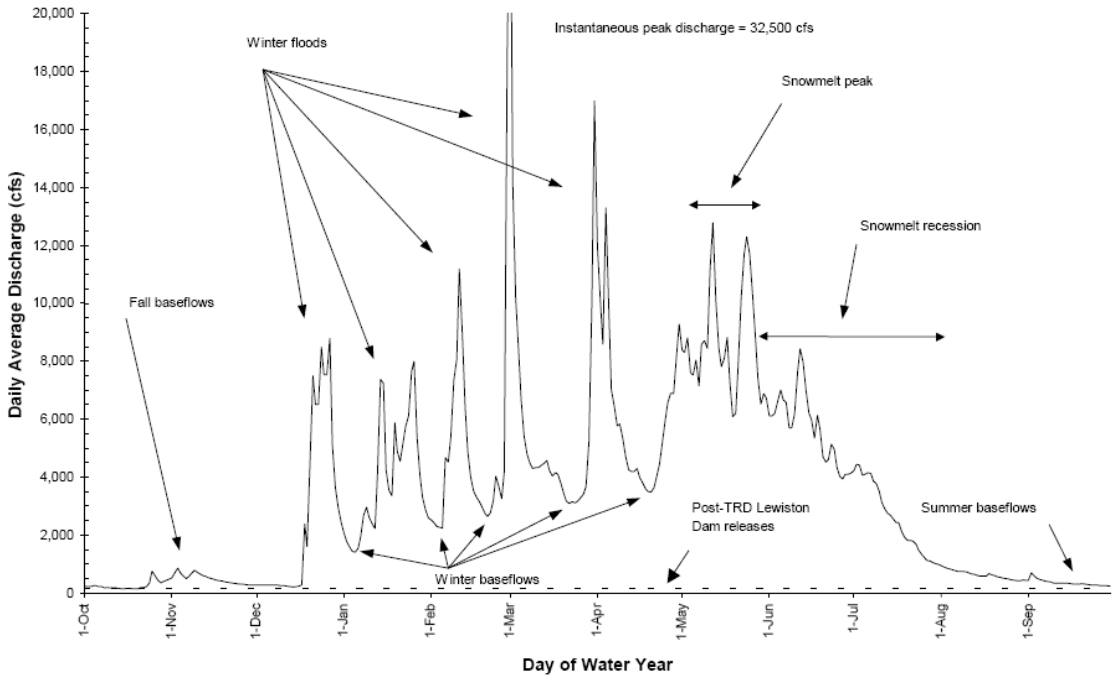

Figure 1. Streamflow hydrograph of the Trinity River at Lewiston, demonstrating post-TRD Lewiston Dam releases compared to an extremely wet water year prior to TRD (Extremely Wet water year 1941). Adapted from Figure 4.10 in the Trinity River Flow Evaluation Study (USFWS and Hoopa Valley Tribe 1999).

deposit near the base of the riparian zone. The result is formation of a sand berm with thick vegetation. Riparian berm is now a dominant channel feature of the Trinity River from Lewiston Dam to the North Fork Trinity River. From 1960 (pre-TRD) to 1989, the acreage of riparian community downstream of Lewiston Dam to the North Fork more than doubled (Wilson 1993), and moved from higher floodplain benches to lower flow water's edge. Downstream of the North Fork, tributary accretion and valley narrowing greatly reduces riparian berm incidence, but does not completely eliminate this feature.

One characteristic of the berm-dominated channel is its U-shaped confinement with general lack of topographic complexity. At base flows, the impaired river flows broad and uniform within confines of the U-shaped channel. When flows increase, they initially remain confined between the berms, resulting in largely uniform and high water velocities, which offer little low-velocity refuge to rearing fish. Only when flows breach or overtop the berm is the remnant pre-TRD alluvial channel wetted. The diverse topography of the remnant alluvial channel creates abundant low-velocity refuge and a diversity of habitats for rearing fish when flows reach behind the berms, but can lead to stranding when flows recede and fish are trapped behind the berm (Chamberlain 2003).

In the early to mid-1990's, nine pilot restoration projects were constructed on the mainstem Trinity River in an attempt to provide fry habitat at these project sites through a wide range of flows (USFWS 1994). These sites were commonly referred to as "bank feathers" or "feathered edges", and were constructed by simply removing the riparian berm to expose the surface of the pre-TRD cobble riverbed so that low-velocity refuge for rearing fish could be found over a broader range of flows. Additionally, 18 side channels were constructed in an attempt to increase available spawning and rearing habitat in the mainstem (USFWS and Hoopa Valley Tribe 1999). Previous biological evaluations of these early pilot rehabilitation actions focused on comparison of the mechanically feathered edges to nearby control sites, or to characterize habitat in the constructed side channels (Krakker 1991; Hampton 1992; Glase 1994; Reese et al 1995; Gallagher 1995; USFWS 1997; Gallagher 1999a, 1999b, 1999c; Chamberlain 2003).

As part of the current fishery restoration program for the Trinity River, an extensive channel rehabilitation program is being instituted along with variable flow regimes designed to restore some alluvial functions of the Trinity and the fish habitat associated with the features of an alluvial river (USFWS and Hoopa Valley Tribe 1999; USDOI 2000). Future channel rehabilitation projects will, in most cases, be much more complex and extensive than the simple and relatively short (130 to 330 yards) feathered edges constructed in the 1990's. Channel rehabilitation projects may incorporate a variety of features (removal or manipulation of multiple individual riparian berms, reshaped floodplains designed to function under the new flow regimes, channel meanders, split

and/or secondary channels) into a single complex rehabilitation design such as the 1.1 mile long site at Hocker Flat (USBR 2004).

A critical element in the post-Trinity River Mainstem Fishery Restoration Record of Decision (ROD; USDOI 2000) era of channel rehabilitation is the implementation of higher and more variable water allocations by water-year type advocated in the Trinity River Flow Evaluation Study (USFWS and Hoopa Valley Tribe 1999) later adopted in the ROD. Channel rehabilitation depends on higher release volumes than were available pre-ROD. These ROD discharge volumes are key to the long term maintenance and evolution of these sites, expanding them beyond their original mechanical footprint, and restoring alluvial function to the river. Indeed, in the absence of ROD flows, re-evolution of riparian berm has been observed near low summer water's edge at many of the feathered edge rehabilitation sites constructed in the mid-1990's (Bair 2001, 2003; Chamberlain 2003).

Anadromous salmonid production in the upper Trinity River between Lewiston Dam and the North Fork Trinity River is believed to be limited at present by lack of fry rearing habitat resulting from riparian berm encroachment and U-shaped channel form discussed previously (USFWS 1994; USFWS and Hoopa Valley Tribe 1999). This study is primarily focused at quantifying fry rearing habitat within study sites, though some juvenile habitat evaluation is also presented (for fish less than 120 mm). Contemporary baseline habitat conditions at select proposed channel rehabilitation sites and some additional sites are documented here so comparisons can be made after large-scale rehabilitation efforts are completed. After construction and evolutionary channel response to the ROD flow volumes, revisit of these sites will provide feedback to the Trinity River Restoration Program (TRRP) regarding channel rehabilitation design and habitat response of these sites to ROD flow volumes, and provide input to managers regarding flow and habitat relationships at these sites.

Study Area

Channel rehabilitation activities of the TRRP are focused on the 40 miles between Lewiston Dam and the North Fork Trinity River. Riparian encroachment is pronounced throughout this reach and 79 berm-dominated sites have been identified for potential mechanical rehabilitation, in addition to the nine pilot feathered edges constructed in the early 1990's (Ed Solbos, personal communication).

Due to litigation over implementation of the ROD and uncertainty that full ROD flows would be implemented, the Restoration Program in 2003 shifted first priority of rehabilitation sites away from those near the dam where continued limited flow volumes

would not be adequate to maintain alluvial function, to those sites downstream of Canyon Creek at Junction City where tributary accretions would increase the likelihood that alluvial functions would at least be partially maintained. As a result, the Hocker Flat Rehabilitation Site complex near Junction City (Figure 2) became a focus for engineering and construction permit related efforts of the Restoration Program. The Hocker Flat rehabilitation site was a group of individually identified riparian encroached sites and also encompassed a pilot rehabilitation site constructed in the early 1990's (USBR 2004). Since little baseline habitat data existed for this area, fish habitat assessment activities were focused on Hocker Flat.

Pilot channel rehabilitation sites (feathered edges)

The Jim Smith pilot feathered edge was within the Hocker Flat Rehabilitation site Complex, all of which were incorporated into this study. The study site "Jim Smith" for this report however, encompassed the feathered edge and a considerable portion of "un-restored" river channel downstream that was part of the same parcel. The pilot feathered edge site near Douglas City was also included because of its long-term history as a study site in previous evaluations (Gallagher 1995; USFWS 1997; Gallagher 1999a, 1999b, 1999c).

Proposed channel rehabilitation sites

Proposed channel rehabilitation sites are typified by armored riparian berms and associated high volumes of sand storage. Individual sites were identified by TRRP participants in the mid-to-late 1990's and given an alphabetical designation. Subsequently, the TRRP has incorporated multiple individual sites into larger design complexes such as the Hocker Flat Rehabilitation site, which was intensively mapped for this study. The Hocker Flat complex with its 1.1 mile long footprint incorporated all of sites designated as CL, CK, CM, and Jim Smith (including the pilot feathered edge mentioned above). These sites were all included in this study (Table 1).

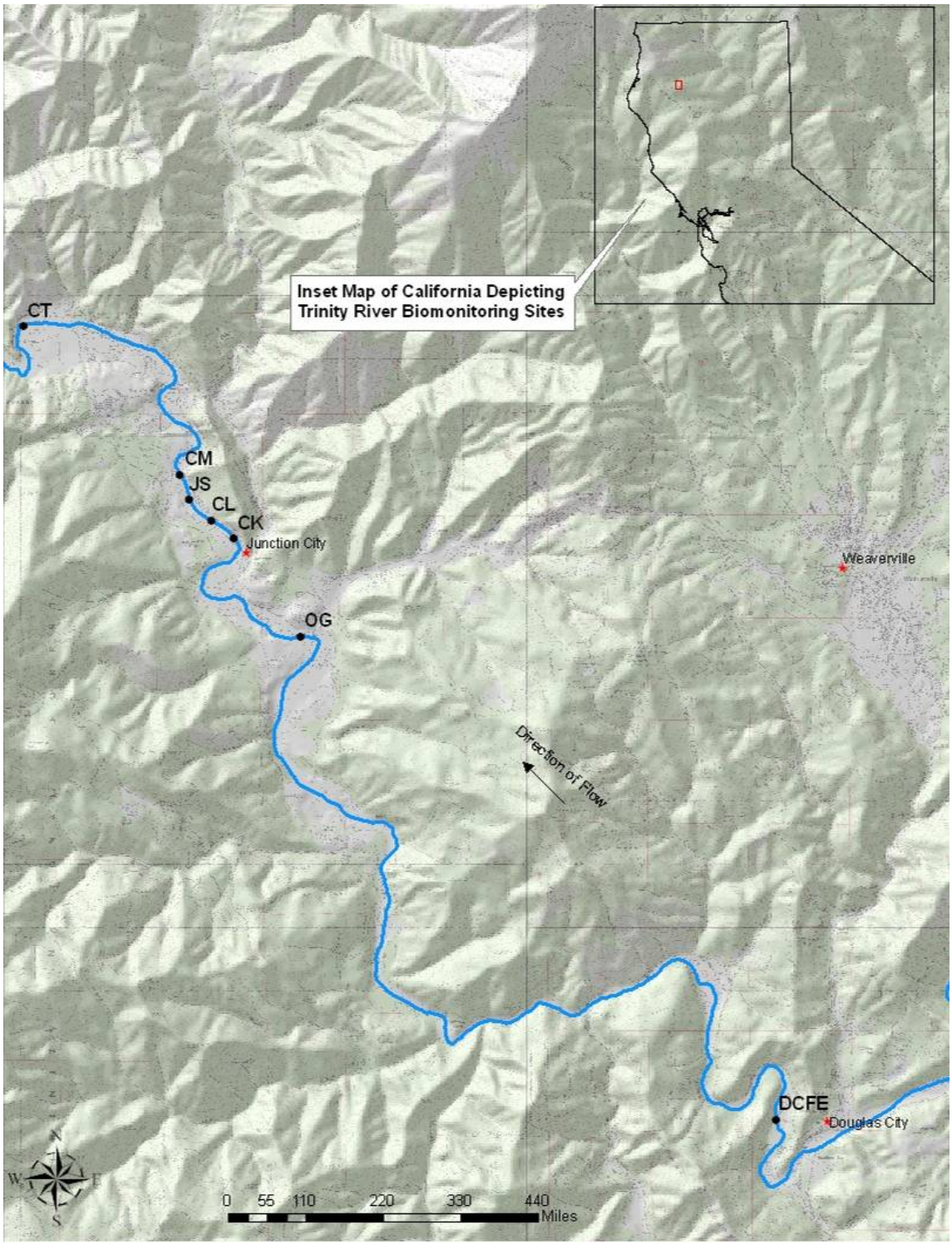

Figure 2. Study area. Study sites from upstream to downstream: DCFE = Douglas City Feathered Edge; OG = Oregon Gulch; Sites CK, CL, JS, and CM collectively comprise the Hocker Flat Rehabilitation Site with the Jim Smith study site represented by JS; site CT is within the Valdor Gulch Rehabilitation Site.

Riparian encroached control site

The entire Trinity River mainstem downstream of Lewiston Dam will be subject to rehabilitation flows specified in the ROD. As such, channel and habitat response will not be confined only to the mechanically altered rehabilitation sites. Even though they are expected to exhibit some response to ROD flows themselves, establishing control sites that are similar in morphology to the rehabilitation sites prior to construction can help determine habitat responses to mechanical rehabilitation and site design. Ideal sites to serve as potential controls are those that are located near a rehabilitation site, have similar degraded channel morphology, and are subject to similar tributary accretion of sediment and water (and tributary contributions of fish if fish use comparisons are made). However, most such sites, including those that have served as control for past evaluations of the pilot feathered edges, are typically also identified for future rehabilitation because of their degraded morphology. If implementation occurs over the course of several years however, these sites may serve as control until they themselves are constructed. Site CT near Coopers Bar (part of the Valdor Gulch Rehabilitation Site) was included in this study as a control site because of its proximity and general similarity to much of the Hocker Flat reach. However, channel rehabilitation construction at Valdor Gulch has since occurred (autumn of 2006) so it no longer has utility as control for the Hocker Flat reach.

"Natural" control site

The section of mainstem Trinity River adjacent to and immediately downstream of Oregon Gulch was selected to represent a "natural channel" that exhibited some features expected of a functioning alluvial channel, albeit at a smaller scale than is anticipated under future conditions. Tributary contributions of flow and large sediment here result in localized channel dynamics that do not completely eliminate, but discourage riparian berm formation. The resulting diversity at this site may already be representative of some of the changes we expect to see at rehabilitation sites following channel modifications and ROD flows. As this site responds over time to ROD flows, it will contribute information regarding channel response in reaches not designated for mechanical rehabilitation.

Methods

Habitat characterization and mapping

Study sites were mapped over a range of low to moderate flows to develop flow/habitat relationships (Table 1). River discharge for the Douglas City Feathered Edge site was obtained from the U.S. Geological Survey (USGS) gage at Douglas City. Site discharge at Oregon Gulch was estimated at the gage site just downstream at Junction City. Discharges at all other sites were estimated by adding the Junction City gage estimates to Canyon Creek estimates (a gage at Canyon Creek was operated by the Hoopa Valley Tribe during the time of this study). During mapping visits, discharge from Lewiston Dam accounted for anywhere from less than 10% to nearly 100% of the flow at the sites because of variable dam releases and tributary accretions.

Because habitat typing and mapping of a site at any one flow by the methods described below took several days, mapping surveys were restricted to periods when flows were relatively stable. Each mapping visit began with the generation of base maps depicting the wetted edge, dominant stream margin substrate and dominant vegetation types (Table 2); these features were surveyed with a total station. Dominant substrate and vegetation

Table 1. 2003 Trinity River Pacific salmonid fry and juvenile habitat baseline study site locations.

Site	Approximate river mile (miles from mouth)	Approximate site length in feet	Approximate discharges mapped (cubic feet per second at site)
Douglas City Feathered Edge	93.25	1,480	501 849 1,948 2,906
Oregon Gulch	81.95	2,540	550 771 1,117 2,039 2,881
CK (Hocker Flat)	80.15	1,480	596 1,305 2,756 3,871
CL (Hocker Flat)	79.85	1,640	615 2,900 3,749
Jim Smith (Hocker Flat)	79.50	1,890	595 1,344 3,123 4,500
CM (Hocker Flat)	79.20	1,070	582 969 3,173 4,500
CT (Valdor Gulch)	76.25	1,640	588 994 2,671 3,627

Table 2. Descriptions used to characterize dominant substrate and vegetation types along the stream margin.

Vegetation type	Substrate type
No vegetation (bare substrate)	Clay, silt, or sand (particle size < 2 mm)
Duff, leaf litter, or organic debris	Gravel (particle size 2 to 64 mm)
Aquatic vegetation (emergent or non-emergent)	Cobble (particle size 64 to 256 mm)
Grass	Boulder (particle size 256 to 4064 mm)
Sedge or cattail	Bedrock
Starthistle, cocklebur, etc.	
Berry or grape vine	
Willow	
Tree other than willow (alder, cottonwood, etc.)	
Exposed roots	
Root wad	
Aggregate (dense aggregate of multiple species)	
Woody debris	

types were visually estimated. Base maps from the total station surveyed data were generated using Geographical Information System (GIS) software and printed for use in subsequent mesohabitat and microhabitat mapping (see below). Substrate and vegetation data were subsequently utilized to distribute snorkeling effort for habitat suitability criteria development (discussed later).

Microhabitat Delineation – (depth and velocity)

Smoothed distributions of Trinity River salmonid depth and velocity habitat use observations from Hampton (1997) were reviewed to select appropriate breaks to use for making microhabitat delineations. Particular emphasis was placed on reviewing these data for fry (fish less than 50 mm in fork length) since fry habitat has been identified as the primary limiting feature for natural production of anadromous Trinity River salmonids post construction of the TRD (USFWS 1994; USFWS and Hoopa Valley Tribe 1999), Large portions of those reported observations (approximately 67% for Chinook salmon fry, 84% for coho salmon fry, and 36% for steelhead fry) occurred in water velocities less than 0.4 feet/second, and nearly all fry observations (approximately 91% for Chinook salmon fry, 96% for coho salmon fry, and 74% for steelhead fry) occurred in velocities less than 0.8 feet/second. Distributions of depth observations in Hampton's data showed that approximately 68% of Chinook salmon fry observations, 79% of coho salmon fry observations, and 93% of steelhead fry observations occurred in depths of two

feet or less. Based on this review, velocities of 0.4 and 0.8 feet/second and a depth of two feet were selected as break points for our habitat mapping.

Hampton (1997) characterized juvenile size classes as those fish with fork lengths from 50 to 200 mm. For this larger size range of fish, velocities of less than 0.8 feet/second captured approximately 63% of the Chinook salmon and 72% of the coho salmon observations, but only 41% of the steelhead juvenile observations. Depths less than 2.0 ft captured 41% of Chinook salmon observations, 40% of coho salmon observations, and 23% of steelhead observations. Including additional break-points for depth and velocity (deeper and faster) in this study would have improved resolution for characterization of habitat for the juvenile size-classes, but were not included because of the emphasis on fry and to reduce mapping complexity.

With a base map of water's edge and mesohabitat units in hand, crews identified and delineated 2 foot water depth contours utilizing either stadia rods or top-setting flow rods. Water velocity breaks at 0.4 feet/second and 0.8 feet/second were identified using Price AA velocity meters and hand-drawn onto the base maps. The maps were later digitized into electronic format and velocity and depth polygons were combined to produce bivariate microhabitat polygons using GIS software.

Habitat Suitability Criteria

Snorkel surveys for habitat suitability criteria occurred late March to mid-July in 2002, and mid-March to mid-August in 2003. Estimated on-site discharges while snorkeling ranged from near 300 cfs to over 3,600 cfs (as determined from nearby stream gage recordings). Higher site discharges were encountered on occasion, but were not snorkel-sampled because of limited visibility and/or safety concerns.

To distribute fish microhabitat observation sampling across the available stream margin habitats within each site, we employed a methodology for edge habitat substrate and vegetation mapping developed for use during a fry habitat use study conducted on the Klamath River by the USFWS, USGS, and California Department of Fish and Game (CDFG). This method was developed to identify stream margin characteristics that may be most important for explaining fry distribution (Tom Shaw, USFWS; and Gary Smith, CDFG, personal communication). Using this system, crews marked the up and downstream extent of edge habitats that had uniform dominant vegetation and substrate types. A change in either vegetation or substrate along the stream margin was marked as a break between units. Each unit was designated with a Stream Margin Edge Type (SMET) based on substrate and wetted-vegetation characteristics. These linear characterizations along the margins formed the framework to distribute snorkel observation effort for Habitat Suitability Criteria (HSC) development. All expressed

combinations of dominant substrate and vegetation along each bank at a study site were tallied after SMET mapping, and a minimum of 1/3 of each SMET combination present was randomly selected for snorkeling.

Fish observation and microhabitat measurement

Fish were classified into three size classes for this study: less than 50 mm fork length; 50 to 120 mm fork length; and greater than 120 mm fork length. Snorkelers categorized fish into these size classes based on visual estimation of fork length. To calibrate fish size estimates, snorkelers periodically observed fish-shaped lures of known sizes underwater. Snorkelers used caution to avoid influencing fish position in the river. Upon observation of fish, the snorkeler noted species, size class, and focal depth of the fish (or group of fish if tightly schooled and using the same microhabitat), and marked the location with a weighted marker. Snorkelers only marked locations for subsequent microhabitat data collection when they were confident that the fish's position was not influenced by the presence of the divers themselves, team members, or other unnatural behavior due to disturbances. Following snorkel observation, measurements of column depth and mean column velocity were made at each marker.

Microhabitat use data process for bivariate HSC

Because of the schooling behavior of salmonids, the number of fish observed in a school using a single microhabitat could be influenced both by the quality and size of the microhabitat and by presence of the school itself. Weighting a single microhabitat observation by the number of fish observed in the school could give undue value to the microhabitat where that observation was made. To avoid this potential over-weighting, each school of fish was treated as a single observation; an approach that conforms to the methods of Hampton (1997) for the Trinity River HSC construction, the results of which were used in the Trinity River Flow Evaluation Study (USFWS and Hoopa Valley Tribe 1999).

The microhabitat mapping we conducted included two categories of depth (< 2 ft, ≥ 2 ft) and three categories of mean column velocity (< 0.4 ft/s, 0.4 to < 0.8 ft/s, ≥ 0.8 ft/s) resulting in six possible bivariate combinations of depth and velocity. Each observation that included both depth and velocity was categorized into one of the six possible combinations. Frequency histograms by microhabitat category were constructed and normalized for each species and size class. The categorical HSC are simply the normalized value of the frequency of observations for each category (Equation 1) and can range in value from 0.0 to 1.0.

$$HSC_i = \frac{F_i}{F_{MAX}}$$

$$Where:$$

Equation 1

$$F_i = frequency\ of\ observations\ in\ category\ i$$

$$F_{MAX} = frequency\ of\ observations\ in\ the\ category\ with\ most\ observations$$

Weighted Usable Area for mapped habitats

Area was determined for each of the six bivariate microhabitat categories using GIS. To calculate weighted usable area (WUA) for a particular species and size class, the area of each microhabitat category was multiplied by its corresponding categorical HSC value and the resulting values were summed.

Low value habitats can inflate WUA estimates when there are large areas of marginally or poorly suitable habitat. This is especially a concern for the most "extreme" of our six habitat categories – those with mean water column velocities of greater than 0.8 feet/second and a depth of 2 feet or greater. Marginally useable habitat that only slightly exceeds these depth and velocity values could not be differenciated on our maps from entirely unusable habitat that far exceed these thresholds. Including this habitat category in WUA calculations artificially inflates WUA for those species/life-stages that exhibit even trivial HSC value in the "extreme" habitat category. For these reasons, a microhabitat category HSC value of 0.4 was arbitrarily selected as a cutoff to eliminate the influence of low-quality habitat on WUA estimates. For depth and velocity categories that had HSC values less than 0.4, HSC was set to zero.

The Hocker Flat rehabilitation complex is represented by four study sites, each of which were mapped independently across a range of flows. To characterize WUA-to-discharge relationships for Hocker Flat in its entirety, WUA/linear foot estimates for mapped discharges at each of the four individual study sites were weighted by their relative contribution to Hocker Flat by length, and S-PLUS statistical software was used to fit a smooth curve to the data using a cubic smoothing spline routine with 5 degrees of freedom (S-PLUS 6.1).

Results

Habitat Suitability Criteria

A total of 1,606 microhabitat observations of depth and/or velocity representing 15,271 fry and juvenile salmonids were made in 2002 and 2003. These data included 1,532 paired depth and velocity observations. Very few observations were made of fish greater

than 120 mm fork length. Those that were observed often fell into the most extreme of our habitat categories (velocity ≥ 0.8 ft/sec and ≥ 2 ft deep). As such, habitat analyses for size classes greater than 120 mm are not included in this study.

The greatest number of observations for all species/size classes except juvenile steelhead occurred in the shallowest and slowest habitat category (less than 2 feet deep and less than 0.4 feet/second) making this shallow/slow water the "most suitable" (see scatter-plots Figure 3 through Figure 5, and HSC values Table 3 through Table 5). Fry of all target species showed a strong affinity for shallow and slow habitat. Juvenile size classes also exhibited an affinity for shallow/slow water, though less so than fry. Juvenile steelhead in particular were more often observed in water with velocities greater than 0.8 feet/second, but still in water less than 2 feet deep (Figure 5, Table 5). However, because this study emphasized fry, stream margin habitats received most of the sampling effort. Additional effort in deeper mid-channel water along with more categories of depth would have increased the resolution of our HSC data for juvenile steelhead, and deeper habitat would likely show more importance for steelhead than is reflected in our results.

Chinook salmon fry and juvenile use of shallow water with velocities ≥ 0.8 ft/sec was higher than was observed for steelhead fry or coho salmon fry and juveniles (Table 3 through Table 5). Resultant HSC for Chinook salmon and juveniles were nearly identical (Table 3). Likewise, HSC for fry and juveniles of coho salmon and steelhead fry are all nearly identical to each other. Based on these similarities, the species and life stages of this study fell into three general guilds: 1) Chinook salmon fry and juveniles; 2) coho salmon fry, coho salmon juveniles, and steelhead fry; and 3) steelhead juveniles.

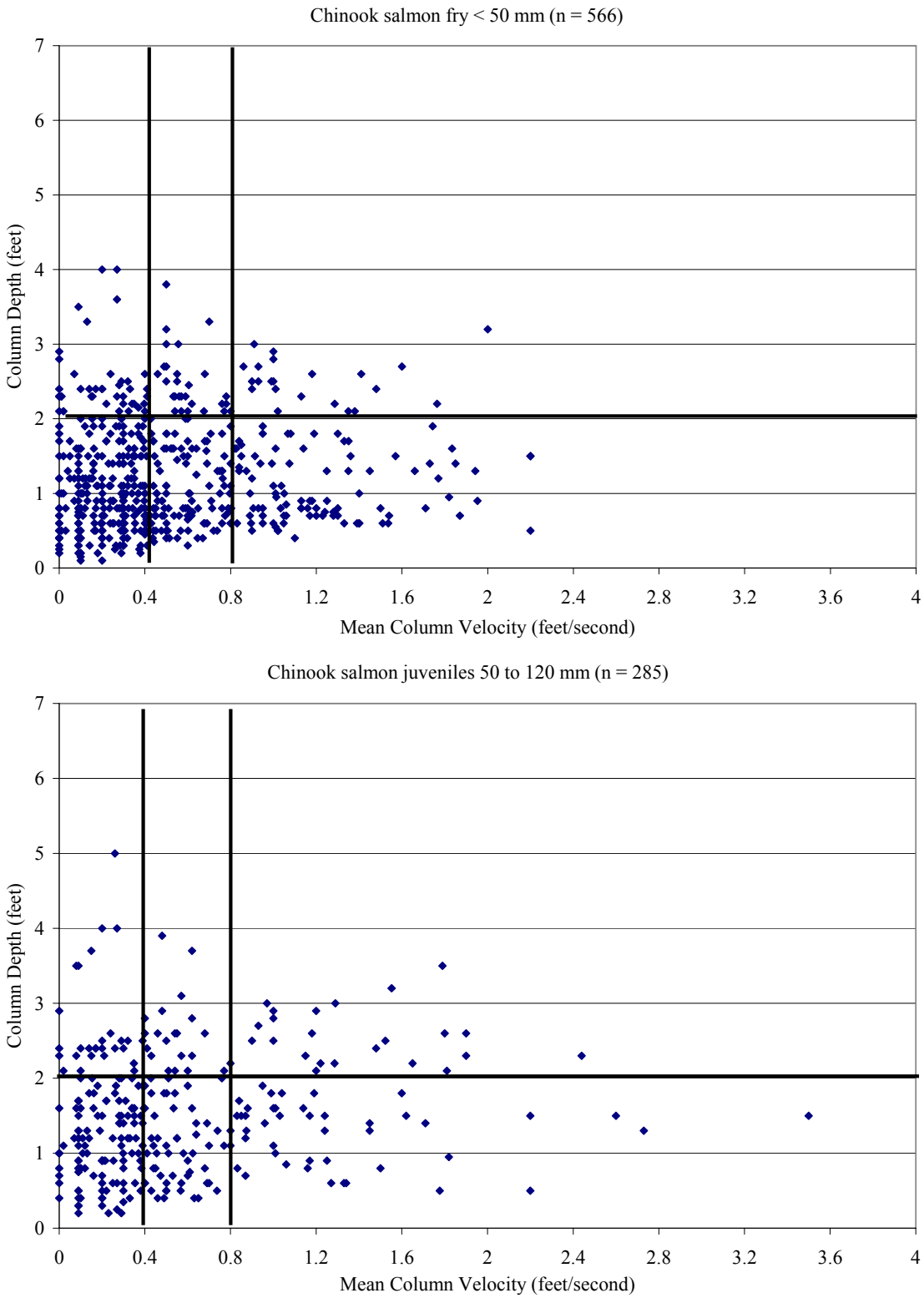

Figure 3. Scatter-plots of depth and velocity observations made in the Trinity River during 2002 and 2003 for Chinook salmon fry (top) and juvenile (bottom) size classes. Bold lines indicate breaks used to delineate microhabitat.

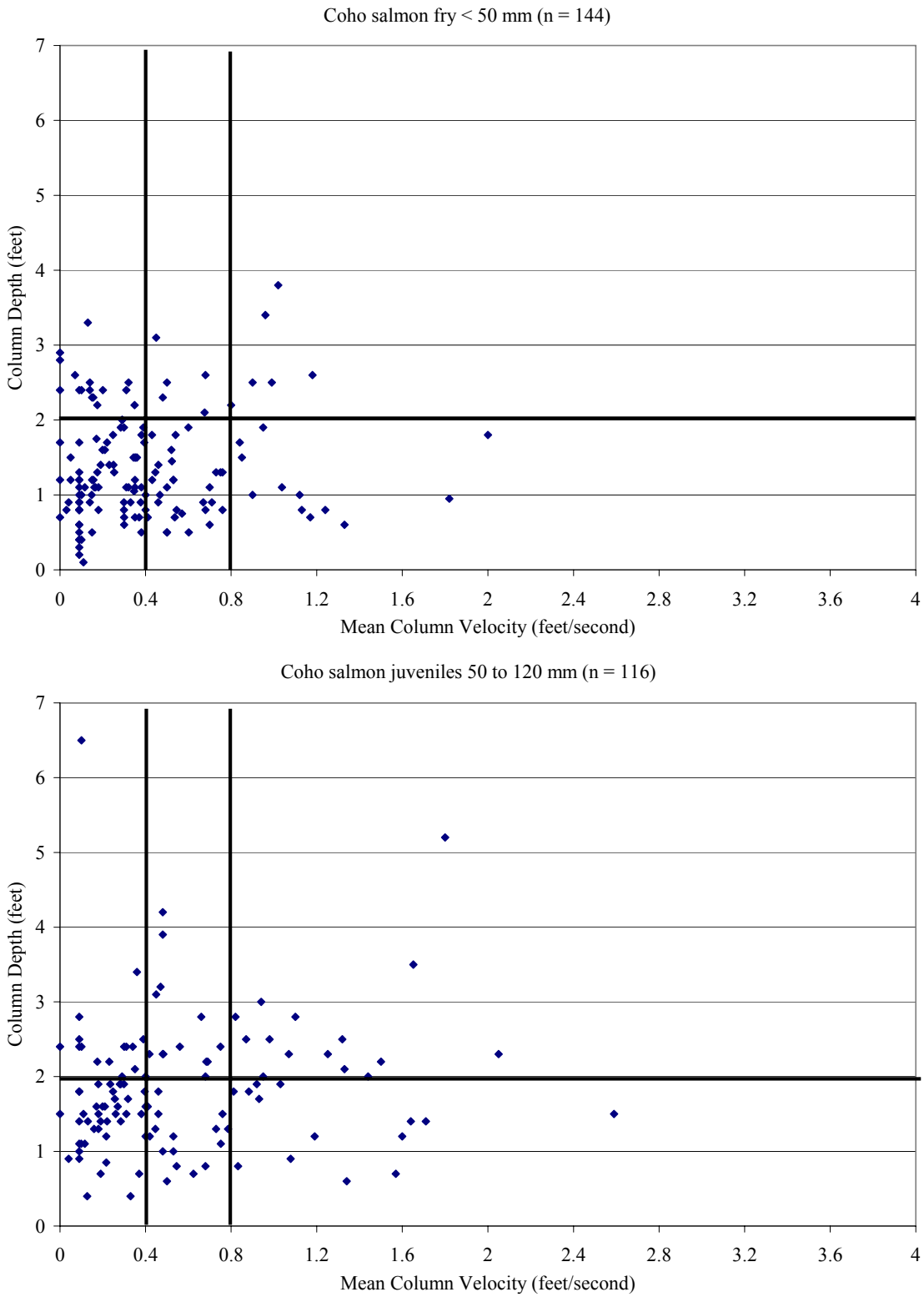

Figure 4. Scatter-plots of depth and velocity observations made in the Trinity River during 2002 and 2003 for coho salmon fry (top) and juvenile (bottom) size classes. Bold lines indicate breaks used to delineate microhabitat.

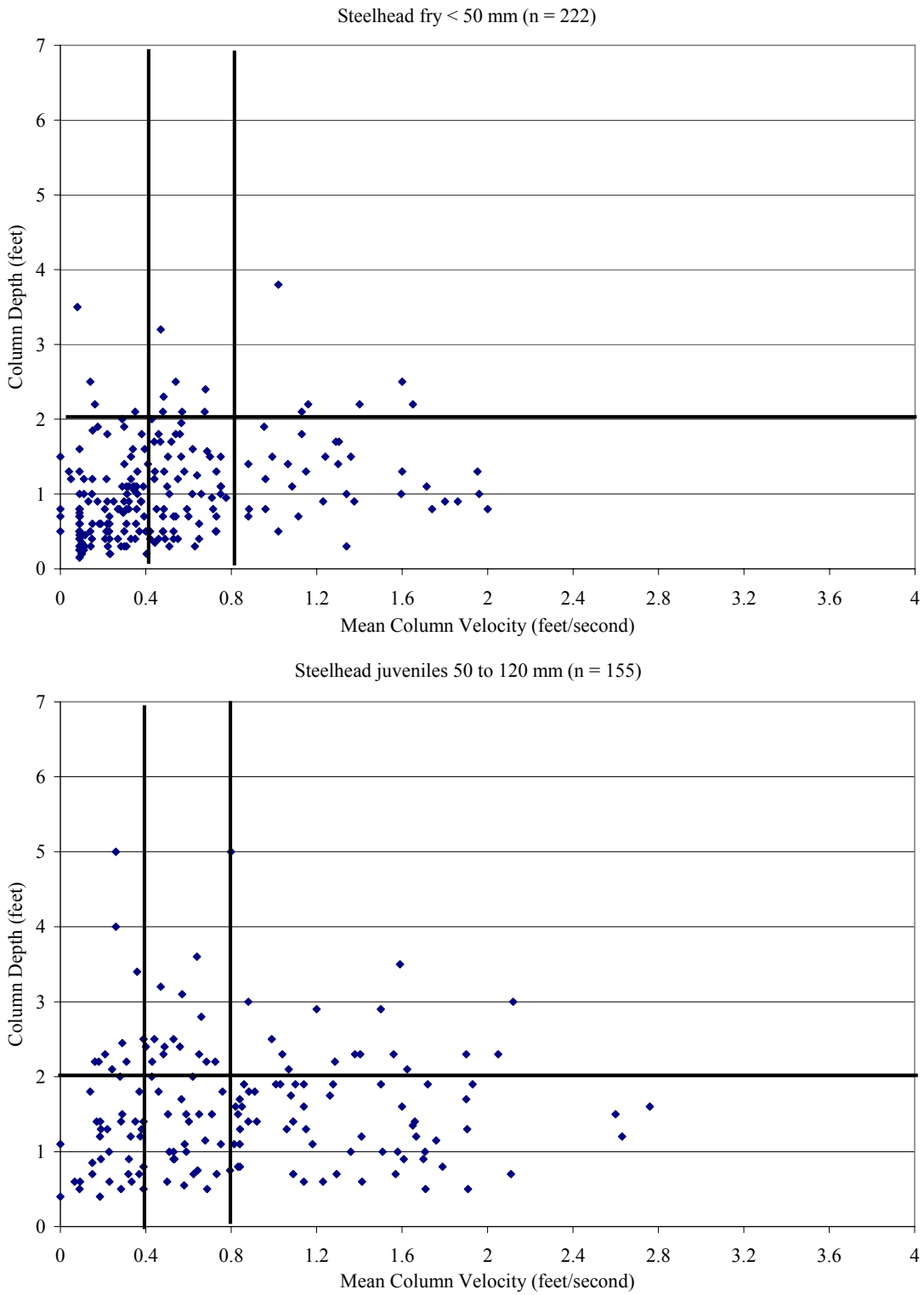

Figure 5. Scatter-plots of depth and velocity observations made in the Trinity River during 2002 and 2003 for steelhead fry (top) and juvenile (bottom) size classes. Bold lines indicate breaks used to delineate microhabitat. One steelhead juvenile observation at 4.4 ft/sec and 1.1 feet deep not pictured

Table 3. Bivariate depth and velocity Habitat Suitability Criteria for Chinook salmon fry (< 50 mm) and juvenile (50 to 120 mm) size classes. Calculated values of HSC less than 0.4 were truncated to "zero" to exclude marginal habitat from the WUA calculations.

	Chinook salmon < 50 mm	Chinook salmon 50 to 120 mm
n fish =	9,440	3,181
n observations =	566	285
< 0.4 ft/sec, < 2 ft deep	1.00	1.00
<0.4 ft/sec, ≥ 2 ft deep	0.17 (truncated to 0.0)	0.30 (truncated to 0.0)
0.4 to <0.8 ft/sec, < 2 ft deep	0.50	0.45
0.4 to <0.8 ft/sec, ≥ 2 ft deep	0.14 (truncated to 0.0)	0.21 (truncated to 0.0)
≥ 0.8 ft/sec, < 2 ft deep	0.40	0.41
≥ 0.8 ft/sec, ≥ 2 ft deep	0.09 (truncated to 0.0)	0.22 (truncated to 0.0)

Table 4. Bivariate depth and velocity Habitat Suitability Criteria for coho salmon fry (< 50 mm) and juvenile (50 to 120 mm) size classes. Calculated values of HSC less than 0.4 were truncated to "zero" to exclude marginal habitat from the WUA calculations.

	Coho salmon < 50 mm	Coho salmon 50 to 120 mm
n fish =	623	527
n observations =	144	116
<0.4 ft/sec, < 2 ft deep	1.00	1.00
<0.4 ft/sec, ≥ 2 ft deep	0.25 (truncated to 0.0)	0.38 (truncated to 0.0)
0.4 to <0.8 ft/sec, < 2 ft deep	0.43	0.45
0.4 to <0.8 ft/sec, ≥ 2 ft deep	0.07 (truncated to 0.0)	0.35 (truncated to 0.0)
≥ 0.8 ft/sec, < 2 ft deep	0.17 (truncated to 0.0)	0.35 (truncated to 0.0)
≥ 0.8 ft/sec, ≥ 2 ft deep	0.08 (truncated to 0.0)	0.38 (truncated to 0.0)

Table 5. Bivariate depth and velocity Habitat Suitability Criteria for steelhead fry (< 50 mm) and juvenile (50 to 120 mm) size classes. Calculated values of HSC less than 0.4 were truncated to "zero" to exclude marginal habitat from the WUA calculations.

	Steelhead < 50 mm	Steelhead 50 to 120 mm
n fish =	623	417
n observations =	222	155
<0.4 ft/sec, < 2 ft deep	1.00	0.56
<0.4 ft/sec, ≥ 2 ft deep	0.04 (truncated to 0.0)	0.19 (truncated to 0.0)
0.4 to <0.8 ft/sec, < 2 ft deep	0.51	0.40
0.4 to <0.8 ft/sec, ≥ 2 ft deep	0.07 (truncated to 0.0)	0.30 (truncated to 0.0)
≥ 0.8 ft/sec, < 2 ft deep	0.27 (truncated to 0.0)	1.00
≥ 0.8 ft/sec, ≥ 2 ft deep	0.05 (truncated to 0.0)	0.26 (truncated to 0.0)

Habitat Category areas and Weighted Usable Area

The total area of "extreme" habitat sometimes dominated the extent of our study sites, ranging between approximately 27 and 92 % of the wetted surface area depending on location and discharge (Table 6 through Table 12 and maps Figure A-1 through Figure G-4). For all target species and size classes, the calculated HSC value for the extreme category was less than 0.4, which was truncated to zero and therefore did not influence WUA calculations.

Table 6. Mapped habitat areas at the Douglas City feathered edge study site. Site length 1,480 feet

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
08/18/03	465	501	2,845 ft²	4,122 ft²	65,852 ft²	918 ft²	1,354 ft²	43,619 ft²	118,708 ft²
04/15/03	313	849	5,695 ft²	3,079 ft²	20,655 ft²	714 ft²	1,094 ft²	92,072 ft²	123,309 ft²
06/18/03	1,980	*1,948	1,721 ft²	1,557 ft²	8,047 ft²	52 ft²	262 ft²	120,292 ft²	131,931 ft²
05/13/03	2,520	2,906	7,087 ft²	4,316 ft²	8,127 ft²	82 ft²	767 ft²	120,909 ft²	141,288 ft²

*Even though downstrem of Lewiston Dam, the gage at Douglas City occasionally reports less discharge than the gage near Lewiston Dam.

Table 7. Mapped habitat areas at the Oregon Gulch study site. Site length 2,540 feet

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
08/13/03	465	550	13,452 ft²	9,292 ft²	65,470 ft²	3,045 ft²	2,034 ft²	62,672 ft²	155,964 ft²
04/08/03	307	729	11,503 ft²	9,942 ft²	54,421 ft²	5,833 ft²	5,905 ft²	74,837 ft²	162,440 ft²
03/18/03	313	1,117	9,641 ft²	6,089 ft²	26,532 ft²	6,216 ft²	8,985 ft²	118,283 ft²	175,747 ft²
06/24/03	1,980	2,039	14,859 ft²	4,400 ft²	18,068 ft²	2,260 ft²	1,918 ft²	164,152 ft²	205,658 ft²
05/20/03	2,440	2,881	38,223 ft²	9,792 ft²	27,387 ft²	772 ft²	3,194 ft²	181,421 ft²	260,789 ft²

Table 8. Mapped Habitat areas at the CK study site. Site length 1,480 feet. This site is part of the Hocker Flat Rehabilitation Site Complex.

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
07/24/03	404	596	5,657 ft²	4,337 ft²	94,449 ft²	1,388 ft²	1,356 ft²	39,310 ft²	146,496 ft²
04/15/03	313	1,305	5,598 ft²	2,740 ft²	14,990 ft²	756 ft²	914 ft²	131,185 ft²	156,182 ft²
06/03/03	1,980	2,756	1,948 ft²	1,597 ft²	8,299 ft²	671 ft²	335 ft²	153,847 ft²	166,696 ft²
05/06/03	2,520	3,871	4,923 ft²	2,995 ft²	3,923 ft²	202 ft²	943 ft²	161,506 ft²	174,492 ft²

Table 9. Mapped habitat areas at the CL study site. Site length 1,640 feet. This site is part of the Hocker Flat Rehabilitation Site Complex.

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
07/29/03	455	615	9,131 ft²	5,969 ft²	74,781 ft²	2,022 ft²	3,776 ft²	123,363 ft²	219,042 ft²
06/03/03	1,980	2,900	5,763 ft²	3,496 ft²	5,166 ft²	493 ft²	1,131 ft²	227,690 ft²	243,740 ft²
05/06/03	2,520	3,749	8,342 ft²	3,639 ft²	3,598 ft²	1,058 ft²	2,385 ft²	230,636 ft²	249,657 ft²

Table 10. Mapped habitat areas at the Jim Smith study site. Site length 1,890 feet. Site includes the Jim Smith pilot feathered edge rehabilitation site constructed in the 1990's as well as channel downstream. This site is part of the Hocker Flat Rehabilitation site Complex.

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
07/30/03	465	595	3,206 ft²	2,971 ft²	47,213 ft²	15 ft²	28 ft²	89,690 ft²	143,122 ft²
03/20/03	317	1,344	6,214 ft²	3,651 ft²	16,689 ft²	186 ft²	397 ft²	127,742 ft²	154,880 ft²
05/27/03	2,010	3,123	4,904 ft²	3,324 ft²	17,250 ft²	283 ft²	575 ft²	161,760 ft²	188,095 ft²
04/29/03	317	4,500	25,212 ft²	5,406 ft²	27,814 ft²	37 ft²	192 ft²	183,284 ft²	241,945 ft²

Table 11. Mapped habitat areas at the CM study site. Site length 1,070 feet. This site is part of the Hocker Flat Rehabilitation site Complex.

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
08/06/03	473	582	7,650 ft²	1,844 ft²	10,685 ft²	2,525 ft²	2,717 ft²	61,574 ft²	86,995 ft²
03/12/03	324	969	2,847 ft²	2,289 ft²	5,700 ft²	1,459 ft²	1,511 ft²	75,575 ft²	89,380 ft²
05/27/03	2,010	3,173	4,139 ft²	4,591 ft²	5,201 ft²	511 ft²	493 ft²	92,694 ft²	107,629 ft²
04/29/03	317	4,500	5,158 ft²	1,595 ft²	4,964 ft²	606 ft²	1,158 ft²	106,563 ft²	120,044 ft²

Table 12. Mapped habitat areas at the CT (Valdor Gulch) study site. Site length 1,640 feet.

Date mapped	Lewiston Dam discharge (cfs)	Approximate discharge at site (cfs)	Depth < 2 ft			Depth ≥ 2 ft			Total wetted site area
			Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	Velocity < 0.4 ft/s	0.4 ≤ Velocity < 0.8 ft/s	Velocity ≥ 0.8 ft/s	
08/11/03	464	588	11,778 ft²	4,165 ft²	44,152 ft²	2,138 ft²	1,653 ft²	108,621 ft²	172,506 ft²
04/08/03	307	994	5,522 ft²	3,233 ft²	17,804 ft²	183 ft²	533 ft²	152,362 ft²	179,637 ft²
06/10/03	1,980	2,571	4,238 ft²	2,946 ft²	5,540 ft²	272 ft²	722 ft²	182,313 ft²	196,030 ft²
05/13/03	2,520	3,671	6,952 ft²	2,587 ft²	7,907 ft²	1,517 ft²	2,077 ft²	183,096 ft²	204,135 ft²

Because HSC values between species and life stages within each of the three guilds (Chinook salmon fry and juveniles; coho salmon fry, coho salmon juveniles, and steelhead fry; steelhead juveniles) were nearly identical, WUA estimates were likewise nearly identical. For simplification, graphs for WUA per linear river foot presented in Figure 9 through Figure 14 represent guilds of fish. The exact calculated WUA per linear river foot values for each species and life stage are given in Appendix H.

Hocker Flat study sites (CK, CL, Jim Smith, and CM) are presented together in the following graphs for comparison purposes (Figure 9, Figure 12, Figure 15). Likewise, the Douglas City feathered edge and Jim Smith (which included a feathered edge) sites are presented together (Figure 10, Figure 13, Figure 16), and Oregon Gulch (upstream of Hocker Flat) is presented with site CT (downstream of Hocker Flat; Figure 11, Figure 14, Figure 17).

Under pre-construction conditions at Hocker Flat, the availability of slow/shallow habitat initially declined with increasing discharge over base flow, and remained low up to flows of around 3,000 cfs at our study sites CK, CL, and CM. At higher flows, water began to flood the berm and/or wet the ancestral floodplain behind it and provide more slow/shallow habitat (Figure 6, and Figure F-3), but habitat gains with these flows were minimal. This is in contrast to the flow/habitat relationship at the Jim Smith study site. A feathered edge was constructed at the top of this site in 1993. We found availability of slow/shallow habitat initially declined with flows above base like the other Hocker Flat sites, but flows above 4,000 cfs flooded over the feathered edge and spilled into a secondary side channel on the downstream half of this site. Slow/shallow habitat sharply increased at these higher flows in this side channel area (Figure 7, and Figure E-4).

A similar upturn occurred at the Oregon Gulch study site where alluvial deposits from the tributary Oregon Gulch were flooded at flows near 2,500 cfs and increased the availability of shallow/slow habitat (Figure 8). The tributary Oregon Gulch enters the river at this site and periodically deposits significant amounts of course sediment into the Trinity River. Because of the tributary input of water and sediment, the channel in this immediate vicinity is dynamic (frequently mobilized surface, variable topography from year-to-year, lack of established berm). The topography here frequently changes in response to flow events. One of the reasons the Oregon Gulch site was selected was for its relative lack of riparian berm resulting from these channel dynamics. Adding to the complexity here is a side channel that was constructed in 1991. Two entrances were originally constructed to this channel, one about 260 ft upstream of the other. The upper end of the artificial channel was filled in with sediment during winter storms in 1992-1993. The remainder of the channel continued to act as a secondary high flow channel at flows higher than those mapped for this study. The topography of this area at the time of

this study was such that the dynamic depositional area downstream from the tributary Oregon Gulch flooded at flows of about 2,500 cfs and created high value fry habitat (Figure 8, and Figure B-5).

Figure 6. Downstream end of proposed Trinity River rehabilitation site CM (part of the Hocker Flat Rehabilitation site complex) on 5-28-2003. Water in this photo is spilling over an early-successional berm feature and forming prime salmonid fry habitat in the foreground. River discharge here at the time of this photo was approximately 3,173 cubic feet per second.

Figure 7. Jim Smith pilot rehabilitation site on the Trinity River 5-14-2002. This site was part of the Hocker Flat Rehabilitation site Complex. Photo was taken facing downstream toward the lower end of a "feathered edge" constructed in 1993. Flows of about 4,000 cfs and higher spilled over this feature into a secondary high flow side channel downstream of the feathered edge, creating high quality salmonid fry habitat.

Figure 8. Downstream end of the "Natural" Oregon Gulch study site on May 21, 2003. Excellent fry habitat was created here as waters flooded alluvial deposits from Oregon Gulch. Trinity River discharge here at the time of this photo was approximately 2,881 cubic feet per second.

Weighted usable area for Chinook salmon fry and juvenile life histories were relatively high at all sites for the base flows mapped, decreased sharply as flows transitioned through base to about 2,000 cfs, and then eventually increased at the higher flows mapped (3,000 to 4,500 cfs; Figure 9 through Figure 11). Prior to rehabilitation at Hocker Flat, collective WUA of habitat for Chinook salmon fry and juveniles per linear river foot was about 20 at site base flows of around 500 cfs, decreased to a minimum of about 5 near site flows of 2,000 cfs or so, and improved as flows exceeded about 4,000 cfs largely as a result of the secondary channel found at our Jim Smith site (Figure 9 and Figure 10; Figure E-4).

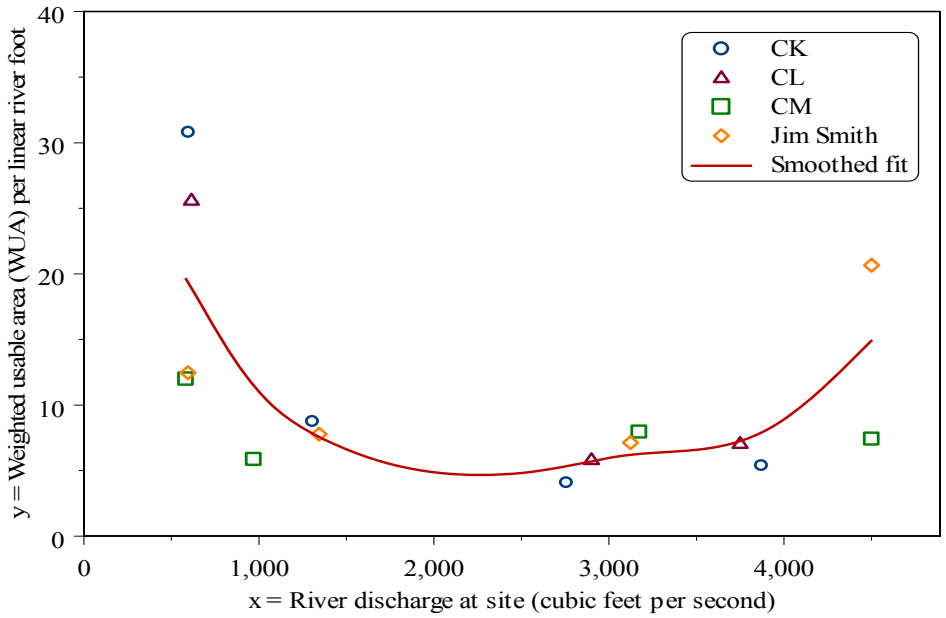

Figure 9. Weighted usable area per river-foot of habitat for Chinook salmon fry (< 50 mm) and juveniles (50 to 120 mm) at the study sites within the Trinity River Hocker Flat rehabilitation site complex. The Jim Smith site included feathered edge and unmodified river channel, all entirely enveloped by the Hocker Flat Rehabilitation site complex. Smoothed curve was fit to mapped nodes (weighted by their length contribution to Hocker Flat) using a cubic smoothing spline routine with 5 degrees freedom (software S-PLUS 6.1).

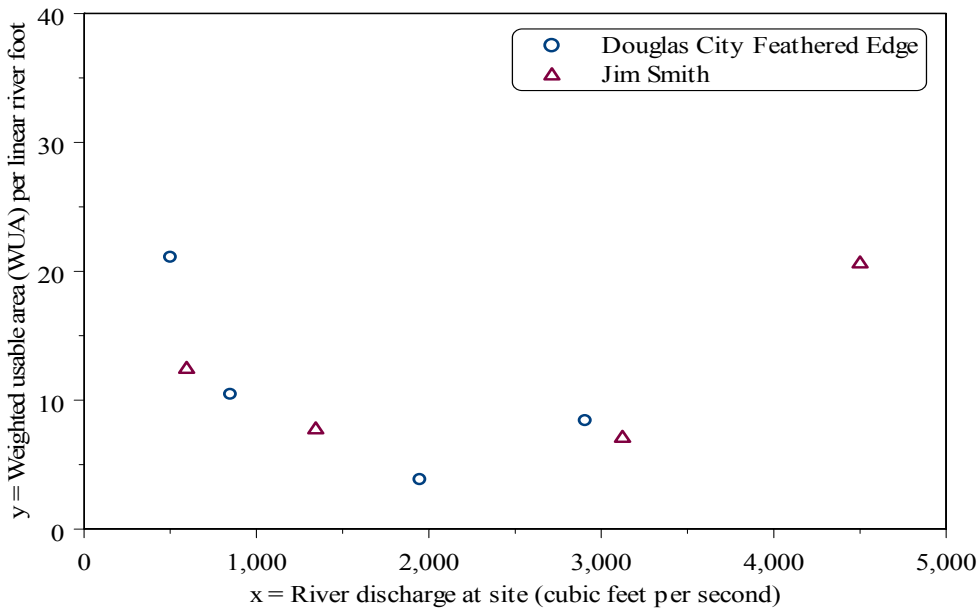

Figure 10. Weighted usable area per river-foot of habitat for Chinook salmon fry (< 50 mm) and juveniles (50 to 120 mm) at study sites that included pilot feathered edges constructed in the 1990's. The Jim Smith site included feathered edge and unmodified river channel, all entirely enveloped by the Hocker Flat Rehabilitation site complex.

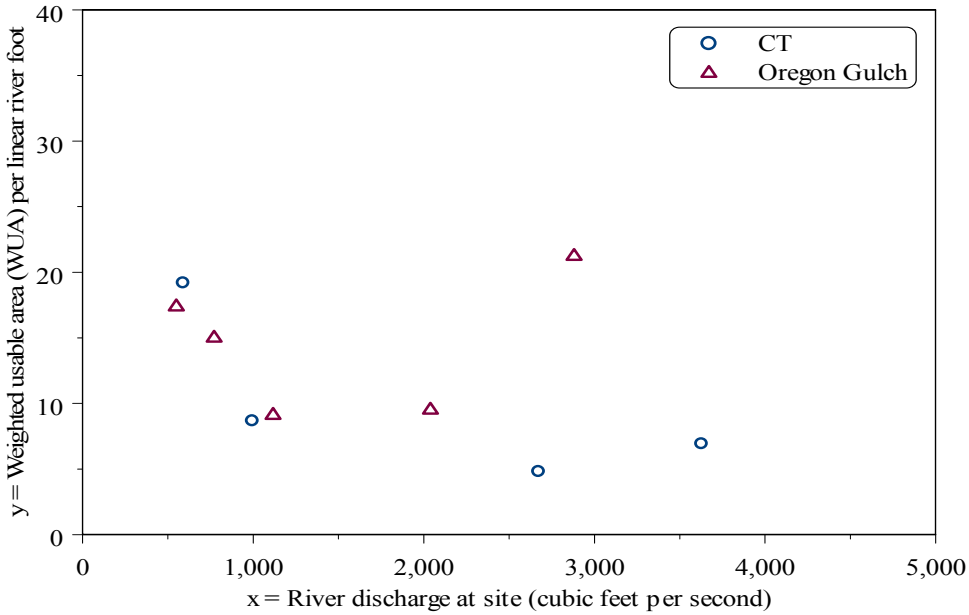

Figure 11. Weighted usable area per river foot of habitat for Chinook salmon fry (< 50 mm) and juveniles (50 to 120 mm) at Trinity River proposed rehabilitation site CT (at Valdor Gulch downstream of Hocker Flat) and at Oregon Gulch (upstream of Hocker Flat and Canyon Creek).

Habitat for coho salmon fry/juveniles and steelhead fry was much more limited than for the Chinook salmon size classes at the base flows mapped (Figure 12 through Figure 14). At Hocker Flat, WUA of habitat per linear river foot for habitat for this guild of was only about 5 at base flows and remained relatively static until the secondary channel located within the Jim smith study site was wetted at flows exceeding 4,000 or so (Figure 12 and Figure 13). As observed with the Chinook salmon guild, flooding the broad alluvial deposits at the Oregon Gulch study site created a similar upturn in available habitat for coho salmon fry/juveniles and steelhead fry (Figure 14).

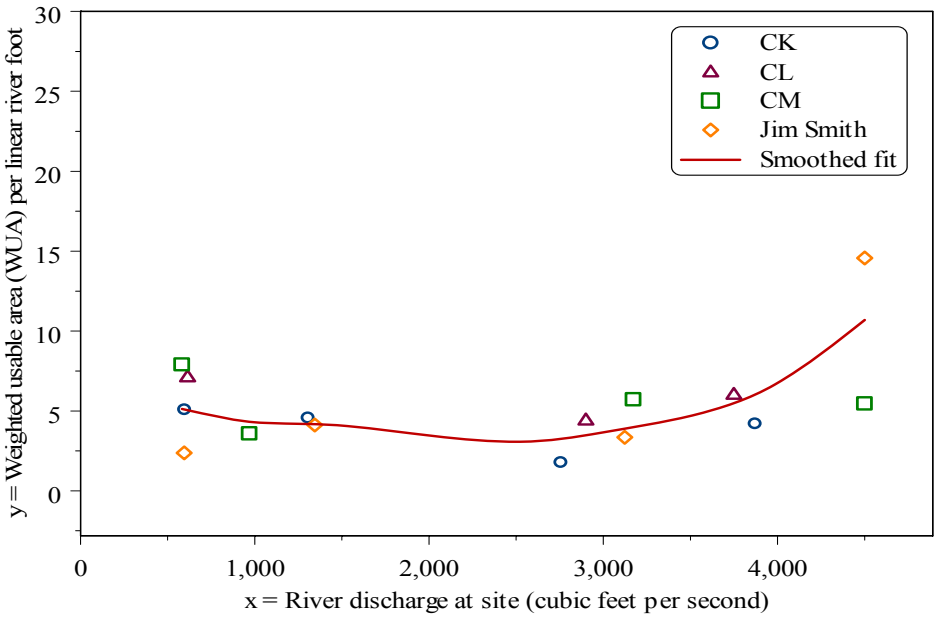

Figure 12. Weighted usable area per river foot of habitat for coho salmon and steelhead fry (< 50 mm) and coho salmon juveniles (50 to 120 mm) at the study sites within the Trinity River Hocker Flat rehabilitation site complex. The Jim Smith site included feathered edge and unmodified river channel, all entirely enveloped by the Hocker Flat Rehabilitation site complex. Smoothed curve was fit to mapped nodes (weighted by their length contribution to Hocker Flat) using a cubic smoothing spline routine with 5 degrees freedom (software S-PLUS 6.1).

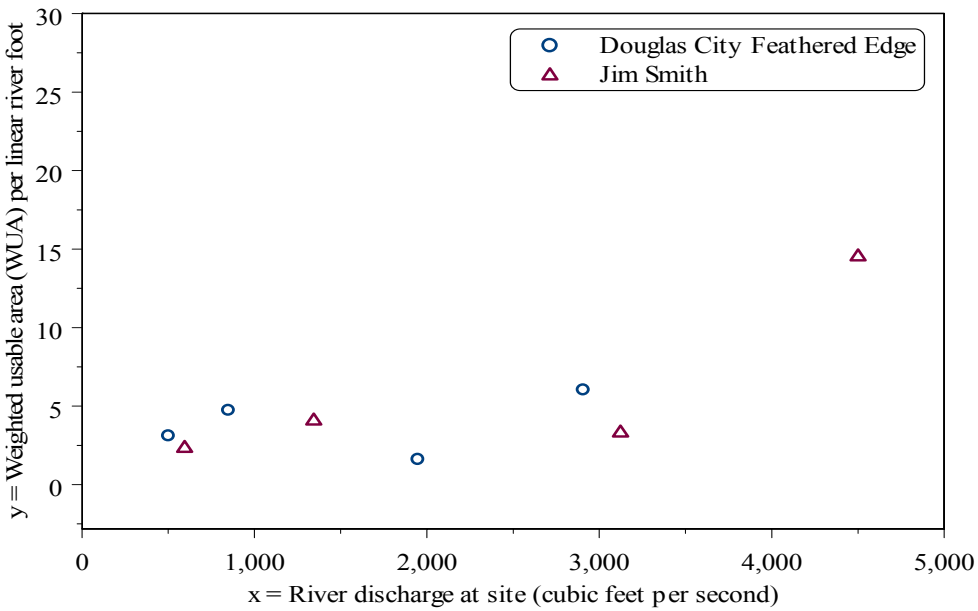

Figure 13. Weighted usable area per river foot of habitat for coho salmon and steelhead fry (< 50 mm) and coho salmon juveniles (50 to 120 mm) at study sites that included pilot feathered edges constructed in the 1990's. The Jim Smith site included feathered edge and unmodified river channel, all entirely enveloped by the Hocker Flat Rehabilitation site complex.

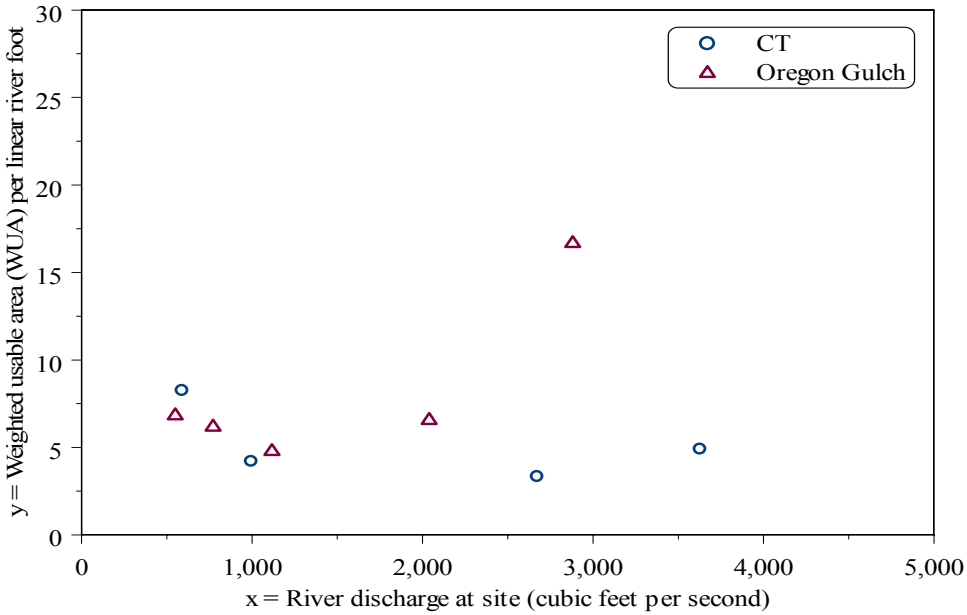

Figure 14. Weighted usable area per river foot of habitat for coho salmon and steelhead fry (< 50 mm) and coho salmon juveniles (50 to 120 mm) at Trinity River proposed rehabilitation site CT (at Valdor Gulch downstream of Hocker Flat) and at Oregon Gulch (upstream of Hocker Flat).

The smoothed curve for steelhead juvenile habitat availability at the Hocker Flat site was somewhat similar in shape to that for the Chinook salmon guild, but WUA per linear river foot values were about double those for Chinook salmon through the lower range of flows mapped and exhibited a less pronounced gain of habitat at the highest flows mapped (compare Figure 15 with Figure 9). Figure 16 and Figure 17 show similar relationships where WUA is highest at base flows, decreases sharply with flow, and exhibits less gain of habitat at the highest flows mapped than was observed with the Chinook salmon guild.

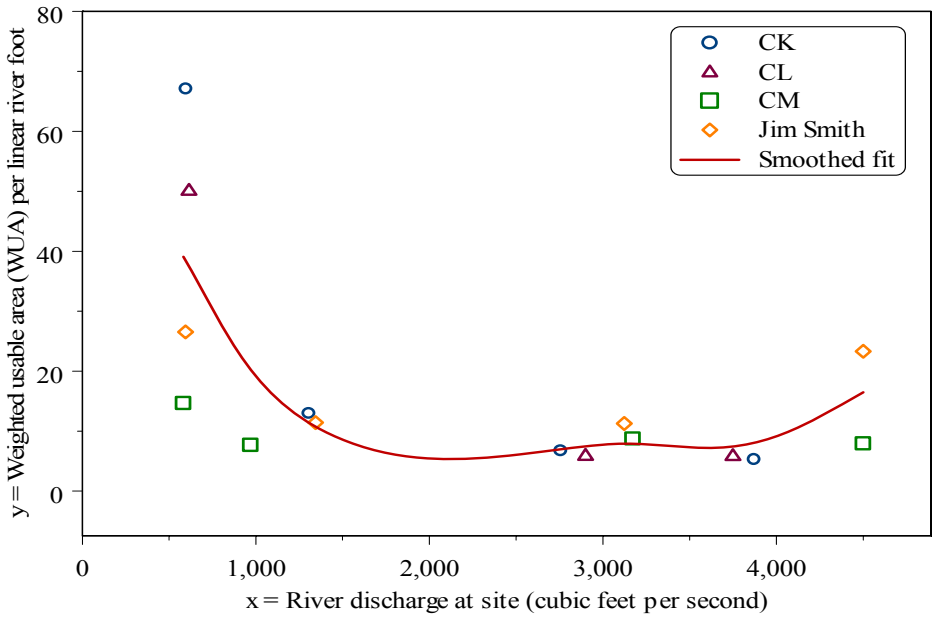

Figure 15. Weighted usable area per river foot of habitat for steelhead juveniles (50 to 120 mm) at the study sites within the Trinity River Hocker Flat rehabilitation site complex. The Jim Smith site included feathered edge and unmodified river channel, all entirely enveloped by the Hocker Flat Rehabilitation site complex. Smoothed curve was fit to mapped nodes (weighted by their length contribution to Hocker Flat) using a cubic smoothing spline routine with 5 degrees freedom (software S-PLUS 6.1).

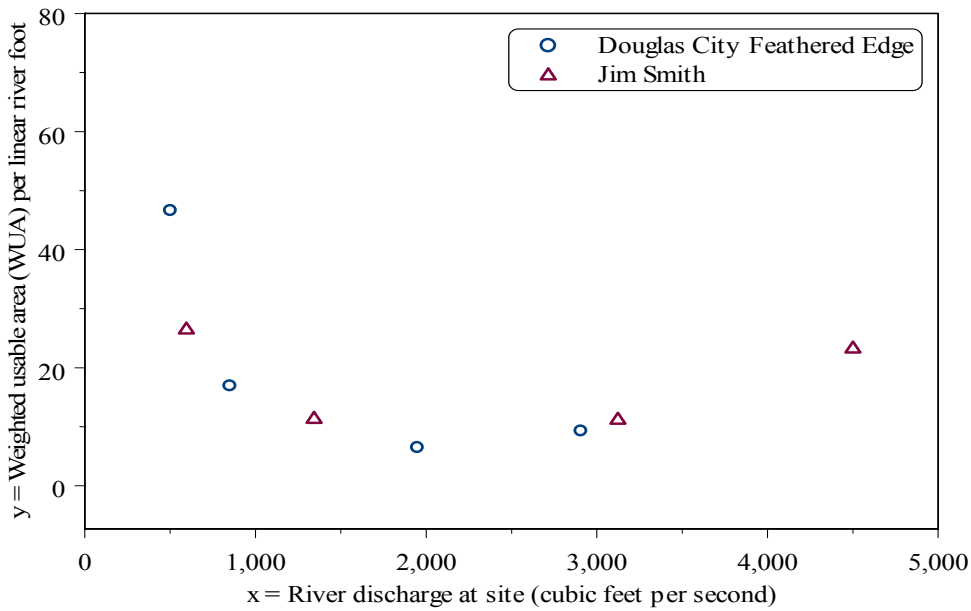

Figure 16. Weighted usable area per river foot of habitat for steelhead juveniles (50 to 120 mm) at study sites that included pilot feathered edges constructed in the 1990's. The Jim Smith site included feathered edge and unmodified river channel immediately downstream, all entirely enveloped by the Hocker Flat Rehabilitation site complex.

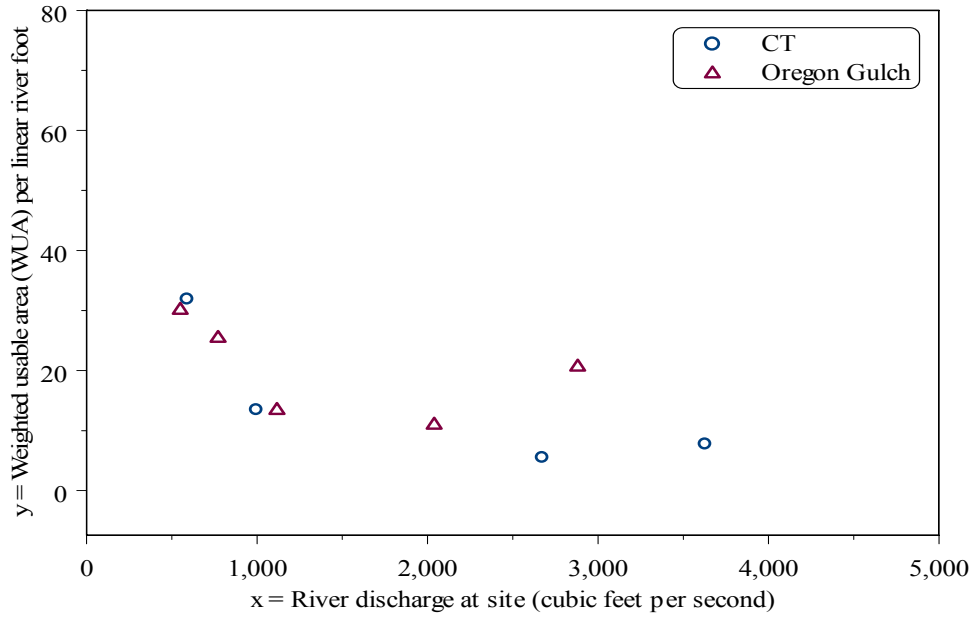

Figure 17. Weighted usable area per river foot of habitat for steelhead juveniles (50 to 120 mm) at Trinity River proposed rehabilitation site CT (at Valdor Gulch downstream of Hocker Flat) and at Oregon Gulch (upstream of Hocker Flat).

Site CT was selected for its proximity and general similarity in character to the berm-dominated portions of Hocker Flat. Indeed, the WUA relationships at study site CT were similar to those for the sites CK, CL, and CM, suggesting that prior to its own construction in autumn 2006 (Figure 18), study site CT was a good "control" site for these sites within Hocker Flat.

Our Jim Smith and Douglas City Feathered Edge study sites are only partially comparable. The results are confounded by the inclusion of "un-restored" channel in our Jim Smith site which was characterized by a secondary side channel that dominated WUA/flow dynamics at the higher discharges mapped. The maximum flow mapped at Jim Smith was also significantly higher than was mapped for Douglas City Feathered Edge. Nonetheless, the WUA/flow relationships exhibited at these two sites are remarkably similar through a range of flow from base to about 2,900 (maximum flow mapped at Douglas City).

Figure 18. Study site CT (Valdor Gulch) before and immediately after mechanical channel rehabilitation. Photos from Trinity River Restoration Program.

Discussion

Habitat Suitability Criteria

The authors caution interpretation of our HSC from this study, especially for species and size classes that exhibit less fidelity to shallow edge-waters where the majority of our sampling occurred. Microhabitat observations from Hampton (1997) were distributed to represent large reaches of river and occurred over wide range of habitats including pools and other deepwater habitat. Our sampling, by virtue of occurring largely in proposed channel rehabilitation sites, was performed in predominantly degraded and u-shaped channelized reaches with encroaching riparian berm where the availability of pools, and slow/shallow water was limited. As a consequence, a higher portion of our sampling occurred in habitats shallower and faster than those of Hampton (1997) and influences our HSC values (see comparison of our Chinook salmon fry observations to those of Hampton, Figure 19 and Figure 20).

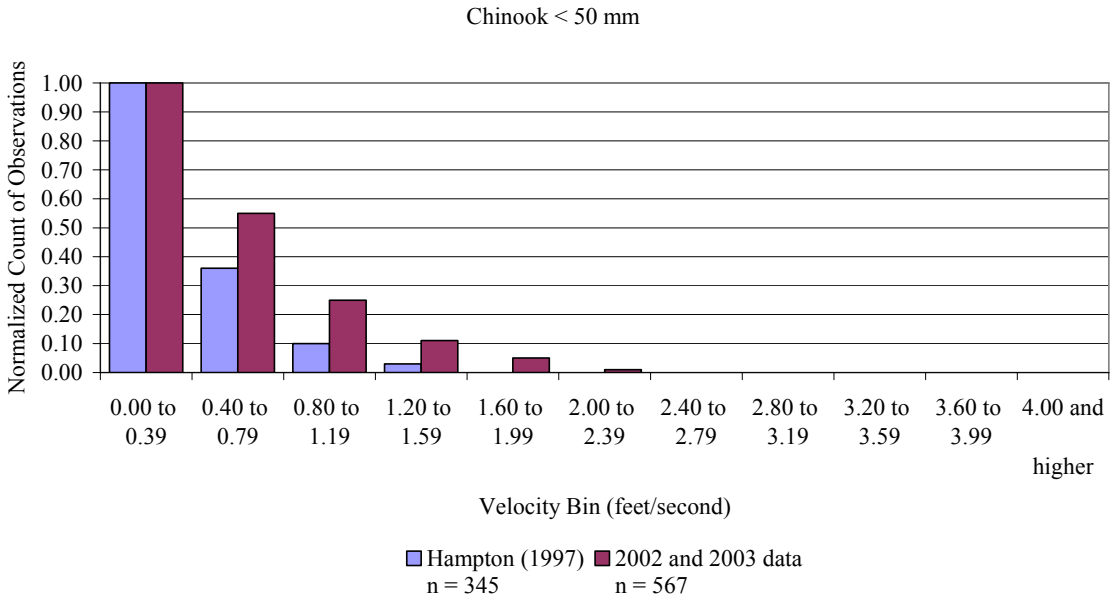

Figure 19. Comparison of observed Chinook salmon fry (fork length less than 50 millimeter) velocity distributuions from Habitat Suitability Criteria reported in Hampton (1997) and this study.

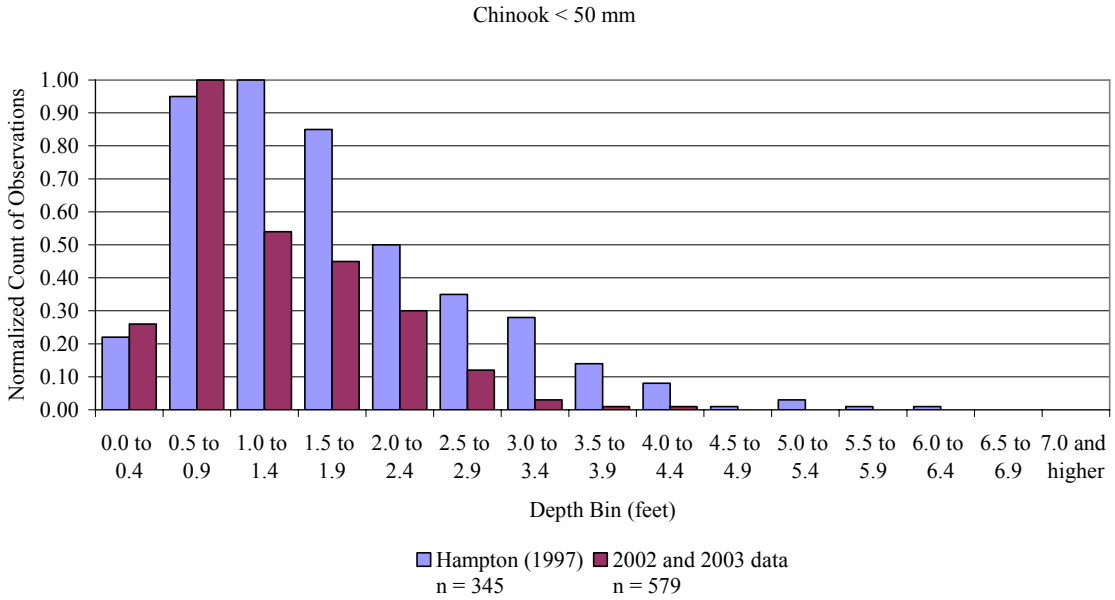

Figure 20. Comparison of observed Chinook salmon fry (fork length less than 50 millimeter) water column depth distributuions from Habitat Suitability Criteria reported in Hampton (1997) and this study.

Differences in HSC between our results and those of Hampton (1997) are even more pronounced for juvenile steelhead. Hampton classified juveniles as those fish with a size class range of 50 to 200 mm whereas we used the range 50 to 120 mm. Regardless, Hampton's juvenile steelhead data show a higher affinity for faster water (Figure 21) and greater depths (Figure 22).

Because the bulk of our data were collected within proposed restoration sites, interpretation of it should be limited to predominantly degraded channel. We do not recommend combining our HSC data with any larger generalized data set intended to represent the entire reach from Lewiston Dam to the North Fork Trinity River. As the channel responds to rehabilitation over time and the distributions of available habitats change, HSC curves based on fish use will likely have to be adjusted as flow and habitat relationships respond in kind.

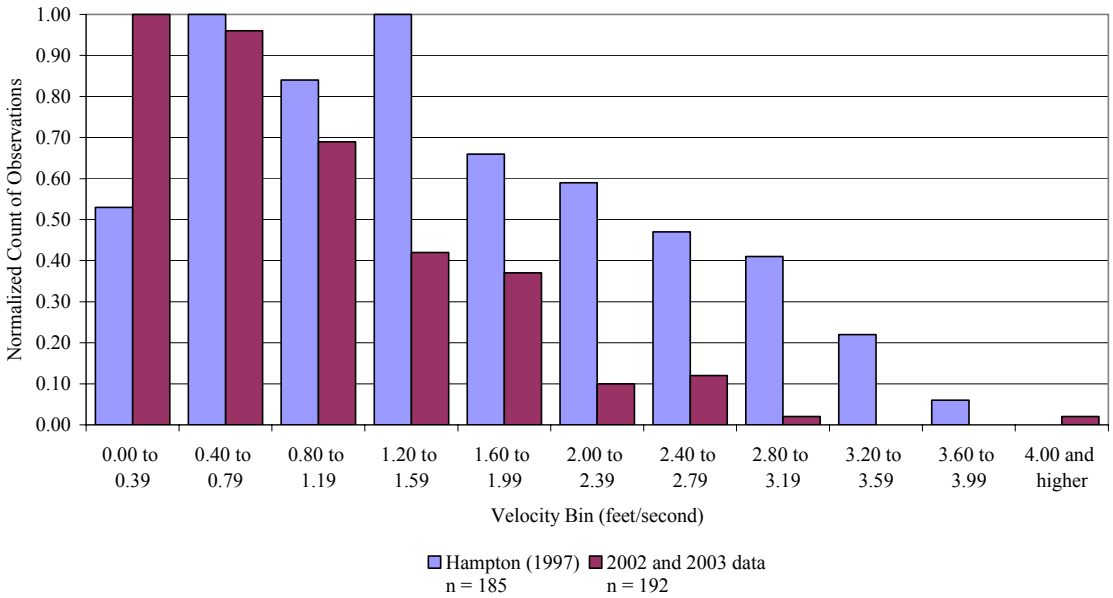

Figure 21. . Comparison of observed steelhead juvenile water velocity distributuions from Habitat Suitability Criteria reported in Hampton (1997) and this study.

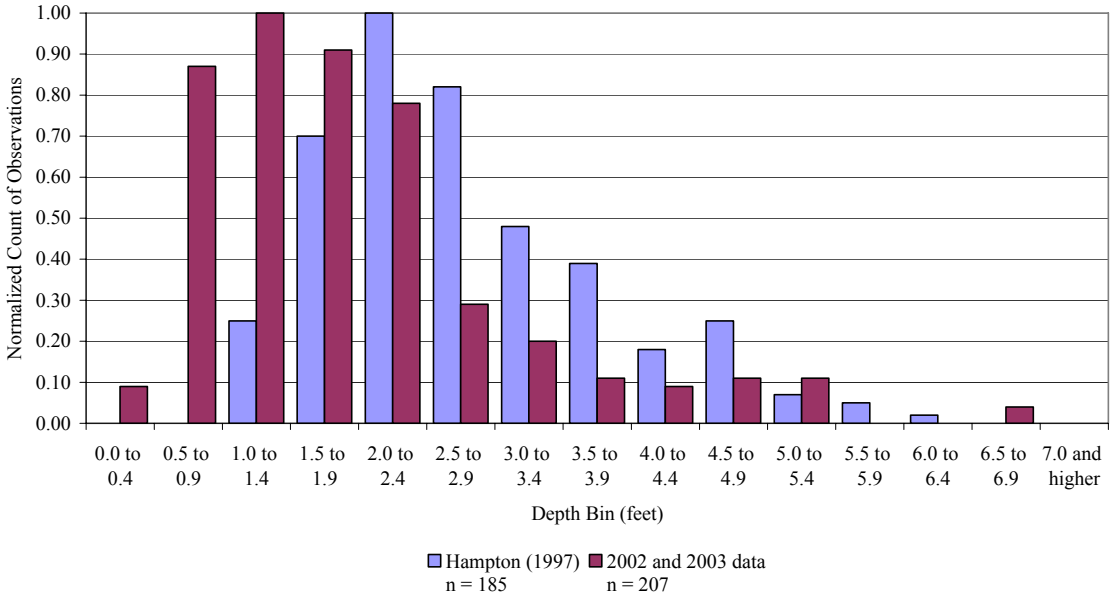

Figure 22. Comparison of observed steelhead juvenile water column depth distributuions from Habitat Suitability Criteria reported in Hampton (1997) and this study.

Douglas City feathered edge

For the Trinity River Flow Evaluation Study (USFWS and Hoopa Valley Tribe 1999), flow and habitat relationships were investigated at several sites, including the Douglas City feathered edge included in this study. For that evaluation, multiple one-dimensional

cross-sections of the site were modeled using PHABSIM to estimate WUA shortly after construction. Unlike the results of our study, post-construction habitat relationships modeled then show WUA to increase with flows above base until a peak at about 1,200 cfs (Figure 23). Interestingly, pre-construction habitat measurements exhibited a relationship to flow with a shape more similar to ours whereby WUA initially dropped as flows increased above base, and was higher at the measurement made when discharge was near 3,000 cfs (compare Figure 23 to Figure 10). Since construction of the feathered edge at this site, riparian encroachment has begun to re-occur and early successional berm is reestablishing (Bair 2003; Chamberlain 2003; see Figure 24 this report) and may explain the greater similarity of our results to the pre-construction measurements. The feathered edge portion of Jim Smith was also experiencing reestablishment of the riparian berm prior to the latest rehabilitation at Hocker Flat.

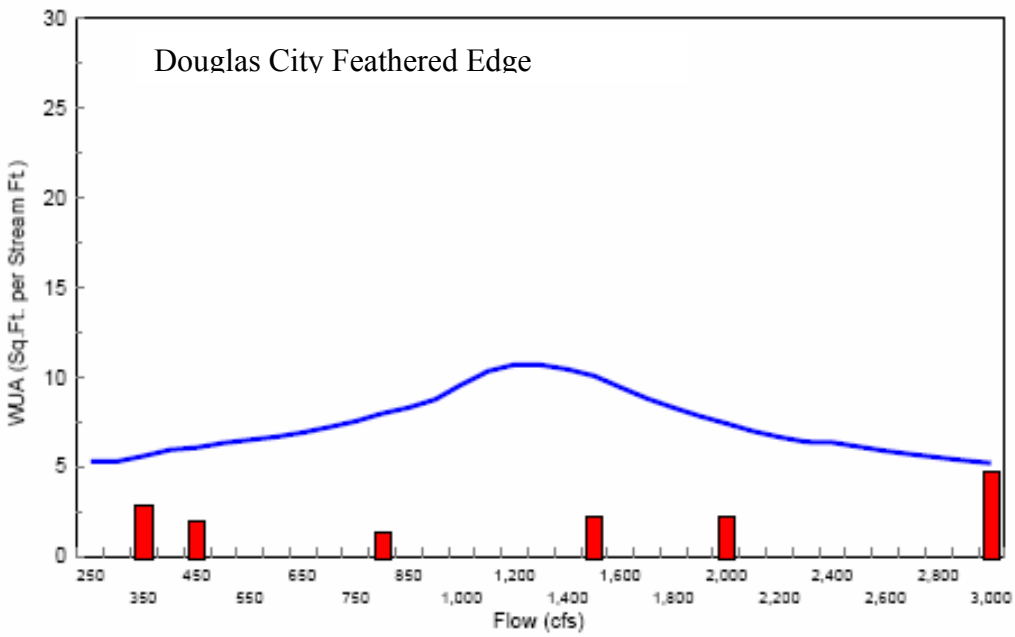

Figure 23. Flow and Chinook salmon fry habitat relationship at the Douglas City feathered edge study site shortly after its construction in the mid 1990's. Blue line represents estimated habitat after construction of the feathered edge derived through modeling. Bars represent empirical habitat measurements made before construction. Adapted from Figure 5.22 of the Trinity River Flow Evaluation Study (USFWS and Hoopa Valley Tribe 1999).

Figure 24. Photo from 2002 at the Douglas City feathered edge site. Re-evolution of the riparian berm near water's edge is clearly visible in this photo.

Weighted Usable Area relationships from Lewiston to North Fork Trinity River

A common relationship between habitat and flow is exhibited among the proposed rehabilitation sites where suitable habitat generally decreases as flows increase above summer base flows (about 600 cfs at Hocker Flat) to about 2,500 to 3,000 cfs. Aceituno et al. (1997) described a similar flow/WUA relationship in this range of flows for the Trinity River between Dutch Creek and North Fork Trinity River. Aceituno et al. did not have the opportunity to characterize WUA/flow relationships at higher discharges.

Limitations

At the Hocker Flat study sites, no mapping was conducted when flows at the site were between about 1,350 and 2,750 cfs. Our mapping methods required two or more days of relatively stable flows to complete, and when the mapping for this report was conducted in 2003, discharge transitioned relatively quickly through this range at Hocker Flat. The cluster of site visits that occurred at site discharges of around 3,000 cfs were performed during the 2,000 cfs bench release common in the three wettest of ROD water release hydrographs. Additional mapping in the transition ranges would have provided better resolution of WUA/discharge relationships. If these techniques are applied in the future, it may be beneficial to coordinate controlled discharge from Lewiston Dam with field mapping exercises in order to map specific flow targets throughout a range of flows.

By the time of this report, mechanical alterations will have been made at Hocker Flat and at Valdor Gulch (our study site CT). Likewise, the topography at the Oregon Gulch study site is very dynamic and has already changed in response to mainstem flow and flow and sediment input from Oregon Gulch. After flows have had a chance to influence the evolution of the Hocker Flat area, revisit of these sites using methods presented in this report could provide a direct comparison of before and after habitat conditions. We point to two previous studies, Gallagher 1995 and Gallagher 1999b, that occurred on the same pilot feathered edge sites. The 1995 study, conducted soon after site construction, concluded that fry rearing habitat was not increased as a result of rehabilitation. However, after a few wet years with relatively high site discharges, Gallagher (1999b) discovered greater channel complexity and higher fish use at pilot feathered edge sites than was observed in the 1995 study.

We used this study to document contemporary habitat conditions at several proposed channel rehabilitation sites. The channel outside the mechanical footprint of the rehabilitation sites is also expected to respond to ROD rehabilitation flows, so habitat conditions in river reaches not subject to mechanical rehabilitation should be documented to assess habitat availability in a more comprehensive manner.

Acknowledgements

The authors wish to acknowledge current and former staff from the Arcata Fish and Wildlife Office (AWFO), the Yurok Tribal Fisheries Program (YTFP) and the Hoopa Valley Tribal Fisheries Program (HVTFP) for their hard work over the course of this study. Many of these participants spent their work-weeks stationed away from permanent residence and families. Funding for this project was made possible through the U.S. Fish and Wildlife Service, U.S Bureau of Reclamation, and the Trinity Management Council.

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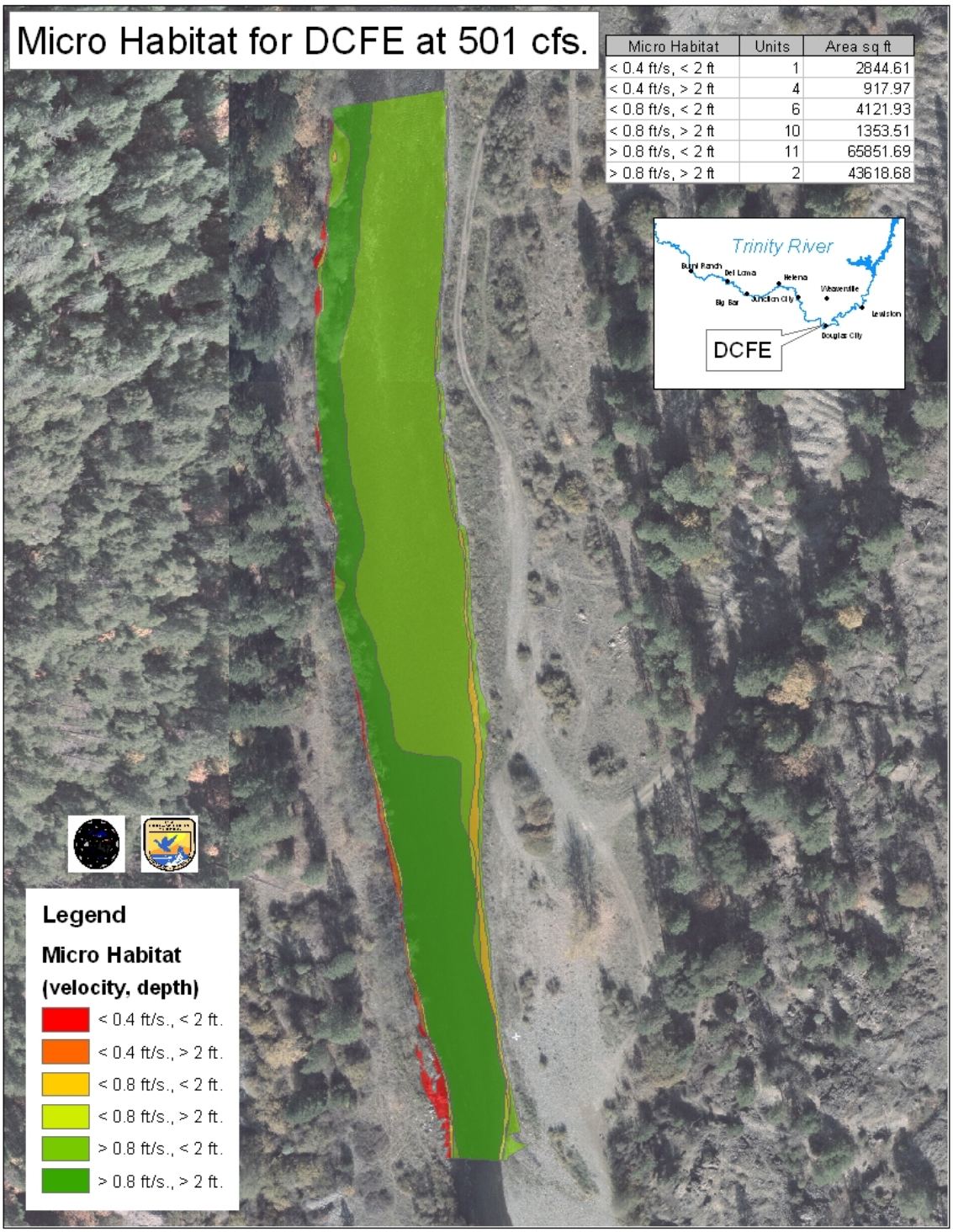
Smith, Gary. California Department of Fish and Game. Sacramento, CA.

Solbos, Ed. U.S. Bureau of Reclamation. Weaverville, CA.

Appendices

Appendix A. Microhabitat maps for study site Douglas City Feathered Edge.



Micro Habitat	Units	Area sq ft
< 0.4 ft/s, < 2 ft	1	2844.61
< 0.4 ft/s, > 2 ft	4	917.97
< 0.8 ft/s, < 2 ft	6	4121.93
< 0.8 ft/s, > 2 ft	10	1353.51
> 0.8 ft/s, < 2 ft	11	65851.69
> 0.8 ft/s, > 2 ft	2	43618.68

Figure A-1 Microhabitat map at study site Douglas City Feathered Edge at estimated river discharge of 501 cubic feet per second.

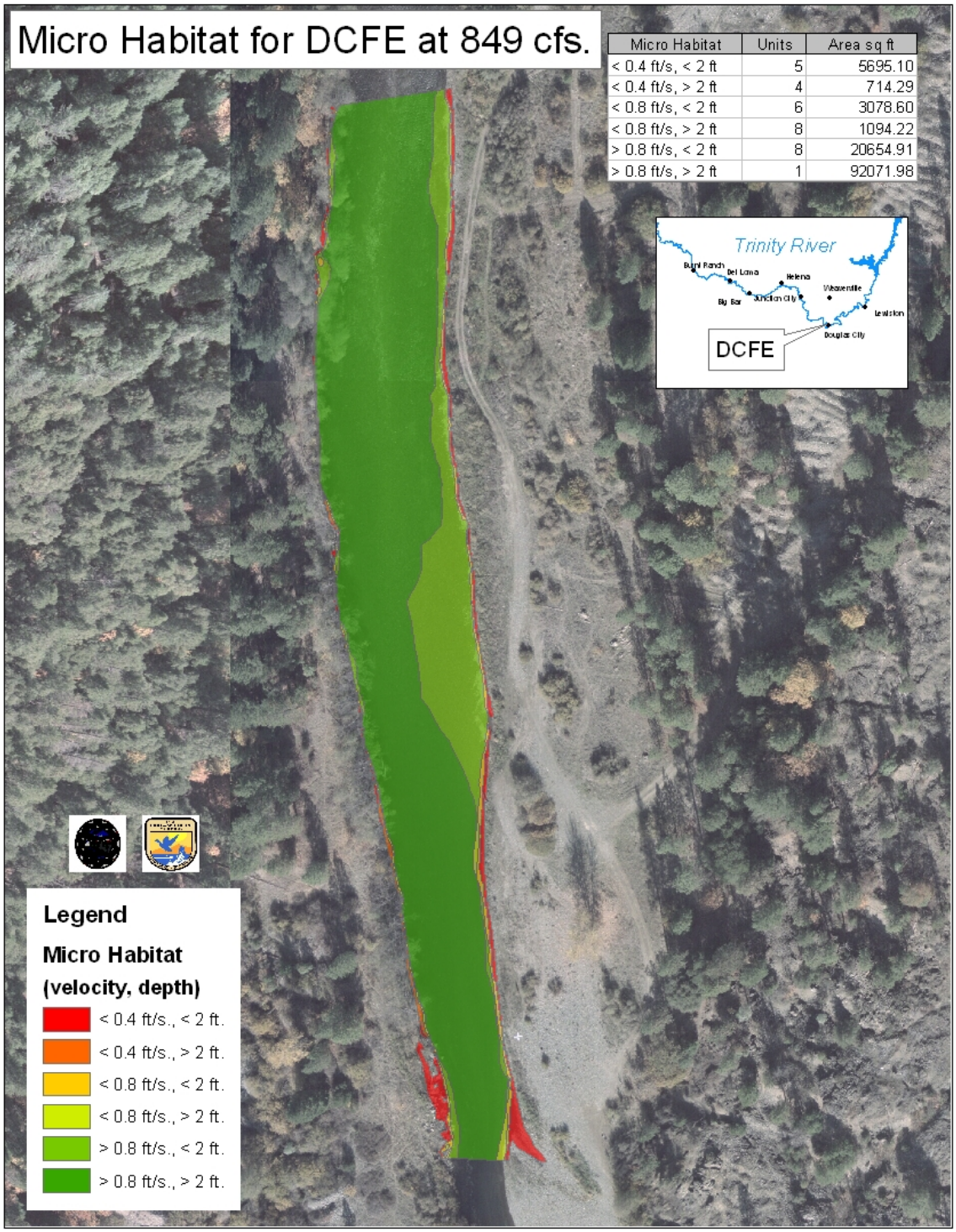
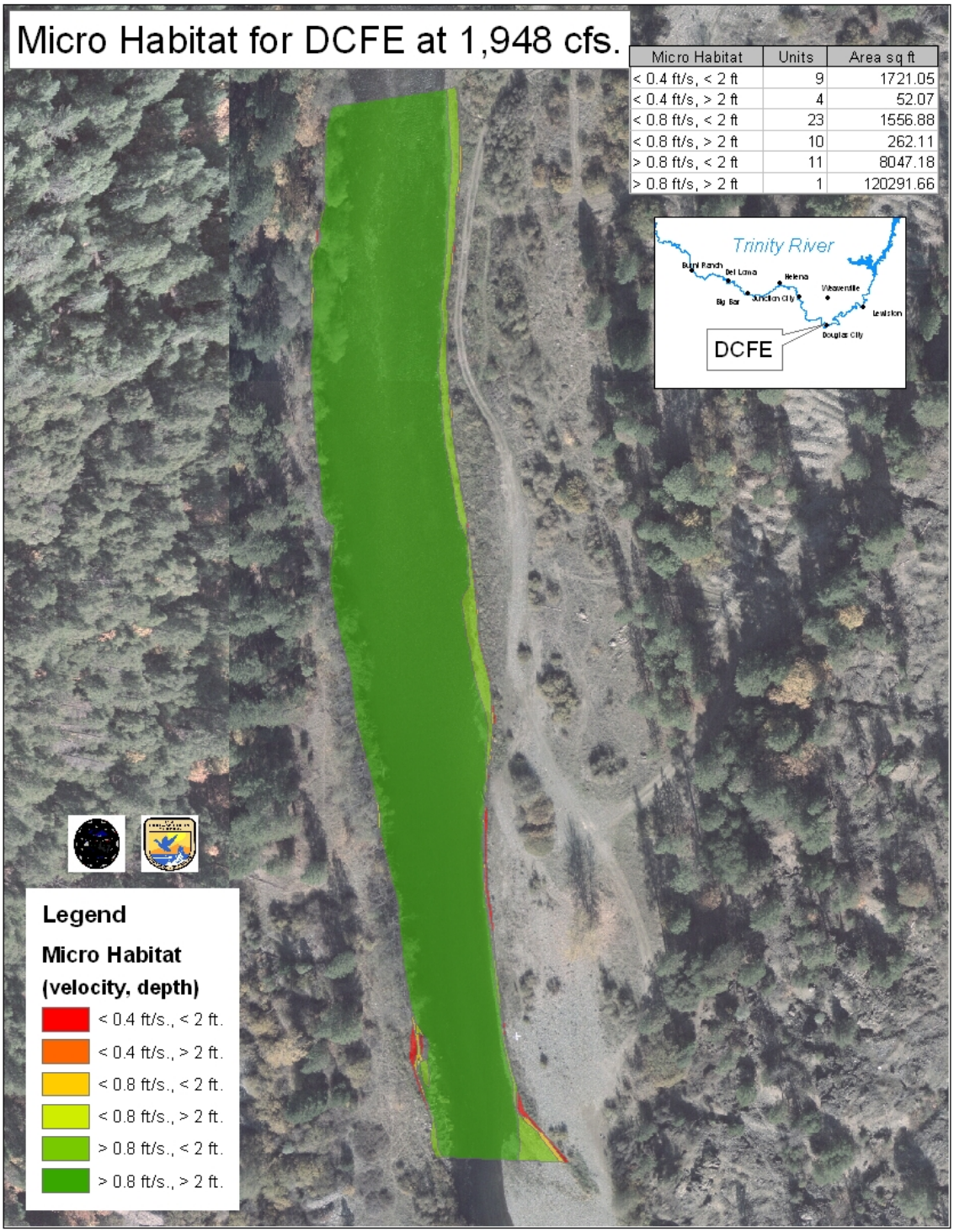


Figure A-2 Microhabitat map at study site Douglas City Feathered Edge at estimated river discharge of 849 cubic feet per second.



Micro Habitat	Units	Area sq ft
< 0.4 ft/s, < 2 ft	9	1721.05
< 0.4 ft/s, > 2 ft	4	52.07
< 0.8 ft/s, < 2 ft	23	1556.88
< 0.8 ft/s, > 2 ft	10	262.11
> 0.8 ft/s, < 2 ft	11	8047.18
> 0.8 ft/s, > 2 ft	1	120291.66

Figure A-3 Microhabitat map at study site Douglas City Feathered Edge at estimated river discharge of 1,948 cubic feet per second.

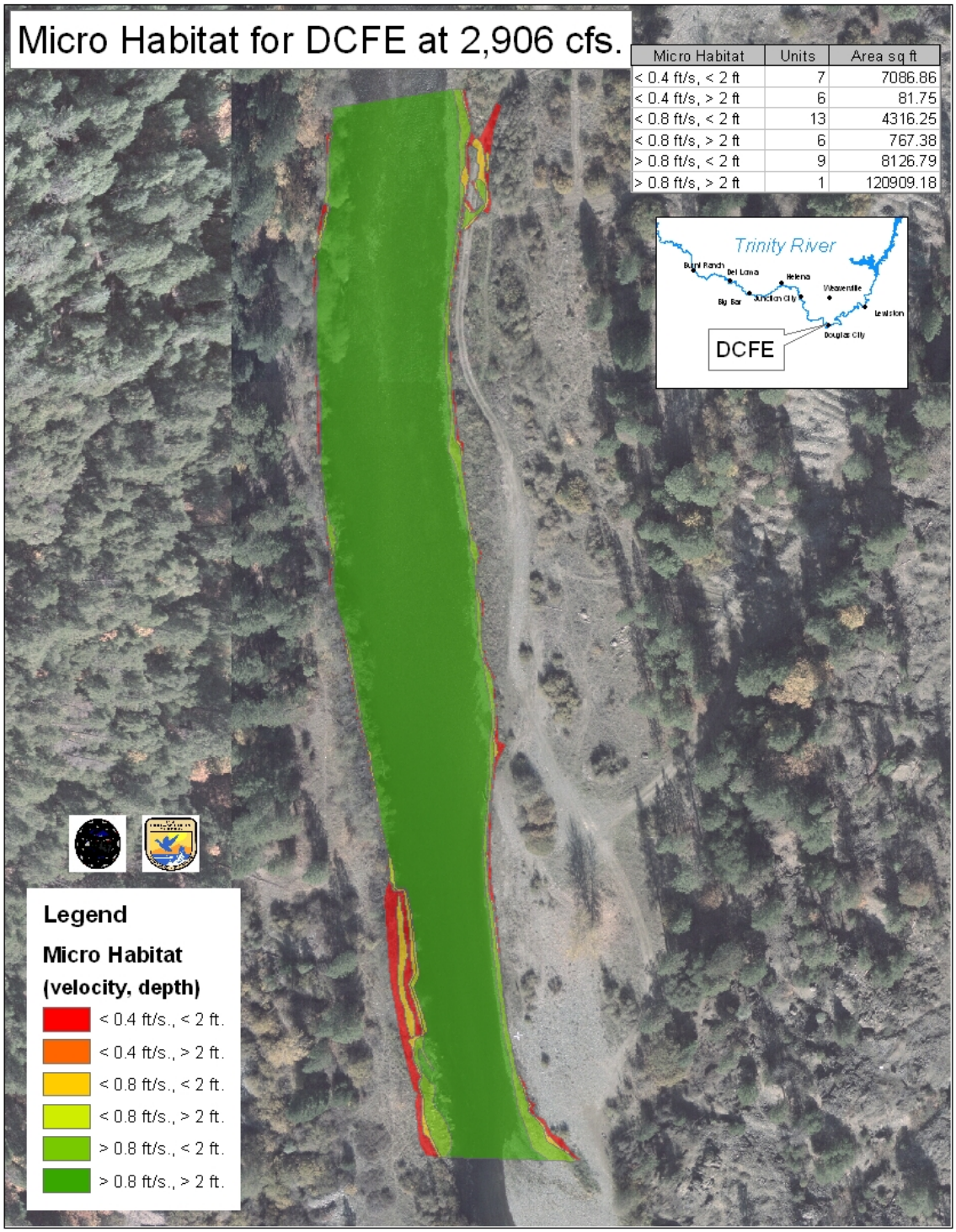
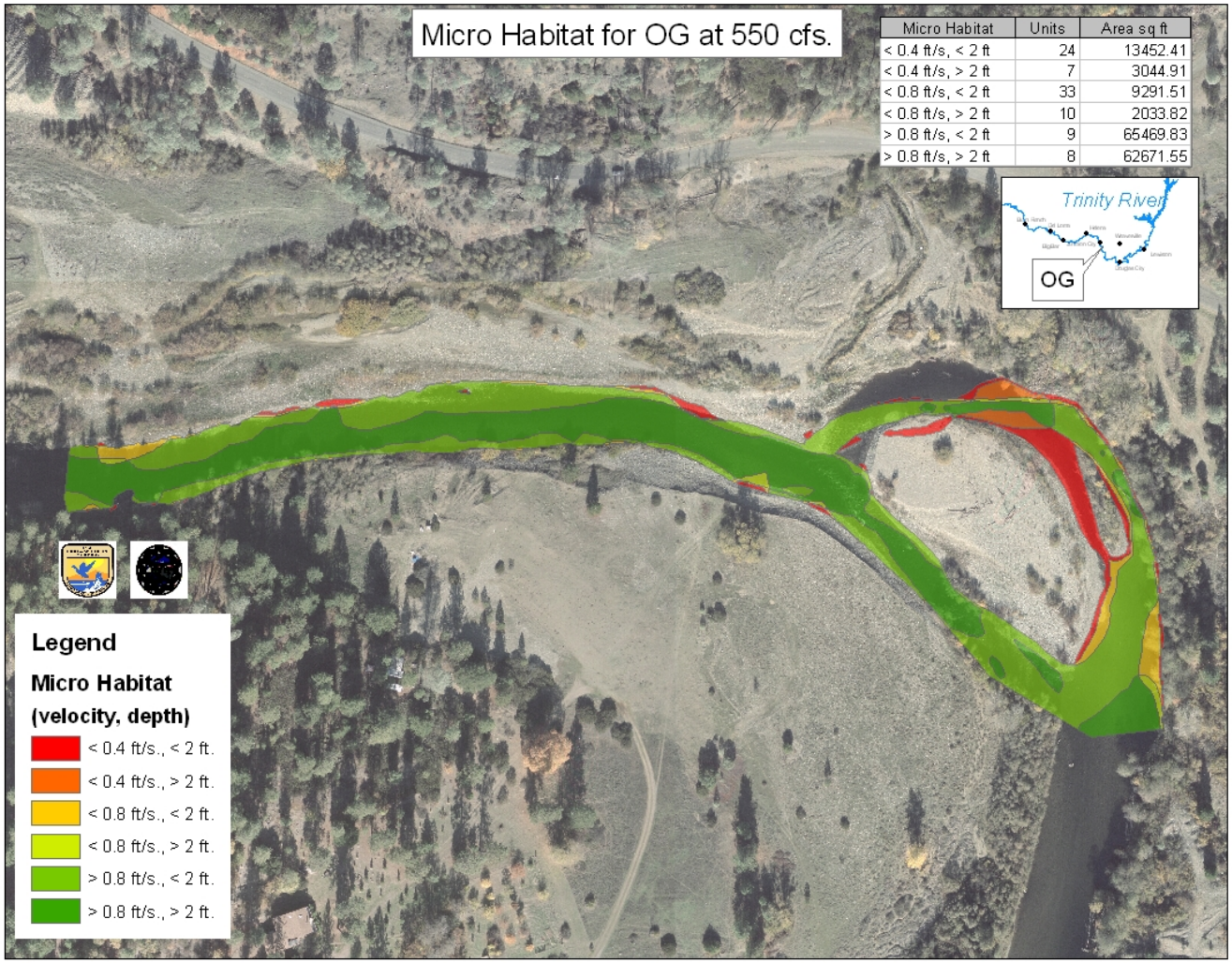


Figure A-4 Microhabitat map at study site Douglas City Feathered Edge at estimated river discharge of 2,906 cubic feet per second.

Appendix B. Microhabitat maps for study site Oregon Gulch .



Micro Habitat	Units	Area sq ft
< 0.4 ft/s, < 2 ft	24	13452.41
< 0.4 ft/s, > 2 ft	7	3044.91
< 0.8 ft/s, < 2 ft	33	9291.51
< 0.8 ft/s, > 2 ft	10	2033.82
> 0.8 ft/s, < 2 ft	9	65469.83
> 0.8 ft/s, > 2 ft	8	62671.55

Figure B-1 Microhabitat map at study site Oregon Gulch at estimated river discharge of 550 cubic feet per second.

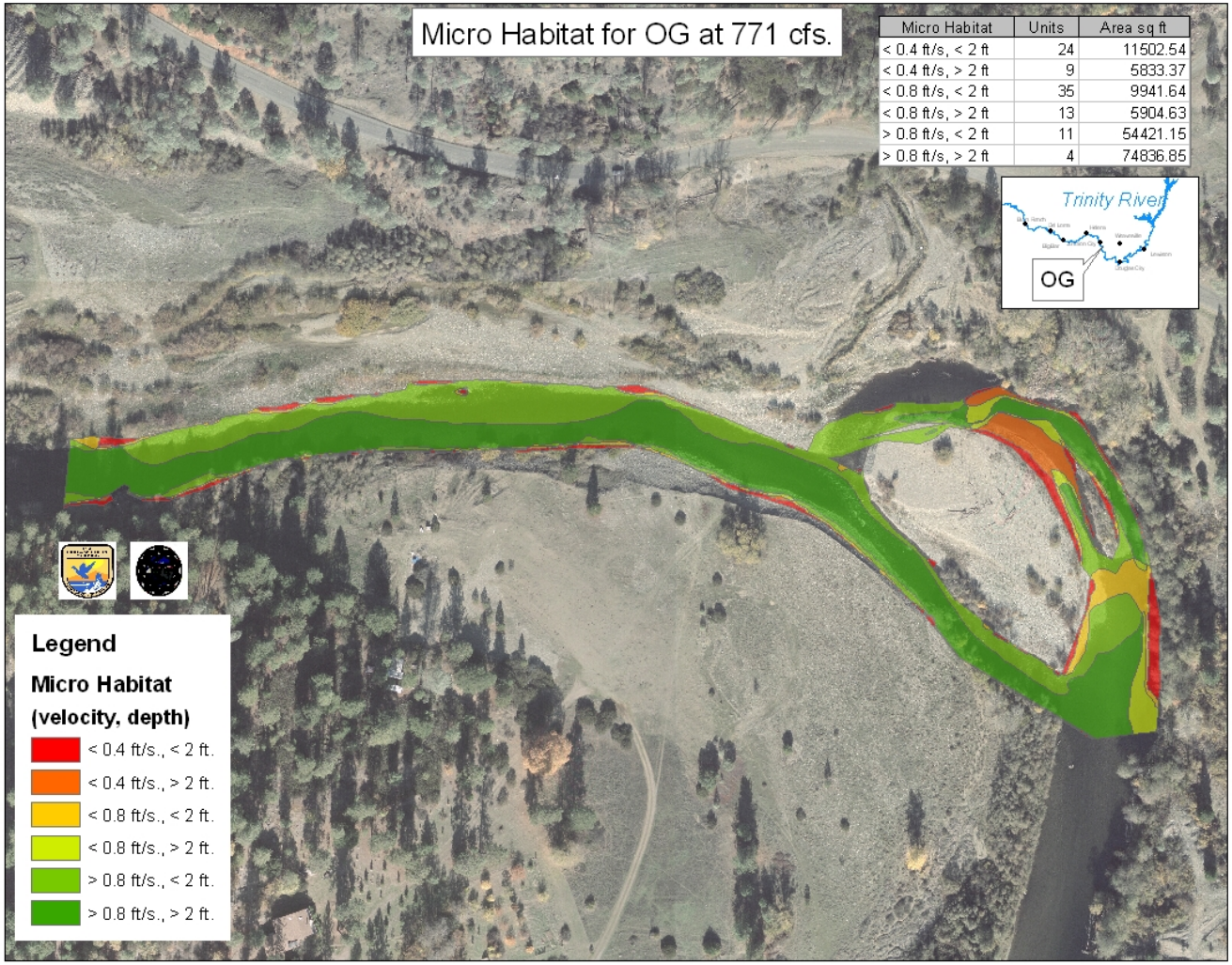


Figure B-2 Microhabitat map at study site Oregon Gulch at estimated river discharge of 771 cubic feet per second.

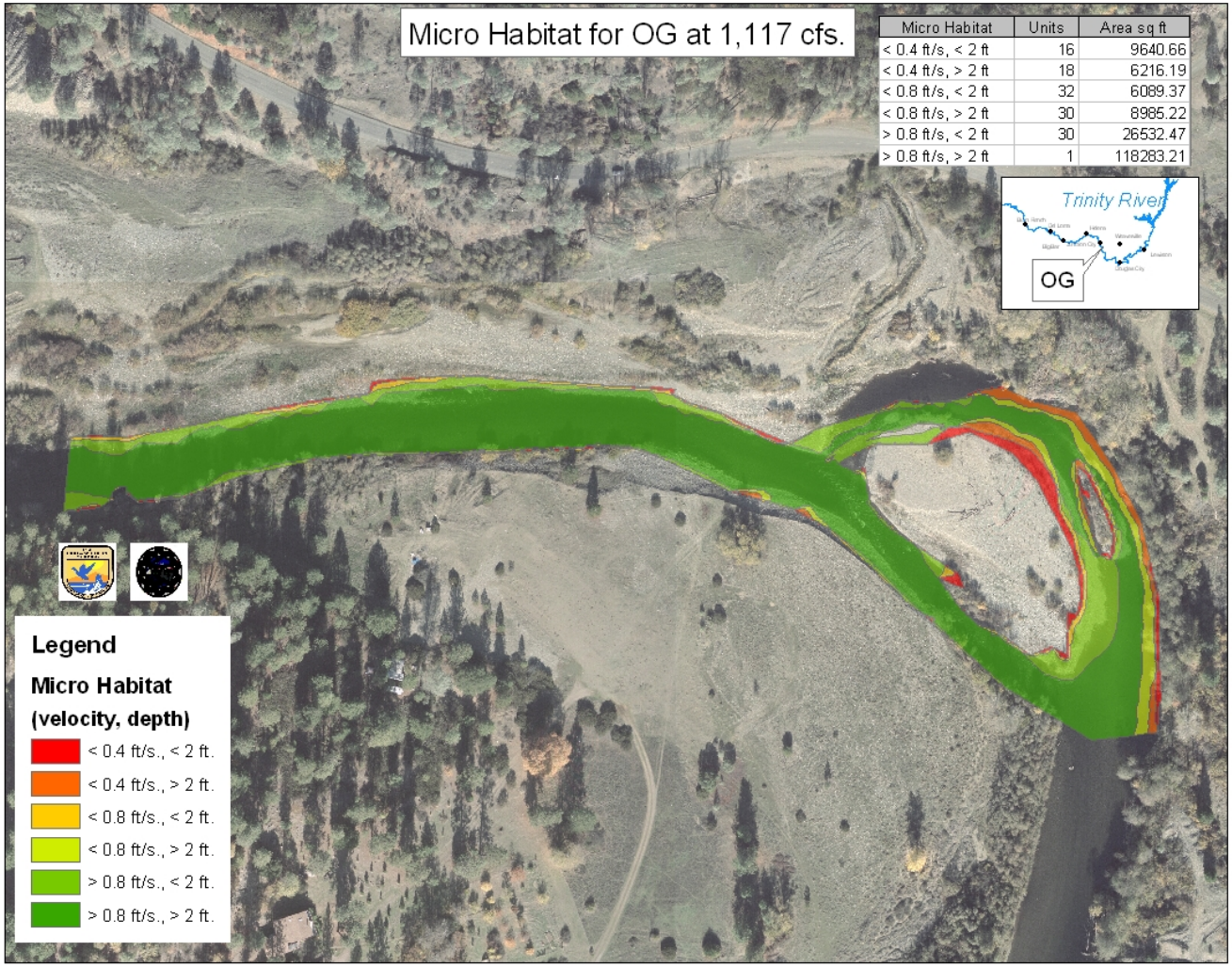


Figure B-3 Microhabitat map at study site Oregon Gulch at estimated river discharge of 1,117 cubic feet per second.

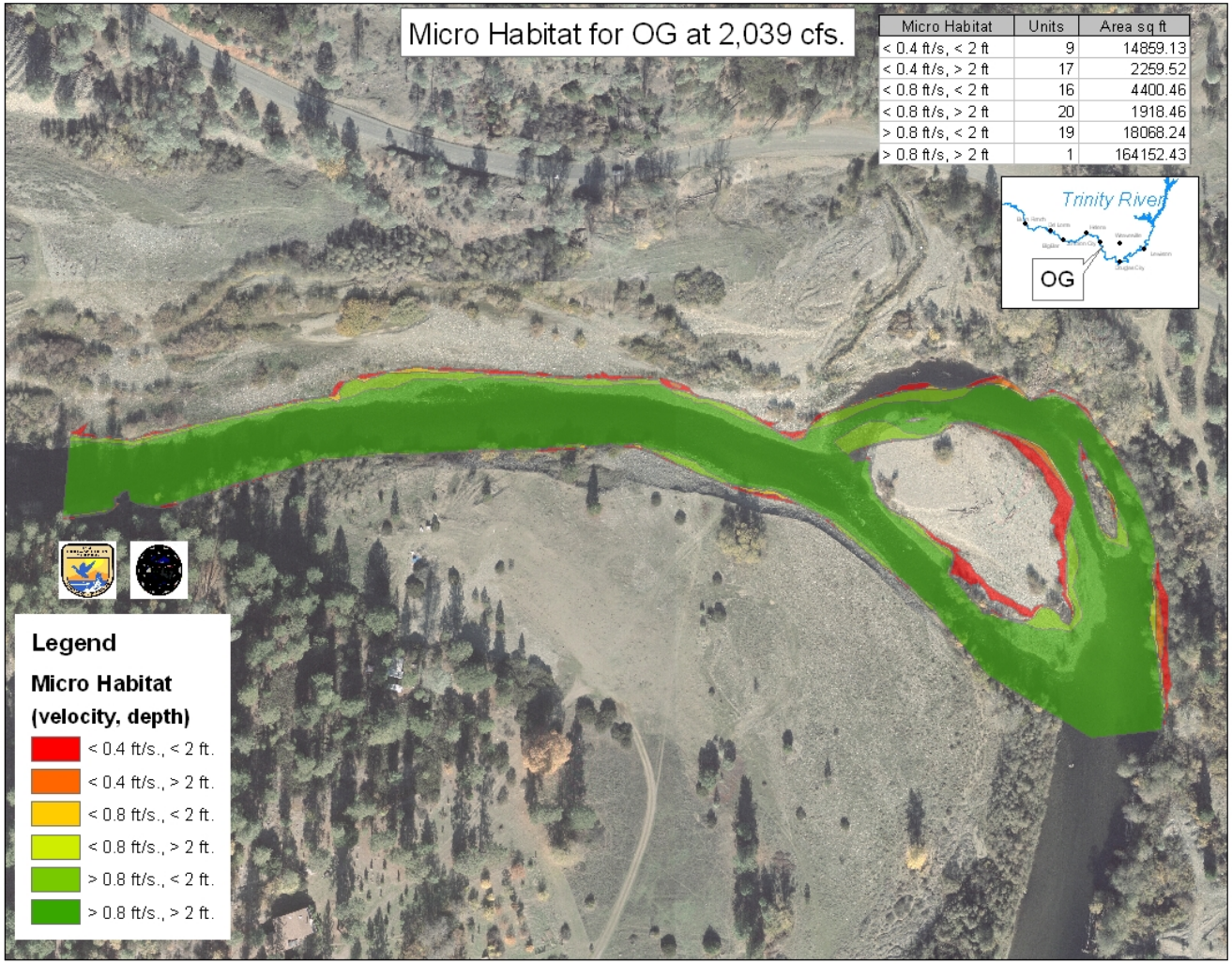


Figure B-4 Microhabitat map at study site Oregon Gulch at estimated river discharge of 2,039 cubic feet per second.

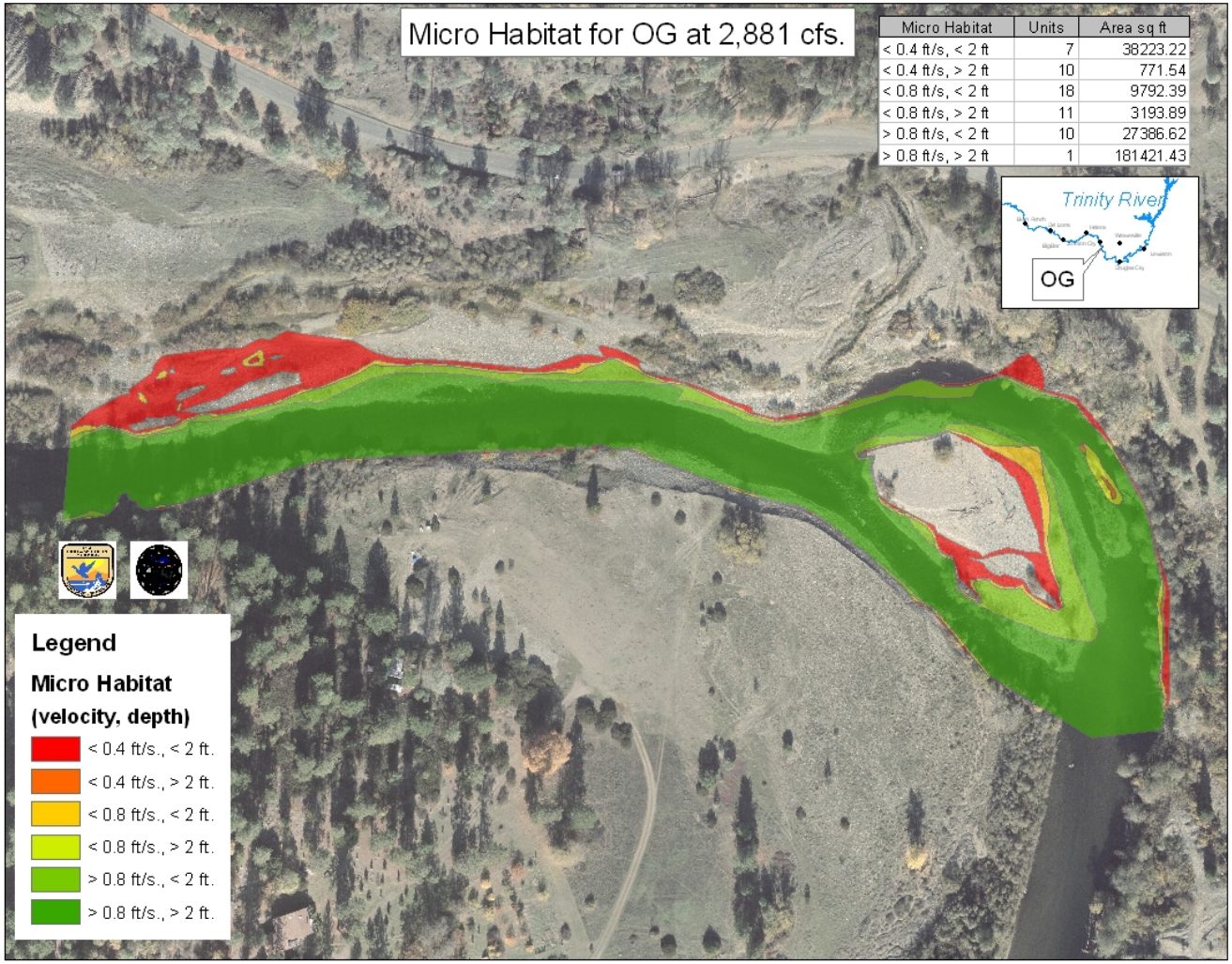


Figure B-5 Microhabitat map at study site Oregon Gulch at estimated river discharge of 2,881 cubic feet per second.

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Appendix C. Microhabitat maps at study site CK (Hocker Flat).

Figure C-1 Microhabitat map at study site CK at estimated river discharge of 596 cubic feet per second.

Figure C-2 Microhabitat map at study site CK at estimated river discharge of 1,305 cubic feet per second.

Figure C-3 Microhabitat map at study site CK at estimated river discharge of 2,756 cubic feet per second.

Figure C-4 Microhabitat map at study site CK at estimated river discharge of 3,871 cubic feet per second.

Appendix D. Microhabitat maps at study site CL (Hocker Flat).

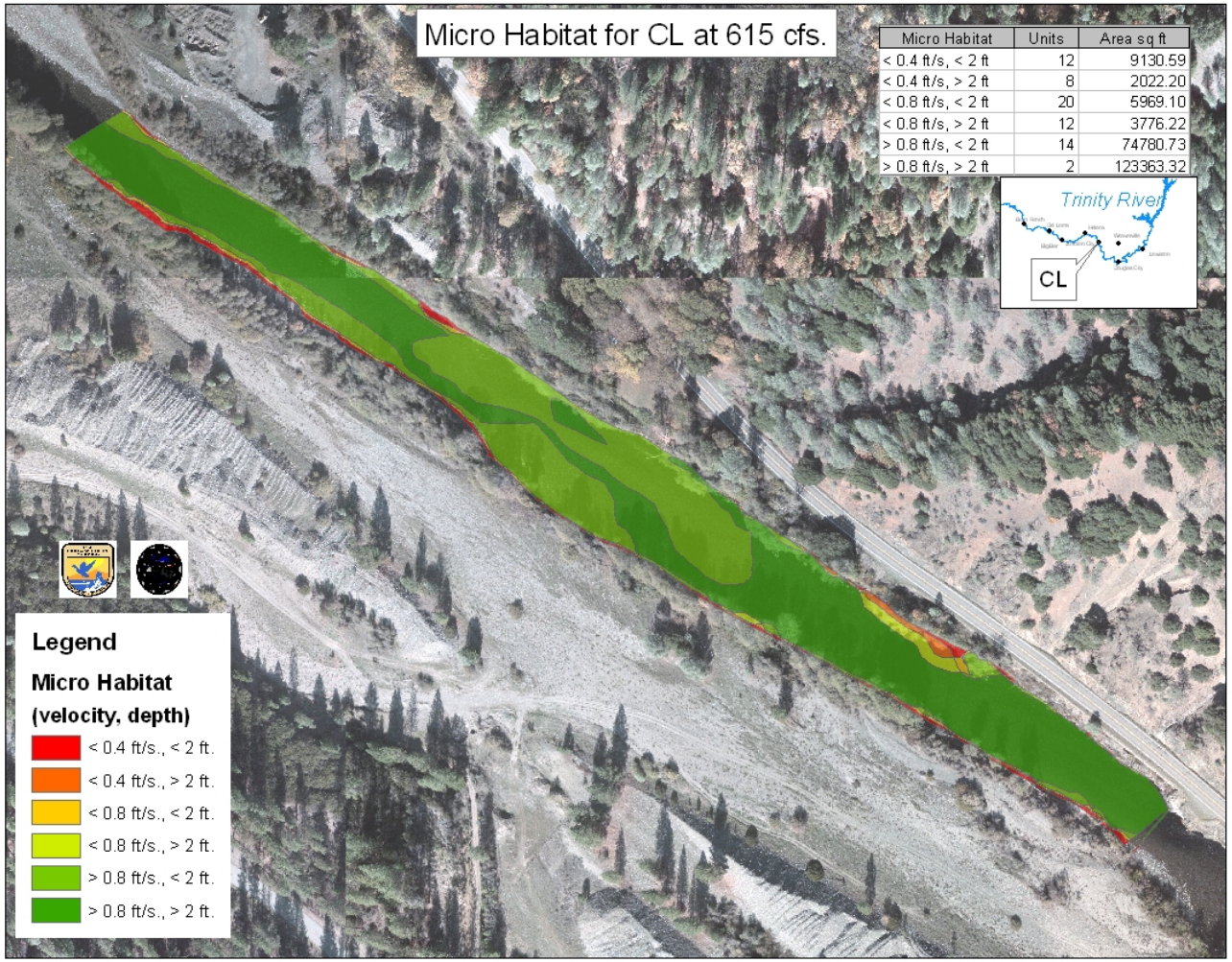

Figure D-1 Microhabitat map at study site CL at estimated river discharge of 615 cubic feet per second.

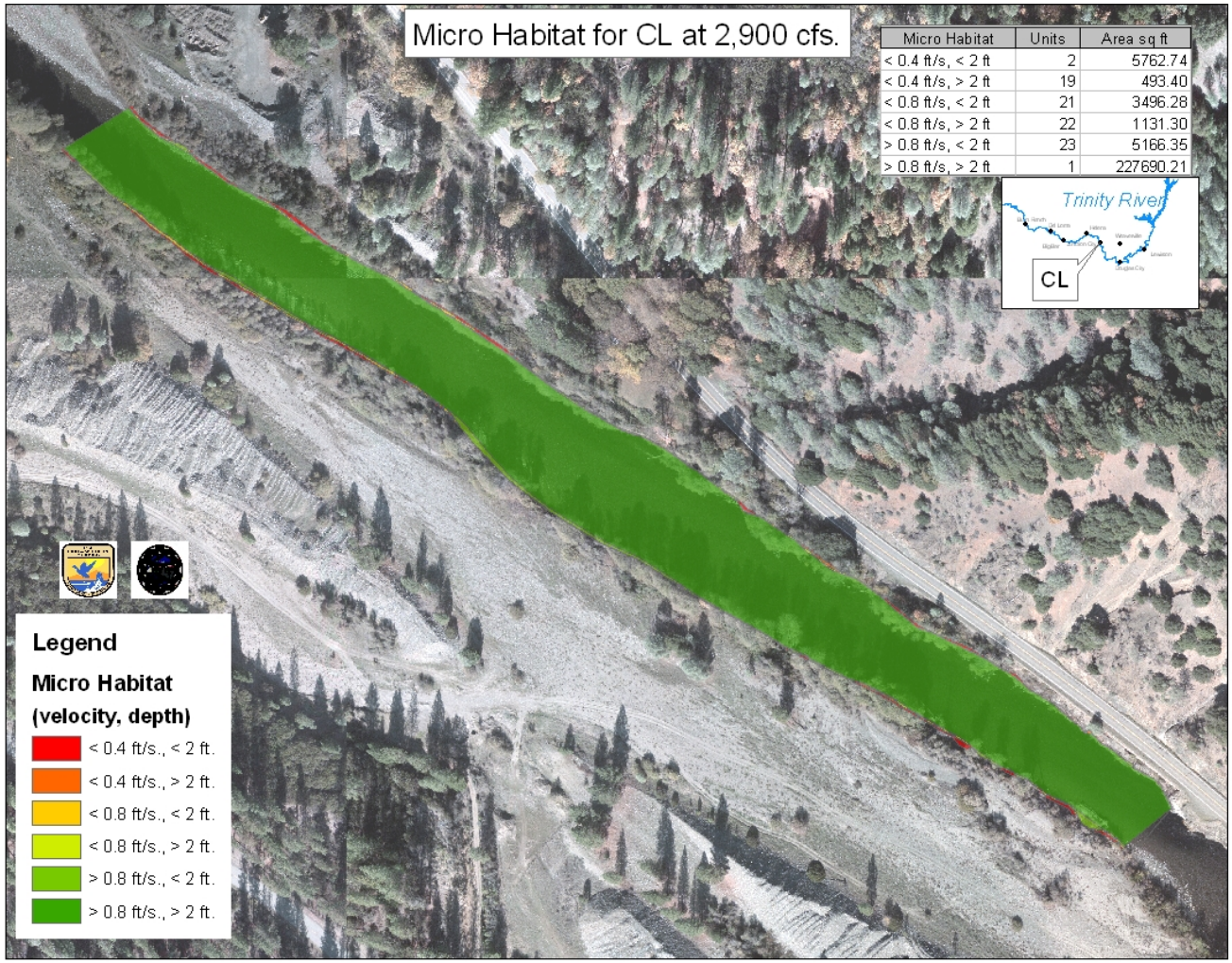

Figure D-2 Microhabitat map at study site CL at estimated river discharge of 2,900 cubic feet per second.

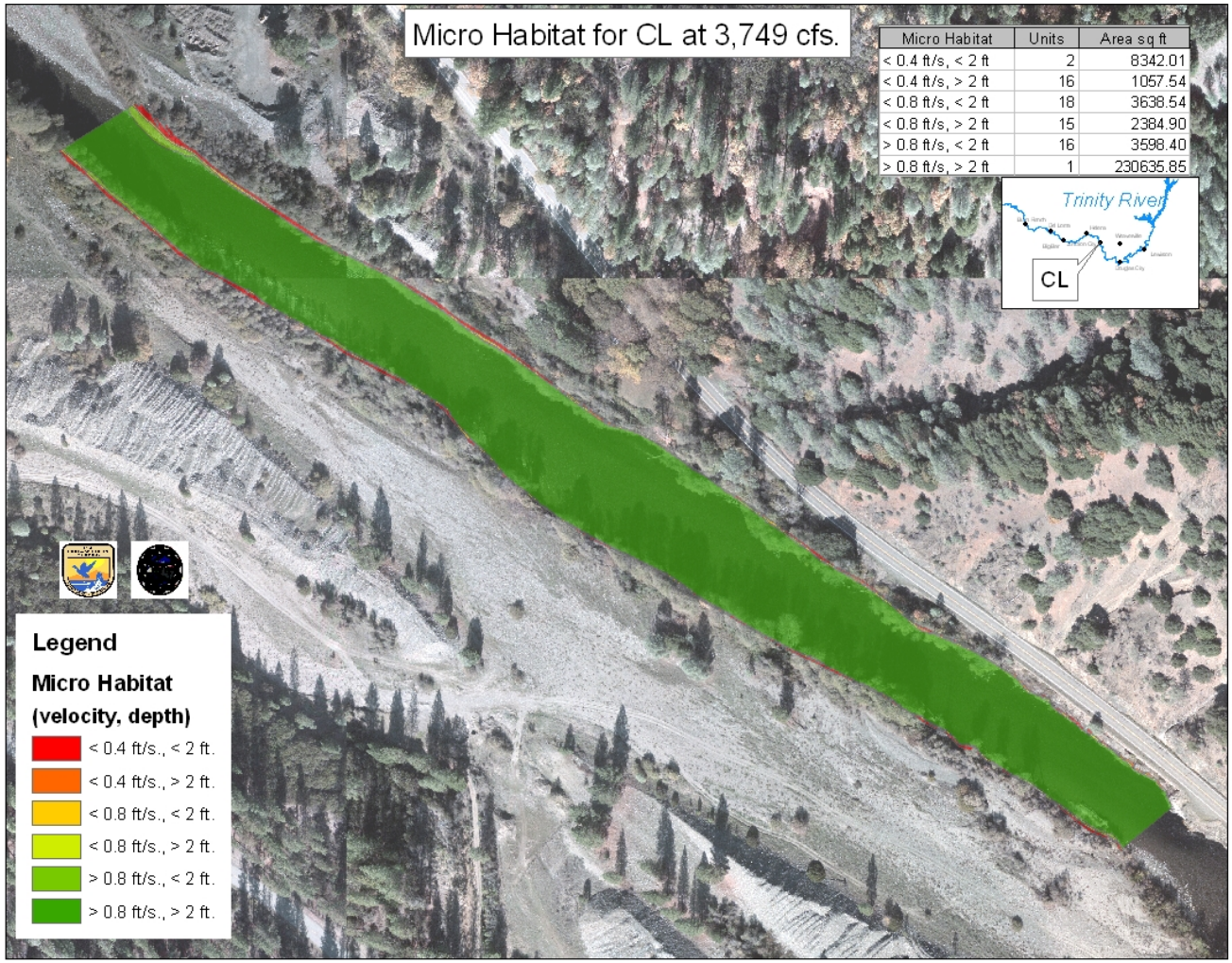

Figure D-3 Microhabitat map at study site CL at estimated river discharge of 3,749 cubic feet per second.

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Appendix E. Microhabitat maps at study site Jim Smith (Hocker Flat).

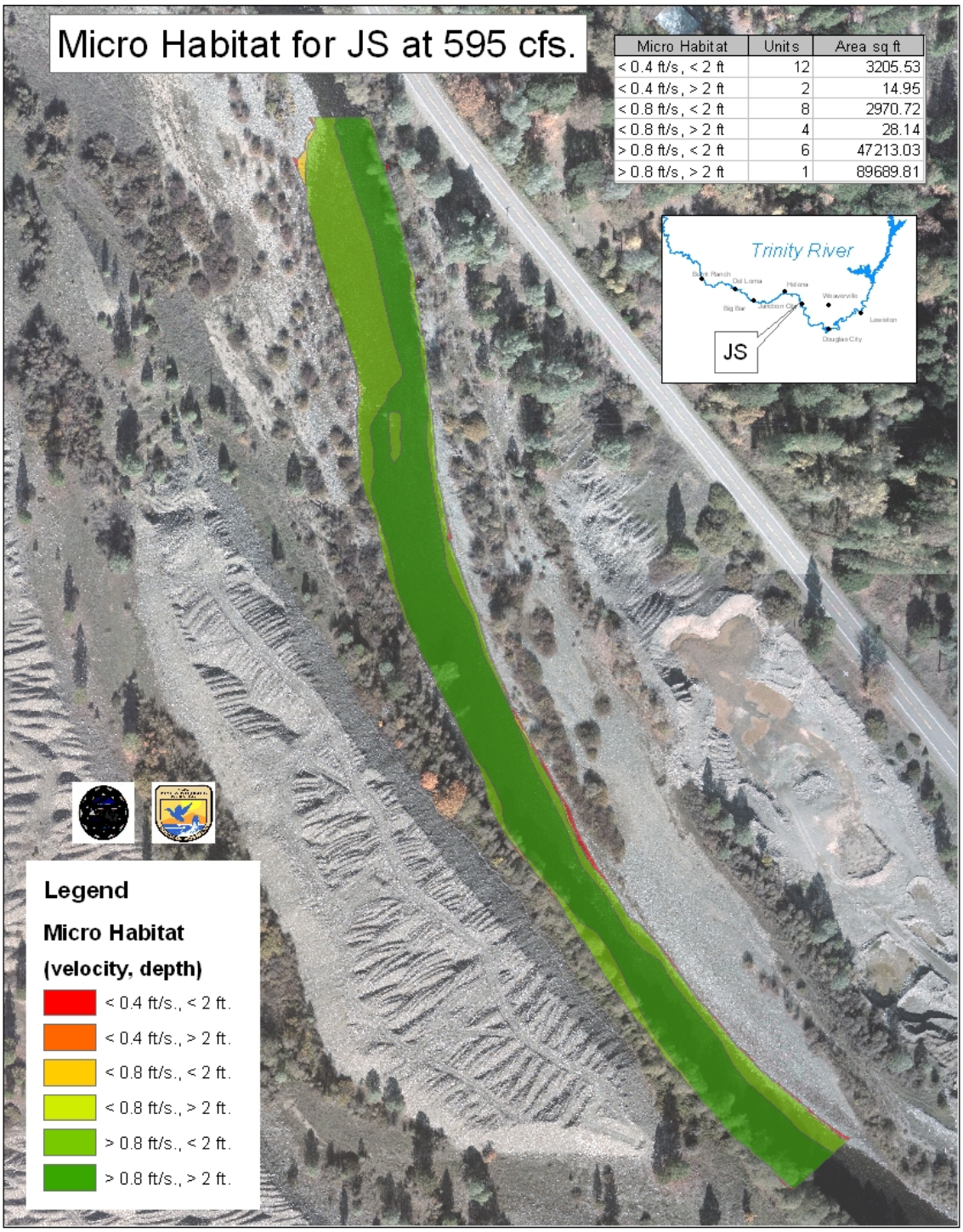


Figure E-1 Microhabitat map at study site Jim Smith at estimated river discharge of 595 cubic feet per second.

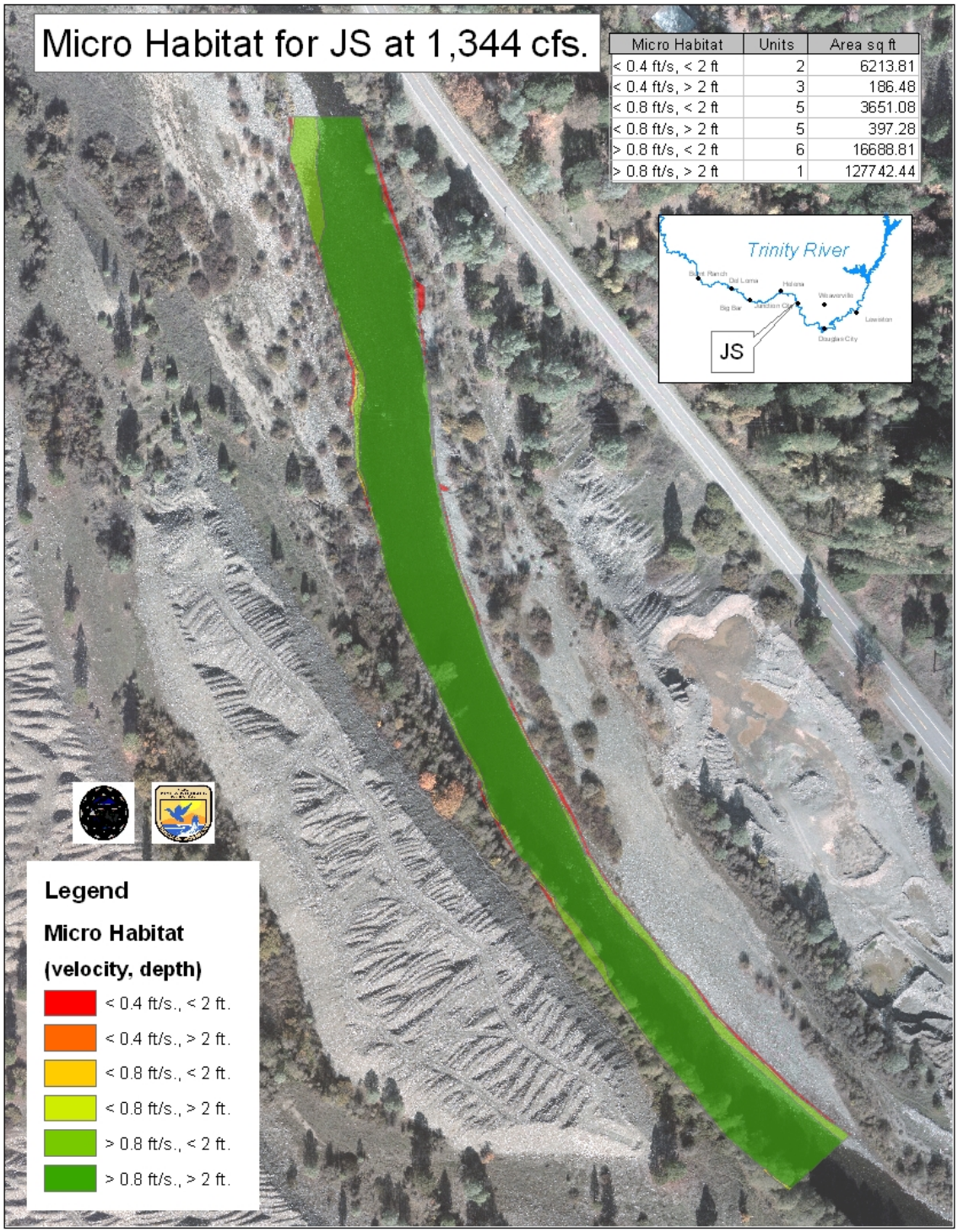


Figure E-2 Microhabitat map at study site Jim Smith at estimated river discharge of 1,344 cubic feet per second.

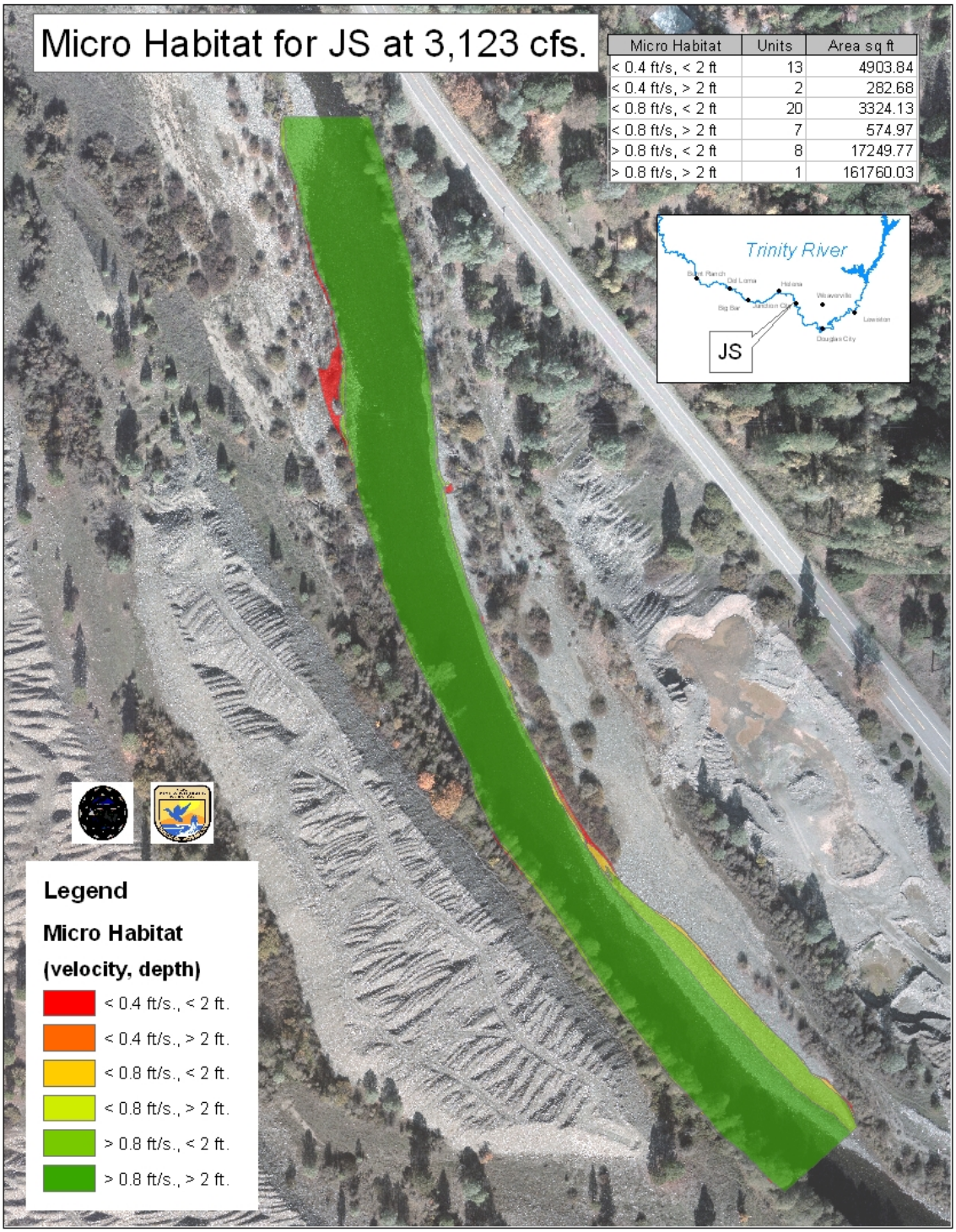


Figure E-3 Microhabitat map at study site Jim Smith at estimated river discharge of 3,123 cubic feet per second.

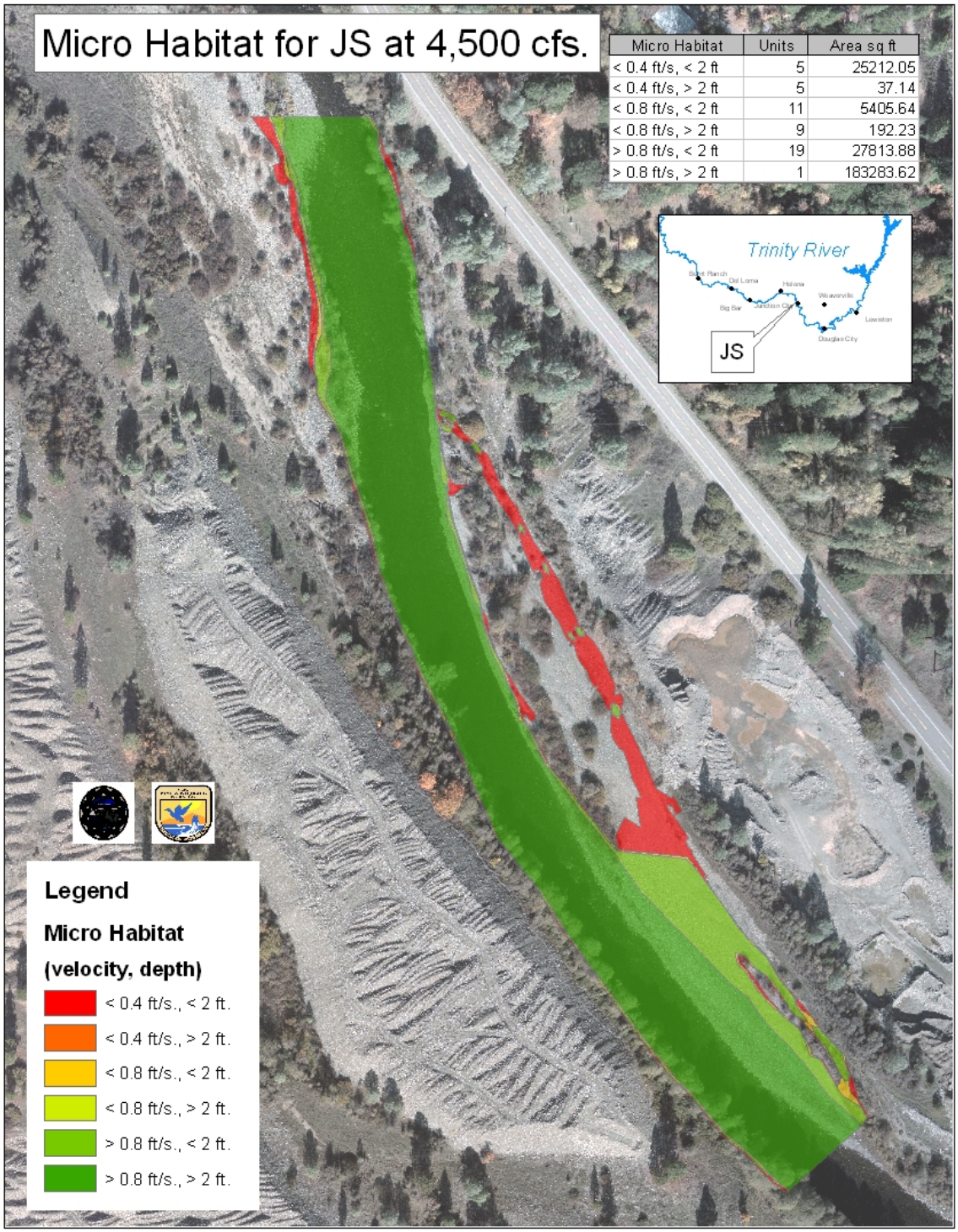


Figure E-4 Microhabitat map at study site Jim Smith at estimated river discharge of 4,500 cubic feet per second.

Appendix F. Microhabitat maps at study site CM (Hocker Flat).

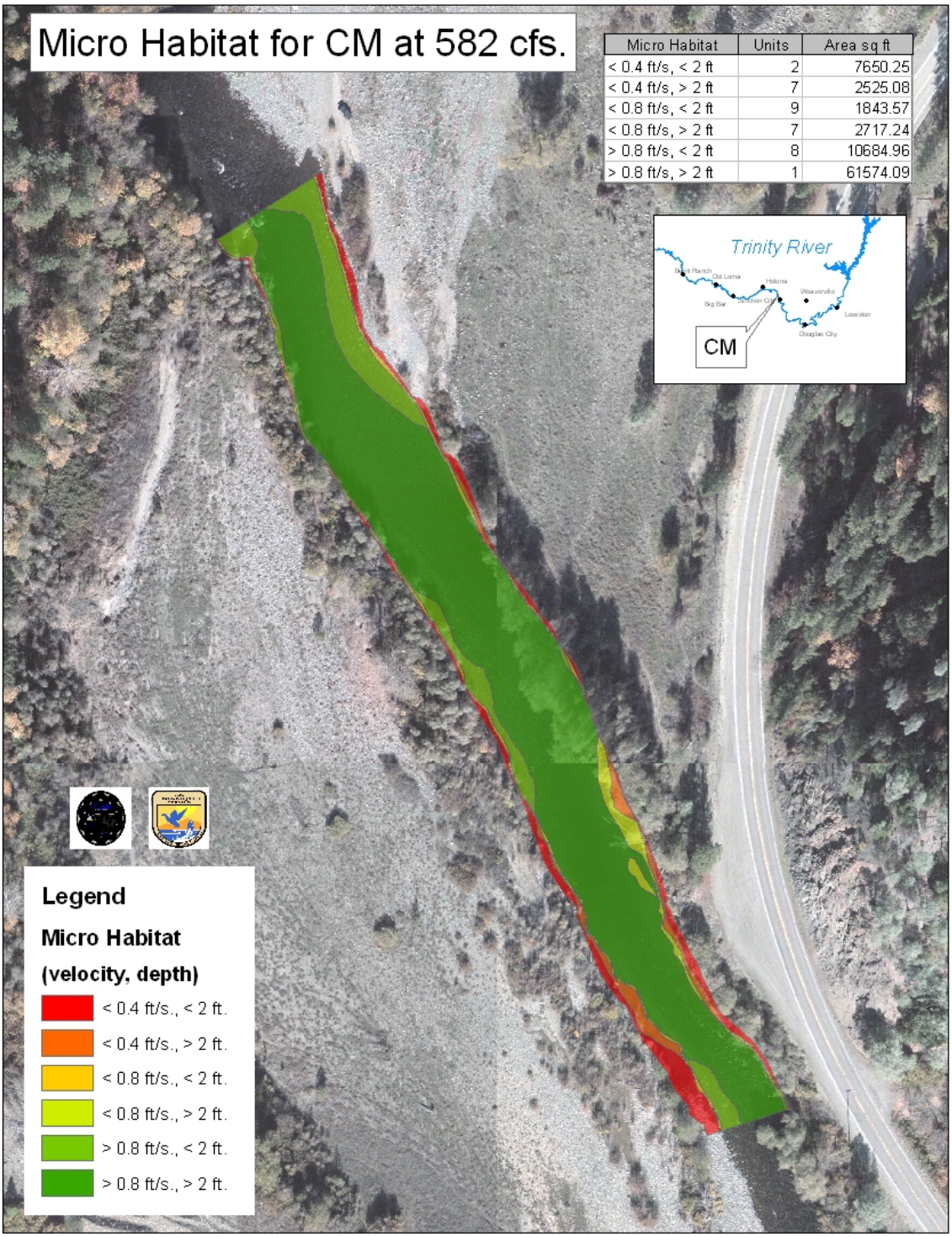


Figure F-1 Microhabitat map at study site CM at estimated river discharge of 582 cubic feet per second.

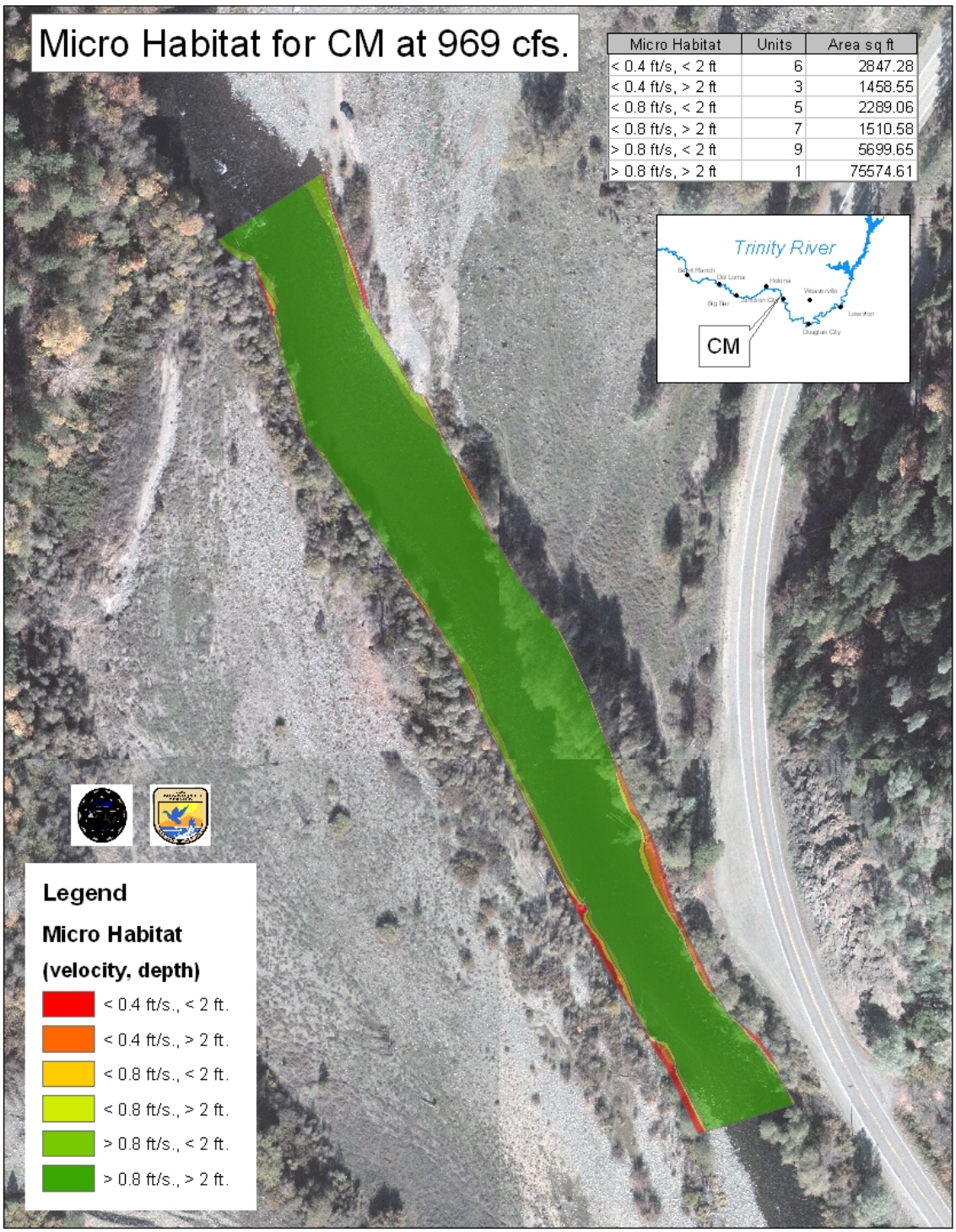


Figure F-2 Microhabitat map at study site CM at estimated river discharge of 969 cubic feet per second.

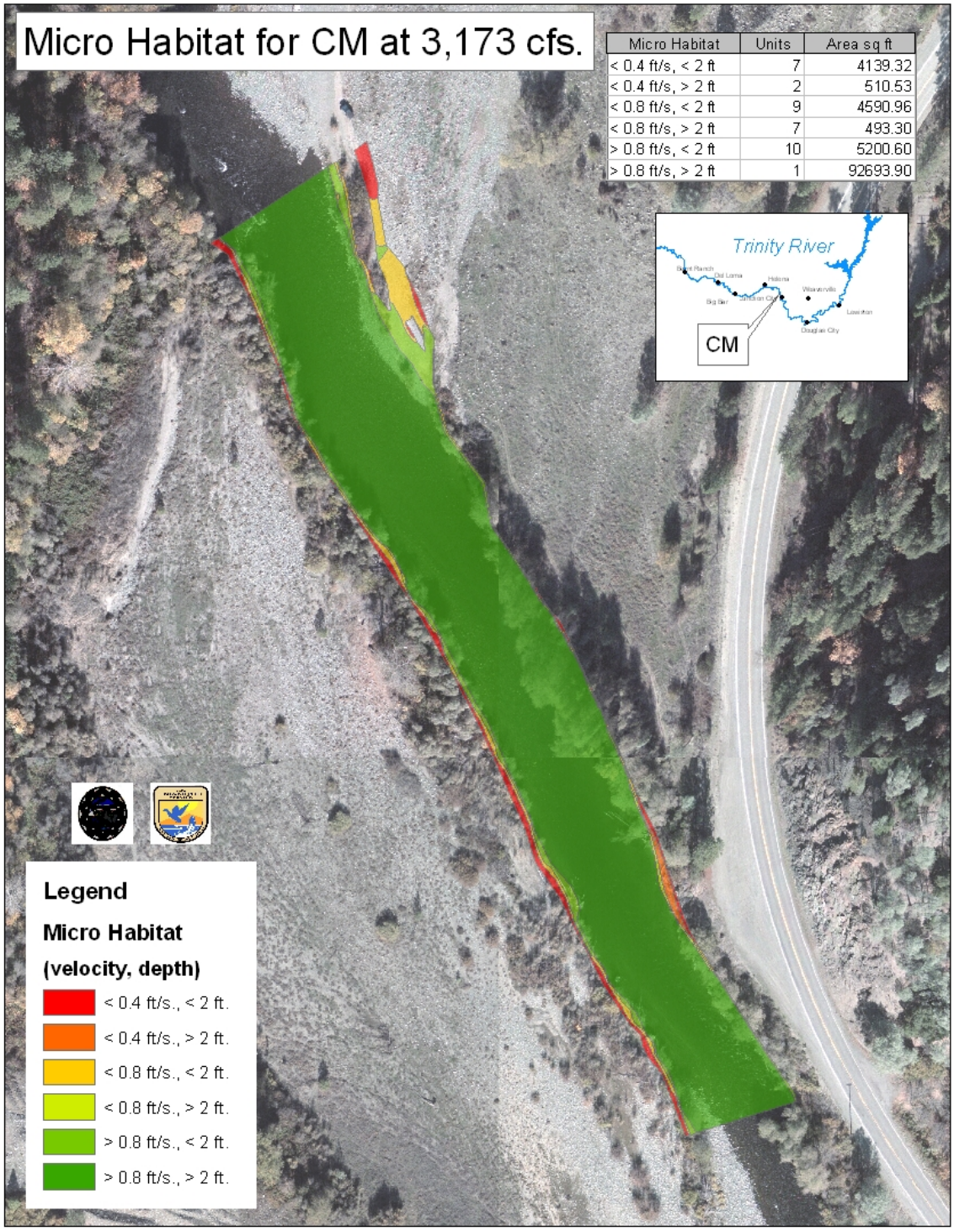
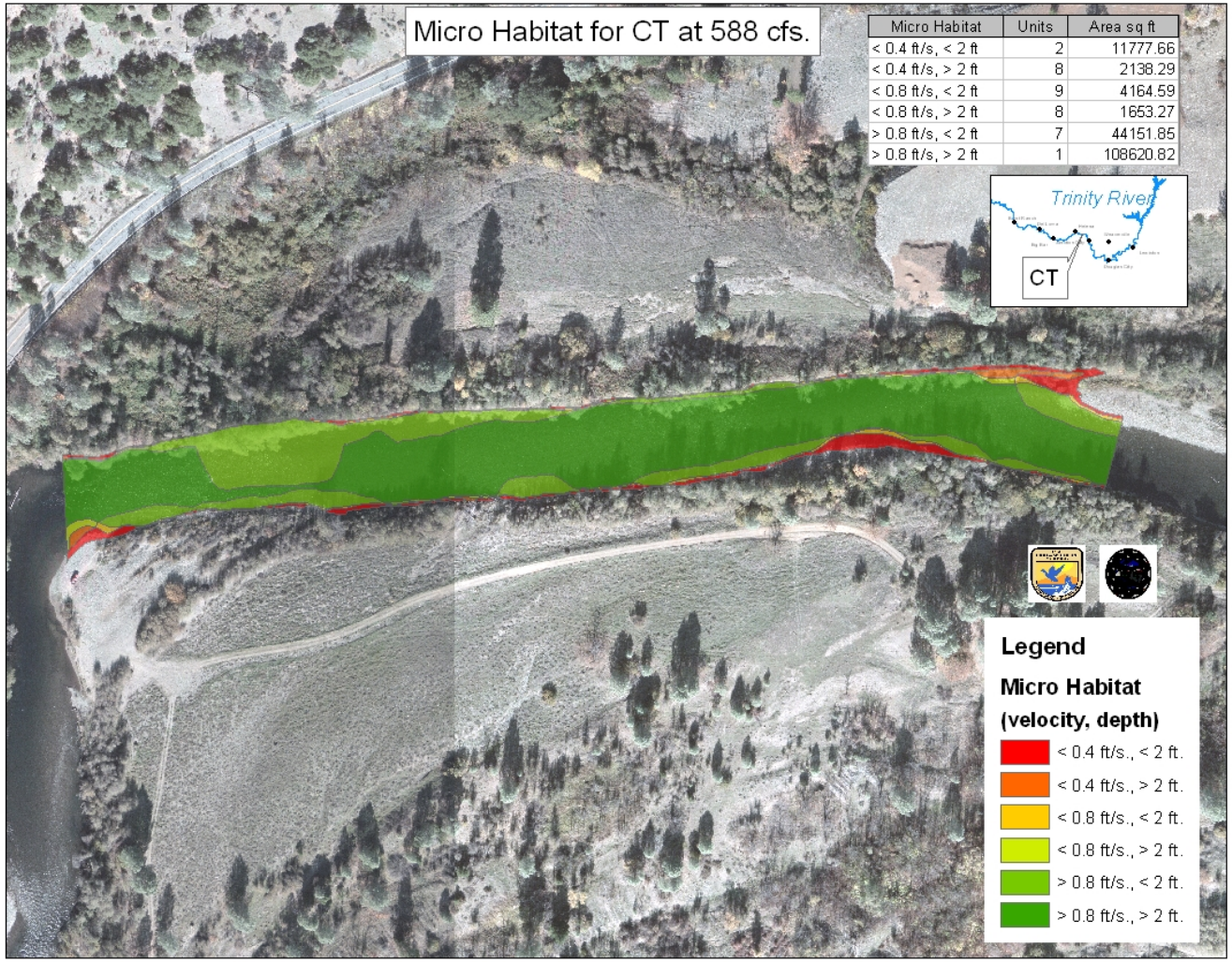


Figure F-3 Microhabitat map at study site CM at estimated river discharge of 3,173 cubic feet per second.

Micro Habitat	Units	Area sq ft
< 0.4 ft/s, < 2 ft	9	5158.07
< 0.4 ft/s, > 2 ft	10	606.37
< 0.8 ft/s, < 2 ft	19	1595.21
< 0.8 ft/s, > 2 ft	11	1158.29
> 0.8 ft/s, < 2 ft	12	4963.78
> 0.8 ft/s, > 2 ft	1	106562.56

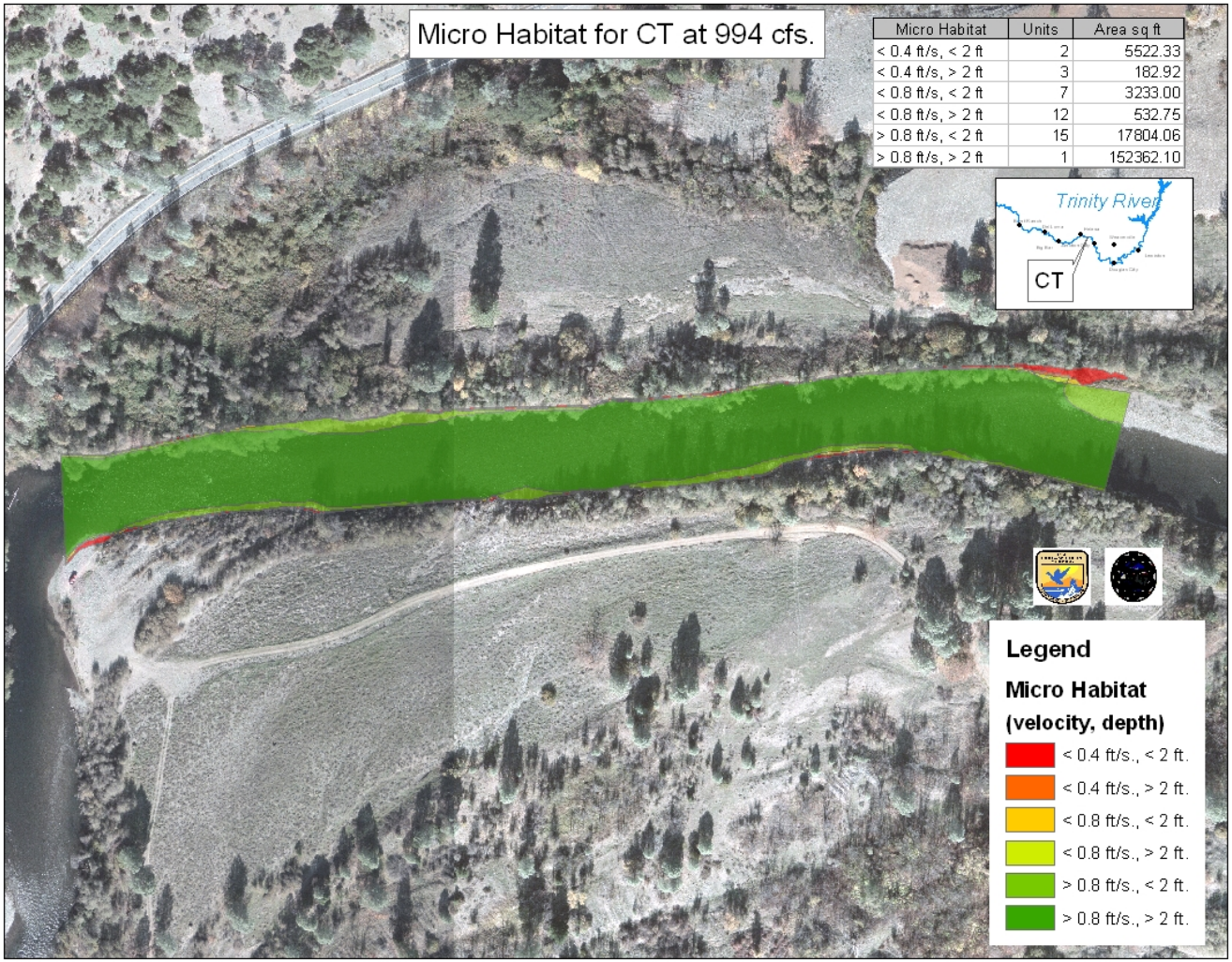
Figure F-4 Microhabitat map at study site CM at estimated river discharge of 4,500 cubic feet per second.

Appendix G. Microhabitat maps for study site CT (Valdor Gulch).



Micro Habitat	Units	Area sq ft
< 0.4 ft/s, < 2 ft	2	11777.66
< 0.4 ft/s, > 2 ft	8	2138.29
< 0.8 ft/s, < 2 ft	9	4164.59
< 0.8 ft/s, > 2 ft	8	1653.27
> 0.8 ft/s, < 2 ft	7	44151.85
> 0.8 ft/s, > 2 ft	1	108620.82

Figure G-1 Microhabitat map at study site CT at estimated river discharge of 588 cubic feet per second.



Micro Habitat	Units	Area sq ft
< 0.4 ft/s, < 2 ft	2	5522.33
< 0.4 ft/s, > 2 ft	3	182.92
< 0.8 ft/s, < 2 ft	7	3233.00
< 0.8 ft/s, > 2 ft	12	532.75
> 0.8 ft/s, < 2 ft	15	17804.06
> 0.8 ft/s, > 2 ft	1	152362.10

Figure G-2 Microhabitat map at study site CT at estimated river discharge of 944 cubic feet per second.

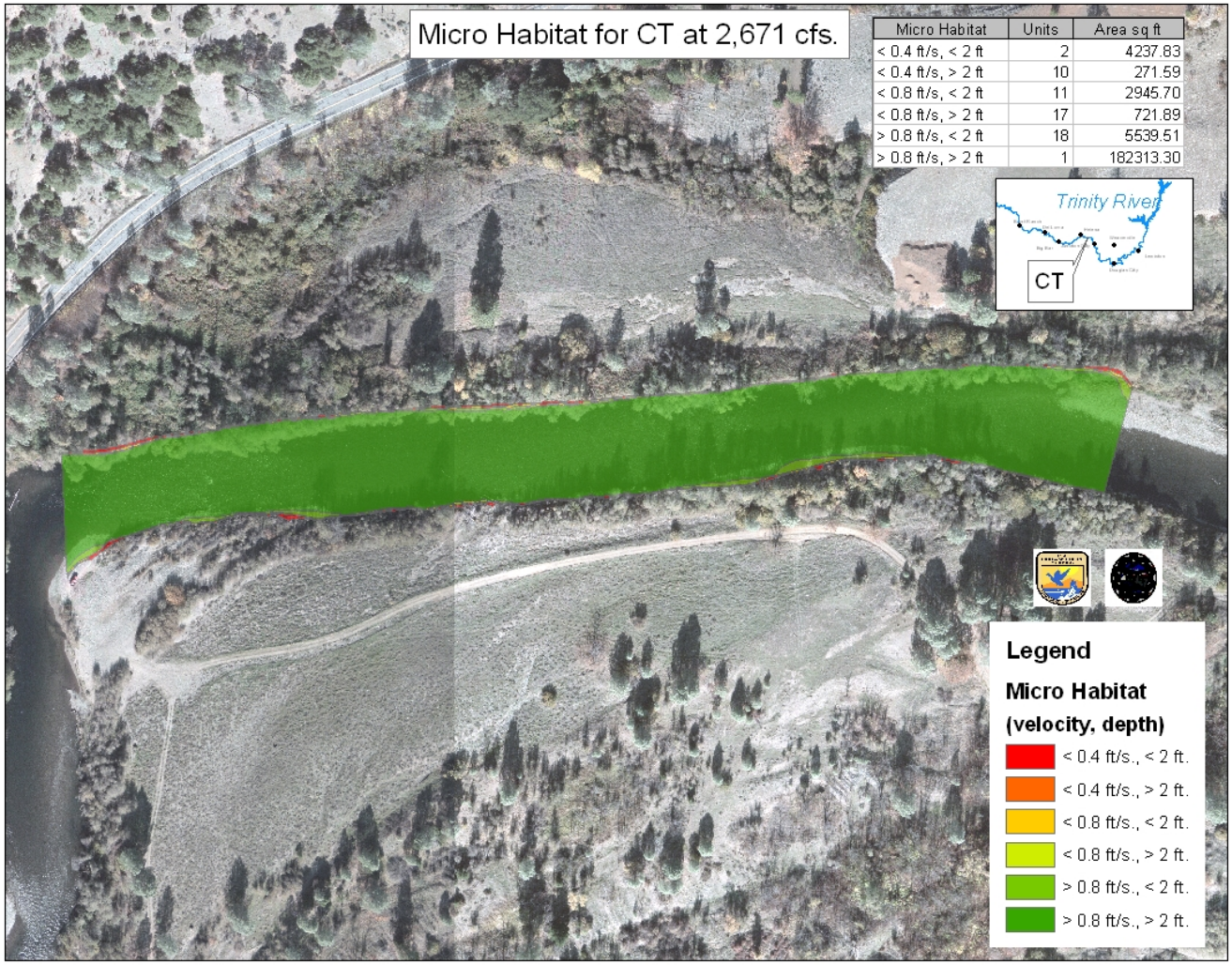


Figure G-3 Microhabitat map at study site CT at estimated river discharge of 2,671 cubic feet per second.

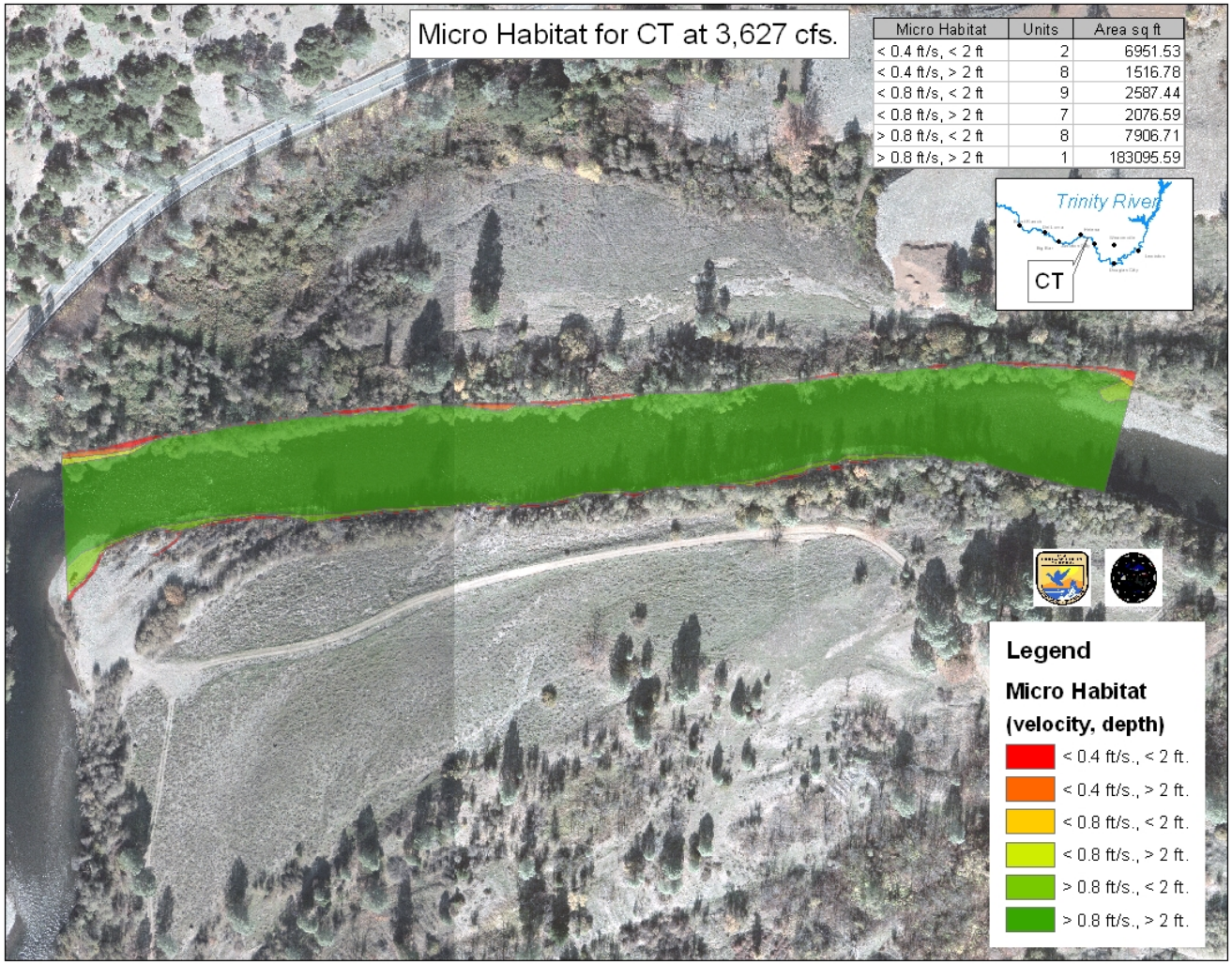


Figure G-4 Microhabitat map at study site CT at estimated river discharge of 3,627 cubic feet per second.

Appendix H. Weighted usable area tables

Table H-1 Weighted Usable Area estimates in ft^2 per linear river foot for the Douglas City Feathered Edge study site.

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
501	21.11	21.42	3.12	3.18	3.34	46.68
849	10.47	10.51	4.74	4.78	4.91	16.94
1,948	3.86	3.87	1.62	1.64	1.70	6.51
2,906	8.44	8.35	6.04	6.10	6.28	9.34

Site length 1,480 feet

Table H-2 Weighted Usable Area estimates in ft^2 per linear river foot for the Oregon Gulch study site.

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
550	17.44	17.51	6.87	6.94	7.16	30.20
729	15.06	15.07	6.21	6.29	6.52	25.53
1,117	9.17	9.16	4.83	4.87	5.02	13.53
2,039	9.56	9.55	6.60	6.63	6.73	11.08
2,881	21.29	21.20	16.71	16.78	17.01	20.75

Site length 2,540 feet

Table H-3 Weighted Usable Area estimates in ft^2 per linear river foot for the CK study site.

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
596	30.81	31.31	5.08	5.14	5.32	67.13
1,305	8.76	8.77	4.58	4.62	4.73	12.99
2,756	4.10	4.10	1.78	1.80	1.87	6.78
3,871	5.40	5.32	4.20	4.24	4.36	5.32

Site length 1,480 feet

Table H-4 Weighted Usable Area estimates in ft^2 per linear river foot for the CL study site.

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
615	25.63	25.90	7.13	7.21	7.42	50.17
2,900	5.84	5.76	4.43	4.47	4.60	5.97
3,749	7.07	6.98	6.04	6.08	6.22	5.93

Site length 1,640 feet

Table H-5 Weighted Usable Area estimates in ft^2 per linear river foot for the Jim Smith study site.

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
595	12.47	12.65	2.37	2.40	2.50	26.56
1,344	7.79	7.78	4.12	4.16	4.27	11.44
3,123	7.12	7.13	3.35	3.39	3.49	11.28
4,500	20.66	20.66	14.57	14.63	14.80	23.33

Site length 1,890 feet

Table H-6 Weighted Usable Area estimates in ft^2 per linear river foot for the CM study site.

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
582	12.01	12.02	7.89	7.93	8.03	14.68
969	5.86	5.81	3.58	3.62	3.75	7.67
3,173	7.96	7.79	5.71	5.80	6.06	8.74
4,500	7.42	7.39	5.46	5.49	5.58	7.93

Site length 1,070 feet

Table H-7 Weighted Usable Area estimates in ft^2 per linear river foot for the CT study site (Valdor Gulch).

Approximate discharge at site (cfs)	Chinook salmon fry (< 50 mm)	Chinook salmon juvenile (50 to 120 mm)	Coho salmon fry (< 50 mm)	Coho salmon juvenile (50 to 120 mm)	Steelhead fry (< 50 mm)	Steelhead juvenile (50 to 120 mm)
588	19.22	19.36	8.27	8.32	8.48	31.96
994	8.70	8.71	4.21	4.25	4.37	13.53
2,571	4.83	4.78	3.36	3.39	3.50	5.54
3,671	6.96	6.93	4.92	4.95	5.04	7.83

Site length 1,640 feet