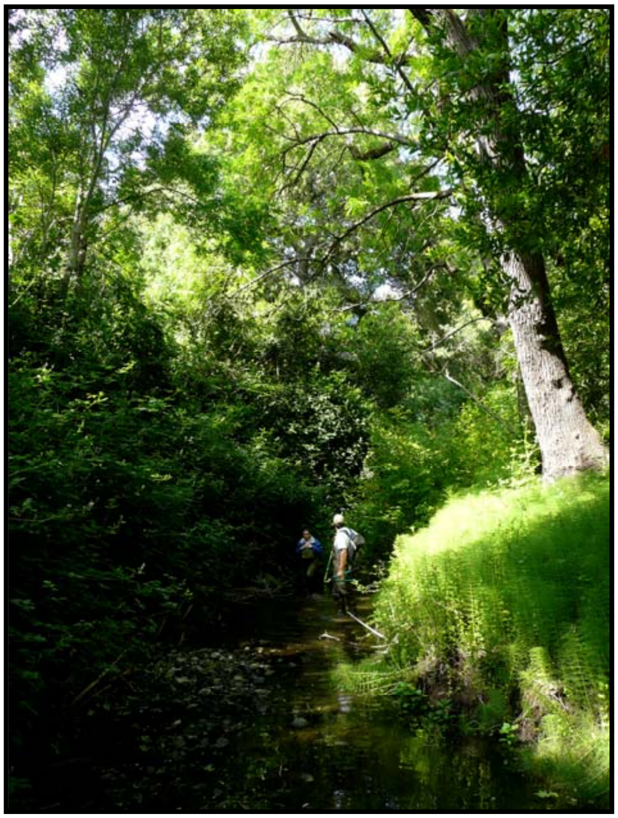

Lower Pinole Creek Steelhead Habitat Assessment

Hagar Environmental Science
and
Pacific Biology

For:
Contra Costa Resource Conservation District

31 July 2009

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Acknowledgements

Funding for the habitat assessment study was obtained by the Contra Costa County Resource Conservation District from the Contra Costa County Fisheries and Wildlife Propagation Fund. This assessment was coordinated with a parallel assessment conducted by the East Bay Municipal Utility District (EBMUD) in the upper part of the Pinole Creek watershed.

1.0 BACKGROUND AND OBJECTIVES

The project was undertaken to assess the quality of fisheries habitat in Pinole Creek and its potential to support steelhead (*Oncorhynchus mykiss*). Steelhead/rainbow trout (*O. mykiss*) have a highly flexible life history and may follow a variety of life-history patterns including residents (non-migratory) at one extreme and individuals that migrate to the open ocean (anadromous) at another extreme. Intermediate life-history patterns include fish that migrate within the stream (potamodromous), fish that migrate only as far as estuarine habitat, and fish that migrate to near-shore ocean areas. These life-history patterns do not appear to be genetically distinct, and have been observed interbreeding (Shapovalov and Taft 1954). Steelhead are the anadromous form of *O. mykiss* and are unique among Pacific salmon in that ocean migrating individuals may return to the ocean after spawning and return to freshwater to spawn one or more times. Rainbow trout are the non-migratory form of *O. mykiss*. In the stream environment, rearing juvenile *O. mykiss* of steelhead parentage are indistinguishable from resident rainbow trout[1].

Pinole Creek has a healthy population of native fishes including *O. mykiss* which have been documented on numerous occasions and in a number of locations in Pinole Creek (Mulchaey 2009, Leidy et al. 2005). The extent to which steelhead contribute to this population or whether it is composed of resident rainbow trout is currently unknown. However, in recent years steelhead have been observed on several occasions in the lower reaches of Pinole Creek and in the upper watershed on East Bay Municipal utility District (EBMUD) land (Mulchaey 2009). There is interest in restoring a viable steelhead population in the Pinole Creek watershed.

Parts of Lower Pinole Creek have been channelized for flood control and a set of box culverts conducting the creek beneath US Interstate 80 (I-80) form a potential migration obstacle for steelhead. During the dry February of 2002, several adult steelhead were observed holding and attempting to spawn in the channel downstream of the box culverts. The shallow depth of flow through the culverts presented a barrier to steelhead migration at low flows during the spawning season that year. Since then, analysis using FishXing software has demonstrated that these box culverts present a migration barrier to adult steelhead due to shallow depth (at all modeled flows) and high velocity at flows above 66 cfs (Leventhal and Love 2009). The culvert is also a barrier for both juvenile and adult resident rainbow trout due to shallow depth and high velocity (Leventhal and Love 2009). These culverts present the only significant barrier to steelhead migration in Pinole Creek up to the natural falls located on EBMUD lands much higher in the watershed.

A group consisting of the Contra Costa Resource Conservation District (CCRCD), EBMUD, the Friends of Pinole Creek Watershed (FOPCW), consultants, the City of Pinole and the Contra Costa County Flood Control and Water Conservation District is working to remediate this passage obstacle at the I-80 culverts. The Coastal Conservancy and the US Fish and Wildlife Service have provided funds for development of a plan and engineering design work. The CCRCD, with assistance from its partners, has applied for a grant from the California

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[1] Laboratory analysis of internal structures of sacrificed specimens has been used to distinguish between *O. mykiss* of steelhead parentage from those of resident rainbow trout.

Department of Fish and Game (CDFG) Fisheries Restoration Grant Program to fund the construction.

The Lower Pinole Creek fisheries habitat assessment was undertaken to supply information needed to obtain funding for the construction of the fish passage improvement project. The assessment has measured the quantity and quality of steelhead habitat present in approximately 2.6 miles of Pinole Creek from Highway I-80 up to the Pinole City limit (Figure 1). EBMUD will complete the same habitat mapping protocol on its watershed lands above the Pinole City limit with funding from its Habitat Conservation Plan. These coordinated data collection efforts will result in a complete assessment of all available steelhead habitat in Pinole Creek.

2.0 HABITAT ASSESSMENT METHODS

The goal of the habitat assessment was to determine the distribution and assess the quality of habitat features that are of most importance to persistence of steelhead populations. The habitat assessment included detailed characterization of stream habitat features in accordance with the California Salmonid Stream Habitat Restoration Manual (CDFG Method) (Flosi et al. 1998). Surveys were conducted between June 4 and June 9, 2009. The survey was completed by a two-person team with one person estimating habitat parameters and one recording the data. Data was taken electronically using a GPS unit (Trimble GeoXH) with sub-meter accuracy and downloaded in the office to Microsoft Access and Excel for analysis. Habitat characterization was conducted using the following protocols and modifications to the CDFG Method:

- Habitat typing was conducted at a Level IV classification (habitats are identified to the finest level of detail with 25 discreet habitat sub-types) using a twenty percent sampling protocol (Flosi et al. 1998). Given budget constraints, this provides an acceptable level of detail in terms of habitat description while allowing for coverage of a greater length of stream reaches in the watershed.
- In each sample reach all habitat units were identified by type and length measured. First encounters for each habitat type and every fifth unit of each type were characterized in full detail.
- For detailed characterization, the proportion of each habitat unit that was influenced by some type of shelter was estimated as a percentage of the total surface area of the unit. A shelter complexity rating of low, medium, or high was also estimated based on structural complexity and diversity of shelter types present. Presence of shelter is most important in the pool and flatwater habitats used most frequently by *O. mykiss* and is not as important in riffle habitats.
- Maximum depth, pool tail crest depth, and pool tail embeddedness were recorded for every pool encountered. In addition to other characteristics, pools were defined as having a residual maximum depth of 1 foot or more.
- Potential spawning area for rainbow trout and steelhead was estimated based on appropriate substrate types occurring in suitable locations. Generally, substrate size was mixed at these locations and included size ranges useable by either resident rainbow trout or steelhead. No attempt was made to determine separate estimates for the two life-history types.

- Canopy density was visually estimated and recorded for units selected for detailed characterization.
- Bank composition and vegetation estimates are standard components of the California Salmonid Stream Habitat assessment method. This information was not central to the objectives of the present survey. To streamline data collection, bank composition and vegetation parameters were omitted from the habitat assessment.

Although fish population surveys are not usually part of the habitat assessment, visual observations of fish can be easily incorporated into the habitat assessment and this documentation can provide valuable information to support conclusions concerning habitat quality and suitability. The habitat assessment was completed during the early summer under low flow conditions. Visibility was only fair due to relatively high turbidity and fish observations were only incidental for this survey.

As part of the habitat assessment, potential obstacles to migration were identified, located by GPS, photo documented and described with reference to species specific criteria in the scientific literature for passage at both natural and constructed obstacles (Bjornn and Reiser 1991; NMFS 2000; WDFW 1999).

The results of habitat surveys and fish sampling were qualitatively evaluated to identify key factors that potentially limit fish populations in the watershed. The analysis segmented the study reach into five separate sub-reaches at major road crossings. The first sub-reach, from I-80 to Ramona Street was bordered by commercial and residential development and was characterized by long, deep pool habitat in the lower part. The next two sub-reaches, Ramona Street to Simas Avenue and Simas Avenue to Pinole Valley Road, were similar to each other and ran through residential neighborhoods. The fourth sub-reach was bordered by open space and park land with a narrower deeper channel and more dense riparian vegetation. The fifth sub-reach, from Pinole Valley Road to the City limit was bordered by residential development with a slightly wider riparian zone than in the first three sub-reaches. These divisions were somewhat arbitrary and do not necessarily correspond with stream channel features such as gradient, confinement or other indicators of channel type.

Several key factors were considered in determining potentially limiting factors and potential for improvement including the relative proportion of different habitat types (pools, riffles, and flatwater), stream size (depth and width), shelter characteristics, substrate characteristics, and obstacles to fish movement. The importance of these factors is discussed briefly as follows:

Macro-habitat Type

The relative proportion of different habitat types is important because steelhead use different habitats during different life stages. Spawning occurs in the riffle head/pool tail transition areas and in glides and runs. After emergence from the gravel, steelhead fry inhabit low velocity areas along the stream margins and in riffles and glides. As they feed and grow they gradually move to deeper and faster water. Pool habitat is important because pools provide habitat during the critical summer low flow period occurring from May through October and during periodic droughts. Streamflow can drop to very low levels with loss of depth and velocity in riffle and run habitats, or in the extreme, only isolated pools with intervening dry sections of stream.

Deeper waters where low velocity areas are in close proximity to higher velocity areas and shelter is provided by boulders, undercut banks, logs, or other objects provide ideal conditions for steelhead to grow to smolt size (about 6 inches or more). Heads of pools generally provide classic conditions for older juvenile steelhead. Rearing steelhead can inhabit quite small streams, particularly in coastal streams with better baseflows and cooler temperature. Often habitat may be far more limiting for older juveniles than habitat for younger fish. Although adult resident rainbow trout and rearing juvenile steelhead may inhabit pools with mean depths in the range of 0.5 to 1.5 feet in small streams, they generally occur at greater densities in streams with more pools in the 1.5 to 2.5 foot mean depth range or deeper. Greater depth provides protection from avian and terrestrial predators and may provide refuge from high velocity during high winter flows.

Riffle habitat can also be very important to rearing steelhead since many of the food organisms they rely on originate there. The highest production of aquatic invertebrates is in gravel and cobble substrate with low amounts of fine sediments, often occurring in riffle type habitats. More extensive riffle habitat can produce greater numbers of food organisms that drift downstream to pools where steelhead are rearing. In some cases however, steelhead diets may incorporate other types of aquatic organisms or terrestrial invertebrates in place of organisms produced in riffles.

Shelter

Vegetation on the stream bank is intricately linked to the aquatic environment and influences it in many ways (Bjornn and Reiser 1991). Riparian vegetation provides shade and moderates water temperature. This vegetation also serves as an important source of nutrients to the stream, both through direct input of organic matter and as a source of terrestrial insects. Aquatic productivity can be inhibited under conditions of continuous closed canopy, and the ideal condition for *O. mykiss* production is a moderately dense canopy (55-85%) with occasional small openings. The roots of riparian shrub and tree species such as alder, willow, sycamore, and redwood form networks that strengthen and retain the bank and lead to formation of scour pools and undercut banks that provide excellent instream shelter for fish and substrates for production of benthic macro-invertebrates (BMI). Trees may eventually fall into the stream as a result of aging or erosion and their trunks and branches alter flow patterns and provide hard structures resulting in scouring of pools. This large woody material also provides instream shelter for rearing steelhead. Terrestrial vegetation hanging over the stream bank also can provide useful overhead shelter/cover for fish. In many developed areas, large woody debris is actively removed from stream channels to prevent flooding and bank erosion, resulting in fewer pools and less shelter for fish.

Substrate

Larger substrate such as cobbles and boulders can provide hiding areas and velocity refugia for juvenile *O. mykiss*, particularly during the winter when high velocity and reduced food abundance occurs. Silt and sand present in excessive amounts fill spaces between the larger substrate elements and reduce its ability to support BMI production, habitat for spawning, egg incubation, and escape cover (Bjornn and Reiser 1991, Harrington and Born 2000). Fish density, particularly for juvenile *O. mykiss* and salmon, is generally reduced as the proportion of fine sediments increases (Bjornn and Reiser 1991). Bjornn *et al.* (1977) found that the density of rearing steelhead and chinook salmon in artificial channels was reduced in nearly direct proportion to increased cobble embeddedness. Response to increased embeddedness was even greater during the winter. Young-of-year *O. mykiss* are particularly sensitive during winter and can be impacted at fine sediment levels greater than 5-10% (Bjornn and Reiser 1991). During summer older juvenile *O. mykiss* may tolerate fine sediment levels of 30-50% without significant impacts on population density (Bjornn and Reiser 1991). Excessive amounts of silt and sand may also fill in pools and other deep areas and reduce their utility as habitat for adult fish. The amount of fine sediment present is commonly evaluated in habitat surveys by estimating cobble embeddedness. This is accomplished by observing the average proportion of individual cobble size substrate that is embedded in finer material.

Steelhead select spawning sites with gravel/cobble substrate and with sufficient flow velocity to maintain circulation through the gravel and provide a clean, well-oxygenated environment for incubating eggs. Preferred flow velocity is in the range of 1-3 feet per second for steelhead (Raleigh 1984) and preferred gravel substrate is in the range of 0.25 to 4 inches in diameter (Bjornn and Reiser 1991). Typically, sites with preferred features for spawning occur most frequently in the pool tail/riffle head areas where flow accelerates out of the pool into the higher gradient section below. In such an area, the female will create a pit, or redd, by undulating her tail and body against the substrate. This process also disturbs fine sediment in the substrate and lifts it into the current to be carried downstream, cleaning the nest area. Incubation and emergence success are influenced by accumulation of fine sediments (generally less than 3.3 mm) in the substrate. Embryo survival for steelhead decreases when the percentage of substrate particles less than 6.4mm in diameter reaches 25-30% and is extremely low when fines are 60% or more. Emergence of steelhead fry is generally high when fine sediments are less than 5% of substrate volume but drops sharply with fine sediment volume of 15% or more (Bjornn and Reiser 1991).

Temperature

Stream temperature generally fluctuates on a daily basis in parallel with air temperature and reaches maximum levels in central California in July and August. Steelhead are generally expected to survive and grow well at temperature up to about 19°C to 21°C with temperature of 19°C or less considered optimal under most conditions (Bidgood and Berst 1969, Hokanson *et al.* 1977, Smith and Li 1983). Steelhead may actually grow faster at higher temperatures if food is abundant (Smith and Li 1983) but at temperature in excess of 21°C, increased mortality may offset the benefits of increased growth rates at the population level (Hokanson *et al.* 1977). Water temperature becomes lethal for rearing *O. mykiss* as it approaches and exceeds about 25°C (77°F) (Bidgood and Berst 1969, Hokanson *et al.* 1977). Temperature monitoring results in Lower Pinole Creek show that temperature rarely exceeds 20°C during the peak of summer (Mulchaey 2009).

Migration

Steelhead along the Central California coast enter freshwater to spawn when winter rains have been sufficient to raise streamflows and breach the sandbars that form at the mouths of many streams during the summer (Shapovalov and Taft 1954). Increased streamflow during runoff events also appears to provide cues that stimulate migration and allows better conditions for fish to pass obstructions and shallow areas on their way upstream. The season for upstream migration of steelhead adults lasts from late October through the end of May but typically the bulk of migration (over 95% in Waddell Creek) occurs between mid-December and mid-April (Shapovalov and Taft 1954).

Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4.5 feet per second (fps) for extended periods of time and can achieve burst speeds of 14 to 26 fps during passage through difficult areas (Bell 1986). Leaping ability is dependent on the size and condition of fish and hydraulic conditions at the jump. Given satisfactory conditions, a conservative estimate of steelhead leaping ability is a height of 6 to 9 feet (Bjornn and Reiser 1991), though other estimates range from 11 feet (Bell 1986) to as high as 15 feet (McEwan 1999).

Juvenile steelhead may migrate downstream at various ages throughout the year with smolts generally migrating to sea from March through late May (Shapovalov and Taft 1954). In addition to temperature and flow conditions, smolts are subject to predation, primarily by birds including cormorants, mergansers, and herons, but also predatory fish. Predation by birds can increase under conditions where smolts have to traverse shallow sections of streams without cover. With clear water, birds can be particularly effective predators. Conditions favoring predation by birds occur in channel reaches modified for flood control where the channel is maintained in a wide, shallow configuration and is largely devoid of in-stream large woody debris and riparian vegetation. Behavioral adaptations of smolts including nocturnal migration may moderate the effects of predation.

Steelhead that survive spawning return downstream to re-enter the ocean. As many as 20% of adult spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times (Shapovalov and Taft 1954). In some streams fish return downstream immediately after spawning while in others they may remain for a period up to several months. After spawning, these fish do not typically resume feeding while in freshwater. In Waddell Creek the bulk of adults returned downstream from April through June (Shapovalov and Taft 1954). Fish that remain in the stream for any period of time generally reside in deeper pools. Adequate cover and cool temperature are critical habitat variables for adults that hold over for the entire summer.

Steelhead populations in central California can occur in streams with relatively low baseflow and in streams varying widely in terms of standard evaluation parameters such as pool:riffle ratio and mean depth. Often, local populations thrive under conditions that may depart widely from species norms (Behnke 1992).

3.0 SURVEY RESULTS

The assessment was completed in early June. Streams in this region typically have lowest flows in late summer (August-September). Late summer is expected to be the most critical for rearing juvenile steelhead due to low flows and high temperature. USGS stream gage records for Pinole Creek indicate that median flow is around 0.5 cfs in June and drops to 0.03 cfs in September.

Discharge during the survey was estimated at 0.5 cfs or less. Water temperature was not recorded during the survey as there is a continuous temperature monitoring network in place for Lower Pinole Creek (Mulchaey 2009). Temperature records from this network indicate that water temperature is not a significant limiting factor for steelhead in Pinole Creek.

No substantial differences were observed in any of the survey parameters between the five different sub-reaches and the entire Lower Pinole Creek reach can be considered a single unit for characterizing steelhead habitat.

A total of 16 different habitat types were identified in the assessment. This included 4 types of flatwater habitat (glides, runs, stepruns, and pocketwater), three types of riffle (low-gradient, high-gradient, and cascade), and nine types of pool (Figure 2). The most common pool type was lateral-scour (48 of 77 pools total). Other pools were enhanced by bedrock (6), roots (4), boulders (1), and logs (1). Pools made up 58% of the surveyed stream length averaged over the entire survey (Table 1, Figure 2 and Figure 3). Riffles were relatively common, but very short, making up less than 10% of the total survey length.

The pools were mostly of moderate depth (Table 2, Figure 4) with an average mean depth of 1.7 feet and an average maximum depth of 3.0 feet. Only 16% of pools had a mean depth of less than 1 foot and only 20% had mean depths of 2 feet or more (Table 3). Eighty-four percent of pools had maximum depths of 2 feet or more and almost 40% had maximum depths of 3 feet or more (Table 3, Figure 5).

Most pools had moderate to high shelter complexity and good shelter coverage (Table 4). The majority of pools had 20% to 30% shelter coverage though, a third had more than 30% coverage. Shelter was most commonly provided by terrestrial vegetation, undercut bank, and the spaces around cobble and boulders (Figure 6). In pools, terrestrial vegetation made up a third of all shelter, undercut bank was a quarter, and boulder and bedrock ledge together were another quarter (Table 5). Shelter derived from trees including root mass and large woody debris was rarely dominant and composed a very small percentage of overall shelter. This may reflect the relatively narrow riparian border or removal of living and/or down trees from the riparian zone. Overall, these characteristics are consistent with shelter conditions in streams with good *O. mykiss* production. Canopy coverage averaged 55%, but ranged as high as 95% (Table 6). The dominant canopy species in about half the habitat units was willow (Table 6), with walnut and buckeye also relatively common. The dominance of these species, the presence of many exotic species, and the relative infrequency of riparian climax species such as alder, sycamore, and redwood is indicative of a somewhat disturbed and immature riparian forest.

Substrate was dominated by silt, sand, and gravel. Half of all habitat units where detailed data was collected had silt/clay or sand as the dominant substrate type (Table 7, Figure 7). Gravel or cobble was dominant in 41% of the surveyed habitat units and 100% of surveyed riffle habitats (Table 8). Pool tail and spawning gravel embeddedness ratings were highly variable. Over 15% of surveyed pool tails had embeddedness ratings of more than 50% while 47% had embeddedness of 15% or less (Table 9). Fine sediments tended to be lower in areas judged to be suitable for salmonid spawning with the majority (87%) having embeddedness ratings of 30% or less and 66% of spawning areas with embeddedness ratings of 15% or less (Tables 10 and 11). Further, half of the potential spawning areas identified had embeddedness ratings of 10% or less

(Table 10). There was an average of 10 square feet of potential spawning area per 100 feet of stream length in the study area although the section between Ramona Street and Simas Avenue had twice that much (Table 11).

No significant migration obstacles were encountered in the study reach although most of the riffles would inhibit movement of adults and juveniles at low summer flows. The most significant low flow obstacles were at the bridge crossings, particularly Simas Avenue. Stickleback, California roach, and Sacramento sucker were observed throughout the study area. Several young-of-year *O. mykiss* were observed in the reach between the upper two Pinole Valley Road crossings.

4.0 DISCUSSION

Lower Pinole Creek appears to provide habitat that is suitable for steelhead and of moderate quality. There is extensive pool habitat with good depth and shelter characteristics to provide over-summer rearing habitat for juvenile steelhead. Large woody material in the form of downed trees or tree limbs is relatively rare in the stream. Shelter components did not include many observations of rootwads, large woody material, or undercut roots in the study area. Most of the in-stream cover is provided by overhanging terrestrial vegetation and undercut banks. Habitat for steelhead would be improved with greater abundance of large trees such as alder and sycamore growing near the channel margins. These trees tend to have extensive root systems at the stream margin that can provide extensive cover and enhancement of pool formation. The canopy coverage is generally good but could be more extensive in some areas. For an urbanized area, the riparian zone is relatively wide and undisturbed in most places. There are a few locations where streamside residents have encroached activities and structures on the stream banks to the detriment of habitat quality for steelhead.

Riffle habitat is somewhat limited in Lower Pinole Creek and this may reduce food resources for rearing steelhead somewhat. Steelhead food resources are also likely influenced by fine sediment deposition and potential water quality impacts in the study reach. Monitoring of benthic macro-invertebrate communities by the Contra Costa Watershed Forum (CCWF) indicate that BMI community health is relatively low in the lower part of the watershed compared to more upstream areas (CCWF 2006).

Substrate conditions are generally favorable to food production and spawning. Spawning areas are relatively small and dispersed but are present throughout the study reach. Fine sediments are somewhat elevated in most of the study reach although areas with good spawning substrate also tended to have relatively low embeddedness ratings. During the surveys, we noted a slight turbidity throughout the study reach that may be a result of watershed soil characteristics or chronic disturbance in the relatively urbanized lower watershed. Fine sediments, while not precluding steelhead, may be a limiting factor in this watershed. In spite of ubiquitous fine sediment deposition, embeddedness ratings were surprisingly low in many pool tails and other potential spawning areas.

Pinole Creek is somewhat limited by low summer streamflows, like many small watersheds in the central coast region. However, all survey parameters were within a range suitable for steelhead. This, together with observations of young-of-year *O. mykiss* in the study reach and past observations of *O. mykiss* and adult steelhead in the watershed suggest that the lower part of Pinole Creek has the potential to support steelhead if passage issues at the I-80 culvert are remedied. Another potential issue in the watershed is the flood-control channel downstream of I-80. While this survey did not address that section of creek, it appears that rearing would be very limited in the flood-control reach and there may also be additional migration issues for both adults and smolts. Future efforts to restore steelhead to Pinole Creek should also consider possible remedies for conditions in the flood-control channel to enhance the potential for both rearing and migration.

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Table 1. Fish Habitat Assessment Summary.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Date surveyed	04-Jun-09	08-Jun-09	09-Jun-09	09-Jun-09	03-Jun-09	
Length surveyed (feet)	2339.00	2521.00	3671.00	2348.00	2264.00	13143.00
Average width (feet)	13.13	10.00	9.60	8.60	10.33	10.34
	Number of units					
Flatwater	8.00	11.00	19.00	10.00	10.00	58.00
Pool	15.00	13.00	26.00	13.00	10.00	77.00
Riffle	10.00	14.00	12.00	4.00	11.00	51.00
	Percentage by length					
Flatwater	21.5%	38.4%	25.5%	36.3%	43.2%	32.2%
Pool	67.5%	49.4%	65.5%	59.7%	43.0%	57.9%
Riffle	11.0%	12.2%	9.0%	4.0%	13.8%	9.9%

Table 2. Frequency of Occurrence of Pool Depth Classes.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Total Number of Pools	15	13	25	13	10	76
Length Surveyed (ft)	2339	2521	3671	2348	2264	13143
Number Pools/Mile	34	27	36	29	23	31
Average Pool Length (ft)	105	108	96	92	97	99
Average Pool Depth (ft)	**Number of Pools**					
0.0 – 0.5						
0.5 – 1.0	2	2	4	1	3	12
1.0 – 1.5	5	8	5	4	2	24
1.5 – 2.0	5	1	12	6	1	25
2.0 – 2.5	1	2	3	2		8
2.5 – 3.0			1		3	4
3.0 – 3.5						
3.5 – 4.0	2				1	3
4.0 – 4.5						
4.5 – 5.0						
Maximum Pool Depth (ft)	**Number of Pools**					
0.5 – 1.0						
1.0 – 1.5		1	2		2	5
1.5 – 2.0	1	2	3	1		7
2.0 – 2.5	6	2	5	3	2	18
2.5 – 3.0	3	3	6	3	2	17
3.0 – 3.5	1	1	5	3		10
3.5 – 4.0	2	3	2	1		8
4.0 – 4.5			2	2	3	7
4.5 – 5.0		1				1
5.0 – 5.5						
5.5 – 6.0	2				1	3

Table 3. Pool Depth Summary.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
% pools with mean depth >=1 ft	87%	85%	84%	92%	70%	84%
% pools with mean depth >=2 ft	20%	15%	16%	15%	40%	20%
% pools with mean depth >= 3ft	13%	0%	0%	0%	10%	4%
% pools with max depth >=2 ft	93%	77%	80%	92%	80%	84%
% pools with max depth >=3 ft	33%	38%	36%	46%	40%	38%
% pools with max depth >= 5ft	13%	0%	0%	0%	10%	4%

Table 4. Shelter Complexity Ratings and Shelter Areal Extent.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Shelter Complexity	Number of Pool Habitat Units					
Low			1		1	2
Medium	3	2	5	1	3	14
High	1	1	2	1		5
	Percent of all Measured Pool Habitat Units					
<=10% of Unit with Shelter	0%	0%	0%	0%	25%	5%
>20% of Unit with Shelter	100%	100%	75%	50%	75%	81%
>30% of Unit with Shelter	50%	33%	25%	50%	25%	33%

Table 5. Relative Extent of Shelter Components.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Shelter Type	**Average Percentage of All Shelter in Pools**					
Terrestrial Vegetation	32.5	36.7	28.1	45.0	36.3	33.3
Undercut Bank	31.3	3.3	38.8	25.0	7.5	25.0
Cobble/Boulder	3.8	35.0	11.9	7.5	12.5	13.3
Bedrock Ledge	15.0	0.0	10.0	0.0	28.8	12.1
Small Woody Debris	5.0	25.0	6.3	22.5	8.8	10.7
Root Mass	1.3	0.0	2.5	0.0	7.5	2.6
Rooted Aquatic Veg	11.3	0.0	0.6	0.0	0.0	2.4
Large Woody Debris	0.0	0.0	1.9	0.0	0.0	0.7
Floating Aquatic Veg	0.0	0.0	0.0	0.0	0.0	0.0
Surface Turbulence	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0
Total Surveyed Units	4	3	8	2	4	21

Table 6. Canopy Characteristics.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Average canopy (%)	30	66	55	71	59	55
Maximum canopy (%)	70	95	95	95	95	95
Minimum total canopy (%)	5	40	5	35	30	5
Dominant Canopy Species	**Number of Habitat Units where Dominant**					
Willow	6	2	3	5	5	21
Walnut	1		2		3	6
Buckeye	1	1		4		6
Bay		2			1	3
Oak				2	1	3
Box elder			1	1		2
Dogwood				1		1
Prunus sp.			1			1
Blackberry				1		1
Total Surveyed Units	8	5	7	14	10	44

Table 7. Substrate Characteristics.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Dominant Substrate Class	**Number of Habitat Units**					
Silt/clay	1	1	5	1	5	13
Sand	5	2	1	2		10
Gravel		5	4	1	1	11
Small cobble	1		1	1	3	6
Large cobble			2			2
Boulder	1				1	2
Bedrock			2			2
Total Surveyed Units	8	8	15	5	10	46

Table 8. Riffle Substrate Characteristics.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
% units with gravel-cobble dominant	100%	100%	100%	100%	100%	100%
% units with sand as dominant	0%	0%	0%	0%	0%	0%
% units with sand as dominant or subdominant	0%	0%	0%	0%	33%	10%
Total Surveyed Units	1	3	2	1	3	10

Table 9. Pool-Tail Embeddedness.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Pool Tail Embeddedness (%)	**Number of Habitat Units**					
0			1			1
5			3	1	3	7
10	5		4	8	4	21
15	1	1		4	1	7
20	3		2	1		6
25		1				1
30	2	1	1	1	1	6
35		3				3
40	1	4		4		9
45		1			1	2
50			1	2		3
60				4		4
90	1	2				3
100	2		1			3
Number of Pools Surveyed	15	13	13	25	10	76

Table 10. Spawning Gravel Embeddedness.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Spawning Gravel Embeddedness (%)	**Number of Spawning Areas**					
0	1					1
5	1	4	1		4	10
10	7	5	7	3		22
15	2	2	2	2	2	10
20	1	4	2		1	8
25		1				1
30	1	1	1	1	1	5
35				1		1
40	1		1	1		3
45				1	1	2
50		1	1			2
0	1					1
Number of Spawning Areas Surveyed	14	18	15	9	9	65

Table 11. Spawning Gravel and Substrate Quality Summary.

	80 to Ramona	Ramona to Simas	Simas to PV Road	PV Road to PV Road	Upstream of PV Road	Over All
Number of Spawning Areas Surveyed	14	18	15	9	9	65
Sum of Spawning gravel area (sq.ft.)	230	550	120	115	240	1255
Reach Length (ft)	2339	2521	3671	2348	2264	13143
Spawning area (sq. ft.) per 100 feet	10	22	3	5	11	10
% of pool tails with embeddedness of 15% or less	40%	8%	62%	52%	80%	47%
% of spawning areas with embeddedness of 15% or less	79%	61%	67%	56%	67%	66%

Figure 1. Lower Pinole Creek Steelhead Habitat Assessment Study Area (source: Pacific Biology).

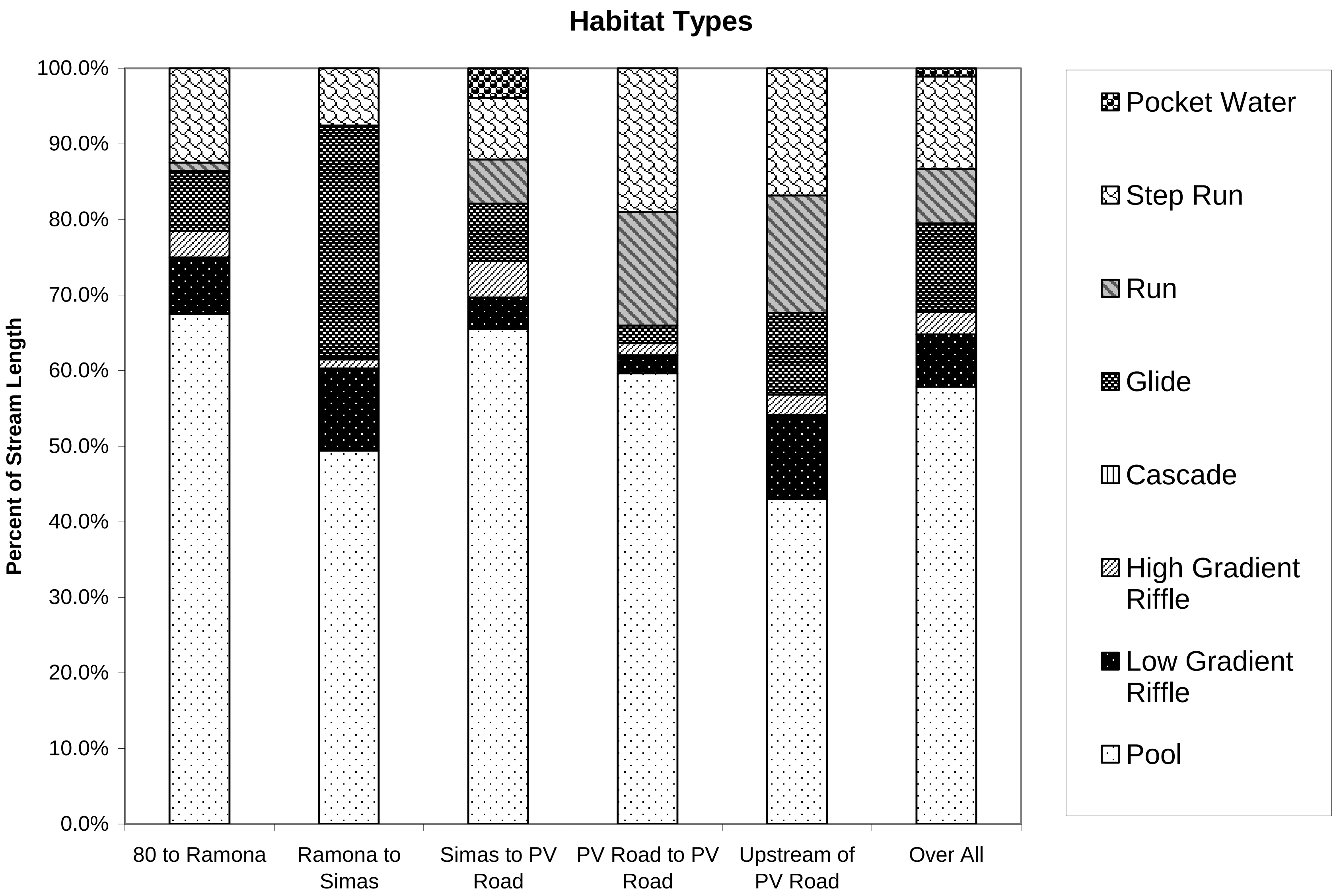

Figure 2. Fish Habitat Sub-type by Reach

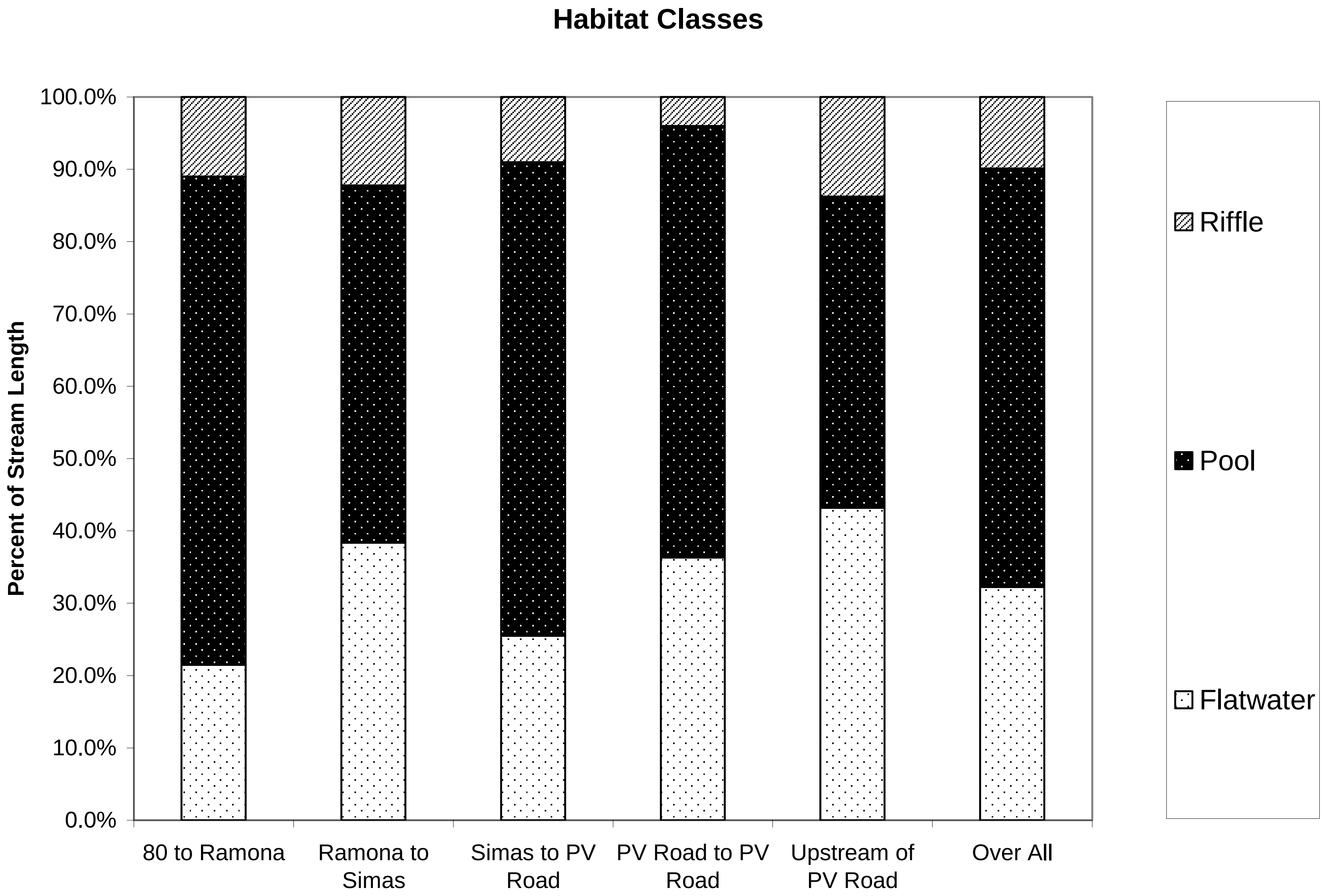

Figure 3. Fish Habitat Type by Reach

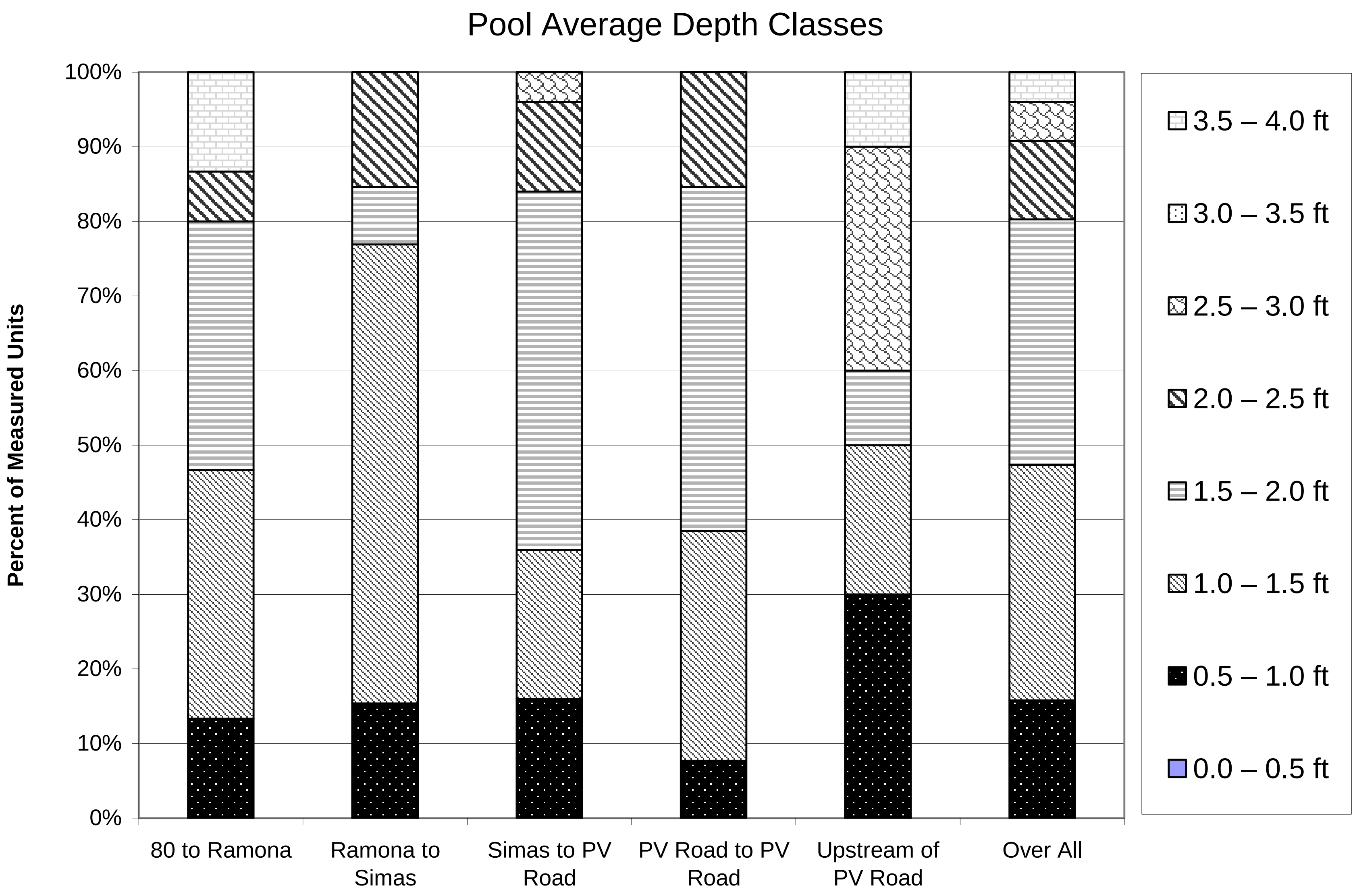

Figure 4. Average Pool Depth by Reach

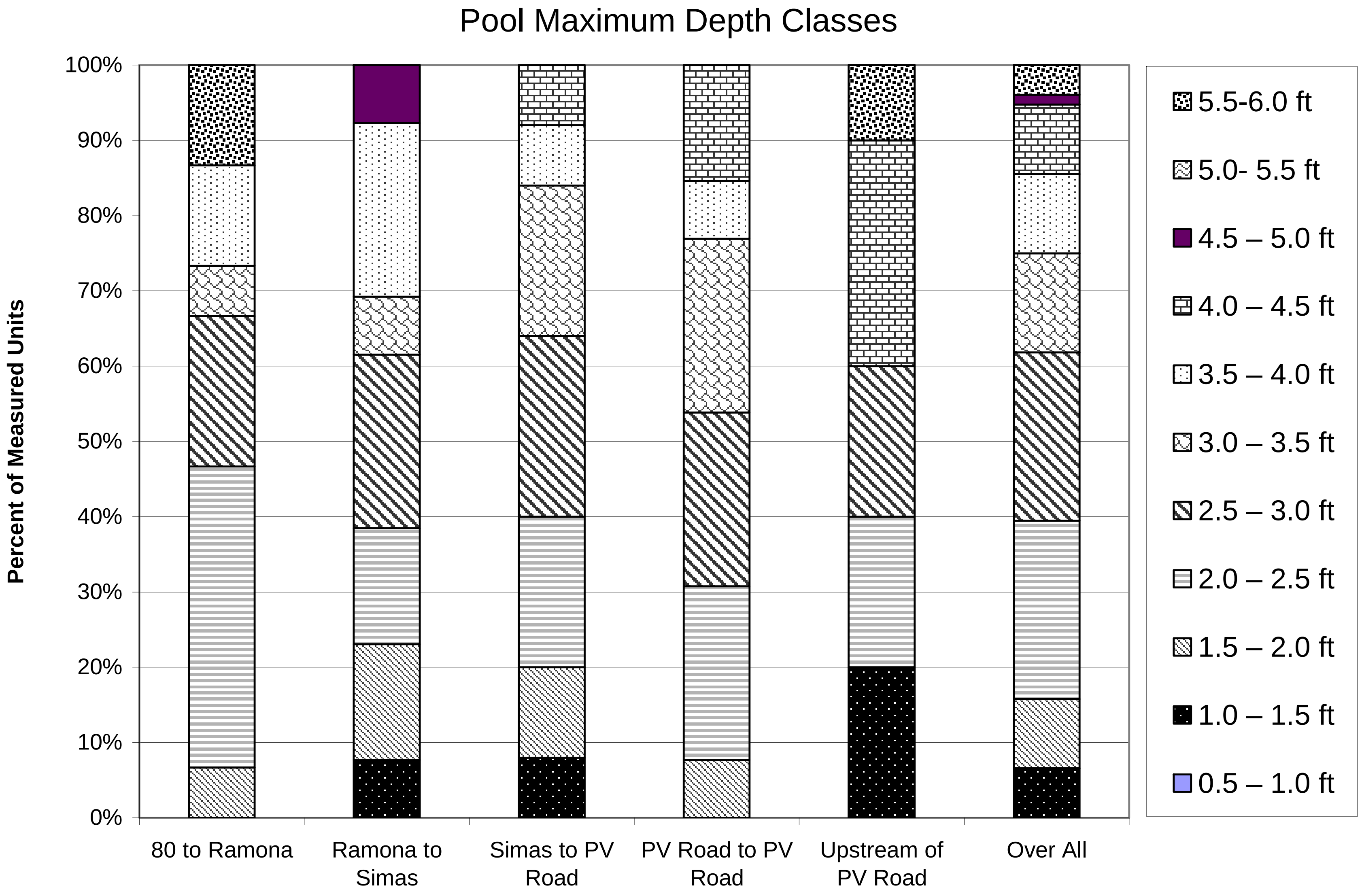

Figure 5. Maximum Pool Depth by Reach

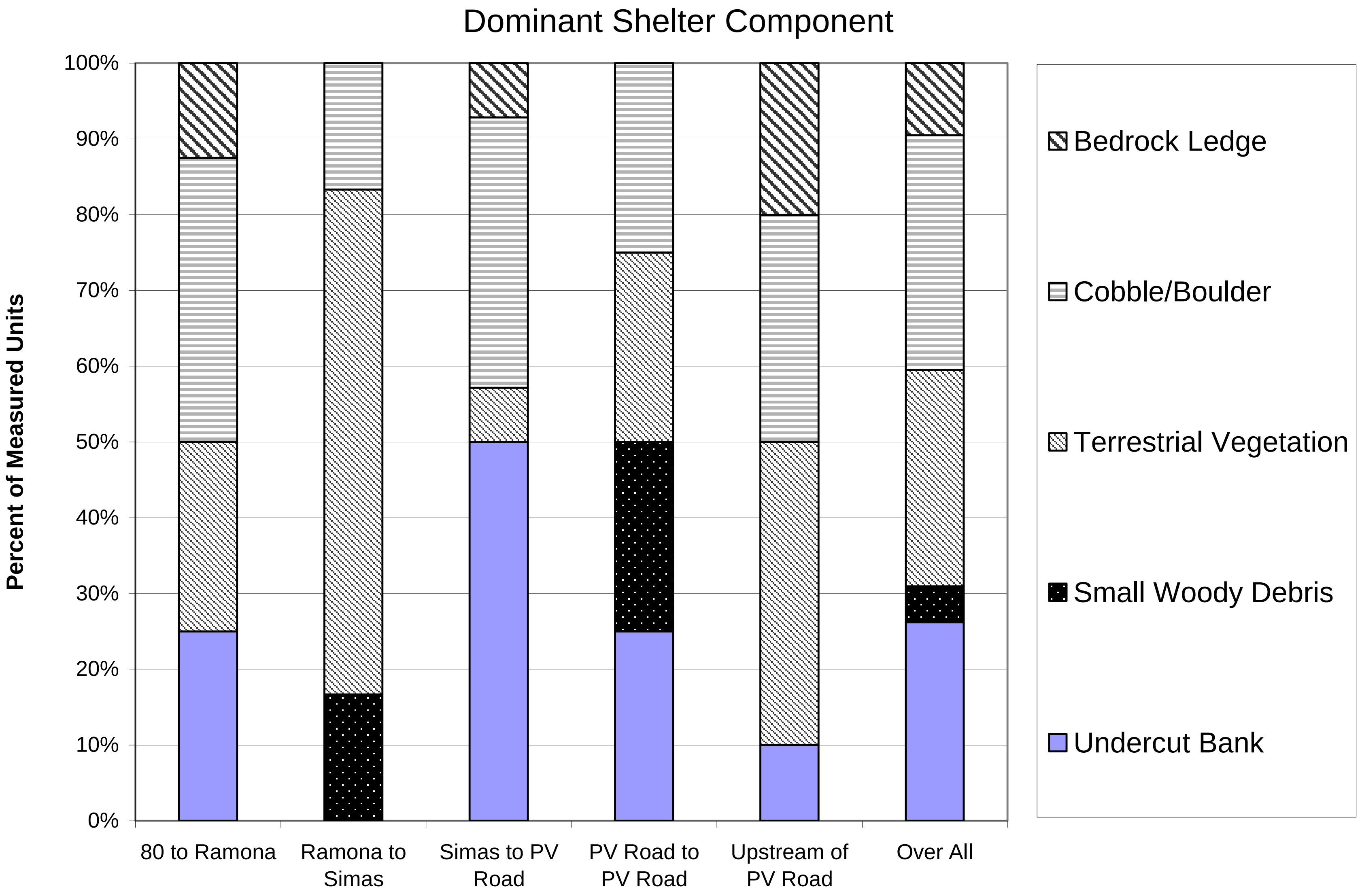

Figure 6. Shelter Components by Reach

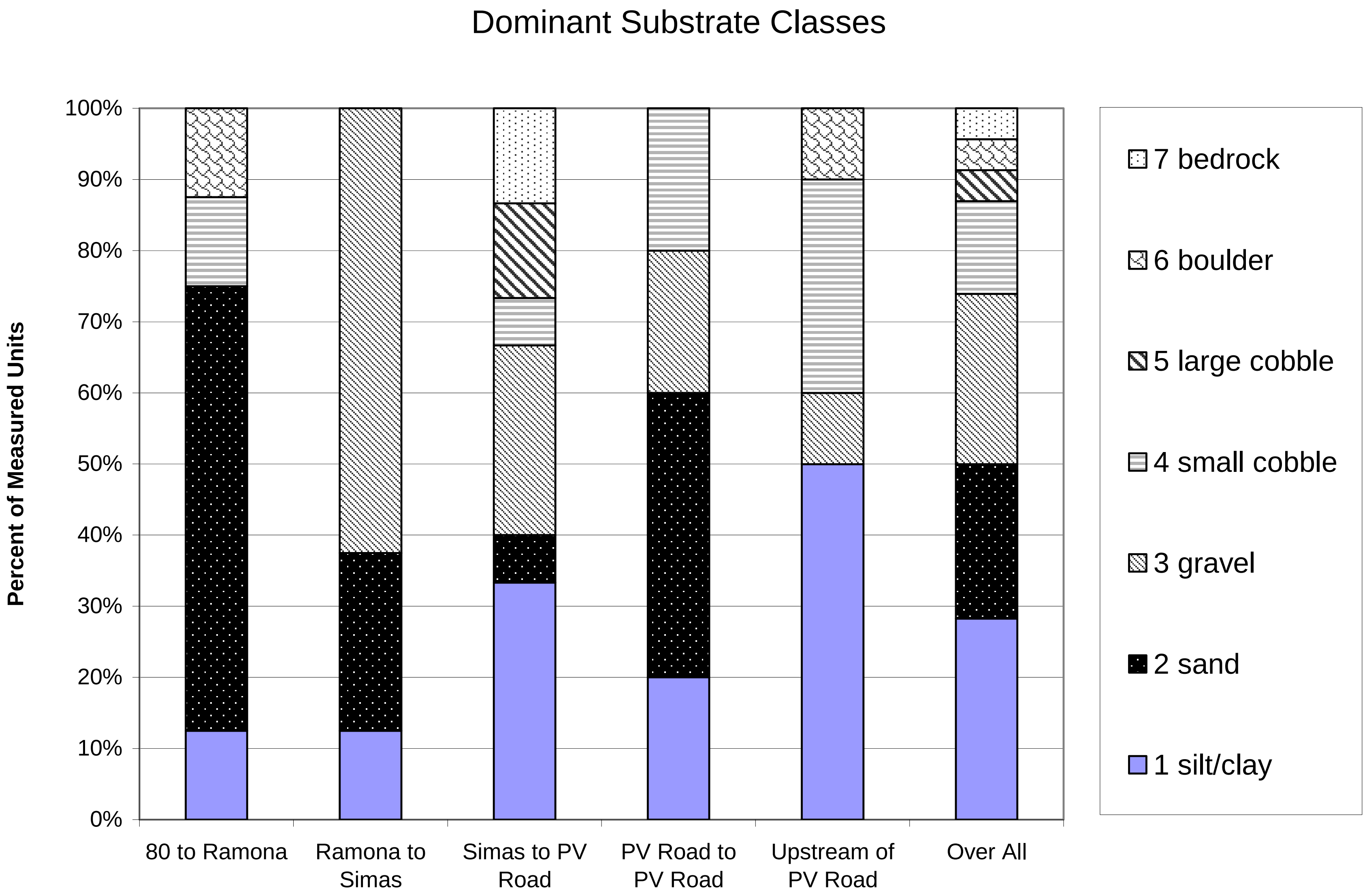

Figure 7. Dominant Substrate Characteristics by Reach