



**California Department of Fish and Game  
East Marin County  
San Francisco Bay Watersheds  
Stream Habitat Assessment Reports**

**Arroyo Avichi Creek**

*Surveyed 2009*

*Report Completed Feb 2011*

**STREAM INVENTORY REPORT  
Arroyo Avichi**

INTRODUCTION

A stream inventory was conducted during 7/6/2009 to 7/8/2009 on Arroyo Avichi. The survey began at the confluence with Novato Creek and extended upstream 3.3 miles.

The Arroyo Avichi inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Arroyo Avichi. The objective of the biological inventory was to document the presence and distribution of juvenile salmonid species.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Arroyo Avichi is a tributary to Novato Creek, is a tributary to Pacific Ocean, located in Marin County, California (Map 1). Arroyo Avichi's legal description at the confluence with Novato Creek is T03N R06W S18. Its location is 38°05'55.6" north latitude and 122°34'03.5" west longitude, LLID number 1225666380990. Arroyo Avichi is a second order stream and has approximately 3.9 miles of blue line stream according to the USGS National Hydrography Dataset (NHD). Arroyo Avichi drains a watershed of approximately 2.26 square miles. Elevations range from about 16 feet at the mouth of the creek to 1,283 feet in the headwater areas. Mixed hardwood forest dominates the watershed. The watershed is primarily privately owned which accounts for 63% of the land area. Thirty-one percent of the land is urban and 69% is considered natural. Vehicle access exists via HWY 101 to Rowland Blvd. to South Novato Blvd. to Garden Court.

METHODS

The habitat inventory conducted in Arroyo Avichi follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The California Conservation Corps (CCC) Technical Advisors and Watershed Stewards Project/AmeriCorps (WSP) Members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are fully measured. All other habitat unit types encountered for the first time in each reach are measured for all the parameters and

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characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement.

### HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Arroyo Avichi to record measurements and observations. There are eleven components to the inventory form.

#### 1. Flow:

Flow is measured in cubic feet per second (cfs) near the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

#### 2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

#### 3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

#### 4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Arroyo Avichi habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

#### 5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Avichi, Arroyo, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was

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assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders or other considerations.

### **6. Shelter Rating:**

Instream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Avichi, Arroyo, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

### **7. Substrate Composition:**

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

### **8. Canopy:**

Stream canopy density was estimated using modified handheld spherical densimeters as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Avichi, Arroyo, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or hardwood trees.

### **9. Bank Composition and Vegetation:**

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Avichi, Arroyo, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

### **10. Large Woody Debris Count:**

Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is

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twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

### 11. Average Bankfull Width:

Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

## BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. One site was electrofished using a Smith-Root Model 12 electrofisher. These sampling techniques are discussed in the *California Salmonid Stream Habitat Restoration Manual*.

## DATA ANALYSIS

Data from the habitat inventory form are entered into Stream Habitat 2.0.18, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Game. This program processes and summarizes the data, and produces the following ten tables:

- Riffle, Flatwater, and Pool Habitat Types
- Habitat Types and Measured Parameters
- Pool Types
- Maximum Residual Pool Depths by Habitat Types
- Mean Percent Cover by Habitat Type
- Dominant Substrates by Habitat Type
- Mean Percent Vegetative Cover for Entire Stream
- Fish Habitat Inventory Data Summary by Stream Reach (Table 8)
- Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Mean Percent Shelter Cover Types for Entire Stream

Graphics are produced from the tables using Microsoft Excel. Graphics developed for Arroyo Avichi include:

- Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
- Riffle, Flatwater, Pool Habitat Types by Total Length
- Total Habitat Types by Percent Occurrence
- Pool Types by Percent Occurrence

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- Maximum Residual Depth in Pools
- Percent Embeddedness
- Mean Percent Cover Types in Pools
- Substrate Composition in Pool Tail-outs
- Mean Percent Canopy
- Dominant Bank Composition by Composition Type
- Dominant Bank Vegetation by Vegetation Type

## HABITAT INVENTORY RESULTS

\* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT \*

The habitat inventory of 7/6/2009 to 7/8/2009 was conducted by T. Macias and C. Bell (WSP). The total length of the stream surveyed was 17,288 feet with an additional 1,154 feet of side channel.

Stream flow was not measured on Arroyo Avichi.

Arroyo Avichi is an F4 channel type for 18,442 feet of the entire reach surveyed.

F4 channels are entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios and gravel-dominant substrates.

Water temperatures taken during the survey period ranged from 54 to 60 degrees Fahrenheit. Air temperatures ranged from 58 to 74 degrees Fahrenheit

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 34% flatwater units, 20% dry units and 20% pool units (Graph 1). Based on total length of Level II habitat types there were 66% dry units, 19% flatwater units and 9% culvert units (Graph 2).

Fifteen Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 20% Dry units, 17% Glide units and 16% Culvert units (Graph 3). Based on percent total length there were 66% Dry units, 9% Culvert units and 9% Glide units.

A total of 23 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 52%, and comprised 57% of the total length of all pools (Graph 4).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. 1 of the 22 pools (5%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 22 pool tail-outs measured, 2 had a value of 1 (9.1%); 4 had a value of 2 (18.2%); 11 had a value of 3 (50%); 5 had a value of 4 (22.7%) (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst.

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A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 0, flatwater habitat types had a mean shelter rating of 11, and pool habitats had a mean shelter rating of 15 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 12 and Scour pools had a mean shelter rating of 18 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Arroyo Avichi. Graph 7 describes the pool cover in Arroyo Avichi. Boulders are the dominant pool cover type followed by undercut banks.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Sand dominance was observed in 14% of pool tail-outs and gravel dominance was observed in 82% of pool tail-outs.

The mean percent canopy density for the surveyed length of Arroyo Avichi was 89%. The mean percentages of hardwood and coniferous trees were 99% and 1%, respectively. 11 percent of the canopy was open. Graph 9 describes the mean percent canopy in Arroyo Avichi.

For the stream reach surveyed, the mean percent right bank vegetated was 36%. The mean percent left bank vegetated was 42%. The dominant elements composing the structure of the stream banks consisted of 93% sand/silt/clay, 6% bedrock and 1% boulder (Graph 10). Hardwood trees were the dominant vegetation type observed in 79% of the units surveyed. Additionally, 18% of the units surveyed had brush as the dominant vegetation type and 3% had grass as the dominant vegetation (Graph 11).

## **BIOLOGICAL INVENTORY RESULTS**

One site was electrofished for species composition and distribution in Arroyo Avichi on October 29, 2009. The water temperature taken during the electrofishing period was 55 degrees Fahrenheit. The air temperature was 49 degrees Fahrenheit. The sites were sampled by A. Villalobos (WSP), C. Bell (WSP) and D. Resnik (DFG).

In reach 1, which comprised the first 18,442 feet of stream, one site was sampled. The reach sites yielded no young-of-the-year steelhead/rainbow trout (SH/RT), no age 1+ SH/RT and no age 2+ SH/RT.

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The following chart displays the information yielded from this site:

2009 Arroyo Avichi Creek e-fish observations

Date	Site #	Reference Point	Distance From Reference Point (ft.)	Steelhead/Rainbow Trout			Non Salmonids Name species
				0+	1+	2+	
10/29/2009	752	Unnamed Tributary #3 Confluence Habitat Unit # 089	200 Downstream	0	0	0	0

### DISCUSSION

Arroyo Avichi is an F4 channel type for the entire 18,442 feet of stream surveyed. The suitability of F4 channel types for fish habitat improvement structures is as follows: Channel type is good for bank-placed boulders. It is fair for plunge weirs; single and opposing wing-deflectors; channel constrictors and log cover. It is poor for boulder clusters.

The water temperatures recorded on the survey days 7/6/2009 to 7/8/2009, ranged from 54 to 60 degrees Fahrenheit. Air temperatures ranged from 58 to 74 degrees Fahrenheit. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 19% of the total length of this survey, riffles 2% and pools 4%. The pools are relatively shallow, with only 1 of the 22 (5%) pools having a maximum residual depth greater than 2 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum residual depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, or where their installation will not conflict with the modification of any log debris accumulations (LDA's) in the stream.

Six of the 22 pool tail-outs measured had embeddedness ratings of 1 or 2. Sixteen of the pool tail-outs had embeddedness ratings of 3 or 4. None of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Sediment sources in Arroyo Avichi should be mapped and rated according to their potential sediment yields, and control measures should be taken.



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Eighteen of the 22 pool tail-outs measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools was 15. The shelter rating in the flatwater habitats was 11. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Arroyo Avichi. Boulders are the dominant cover type in pools followed by undercut banks. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 89%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was 36% and 42%, respectively. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of coniferous and hardwood trees, in conjunction with bank stabilization, is recommended.

### GENERAL RECOMMENDATIONS

Arroyo Avichi should be managed as an anadromous, natural production stream.

Winter storms often bring down large trees and other woody debris into the stream, which increases the number and quality of pools. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Landowners should be sensitive about the natural and positive role woody debris plays in the system, and encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

### RECOMMENDATIONS

- 1) Access for migrating salmonids should be assessed at all road crossings, flood control channels and dams. All fish passage assessments should be done according to Part 9 of the California Salmonid Stream Habitat Restoration Manual (Flosi et al, 1998). Where needed, crossings should be replaced or modified to improve fish passage.
- 2) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover in the pools is from boulders. Adding high quality complexity with woody cover in the pools is desirable.
- 3) Inventory and map sources of stream bank erosion and prioritize them according to present and potential sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream. Active and potential sediment sources related to the road system need to be identified, mapped, and treated according to their potential for sediment yield to the stream and its tributaries.

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- 4) Increase the canopy on Arroyo Avichi Creek by planting appropriate native vegetation like willow, alder, and redwood along the stream where shade canopy is not at acceptable levels. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.
- 5) Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

## COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Position Habitat Comments:

(ft.)	Unit #	
0	0001.00	Start of Survey: Dry flood control channel. N38.09857 W122.56876
380	0002.00	Structures: Culvert #1 Novato Blvd. Single in-stream concrete pipe arch culvert. H=4', W=10', L=1,219'. Possible barrier.
3,432	0011.00	Tributaries: LB Trib #1. Unnamed stream enters Arroyo Avichi. Discharge is 0. Contributes 0% of flow to stream. Water temperatures downstream: 60F. It is accessible to fish. Checked 100' up tributary. No fish observed.
3,763	0014.00	Structures: Culvert #2 Rd. Arthur St. Single in-stream Corrugated Metal Pipe (CMP) arch culvert. W=15' L=69'. Condition is good. Not likely a barrier to juveniles or adults.
7,389	0051.00	General Comment: Aquatic & terrestrial vegetation growing in channel which may obstruct flow.
7,457	0052.00	Fish Passage: (Dam) Dam #1. L=1 H=3 W(0)=3 W(d)=112 ft. No flashboards present. 4 feet of down cutting. Height from water to sill is 4'. Constructed of brick/riprap. Contributes to RB erosion 12'x 20'. Built on top of bedrock plunge: retaining a 1ft deep upstream pool. There is gravel retention. Possible barrier to juveniles and adults. N38.08758 W122.58405
7,518	0054.00	Structures: Dam #2. L=2' H=1.5' W(0)=unknown W(d)=6.3'. Sill to water level is 0.5'. There is no down cutting or gravel retention. Concrete on bedrock. Possible barrier to juveniles but not likely adults. Spans 3/4 of the channel.
7,834	0061.00	General Comment: One foot diameter pipe delivers runoff from Indian Valley road.
7,984	0063.00	Structures: Bridge #1. Private footbridge. W=12, H=6.5, L=6ft. Made of concrete. Water to sill height, 1.5ft. There is down cutting and gravel retention. Not likely a barrier.

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Position (ft.)	Habitat Unit #	Comments:
8,052	0065.00	Structures: Bridge #2. Private driveway. No natural bottom. W=14, H=6, L=13ft. Made of concrete/wood/steel. There is no down cutting but there is gravel retention. Not likely a barrier.
9,057	0077.00	Tributaries: RB Trib #1. Dry unnamed stream enters Arroyo Avichi. Discharge is 0. It is accessible to fish. No fish observed. N38.08542 W122.58662
9,327	0083.00	Structures: Bridge #3. Private footbridge. W=17, H=10, L=4 ft. Made of wood. Retaining gravel, natural bottom. There is no down cutting. Not likely a barrier.
9,552	0089.00	Tributaries: LB Trib #2. Unnamed stream enters Arroyo Avichi. Discharge is <1cfs. Currently contributes 100% of flow to stream. Water temps downstream: 62F, tributary: 60F. Not accessible to fish. N38.08895 W122.58815
9,665	0091.00	Structures: Culvert #3 Private road. Single in-stream corrugated metal culvert. L=79 ft. Diameter, 5.3 ft. Condition: slightly rusted bottom and dented top. Possibly a barrier to juveniles or adults.
10,050	0093.00	Structures: Bridge #4. Private footbridge. W=19, H=8, L=4 ft. Made of wood. There is no down cutting. Not likely a barrier to salmonids
10,259	0095.00	Structures: Culvert #4 Indian Valley open space preserve driveway. Single in-stream concrete culvert. L=37ft. Diameter 5ft. Condition is good. Rust line is 1 ft Possible barrier to juveniles and adults.
10,519	0096.02	Structures: Culvert #5 Indian Valley Fire road. H=4.4, W=4.5, L=51ft. Single in-stream corrugated metal culvert. Plunge height is 2ft. Max Depth is 5ft. Condition: rusted bottom, no holes. Possible barrier to juveniles and adults.
10,519	0096.04	Structures: Culvert #6 Rd, Indian Valley Fire Rd. Single in-stream corrugated metal pipe culvert. L=79ft. Diameter 4.5ft. Plunge height is 6.5ft. Condition is rusted with no holes. Possible barrier to juveniles & adults.
10,519	0097.00	Tributaries: LB Trib #3. Dry unnamed enters stream enters Arroyo Avichi. Accessible to fish, checked 200ft up tributary. No fish observed.
11,135	0098.00	Structures: Bridge #5. Buzzard Burn Rd. Ford crossing. W=19, H=0, L=7ft. Made of earth. There is no down cutting. Not likely a barrier.
11,142	0099.00	General Comment: Foot path down center of stream bed. Starts 50' into unit.
11,542	0100.00	Tributaries: LB Trib #4. Dry unnamed stream enters Arroyo Avichi. It is accessible to fish. No fish observed.
11,993	0101.00	Structures: Bridge #6. Foot path in Indian Valley Open space. W=24, H=8, L=6ft. Made of wood. There is no down cutting or gravel retention. Not likely a barrier. N38.08084 W122.59293

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Position Habitat Comments:

(ft.)	Unit #	
11,999	0102.00	General Comment: Increase in slope.
12,534	0103.00	Structures: Culvert #7 Indian Valley Fire rd. Single in-stream CMP culvert. H=4.5, W=4.5, L=63ft. Diameter, 4.5ft. Plunge height is 0ft. Condition: rusted but no holes. rust line height is 1ft. Retaining approximately 8 inches of gravel. Possibly a barrier to juveniles or adults. N38.08012 W122.59123
12,971	0105.00	Structures: Culvert #8 Indian Valley Fire rd. Single in-stream CMP culvert. H=4.5, W=4.5, L=unknown Diameter is 4.5ft. Plunge height is 0ft. Condition: rusted but no holes. Rust line height 1ft. Possible barrier to juveniles and adults.
13,026	0106.00	Tributaries: RB Trib #2. Dry unnamed stream enters Arroyo Avichi. It is accessible to fish, checked 200ft up tributary No fish observed.
13,247	0107.00	Structures: Bridge #7. Waterfall trail footbridge. Retaining gravel, natural bottom. W=21 H=3, L=6 ft. Made of wood. There is no down cutting. Not likely a barrier.
13,611	0109.00	Structures: Bridge #8. Rd. Capt. Clark Memorial trail. Footbridge. Not retaining gravel, natural bottom. W=12, H=3, L=4 ft. Made of wood. There is no down cutting. Not likely a barrier.
13,615	0110.00	Two left bank and 1 right bank tributaries enter Arroyo Avichi between 13,615 feet and 17,288 feet from start of survey. None of these tributaries are accessible to salmonids.
17,288	0110.00	End of Survey: Foot path crosses Arroyo Avichi 6 times throughout unit. Survey ends at a steep bedrock outcrop. N38.06993 W122.59322

## REFERENCES

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California.

McCain, M., D. Fuller, L. Decker and K. Overton. 1990. Stream habitat classification and inventory procedures for northern California. FHC Currents. No.1. U.S. Department of Agriculture. Forest Service, Pacific Southwest Region.

Rosgen, D.L., 1994. A Classification of Natural Rivers. *Catena*, Vol 22: 169-199, Elsevier Science, B. V. Amsterdam.

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### LEVEL III and LEVEL IV HABITAT TYPES

#### RIFFLE

Low Gradient Riffle	(LGR)	[1.1]	{ 1 }
High Gradient Riffle	(HGR)	[1.2]	{ 2 }

#### CASCADE

Cascade	(CAS)	[2.1]	{ 3 }
Bedrock Sheet	(BRS)	[2.2]	{24}

#### FLATWATER

Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}

#### MAIN CHANNEL POOLS

Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}

#### SCOUR POOLS

Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }

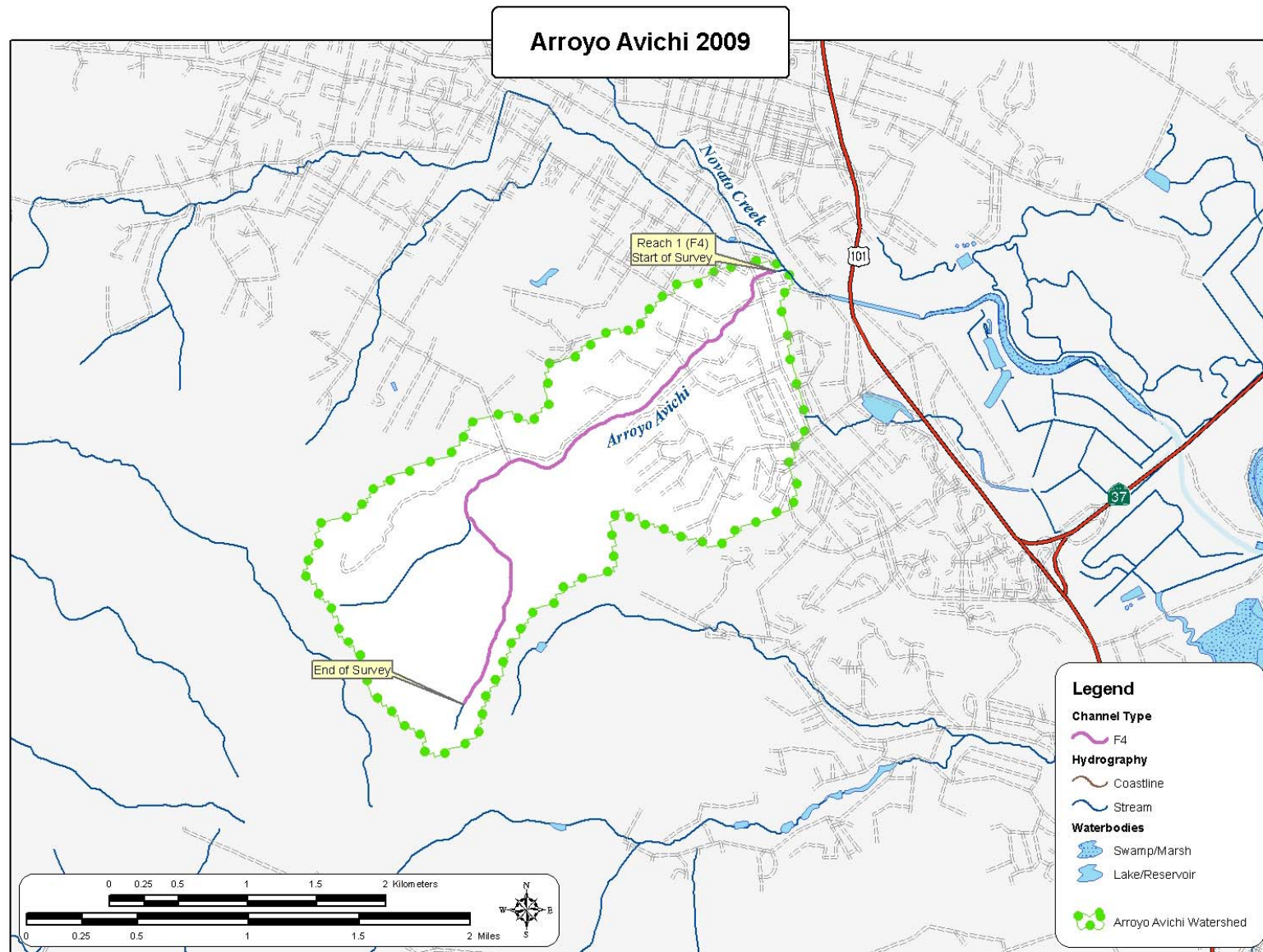
#### BACKWATER POOLS

Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}

### ADDITIONAL UNIT DESIGNATIONS

Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to a marsh	(MAR)	[9.1]	

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## Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating
18	0	CULVERT	15.7	95	1702	9.2									
23	0	DRY	20.0	527	12127	65.8									
39	39	FLATWATER	33.9	90	3510	19.0	5.2	0.4	0.9	455	17743	190	7396		11
23	23	POOL	20.0	30	694	3.8	7.6	0.5	1.4	222	5115	155	3408	111	15
12	12	RIFFLE	10.4	34	409	2.2	4.8	0.2	0.3	131	1574	24	282		0
<b>Total Units</b>	<b>Total Units Fully Measured</b>				<b>Total Length (ft.)</b>						<b>Total Area (sq.ft.)</b>		<b>Total Volume (cu.ft.)</b>		
115	74				18442						24431		11087		

# Arroyo Avichi 2009

## Table 2 - Summary of Habitat Types and Measured Parameters

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating	Mean Canopy (%)
11	11	LGR	9.6	36	399	2.2	5.0	0.2	0.8	141	1554	25	280		0	93
1	1	BRS	0.9	10	10	0.1	2.0	0.1	0.1	20	20	2	2		0	100
19	19	GLD	16.5	83	1579	8.6	5.0	0.4	1.7	446	8472	204	3872		19	83
15	15	RUN	13.0	79	1185	6.4	5.0	0.4	1.1	382	5737	142	2125		3	91
5	5	SRN	4.3	149	746	4.0	5.0	0.4	1.2	707	3533	280	1400		2	94
11	11	MCP	9.6	32	347	1.9	7.0	0.4	1.7	226	2488	153	1686	109	14	93
1	1	STP	0.9	47	47	0.3	5.0	0.5	0.9	235	235	141	141	118	0	100
1	1	CRP	0.9	33	33	0.2	7.0			231	231				15	82
1	1	LSL	0.9	36	36	0.2	10.0	0.4	1.6	360	360	216	216	144	60	85
4	4	LSR	3.5	25	100	0.5	6.0	0.5	1.7	148	592	100	401	67	23	87
1	1	LSBk	0.9	16	16	0.1	7.0	0.8	1.5	112	112	112	112	90	0	95
2	2	LSBo	1.7	32	65	0.4	8.0	0.6	1.5	242	483	180	361	134	13	80
2	2	PLP	1.7	25	50	0.3	13.0	0.6	2.5	307	614	246	492	184	3	100
23	0	DRY	20.0	527	12127	65.8										87
18	0	CUL	15.7	95	1702	9.2										58
<b>Total Units</b>	<b>Total Units Fully Measured</b>				<b>Total Length (ft.)</b>						<b>Total Area (sq.ft.)</b>		<b>Total Volume</b>			
115	74				18442						24431		11087			



**Arroyo Avichi 2009**

**Table 3 - Summary of Pool Habitat Types**

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Residual Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Residual Pool Vol (cu.ft.)	Estimated Total Resid. Vol (cu.ft.)	Mean Shelter Rating
12	12	MAIN	52	33	394	57	7.1	0.5	227	2723	109	1312	13
11	11	SCOUR	48	27	300	43	8.1	0.5	217	2392	114	1136	18
Total Units	Total Units Fully Measured				Total Length (ft.)					Total Area (sq.ft.)		Total Volume (cu.ft.)	
23	23				694					5115		2449	

**Arroyo Avichi 2009**

**Table 4 - Summary of Maximum Residual Pool Depths By Pool Habitat Types**

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey:** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

Habitat Units	Habitat Type	Habitat Occurrence (%)	< 1 Foot Maximum Residual Depth	< 1 Foot Percent Occurrence	1 < 2 Feet Maximum Residual Depth	1 < 2 Feet Percent Occurrence	2 < 3 Feet Maximum Residual Depth	2 < 3 Feet Percent Occurrence	3 < 4 Feet Maximum Residual Depth	3 < 4 Feet Percent Occurrence	>= 4 Feet Maximum Residual Depth	>= 4 Feet Percent Occurrence
11	MCP	50	0	0	11	100	0	0	0	0	0	0
1	STP	5	1	100	0	0	0	0	0	0	0	0
0	CRP	0	0	0	0	0	0	0	0	0	0	0
1	LSL	5	0	0	1	100	0	0	0	0	0	0
4	LSR	18	0	0	4	100	0	0	0	0	0	0
1	LSBk	5	0	0	1	100	0	0	0	0	0	0
2	LSBo	9	0	0	2	100	0	0	0	0	0	0
2	PLP	9	0	0	1	50	1	50	0	0	0	0
<b>Total Units</b>			<b>Total &lt; 1 Foot Max Resid. Depth</b>	<b>Total &lt; 1 Foot % Occurrence</b>	<b>Total 1&lt; 2 Feet Max Resid. Depth</b>	<b>Total 1&lt; 2 Feet % Occurrence</b>	<b>Total 2&lt; 3 Feet Max Resid. Depth</b>	<b>Total 2&lt; 3 Feet % Occurrence</b>	<b>Total 3&lt; 4 Feet Max Resid. Depth</b>	<b>Total 3&lt; 4 Feet % Occurrence</b>	<b>Total &gt;= 4 Feet Max Resid. Depth</b>	<b>Total &gt;= 4 Feet % Occurrence</b>
22			1	5	20	91	1	5	0	0	0	0
Mean Maximum Residual Pool Depth (ft.):			1									

# Arroyo Avichi 2009

## Table 5 - Summary of Mean Percent Cover By Habitat Type

Stream Name:		Arroyo Avichi		Dry Units:		23		LLID:		1225666380990		Drainage:		Novato										
Survey		7/6/2009 to 7/8/2009		Legal Description:		T03NR06WS18		Latitude:		38:05:56.0N		Longitude:		122:34:03.5W										
Confluence Location:		Quad: NOVATO		Habitat Type		Mean % Undercut Banks		Mean % SWD		Mean % LWD		Mean % Root Mass		Mean % Terr. Vegetation		Mean % Aquatic Vegetation		Mean % White Water		Mean % Boulders		Mean % Bedrock Ledges		
11	10	LGR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	BRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12	11	TOTAL RIFFLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
19	17	GLD	0	0	0	0	0	7	19	0	3	0	0	0	0	0	0	0	0	0	0	0	0	
15	12	RUN	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	5	SRN	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	
39	34	TOTAL FLAT	0	0	0	0	0	4	13	0	4	0	0	0	0	0	0	0	0	0	0	0	0	
11	11	MCP	12	0	0	5	2	14	0	23	9	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	STP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	CRP	0	40	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	LSL	70	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	4	LSR	48	25	0	20	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	LSBk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	LSBo	0	0	0	0	10	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	PLP	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	
23	23	TOTAL POOL	17	6	0	10	2	8	0	23	4	0	0	0	0	0	0	0	0	0	0	0	0	
18	0	CUL																						
115	68	TOTAL	6	2	0	3	2	9	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	

Arroyo Avichi 2009

**Table 6 - Summary of Dominant Substrates By Habitat Type**

**Stream Name:** Arroyo Avichi

**Dry Units:** 23

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

Habitat Units	Units Fully Measured	Habitat Type	% Total Silt/Clay Dominant	% Total Sand Dominant	% Total Gravel Dominant	% Total Small Cobble Dominant	% Total Large Cobble Dominant	% Total Boulder Dominant	% Total Bedrock Dominant
11	11	LGR	0	0	64	18	0	9	9
1	1	BRS	0	0	0	0	0	0	100
19	17	GLD	6	6	76	0	0	0	12
15	14	RUN	0	7	71	0	7	0	14
5	5	SRN	0	0	100	0	0	0	0
11	11	MCP	9	27	55	0	0	0	9
1	1	STP	0	0	0	0	0	0	100
1	1	CRP	0	0	100	0	0	0	0
1	1	LSL	0	100	0	0	0	0	0
4	4	LSR	0	75	25	0	0	0	0
1	1	LSBk	0	100	0	0	0	0	0
2	2	LSBo	50	0	50	0	0	0	0
2	2	PLP	0	50	0	0	0	0	50
18	1	CUL	0	0	100	0	0	0	0

## Arroyo Avichi 2009

**Table 7 - Summary of Mean Percent Canopy for Entire Stream**

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
89	1	99	0	36	42

Note: Mean percent conifer and hardwood for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

# Arroyo Avichi 2009

## Table 8 - Fish Habitat Inventory Data Summary

Stream Arroyo Avichi LLID: 1225666380990 Drainage Novato  
 Survey Dates: 7/6/2009 to 7/8/2009 Survey Length (ft.): 18442 Main Channel (ft.): 17288 Side Channel (ft.): 1154  
 Confluence Location: Quad NOVATO Legal Description: T03NR06WS18 Latitude: 38:05:56.0N Longitude: 122:34:03.5W

### Summary of Fish Habitat Elements By Stream Reach

#### STREAM REACH: 1

Channel Type: F4	Canopy Density (%): 88.7	Pools by Stream Length: 3.8
Reach Length (ft.): 17288	Coniferous Component (%): 1.2	Pool Frequency (%): 20.0
Riffle/Flatwater Mean Width (ft.): 5.1	Hardwood Component: 98.8	Residual Pool Depth (%):
BFW:	Dominant Bank: Hardwood Trees	< 2 Feet Deep: 95.5
Range (ft.): 14.00 to 22.00	Vegetative Cover (%): 38.9	2 to 2.9 Feet Deep: 4.5
Mean (ft.): 16.54	Dominant: Boulders	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 2.40	Dominant Bank Substrate: Sand/Silt/Clay	>= 4 Feet Deep: 0.0
Base Flow (cfs):	Occurrence of LWD (%): 0.0	Mean Max Residual Pool Depth: 1.39
Water (F): 54 - 60 Air (F): 58 - 74	LWD per 100 ft.:	Mean Pool Shelter: 15
Dry Channel (ft.): 12127	Riffles: 0	
	Pools: 0	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 13.6 Gravel: 81.8 Sm Cobble: 0.0 Lg Cobble: 0.0 Boulder: 4.5 Bedrock: 0.0		
Embeddedness Values (%): 1. 9.1 2. 18.2 3. 50.0 4. 22.7 5. 0.0		

## Arroyo Avichi 2009

**Table 9 -Mean Percentage of Dominant Substrate and Vegetation**

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

**Latitude:** 38:05:56.0N

**Longitude:** 122:34:03.5W

### Mean Percentage of Dominant Stream Bank Substrate

Dominant Class of Substrate	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage (%)
Bedrock	3	3	6.0
Boulder	0	1	1.0
Cobble/Gravel	0	0	0.0
Sand/Silt/Clay	47	46	93.0

### Mean Percentage of Dominant Stream Bank Vegetation

Dominant Class of Vegetation	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage
Grass	2	1	3.0
Brush	11	7	18.0
Hardwood	37	42	79.0
Coniferous	0	0	0.0
No Vegetation	0	0	0.0

**Total Stream Cobble Embeddedness Values:** 3

## Arroyo Avichi 2009

**Table 10 - Mean Percent of Shelter Cover Types For Entire Stream**

**Stream Name:** Arroyo Avichi

**LLID:** 1225666380990

**Drainage:** Novato

**Survey** 7/6/2009 to 7/8/2009

**Confluence Location: Quad:** NOVATO

**Legal Description:** T03NR06WS18

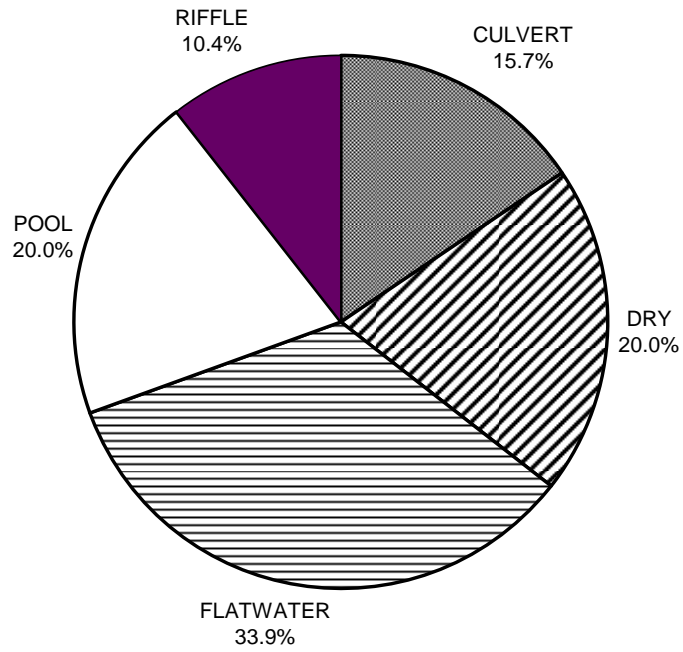
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**Longitude:** 122:34:03.5W

	<b>Riffles</b>	<b>Flatwater</b>	<b>Pools</b>
UNDERCUT BANKS (%)	0	0	17
SMALL WOODY DEBRIS (%)	0	0	6
LARGE WOODY DEBRIS (%)	0	0	0
ROOT MASS (%)	0	0	10
TERRESTRIAL VEGETATION	0	4	2
AQUATIC VEGETATION (%)	0	13	8
WHITEWATER (%)	0	0	0
BOULDERS (%)	0	4	23
BEDROCK LEDGES (%)	0	0	4

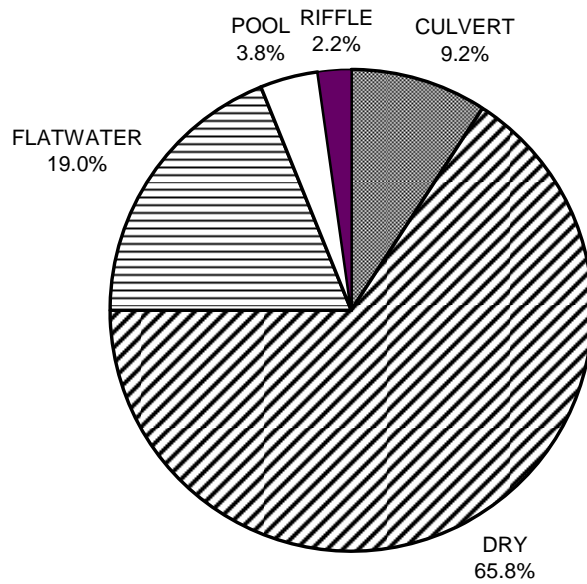


**AVICHI, ARROYO 2009  
HABITAT TYPES BY PERCENT OCCURRENCE**



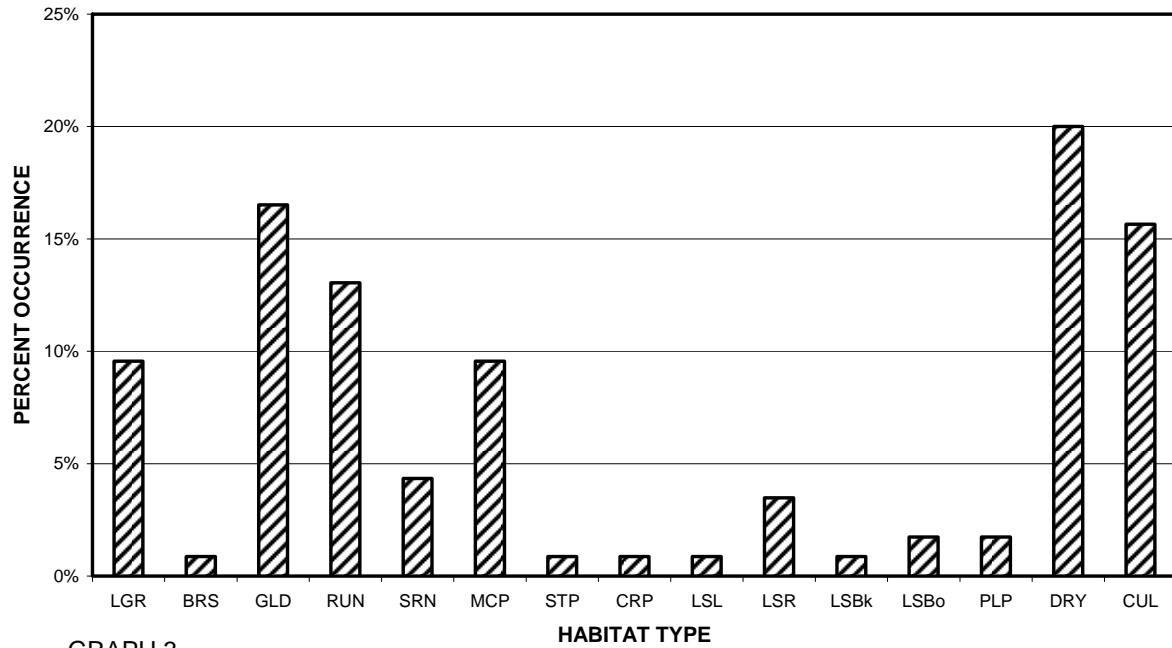
GRAPH 1

**AVICHI, ARROYO 2009  
HABITAT TYPES BY PERCENT TOTAL LENGTH**



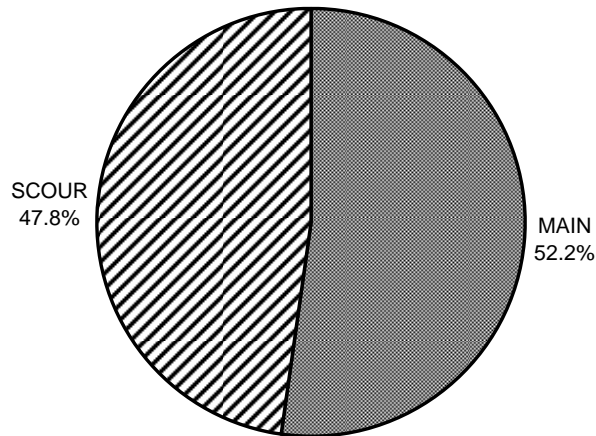
GRAPH 2

AVICHI, ARROYO 2009  
HABITAT TYPES BY PERCENT OCCURRENCE



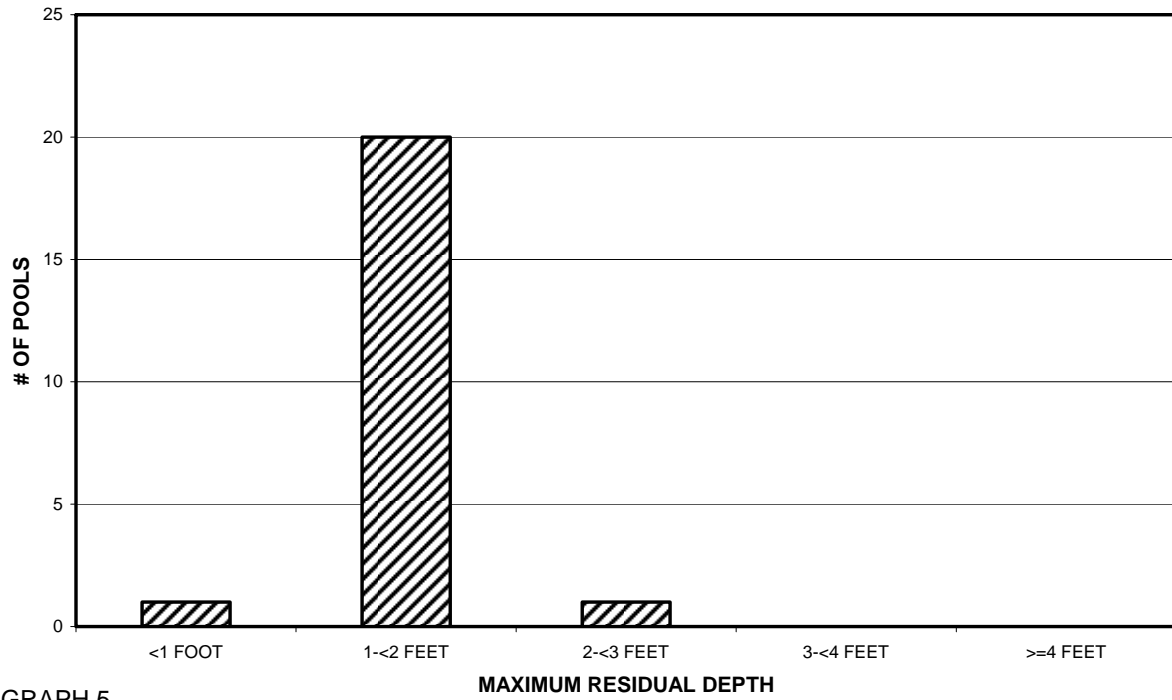
GRAPH 3

AVICHI, ARROYO 2009  
POOL TYPES BY PERCENT OCCURRENCE



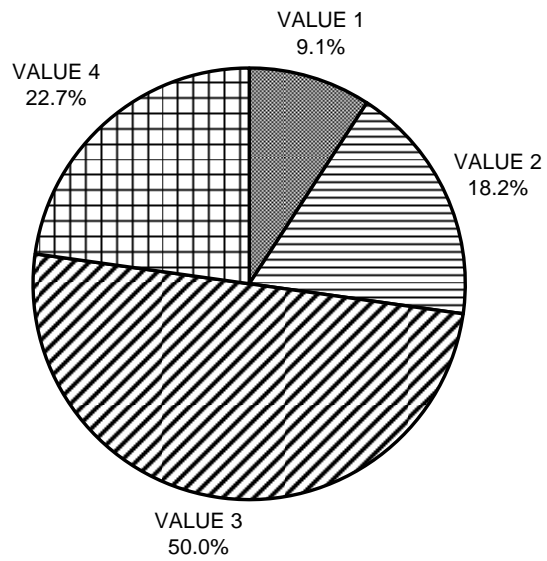
GRAPH 4

**AVICHI, ARROYO 2009  
MAXIMUM DEPTH IN POOLS**



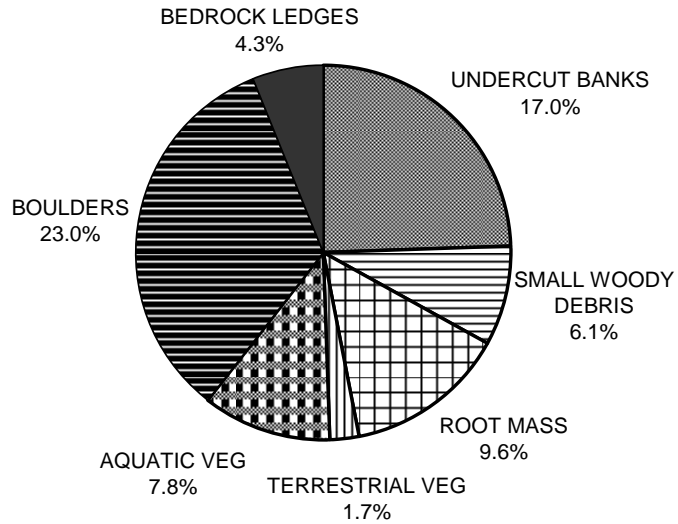
GRAPH 5

**AVICHI, ARROYO 2009  
PERCENT EMBEDDEDNESS**



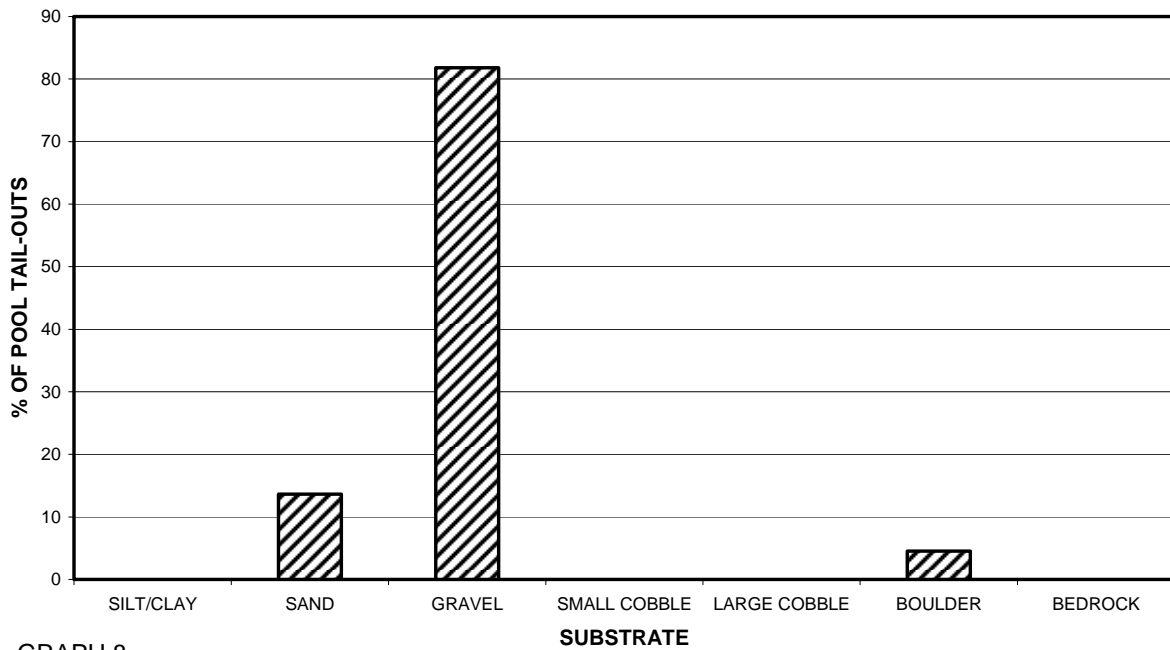
GRAPH 6

**AVICHI, ARROYO 2009  
MEAN PERCENT COVER TYPES IN POOLS**



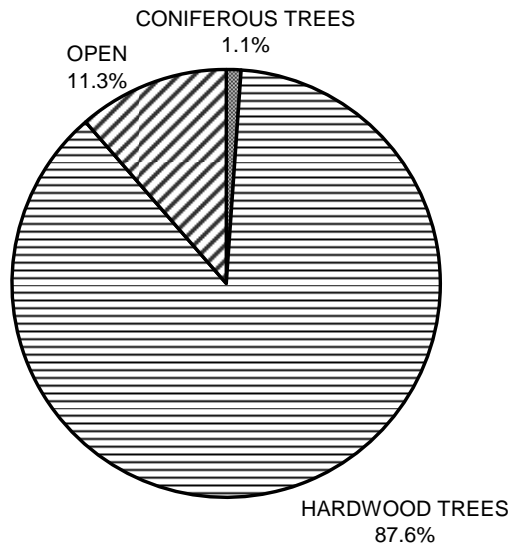
GRAPH 7

**AVICHI, ARROYO 2009  
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS**



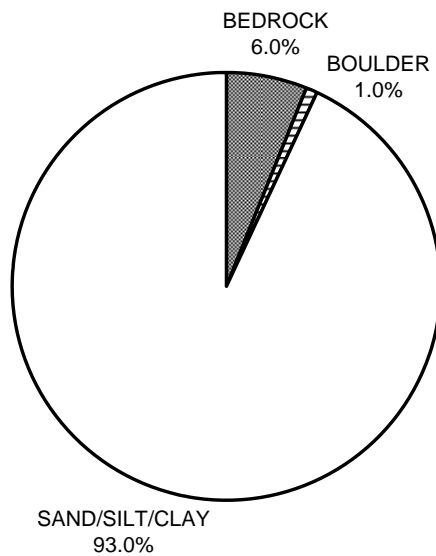
GRAPH 8

**AVICHI, ARROYO 2009  
MEAN PERCENT CANOPY**



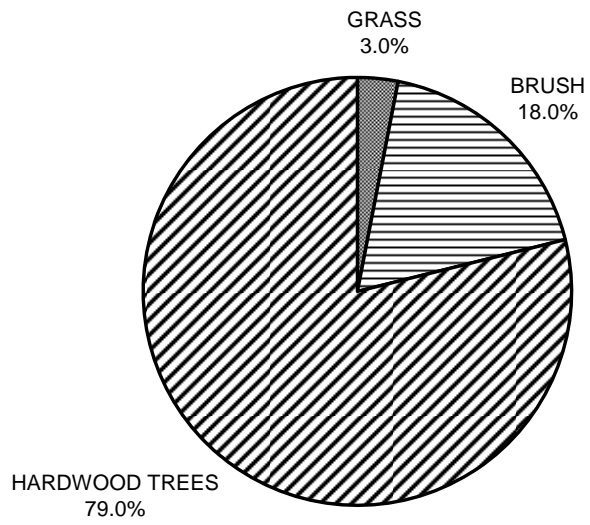
GRAPH 9

**AVICHI, ARROYO 2009  
DOMINANT BANK COMPOSITION IN SURVEY REACH**



GRAPH 10

**AVICHI, ARROYO 2009  
DOMINANT BANK VEGETATION IN SURVEY REACH**



GRAPH 11