



California Department of Fish and Game
Petaluma River Watershed
Stream Habitat Assessment Reports
Willow Brook
Surveyed 2007



STREAM INVENTORY REPORT

Willow Brook

Surveyed: Summer 2007

Report Completed: March 2008

INTRODUCTION

A stream inventory was conducted during 8/13/2007 to 8/16/2007 on Willow Brook. The survey began at the confluence with Lichau Creek and extended upstream 5.9 miles.

The Willow Brook 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 Willow Brook. 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 Chinook salmon and steelhead trout.

Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Willow Brook is a tributary to Lichau Creek, which is a tributary to Petaluma River, that then flows to San Pablo Bay and out to the Pacific Ocean. Willow Brook is located in Sonoma County, California (Map 1) and its legal description at the confluence with Lichau Creek is T005 R007 S07. Its location is 38°17'06" north latitude and 122°39'51" west longitude, LLID number 1226642382850. Willow Brook is a second order stream and has approximately 11.29 miles of blue line stream according to the USGS National Hydrography Dataset (NHD). Willow Brook drains a watershed of approximately 4.47 square miles. Elevations range from about 43 feet at the mouth of the creek to 1,617 feet in the headwater areas. Mixed hardwood forest dominates the watershed. The watershed is entirely privately owned and is managed for rangeland. The land is used for agriculture (52.7%) and the other portion is considered natural (47.2%). Vehicle access exists via Adobe and Lynch Roads, east of Petaluma.

METHODS

The habitat inventory conducted in Willow Brook follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The California Department of Fish and Game (DFG) personnel 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. 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 measured for maximum depth, depth of pool tail crest (measured in the thalweg), dominant substrate composing the pool tail crest, and embeddedness. Habitat unit types encountered for the first time are measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement. All pools except step-pools are fully sampled.

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 Willow Brook 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". Willow Brook 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 Willow Brook, 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 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 Willow Brook, 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 Willow Brook, 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 Willow Brook, 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 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. Electrofishing was not conducted on Willow Brook Creek however fish presence was observed from the stream banks.

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)

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- 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 Willow Brook 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
- 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 8/13/2007 to 8/16/2007, was conducted by, H. Fett (CDFG) and J. Hanson (WSP). The total length of the stream surveyed was 31,191 feet. Stream flow was not measured on Willow Brook.

Willow Brook is a B6 channel type for the first 9,674 feet of the stream surveyed (Reach 1), a F4 channel type for the next 8,440 feet of the stream surveyed (Reach 2), a B4 channel type for the next 2,862 feet of the stream surveyed (Reach 3), and a A3 channel type for the last 10,215 feet of the stream surveyed (Reach 4),

B6 channels are moderately entrenched riffle dominated channels with infrequently spaced pools, very stable plan and profile, stable banks on moderate gradients with low width /depth ratios and silt/clay dominant substrates. F4 channels are entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios and gravel-dominant substrates. B4 channels are moderately entrenched riffle dominated channels with infrequently spaced pools, very stable plan and profile, stable banks on moderate gradients with low width /depth ratios and gravel dominant substrates. A3 channels are steep, narrow, cascading, step-pool, high energy debris transporting channels associated with depositional soils, and cobble dominant substrates.

Water temperatures taken during the survey period ranged from 56 to 69 degrees Fahrenheit. Air temperatures ranged from 52 to 76 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 11% culvert units, 42% dry units, 3% nosurvey_marsh units, 31% flatwater units, 9% pool units, and 3% riffle units (Graph 1). Based on total length of Level II habitat types there were 73% dry units, 5% nosurvey_marsh units, 21% flatwater units, and 1% riffle units (Graph 2).

Eight Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 11% Culvert units, 42% Dry units, and 28% Step Run units (Graph 3). Based on percent total length, 73% Dry units, 16% Step Run units, and 5% Not Surveyed due to a marsh units.

A total of 6 pools were identified (Table 3). Scour pools were the most frequently encountered, at 67%, and comprised 38% 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. Two of the 6 pools (33%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 6 pool tail-outs measured, 3 had a value of 1 (50%) and 3 had a value of 5 (50%) (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders, or other considerations.

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 6, and pool habitats had a mean shelter rating of 12 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 23 and Scour pools had a mean shelter rating of 6 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover types in Willow Brook. Graph 7 describes the pool cover in Willow Brook. 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 was observed in 33% of pool tail-outs and gravel observed in 50% of pool tail-outs.

The mean percent canopy density for the surveyed length of Willow Brook was 72%. The mean percentages of hardwood and coniferous trees were 100% and 0%, respectively. Twenty eight percent of the canopy was open. Graph 9 describes the mean percent canopy in Willow Brook.

For the stream reach surveyed, the mean percent right bank vegetated was 28% and mean percent left bank vegetated was 33%. The dominant elements composing the structure of the stream banks consisted of 21% bedrock, 4% boulder, 4% cobble/gravel and 71% sand/silt/clay (Graph 10). Deciduous trees were the dominant vegetation type observed in 46% of the units surveyed.

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Additionally, 25% of the units surveyed had grass as the dominant vegetation type, and 14% had brush as the dominant vegetation (Graph 11).

BIOLOGICAL INVENTORY RESULTS

No Biological inventory was conducted on Willow Brook Creek

DISCUSSION

Willow Brook is a B6 channel type for the first 9,674 feet of stream surveyed (Reach 1), a F4 channel type for the next 8,440 feet (Reach 2), a B4 channel type for 2,862 feet (Reach 3), and an A3 channel type for the remaining 10,250 feet of the stream surveyed (Reach 4).

The suitability of B6 channel types for fish habitat improvement structures is as follows: excellent for bank placed boulders and log cover; good for plunge weirs, single and opposing wing-deflector and channel constrictors; and fair for boulder clusters. The suitability of F4 channel types for fish habitat improvement structures is as follows: good for bank-placed boulders, fair for plunge weirs; single and opposing wing-deflectors; channel constrictors; log cover, poor for boulder clusters. The suitability of B4 channel types for fish habitat improvement structures is as follows: excellent for low-stage plunge weirs, boulder clusters, bank placed boulders, single and opposing wing deflectors and log cover. The suitability of A3 channel types for fish habitat improvement structures is as follows: good for bank placed boulders, fair for plunge weirs; opposing wing-deflectors; and log cover, poor for boulder clusters and single wing-deflectors.

The water temperatures recorded on the survey days 8/13/2007 to 8/16/2007, ranged from 56 to 69 degrees Fahrenheit. Air temperatures ranged from 52 to 76 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 21% of the total length of this survey, riffles 1%, and pools 0.3%. The pools are relatively shallow, with only 2 of the 6 (33%) 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 the numerous log debris accumulations (LDA's) in the stream.

Three of the 6 pool tail-outs measured had embeddedness ratings of 1 or 2. None of the pool tail-outs had embeddedness ratings of 3 or 4. Three 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 Willow Brook should be mapped and rated according to their potential

sediment yields, and control measures should be taken.

Three of the 6 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 12. The shelter rating in the flatwater habitats was 6. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by Boulders in Willow Brook. Boulders are the dominant cover type in pools followed by Terrestrial vegetation. 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 72%. Reach 1 had a canopy density of 39%, Reach 2 had a canopy density of 61%, Reach 3 had a canopy density of 0%, and Reach 4 had a canopy density of 83%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was LOW at 28% and 33%, 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

Willow Brook 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 encourages not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

RECOMMENDATIONS

- 1) Water quantity is an on-going issue in many of the Petaluma River tributaries. Water conservation measures should be explored with the landowners and developed where possible.
- 2) Due to road crossings and the high gradient of the stream like at 18,114 and 24,951 feet, access for migrating salmonids is an ongoing potential problem. Fish passage should be evaluated, monitored and improved where possible especially at the Adobe road culvert.
- 3) The limited water temperature data available suggest that maximum temperatures are

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within/above the acceptable range for juvenile salmonids. To establish more complete and meaningful temperature regime information, 24-hour monitoring during the Mat through October temperature extreme period should be performed for 3 to 5 years.

- 4) Increase the canopy on Willow Brook by planting appropriate native vegetation like willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels. The reaches above this survey section should be inventoried and treated as well, since the water flowing here is affected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.
- 5) 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.
- 6) There are sections where the stream is being impacted from cattle trampling the riparian zone. Alternatives should be explored with the grazer and developed if possible.
- 7) Willow Brook Creek would benefit from utilizing bio-technical vegetative techniques for bank stabilization and to re-establish floodplain benches and a defined low flow channel. This would discourage lateral migration of the base flow channel and decrease bank erosion.
- 8) 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.
- 9) 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.
- 10) 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.
- 11) Suitable size spawning substrate on Willow Brook is limited to relatively few reaches. Projects should be designed at suitable sites to trap and sort spawning gravel.

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.

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Position	Habitat Unit #	Comments
0	0001.00	Start of Survey: Start of survey approximately 100 feet upstream from the confluence with Lichau Creek at a train bridge.
0	0001.00	General Comment: Willow Brook mouth is very overgrown and dry. There is an isolated pool under bridge #1 with the following characteristics: maximum depth 1.6 ft, mean 0.9 ft and width 13 ft. Salmonid shelter consists of small wood, aquatic vegetation and small cobble. The substrate is primarily silt followed by cobble.
0	0001.00	Structures: Bridge #1: It is a Railroad bridge with the following dimensions: height 6 ft, width 45ft and length 25 ft. There was zero downcutting observed. The height of water to sill was zero, it is not retaining gravel and there were fish observed in a pool here.
0	0001.00	Bio Sample: (Bank Observation) Roach and stickleback present. No steelhead observed.
25	0002.00	General Comment: The Creek is overgrown for approximately 1,100 feet then the canopy vanishes.
2510	0003.00	General Comment: All intermittent flatwater is 100% covered by green algae. Cattle have access to the creek bed here.
3335	0004.00	General Comment: At the time of the survey there was a dirt crossing over the creek that looked like it was recently poured. There was not any water passage under the crossing. The crossing did not have a bridge or culvert in place and therefore it was called a dry unit. Crossing description: 5' high, 47' wide, 25' long.
3365	0005.00	General Comment: Ducks, turtles, cows, stickleback all present in/near stagnant water. 1205' into unit, ford crossing in creek.
7063	0009.00	General Comment: Stickleback present.
7127	0011.00	Access Points / Location: (Culvert) Adobe Road culvert #1. H10', L27', W12'. Downcutting was 8', and height from water to lip was 4'. No retained gravel. A large pool has been created due to culvert scouring.
7154	0012.00	Access Points / Location: (Ford) 1180' into unit, WP005: 38.29495, 122.64546. (taken at crossing)
9674	0013.00	General Comment: Channel Type Change: B6=>F4, R1=>R2. (Changes at beginning/bottom of unit) 350' into unit, Ford crossing used for stable access. WP006: 38.30023, 122.64457 taken at top of unit (bottom of bridge #2, HU014)
9674	0013.00	Access Points / Location: (Bridge) Small private footbridge 690' into unit. (H5', L7', W35')

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Position	Habitat Unit #	Comments
11934	0014.00	Access Points / Location: (Bridge) Bridge #2, Jacobsen Lane crossing. H6', W45', L25'. No down cutting or retained gravel observed. Isolated pool located under bridge w/ roach and stickleback. Fish were observed, not identified, but steelhead may be present.
12392	0016.00	Access Points / Location: (Bridge) Bridge #3, private drive. H13', W40', L16'. No downcut or retained gravel. There are broken concrete slabs underneath the bridge.
12408	0017.00	Tributaries: Tributary #1 2,145' into unit. LB tributary was not flowing WP008: 38.30360, 122.64063.
14860	0018.00	Access Points / Location: (Bridge) Bridge #4, private farm road. H7', W40', L9'. There was no down-cutting or retained gravel observed.
14869	0019.00	General Comment: WP011: 38.31246, 122.64047. Taken at top of unit before spillway/dam in HU020.
14869	0019.00	Tributaries: Trib #2 180' into unit. It is a left bank tributary and was not flowing at the time of the survey. No fish were observed in the creek. WP010: 38.30568, 122.63320.
14869	0019.00	Access Points / Location: (Ford) 2445' into unit, private road
18114	0020.00	General Comment: Unit begins at spillway to a storage/farm pond. The first 1,082' of unit have abnormal channel because of farm pond. Channel type change: F4=>B4, R2=>R3. Spillway outlet is a 9' drop. Channel is eroding on both banks. Channel is made of boulder riprap for first 223'. Then @ 223' channel turns concrete for 204'. The 427' concrete/riprap spillway is sloped at a 11.5% grade. There is nothing to slow water in channel, providing no resting area for upstream migrating fish.
18596	0021.00	General Comment: HU021 is a 600' storage/farm pond.
19196	0022.00	Access Points / Location: (Ford) Crossing 1455' into unit.
20976	0023.00	General Comment: Channel Type Change: B4=>A3, R3=>R4.
27884	0052.00	Tributaries: Tributary #3 at end of HU052. WP016: 38.31901, 122.61518 A way-point was taken at mouth of the tributary. It is a right bank tributary that was flowing and contributing approximately 50% of the downstream flow. The temperature up from the tributary was 58 degrees Fahrenheit, The temperature down from tributary was 57 degrees Fahrenheit, and the temperature of the water in the tributary was also 57 degrees Fahrenheit. The tributary was determined accessible to fish, but none were seen.
28445	0053.00	General Comment: 200' into unit, dry cascade unit. Slope estimated approximately 50-60%.
28984	0054.00	General Comment: WP018: 38.31720, 122.61268. Taken at top of unit before culvert #2.

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Position	Habitat Unit #	Comments
28984	0054.00	Tributaries: Trib #4 215' into unit. LB tributary was dry No fish were observed; WP017: 38.31700, 122.61368 taken at the tributary.
29592	0055.00	Access Points / Location: (Culvert) Culvert #2, private road crossing. There is an in-stream metal pipe 20' long and 4' in diameter that has likely created the 1' down-cutting that was observed at this location. The distance from the culvert lip to the water's surface was measured to be 0.5'. The culvert was not retaining gravel, and there is currently zero maintenance required.
31031	0062.00	Fish Passage: (Other) 99' into unit there is a 5' high natural bedrock drop with 1' of down-cutting.
31143	0063.00	General Comment: WP019: 38.31964, 122.60895 taken at top of unit before culvert #3.
31161	0064.00	Access Points / Location: (Culvert) Culvert #3, private drive. There was a plastic tube 30' long and 3.4' in diameter observed with 4' of down-cutting from the culvert outlet. The distance from culvert lip to the water's surface was 2.3'. The culvert is not retaining gravel. The Slope was estimated to be greater than 4%. End Of Survey.
31191	0064.00	End of Survey: End of Survey after culvert; water flows at a trickle. Creek is dry at Hillsborough Rd. which is located approximately a quarter mile upstream of culvert #3.

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.

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]	

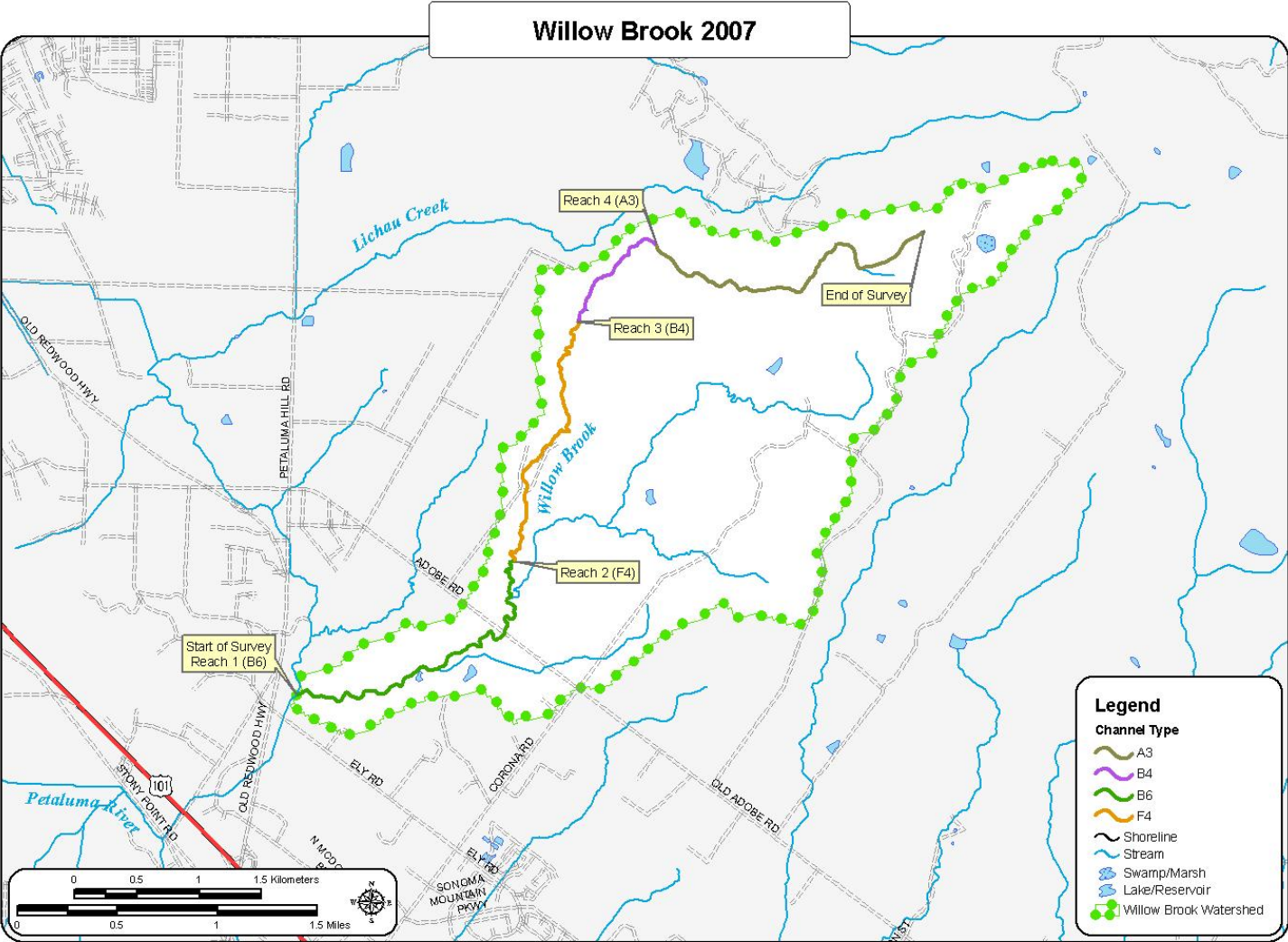


Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI

Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

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
7	0	CULVERT	10.9	21	145	0.5									
27	0	DRY	42.2	842	22730	72.9									
20	7	FLATWATER	31.3	323	6458	20.7	5.4	0.7	1.5	2837	56749	3369	67382		6
2	0	NOSURVEY_ MARSH	3.1	712	1425	4.6									
6	6	POOL	9.4	17	100	0.3	8.3	1.0	2.0	213	1279	401	2404	396	12
2	1	RIFFLE	3.1	166	333	1.1	2.0	0.1	0.3	294	588	29	59		0
Total Units	Total Units Fully Measured				Total Length (ft.)						Total Area (sq.ft.)		Total Volume (cu.ft.)		
64	14				31191						58616		69845		

Table 2 - Summary of Habitat Types and Measured Parameters

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI

Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

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 (%)
2	1	HGR	3.1	166	333	1.1	2.0	0.1	0.3	294	588	29	59		0	43
2	2	GLD	3.1	698	1395	4.5	11.0	1.5	3.5	7673	15345	10791	21582		15	59
18	5	SRN	28.1	281	5063	16.2	3.0	0.4	1.2	903	16262	400	7206		2	85
2	2	MCP	3.1	31	62	0.2	14.0	1.6	4.0	529	1058	1114	2229	1110	23	76
1	1	LSBk	1.6	11	11	0.0	6.0	0.9	2.0	66	66	66	66	59	0	89
2	2	LSBo	3.1	8	16	0.1	5.0	0.7	1.5	39	78	32	63	28	10	89
1	1	PLP	1.6	11	11	0.0	7.0	0.5	1.3	77	77	46	46	39	5	99
27	0	DRY	42.2	842	22730	72.9										58
7	0	CUL	10.9	21	145	0.5										
2	0	MAR	3.1	712	1425	4.6										
Total Units 64	Total Units Fully Measured 14				Total Length (ft.) 31191					Total Area (sq.ft.) 33474		Total Volume (cu.ft.) 31251				

Table 3 - Summary of Pool Types

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI

Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

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
2	2	MAIN	33	31	62	62	13.5	1.6	529	1058	1110	2220	23
4	4	SCOUR	67	10	38	38	5.8	0.7	55	221	38	154	6
Total Units	Total Units Fully Measured				Total Length (ft.)					Total Area (sq.ft.)		Total Volume (cu.ft.)	
6	6				100					1279		2373	

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

Stream Name: Willow Brook **LLID:** 1226642382850 **Drainage:** Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI **Legal Description:** T005R007S07 **Latitude:** 38:17:06.0N **Longitude:** 122:39:51.0W

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
2	MCP	33	0	0	1	50	0	0	0	0	1	50
1	PLP	17	0	0	1	100	0	0	0	0	0	0
2	LSBo	33	0	0	2	100	0	0	0	0	0	0
1	LSBk	17	0	0	0	0	1	100	0	0	0	0
Total Units			Total < 1 Foot Max Resid. Depth	Total < 1 Foot % Occurrence	Total 1 < 2 Feet Max Resid. Depth	Total 1 < 2 Feet % Occurrence	Total 2 < 3 Feet Max Resid. Depth	Total 2 < 3 Feet % Occurrence	Total 3 < 4 Feet Max Resid. Depth	Total 3 < 4 Feet % Occurrence	Total >= 4 Feet Max Resid. Depth	Total >= 4 Feet % Occurrence
6			0	0	4	67	1	17	0	0	1	17

Mean Maximum Residual Pool Depth (ft.): 2

Table 5 - Summary of Mean Percent Cover By Habitat Type

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Dry Units: 27

Confluence Location: Quad: COTATI

Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

Habitat Units	Units Fully Measured	Habitat Type	Mean % Undercut Banks	Mean % SWD	Mean % LWD	Mean % Root Mass	Mean % Terrestrial Vegetation	Mean % Aquatic Vegetation	Mean % White Water	Mean % Boulders	Mean % Bedrock Ledges
2	1	HGR	0	0	0	0	0	0	0	0	0
2	1	TOTAL RIFFLE	0	0	0	0	0	0	0	0	0
2	2	GLD	0	0	0	0	70	30	0	0	0
18	5	SRN	0	0	0	0	0	0	0	20	0
20	7	TOTAL FLAT	0	0	0	0	20	9	0	14	0
2	2	MCP	80	5	0	0	15	0	0	0	0
1	1	LSBk	0	0	0	0	0	0	0	0	0
2	2	LSBo	0	0	0	0	0	0	0	100	0
1	1	PLP	0	0	0	0	0	0	0	100	0
6	6	TOTAL POOL	27	2	0	0	5	0	0	50	0
7	0	CUL									
2	0	MAR									
64	14	TOTAL	11	1	0	0	12	4	0	29	0

Table 6 - Summary of Dominant Substrates By Habitat Type

Stream Name: Willow Brook				LLID: 1226642382850				Drainage: Petaluma River	
Survey Dates: 8/13/2007 to 8/16/2007				Dry Units: 27					
Confluence Location: Quad: COTATI				Legal Description: T005R007S07		Latitude: 38:17:06.0N		Longitude: 122:39:51.0W	
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
2	1	HGR	0	0	100	0	0	0	0
2	2	GLD	100	0	0	0	0	0	0
18	5	SRN	0	0	20	20	60	0	0
2	2	MCP	50	50	0	0	0	0	0
1	1	LSBk	0	100	0	0	0	0	0
2	2	LSBo	50	0	50	0	0	0	0
1	1	PLP	0	100	0	0	0	0	0
7	0	CUL	0	0	0	0	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI

Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
72	0	100	6	28	33

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.

Table 8 - Fish Habitat Inventory Data Summary

Stream Name: Willow Brook LLID: 1226642382850 Drainage: Petaluma River
 Survey Dates: 8/13/2007 to 8/16/2007 Survey Length (ft.): 31191 Main Channel (ft.): 31191 Side Channel (ft.): 0
 Confluence Location: Quad: COTATI Legal Description: T005R007S07 Latitude: 38:17:06.0N Longitude: 122:39:51.0W

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 1

Channel Type: B6	Canopy Density (%): 38.8	Pools by Stream Length (%): 0.5
Reach Length (ft.): 9674	Coniferous Component (%): 0.0	Pool Frequency (%): 8.3
Riffle/Flatwater Mean Width (ft.): 11.0	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Grass	< 2 Feet Deep: 0.0
Range (ft.): 14 to 16	Vegetative Cover (%): 47.5	2 to 2.9 Feet Deep: 0.0
Mean (ft.): 15.67	Dominant Shelter: Terrestrial Veg.	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 0.75	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 100.0
Base Flow (cfs):	Occurrence of LWD (%): 0.0	Mean Max Residual Pool Depth (ft.): 4
Water (F): 56 - 56 Air (F): 61 - 76	LWD per 100 ft.:	Mean Pool Shelter Rating: 40
Dry Channel (ft.): 7358	Riffles:	
	Pools: 0	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay: 100. Sand: 0.0 Gravel: 0.0 Sm Cobble: 0.0 Lg Cobble: 0.0 Boulder: 0.0 Bedrock: 0.0		
Embeddedness Values (%): 1. 0.0 2. 0.0 3. 0.0 4. 0.0 5. 100.0		

STREAM REACH: 2

Channel Type: F4	Canopy Density (%): 61.0	Pools by Stream Length (%): 0.0
Reach Length (ft.): 8440	Coniferous Component (%): 0.0	Pool Frequency (%): 0.0
Riffle/Flatwater Mean Width (ft.):	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.): 10 to 20	Vegetative Cover (%): 0.0	2 to 2.9 Feet Deep:
Mean (ft.): 14.29	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.: 4.95	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs):	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): 56- 69 Air (F): 52 - 54	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft.): 8397	Riffles:	
	Pools:	
	Flat:	
Pool Tail Substrate (%): Silt/Clay: Sand: Gravel: Sm Cobble: Lg Cobble: Boulder: Bedrock:		
Embeddedness Values (%): 1. 2. 3. 4. 5.		

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 3

Channel Type: B4	Canopy Density (%): 0.0	Pools by Stream Length (%): 0.0
Reach Length (ft.): 2862	Coniferous Component (%):	Pool Frequency (%): 0.0
Riffle/Flatwater Mean Width (ft.):	Hardwood Component (%):	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.): 20 to 20	Vegetative Cover (%): 0.0	2 to 2.9 Feet Deep:
Mean (ft.): 20	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.: 0	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs):	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): 69 - 69 Air (F): 52 - 52	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft.): 2262	Riffles:	
	Pools:	
	Flat:	
Pool Tail Substrate (%): Silt/Clay: Sand: Gravel: Sm Cobble: Lg Cobble: Boulder: Bedrock:		
Embeddedness Values (%): 1. 2. 3. 4. 5.		

STREAM REACH: 4

Channel Type: A3	Canopy Density (%): 82.8	Pools by Stream Length (%): 0.5
Reach Length (ft.): 10215	Coniferous Component (%): 0.0	Pool Frequency (%): 11.9
Riffle/Flatwater Mean Width (ft.): 3.0	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Hardwood Trees	< 2 Feet Deep: 80.0
Range (ft.): 13 to 25	Vegetative Cover (%): 26.1	2 to 2.9 Feet Deep: 20.0
Mean (ft.): 20.81	Dominant Shelter: Boulders	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 4.07	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0.0
Base Flow (cfs):	Occurrence of LWD (%): 0.0	Mean Max Residual Pool Depth (ft.): 1.56
Water (F): 56 - 69 Air (F): 52 - 75	LWD per 100 ft.:	Mean Pool Shelter Rating: 6
Dry Channel (ft.): 4713	Riffles: 0	
	Pools: 4	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 40.0 Gravel: 60.0 Sm Cobble: 0.0 Lg Cobble: 0.0 Boulder: 0.0 Bedrock: 0.0		
Embeddedness Values (%): 1. 60.0 2. 0.0 3. 0.0 4. 0		

Table 9 -Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI

Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

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	2	4	21.4
Boulder	1	0	3.6
Cobble/Gravel	0	1	3.6
Sand/Silt/Clay	11	9	71.4

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	4	3	25.0
Brush	3	1	14.3
Hardwood Trees	5	8	46.4
Coniferous Trees	0	0	0.0
No Vegetation	2	2	14.3

Total Stream Cobble Embeddedness Values: 3

Table 10 - Mean Percent of Shelter Cover Types for Entire Stream

Stream Name: Willow Brook

LLID: 1226642382850

Drainage: Petaluma River

Survey Dates: 8/13/2007 to 8/16/2007

Confluence Location: Quad: COTATI

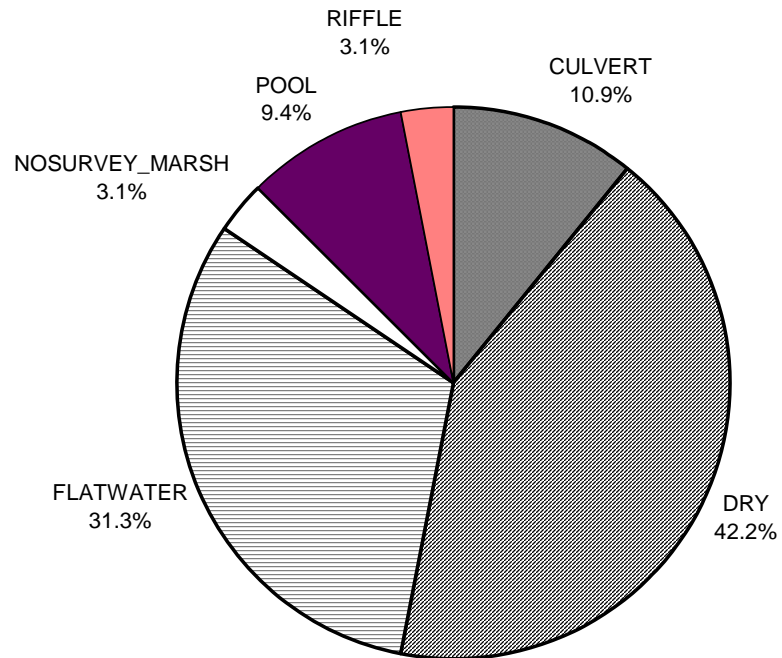
Legal Description: T005R007S07

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Longitude: 122:39:51.0W

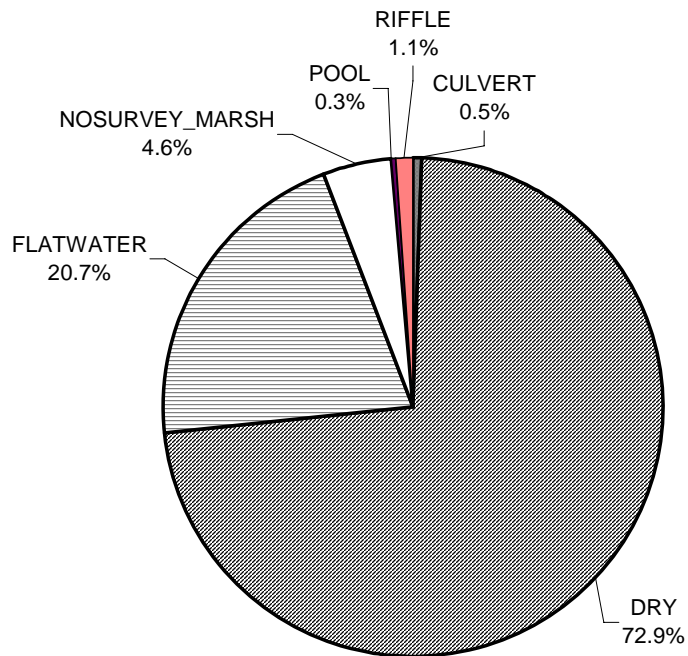
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	0	27
SMALL WOODY DEBRIS (%)	0	0	2
LARGE WOODY DEBRIS (%)	0	0	0
ROOT MASS (%)	0	0	0
TERRESTRIAL VEGETATION (%)	0	20	5
AQUATIC VEGETATION (%)	0	9	0
WHITEWATER (%)	0	0	0
BOULDERS (%)	0	14	50
BEDROCK LEDGES (%)	0	0	0

WILLOW BROOK 2007 HABITAT TYPES BY PERCENT OCCURRENCE



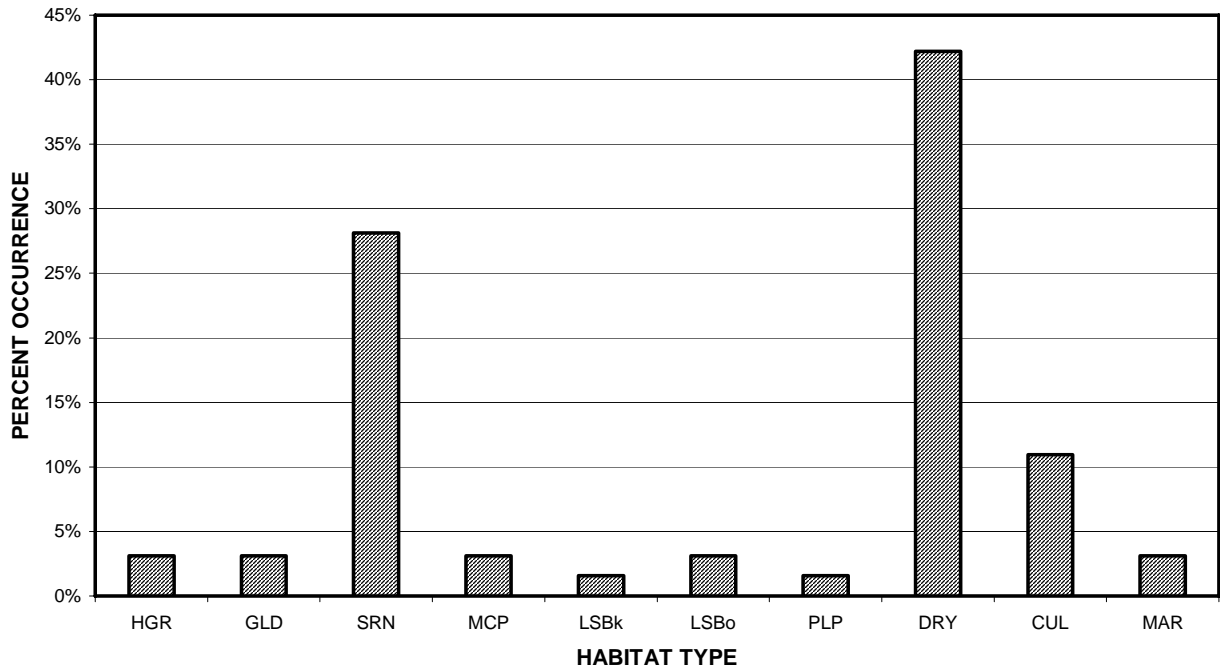
GRAPH 1

WILLOW BROOK 2007 HABITAT TYPES BY PERCENT TOTAL LENGTH



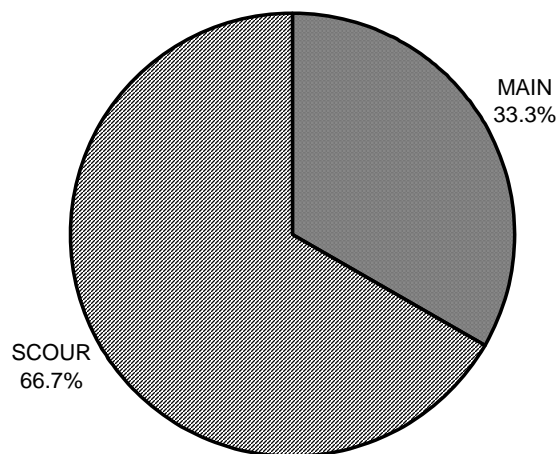
GRAPH 2

WILLOW BROOK 2007 HABITAT TYPES BY PERCENT OCCURRENCE



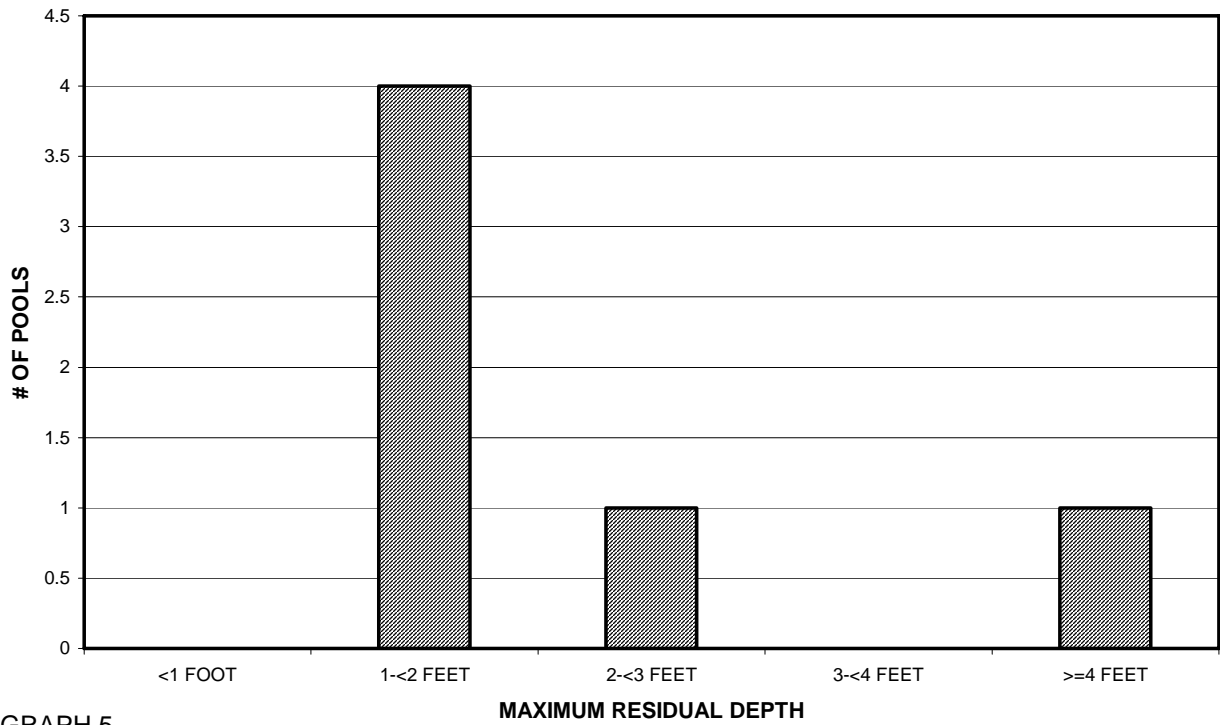
GRAPH 3

WILLOW BROOK 2007 POOL TYPES BY PERCENT OCCURRENCE



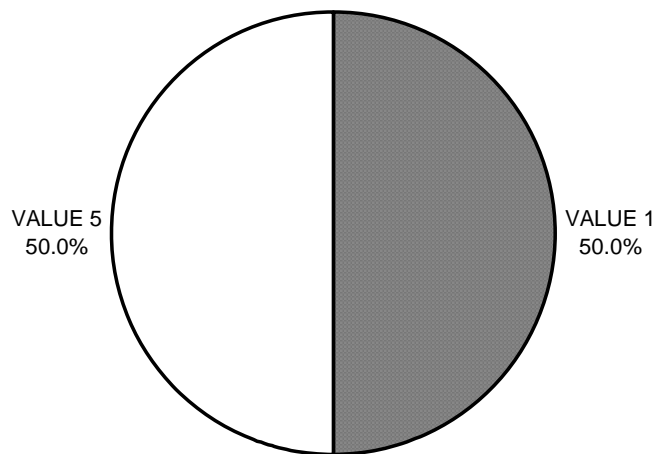
GRAPH 4

WILLOW BROOK 2007 MAXIMUM DEPTH IN POOLS



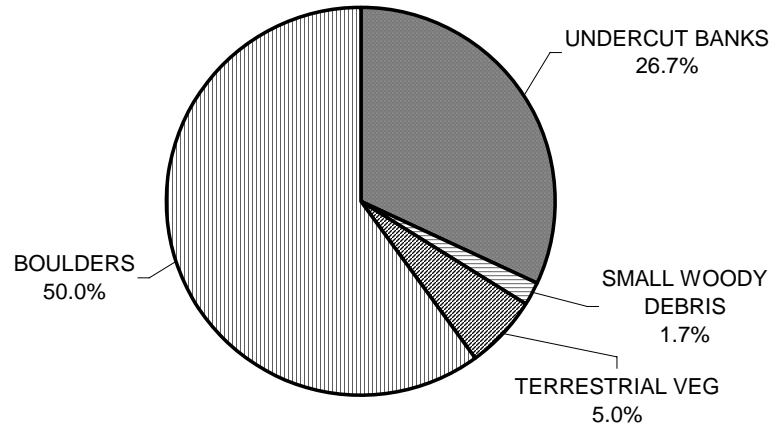
GRAPH 5

WILLOW BROOK 2007 PERCENT EMBEDDEDNESS



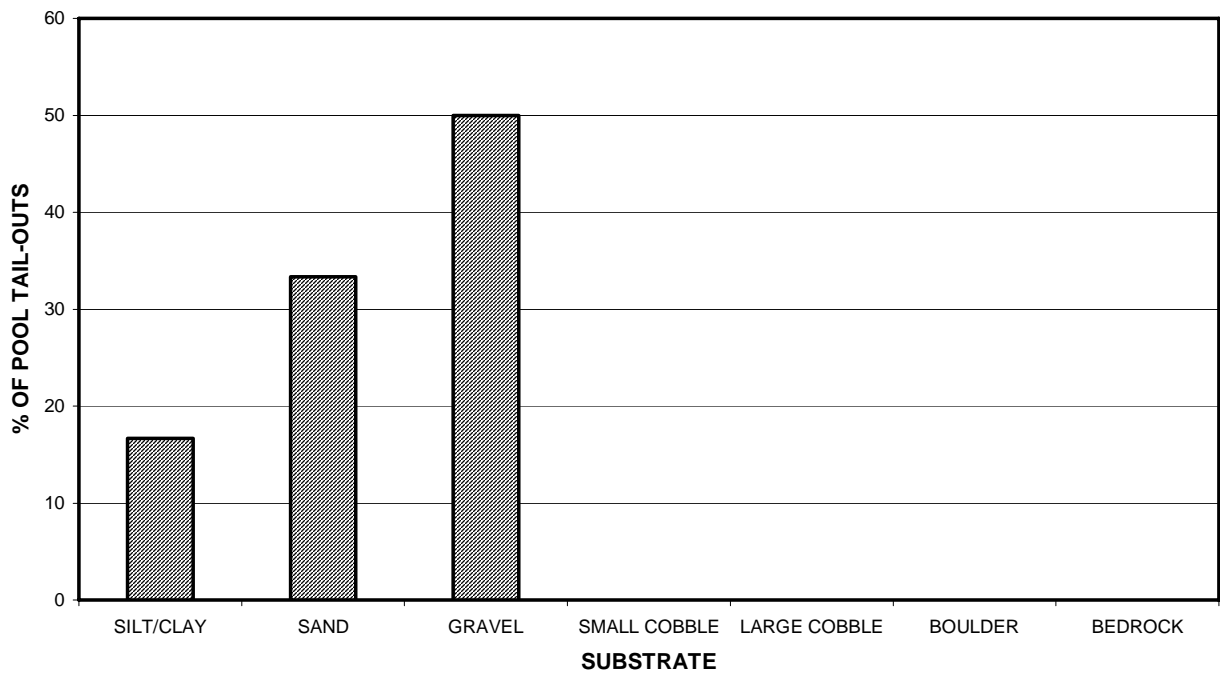
GRAPH 6

WILLOW BROOK 2007 MEAN PERCENT COVER TYPES IN POOLS



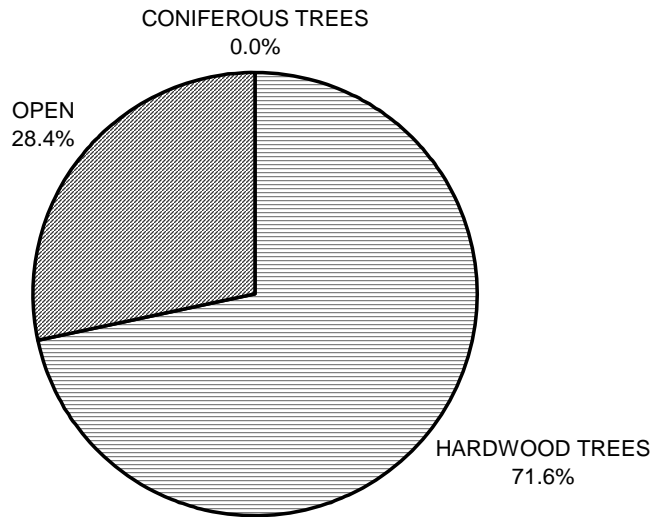
GRAPH 7

WILLOW BROOK 2007 SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



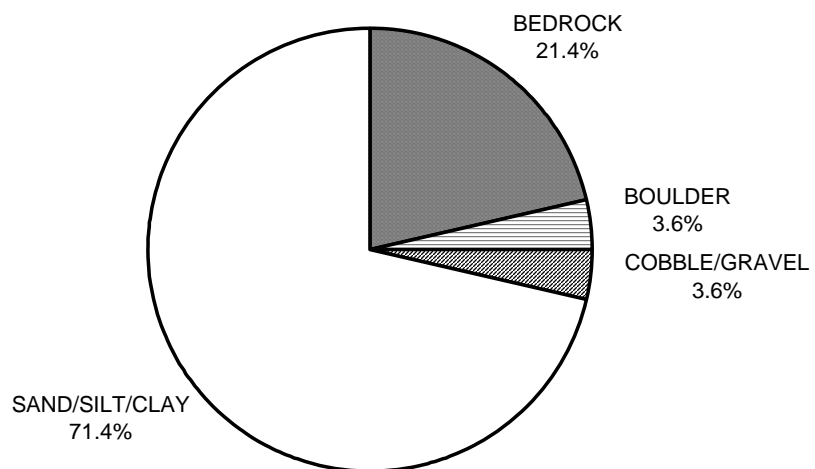
GRAPH 8

WILLOW BROOK 2007 MEAN PERCENT CANOPY



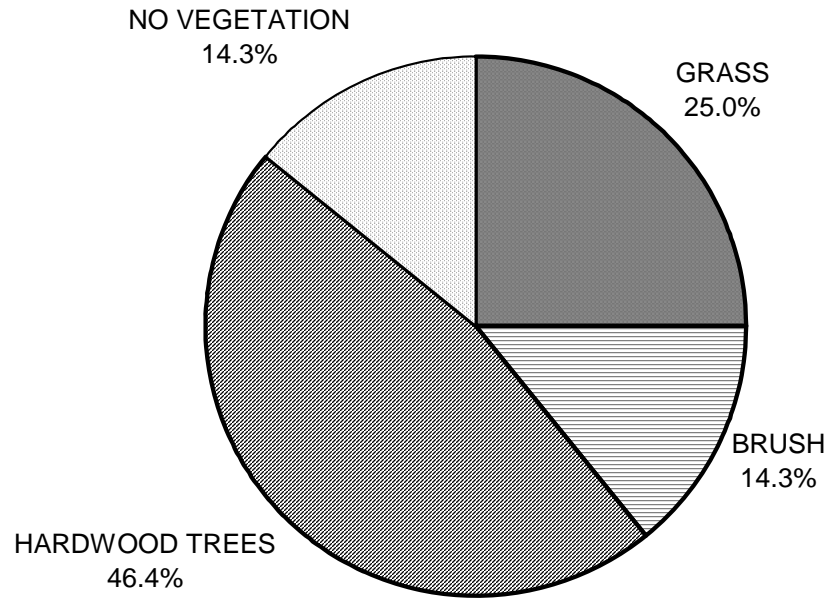
GRAPH 9

WILLOW BROOK 2007 DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 10

WILLOW BROOK 2007 DOMINANT BANK VEGETATION IN SURVEY REACH



GRAPH 11