



California Department of Fish and Game
Petaluma River Watershed
Stream Habitat Assessment Reports
Lichau Creek
Surveyed 2007



STREAM INVENTORY REPORT

Lichau Creek

Survey conducted summer 2007

Report completed March 2008

INTRODUCTION

A stream inventory was conducted during 6/20/2007 to 7/24/2007 on Lichau Creek. The survey began at the confluence with Petaluma River and extended upstream 8.9 miles.

The Lichau Creek 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 Lichau Creek. 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

Lichau Creek is a tributary to Petaluma River, located in Sonoma County, California (Map 1). Lichau Creek's legal description at the confluence with Petaluma River is T05N R07W S18. Its location is 38°16'27.0" north latitude and 122°40'34.0" west longitude, LLID number 1226762382742. Lichau Creek is a third order stream and has 29.58 miles of blue line stream according to the USGS National Hydrography Dataset (NHD). Lichau Creek drains a watershed of 14.39 square miles. Elevations range from about 33 feet at the mouth of the creek to 2,139 feet in the headwater areas. Mixed hardwood forest dominates the watershed. The watershed is entirely privately owned and is managed for rangeland. Approximately 67% of the land is used for agriculture, 30.5% is considered natural and 2% is urban. Vehicle access exists via Adobe Road in the lower reaches and Sonoma Mountain road in the upper reaches.

METHODS

The habitat inventory conducted in Lichau Creek 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 Lichau Creek 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". Lichau Creek 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 Lichau Creek, 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 Lichau Creek, 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 Lichau Creek, 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 Lichau Creek, 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. Fish presence was observed from the stream banks in Lichau Creek. In addition, three sites were 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 Lichau Creek 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 6/20/2007 to 7/24/2007 was conducted by D Resnik, H Fett, (CDFG) and J Hanson, B Nedland, (WSP). The total length of the stream surveyed was 46,879 feet with zero feet of side channel.

Stream flow was not measured on Lichau Creek.

Lichau Creek is a F6 channel type for 1,808 feet of the stream surveyed (Reach 1), a E6 channel type for 1,220 feet of the stream surveyed (Reach 2), a F6 channel type for 2,389 feet of the stream surveyed (Reach 3), a NA channel type for 876 feet of the stream surveyed (Reach 4), a F6 channel type for 9,910 feet of the stream surveyed (Reach 5), a F4 channel type for 1,834 feet of the stream surveyed (Reach 6), a NA channel type for 2,633 feet of the stream surveyed (Reach 7), a F4 channel type for 3,304 feet of the stream surveyed (Reach 8), a E3 channel type for 6,836 feet of the stream surveyed (Reach 9), a B3 channel type for 2,323 feet of the stream surveyed (Reach 10), a A3 channel type for 6,066 feet of the stream surveyed (Reach 11), a NA channel type for 238 feet of the stream surveyed (Reach 12), and an A2 channel type for 7,442 feet of the stream surveyed (Reach 13).

A2 channels are steep, narrow, cascading, step-pool, high energy debris transporting channels associated with depositional soils, and boulder dominant substrates. A3 channels have identical characteristics as A2 channels except for the fact that they have cobble dominant substrates. B3 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 cobble dominant substrates. E3 channels are meandering, riffle/pool streams on low gradients with low width depth ratio, little deposition, high meander width ratio; and they are characterized as very efficient and stable with cobble dominated substrates. E6 channels have identical characteristics as E3 channels except for the fact that they have silt/clay dominant substrates. F4

channels are entrenched, meandering, riffle/pool channels on low gradients with high width/depth ratios and gravel-dominant substrates. F6 channels have identical characteristics as F4 channels except they have silt/clay dominant substrates.

Water temperatures taken during the survey period ranged from 57 to 66 degrees Fahrenheit. Air temperatures ranged from 57 to 77 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 39% flatwater units, 17% pool units, 15% dry units, 5% culvert units, 1% nosurvey units, and 22% riffle units (Graph 1). Based on total length of Level II habitat types there were 43% flatwater units, 6% pool units, 30% dry units, 2% culvert units, 8% nosurvey units, and 11% riffle units (Graph 2).

Sixteen Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 15% Dry units, 17% Step Run units, and 16% Glide units (Graph 3). Based on percent total length, the most frequent habitat types were 30% Dry units, 20% Step Run units, and 14% Glide units.

A total of 58 pools were identified (Table 3). Scour pools were the most frequently encountered, at 55%, and comprised 25% 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. Eleven of the 57 pools (19%) had a residual depth of three feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 58 pool tail-outs measured, 13 had a value of 1 (22.4%); 12 had a value of 2 (20.7%); 7 had a value of 3 (12.1%); 2 had a value of 4 (3.4%); and 24 had a value of 5 (41.4%) (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 3 , flatwater habitat types had a mean shelter rating of 26 , and pool habitats had a mean shelter rating of 25 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 17 and Scour pools had a mean shelter rating of 32 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover types in Lichau Creek. Graph 7 describes the pool cover in Lichau Creek. Boulders are the dominant pool cover type followed by aquatic vegetation.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. A silt/clay substrate type was observed in 28% of pool tail-outs and small Cobble observed in 29% of pool tail-outs.

The mean percent canopy density for the surveyed length of Lichau Creek was 74%. The mean percentages of hardwood and coniferous trees were 99% and 1%, respectively. Twenty six

Lichau Creek 2007

percent of the canopy was open. Graph 9 describes the mean percent canopy in Lichau Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 69%. The mean percent left bank vegetated was 73%. The dominant elements composing the structure of the stream banks consisted of 3% bedrock, 4% boulder, 8% cobble/gravel, and 85% sand/silt/clay (Graph 10). Deciduous was the dominant vegetation type observed in 38% of the units surveyed. Additionally, 36% of the units surveyed had brush as the dominant vegetation type, and 25% had grass as the dominant vegetation (Graph 11).

BIOLOGICAL INVENTORY RESULTS

Three sites were electrofished for species composition and distribution in Lichau Creek on June and July 2007. Water temperatures taken during the electrofishing period ranged from 61 to 79 degrees Fahrenheit. Air temperatures ranged from 70 to 78 degrees Fahrenheit. The sites were sampled by D. Acomb (DFG), D.Resnik (DFG) and H. Fett (DFG).

In reach 6, one site was sampled starting approximately at Habitat Unit 123 and ending at Habitat 127. The reach sites yielded seven young-of-the-year steelhead/ rainbow trout (SH/RT), 50 three-spine stickleback, 2 bullfrogs and 3 California roach.

In reach 9, one site was sampled starting approximately at Habitat Unit 171 and ending at Habitat Unit 186. The reach sites yielded 45 young-of-the-year SH/RT and 4 age 1+ SH/RT.

In reach 11, one site was sampled starting approximately at Habitat Unit 261 and ending at Habitat Unit 270. The reach sites yielded 6 young-of-the-year SH/RT and 2 age 1+ SH/RT.

The following chart displays the information yielded from these sites:

2007 Lichau Creek e-fish observations

Date	Site #	Reference Point	Distance From Reference Point (ft.)	Steelhead/ Rainbow Trout			Non Salmonids Name species
				0+	1+	2+	
06/20/2007	620	Railroad tracks	Down 20	7	0	0	2 Bullfrog, 3 California roach, 50 three-spine stickleback
07/19/2007	622	End of Davis Lane		45	4	0	
07/19/2007	623	Acacia Way	50 up and 100 down	6	2	0	

DISCUSSION

Lichau Creek is a F6 channel type for the first 1,808 feet of stream surveyed (Reach 1), an E6 channel type for the next 1220 feet (Reach 2), a F6 channel type for 2,389 feet (Reach 3), a NA channel type for the next 876 feet (Reach 4), a F6 channel type for 9,910 feet of the stream surveyed (Reach 5), a F4 channel type for the next 1,834 feet (Reach 6), a NA channel type for 2,633 feet of the stream (Reach 7), a F4 channel type for the next 3,304 feet of the stream surveyed (Reach 8), an E3 channel type for the next 6,836 feet (Reach 9), a B3 channel type for 2,323 feet of the stream surveyed (Reach 10), an A3 channel type for 6,066 feet of the stream surveyed (Reach 11), a NA channel type for the next 238 feet of the stream surveyed (Reach 12), and an A2 channel type for the remaining 7,442 feet of the stream surveyed (Reach 13).

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, and log cover; and they are poor for boulder clusters. The suitability of F6 channel types for fish habitat improvement structures is as follows: good for bank placed boulders, fair for plunge weirs, boulder clusters, single and opposing wing deflectors, and log cover. The suitability of E3 channel types for fish habitat improvement structures is as follows: good for bank placed boulders; fair for opposing wing deflectors; poor for plunge weirs, boulder clusters, and single wing-deflectors. The suitability of E6 channel types for fish habitat improvement structures is as follows: good for bank-placed boulders; fair for opposing wing deflectors; poor for plunge weirs, boulder clusters, and single wing deflectors. The suitability of A2 channel types for fish habitat improvement structures generally are not suitable, because they are characterized as high energy streams with stable stream banks, and poor gravel retention capabilities. 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; and they are poor for boulder clusters and single wing-deflectors. The suitability of B3 channel types for fish habitat improvement structures is as follows: excellent for plunge weirs, boulder clusters, bank placed boulders, single and opposing wing-deflectors and log cover.

The water temperatures recorded on the survey days 6/20/2007 to 7/24/2007, ranged from 57 to 66 degrees Fahrenheit. Air temperatures ranged from 57 to 77 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 43% of the total length of this survey, riffles 12%, and pools 6%. The pools are relatively shallow, with only 11 of the 57 (19%) pools having a maximum residual depth greater than 3 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In third and fourth 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.

Twenty five of the 58 pool tail-outs measured had embeddedness ratings of 1 or 2. Nine of the

pool tail-outs had embeddedness ratings of 3 or 4. Twenty four 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 Lichau Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Twenty eight of the 58 pool tail-outs had silt, sand, large cobble, boulders or bedrock as the dominant substrate. This is generally considered unsuitable for spawning salmonids.

The mean shelter rating for pools was 25. The shelter rating in the flatwater habitats was 26. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by Boulders in Lichau Creek. Boulders are the dominant cover type in pools followed by aquatic 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 74%. Reach 1 had a canopy density of 19%, Reach 2 had a canopy density of 52%, Reach 5 had a canopy density of 73%, Reach 6 had a canopy density of 89%, Reach 8 had a canopy density of 42%, Reach 9 had a canopy density of 67%, Reach 10 had a canopy density of 80%, Reach 11 had a canopy density of 85%, and Reach 13 had a canopy density of 86%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was moderate, 69% and 73%, 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

Lichau Creek 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, monitored and improved along the stream, particularly at all road crossings and culverts. Where needed crossings and culverts should be replaced or modified to improve fish passage. Potential barriers noted in the assessment were located at the following locations: 2 private driveways in reach 9, a private driveway in reach 13 and the culvert at Acacia way.

Lichau Creek 2007

- 2) 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.
- 3) There are sections where the stream is being impacted from cattle trampling the riparian zone such as at 17,062 feet. Alternatives should be explored with the grazier and developed if possible.
- 4) 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.
- 5) Increase the canopy on Lichau Creek, especially in the lower reaches 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.
- 6) 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.
- 7) 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.
- 8) The limited water temperature data available suggest that maximum temperatures are above the acceptable range for juvenile salmonids. To establish more complete and meaningful temperature regime information, 24-hour monitoring during the May through October temperature extreme period should be performed for 3 to 5 years.
- 9) Suitable size spawning substrate on Lichau Creek 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.

Position (ft)	Habitat Unit #	Comments
0	0001.00	Start of Survey: Start of Survey on upstream side of bridge. Creek overgrown with reeds and aquatic vegetation. WP001: N 38.27435, W 122.67706

Lichau Creek 2007

Position (ft)	Habitat Unit #	Comments
473	0009.00	General Comment: Fish Observed, No ID.
473	0009.00	Structures: Rip Rap covers both banks
813	0013.00	Access Points / Location: (Bridge) Bridge #1 and #2. Two Hwy 101 bridges; 12' between them; H14', W72', L44' each.
1808	0021.00	General Comment: WP004: N 38.27767, W 122.67167; channel type change F6-E6; R1-R2
1808	0021.00	Access Points / Location: (Bridge) Bridge #3 - McDowell Blvd. H11.5', W104', L56'.
2669	0025.00	General Comment: Dry large pond 75' from Right Bank
3028	0027.00	General Comment: WP006 N 38.27984, W 122.66816; Channel type change E6-F6; R2-R3
3028	0027.00	Access Points / Location: (Bridge) Bridge #4 Old Redwood Hwy crossing. H9', W123', L127'.
3155	0028.00	Tributaries: Willow Brook enters Lichau Creek in HU028; Willow Brook is not flowing. All water temps, d/s, u/s and of tributary were 58 degrees. Willow brook is accessible to fish. Unidentified fish were observed up the tributary.
4338	0029.00	Access Points / Location: (Bridge) Bridge #5 Ely Road. H14', W77', L33'. WP007 N 38.28320, W 122.66635
4415	0030.00	General Comment: End of access; WP008 N 38.28578, W 122.66483; RB sloughing off above Bridge #5 into creek, possible tree planting area; channel type change F6-NA, R3-R4.
5417	0031.00	General Comment: WP009 taken at top of NA unit; WP009: N 38.28850, W122.66439; channel type change NA-F6; R4-R5
6518	0035.00	Tributaries: Tributary # 2 on LB 66' into unit. Tributary had no flow. Tributary is not accessible to fish. First 50' of tributary is a 7' diameter culvert with a 3% slope. WP010: N 38.28918, W 122.66398
8701	0050.00	Structures: Unit starts with creek running up against 15' high concrete wall on RB. Wall extends for approximately 900' ending at top of HU052. Penngrove Fire Station located over wall.
9400	0052.00	Structures: 900' concrete wall on RB ends at top of unit.

Lichau Creek 2007

Position (ft)	Habitat Unit #	Comments
9588	0053.00	Access Points / Location: (Bridge) Old Redwood Hwy Bridge (#6) crossing in Penngrove. H11', W26', L59'. WP033: N 38.29678, W 122.66641
10326	0057.00	Access Points / Location: (Bridge) Bridge #7 - livestock/stable crossing. The wood bridge is H13', W37', L14'. Bridge seems to contribute to a 3' downcut.
12171	0075.00	Access Points / Location: (Bridge) Adobe Road Bridge. H10', W21', L40'. WP037: 38.29980, 122.67256
12872	0087.00	Tributaries: Dry tributary 45' into unit on RB. Tributary had no flow. WP039: 38.30138, 122.67373
14532	0110.00	Tributaries: Tributary #4 is 45' into unit (dry). WP042: 38.30479, 122.67640
16203	0123.00	General Comment: Channel Type Change 250' into unit. (F6-->F4; R5-->R6) Cattle fence crosses creek near channel type change.
16203	0123.00	Tributaries: Tributary #5 768' into unit. Tributary had no flow. WP044: 38.30861, 122.67912
17051	0126.00	Access Points / Location: (Bridge) Bridge #9, railroad bridge. H10', W46', L12'.
17063	0127.00	General Comment: Creek accessible to cattle. WP046: 38.30899, 122.67593
18037	0128.00	General Comment: Channel type change (F4-->NA; R6-->R7)
20670	0129.00	General Comment: Channel type change (NA → F4; R7 → R8). WP047: 38.31232, 122.66859 (beginning of access)
21388	0138.00	Access Points / Location: (Bridge) Unit of bridge #10, Petaluma Hill Road crossing. H9', W19', L57'. Bridge is retaining gravel. There is a cattle fence across the width of the bridge. WP048: 38.31204, 122.66674
22797	0142.00	Access Points / Location: (Bridge) Culvert #1 at East Railroad crossing. Double box culvert. H5', W21', L157'. No downcut or retained gravel, not a barrier. WP049: 38.31429, 122.66355.
23962	0144.00	General Comment: Channel Type changes at top of bridge unit. (F4-->E3; R8-->R9)
23962	0144.00	Access Points / Location: (Bridge) Bridge #11 crossing (private drive). H7', W35', L12'. Good condition. WP050: 38.31604, 122.66017 (Bridge #11)
23974	0145.00	Tributaries: Right bank Tributary #6 located 2933' into dry unit. Tributary was dry, no flow. WP051: 38.31945, 122.64912.

Lichau Creek 2007

Position (ft)	Habitat Unit #	Comments
28629	0160.00	General Comment: WP053: 38.31972, 122.64647 (bridge #12).
28629	0160.00	Fish Passage: (Apron) There is a bridge above unit 160 with a concrete apron underneath it. There is a 6' jump for fish
28640	0161.00	Bio Sample: (Bank Observation) Twelve 4"-8" steelhead were observed in pool below bridge.
28640	0161.00	Access Points / Location: (Bridge) Bridge #12 - Private farm road. H7, W36, L17. Bridge possible cause of 7.5' of downcutting. 6' high from water to sill.
30220	0171.00	General Comment: Many steelhead observed.
30753	0179.00	Structures: Culvert #2, dirt road on private property, # of culverts "1", material "Iron", Diameter 8ft, plunge height 3.5ft, max depth w/in 5ft of outlet 0.4", culvert slope < 2%, condition: good except for a little rust on the bottom, possible barrier to juvenile & adult salmonids.
30810	0180.00	General Comment: channel type change E3 - B3, Reach change 9 - Reach 10
31052	0182.00	Tributaries: #7 at beginning of unit, flowing, water temp. 58F, 60F d/s of tributary, 61F u/s of tributary accessible to fish, slope ~ 3%, no fish observed.
31885	0196.00	General Comment: Ford crossing at 97' into unit.
33133	0214.00	General Comment: channel type change B3 - A3, Reach change 10 - 11
33525	0218.00	Structures: culvert #3, dirt road on private property, made of Iron, diameter 6ft, plunge height 0.2ft, max depth w/in 5ft of outlet 2.0ft, culvert slope 4.3%, condition: a little rusty but in good shape, not a possible barrier for juvenile or adult salmonids.
37865	0265.00	Structures: Culvert # 4 begins at the top of this Unit.
37882	0266.00	General Comment: unidentified fish species observed.
37882	0266.00	Bio Sample: (Bank Observation) Fish observed just below culvert. Pool was E-fished and salmonids were present.
37882	0266.00	Access Points / Location: (Culvert) Culvert #4, Acacia Way crossing. Culvert made of an iron pipe, 7' in diameter, 29' long, at a slope of 1.7%. Possible fish barrier to juveniles, maybe adults. Plunge Height: 6'. Max depth within 5' of outlet: 1.7'.
37911	0267.00	Structures: A 2.5 ft high concrete slab was observed 55 ft into the unit.

Lichau Creek 2007

Position (ft)	Habitat Unit #	Comments
38216	0271.00	General Comment: Side channels were observed, but were dry.
38738	0277.00	General Comment: Channel Type (channel type) change at the top of this unit. The channel type changes at the top of Habitat Unit 277 from an A3 channel to No Access (NA) and from reach 11 to reach 12.
39199	0278.00	General Comment: Channel Type (channel type) change channel type change is from NA - A2, and reach 12 -13.
39918	0285.00	Access Points / Location: (Culvert) Culvert #5 is a concrete single-box culvert. H6.5', W6', L14'. Cement bottom of culvert is eroding away.
39932	0286.00	Structures: There is a man-made wall on right bank that starts 72 ft into the unit, is 4 ft tall, and 150 ft long and is eroding in place.
40576	0287.00	Structures: There is a 4 ft high, 55 ft long wall on the left bank
41712	0297.00	Access Points / Location: (Culvert) Culvert #6 Private drive. Aluminum pipe, 7' in diameter, 60' long. Culvert slope 1.2%. Half filled up with debris and gravel so height is 3.5'.
42592	0310.00	General Comment: slope was found to be greater than 10%
42792	0311.00	General Comment: Slope 9.9%
44467	0326.00	Tributaries: Tributary # 9 was flowing, contributing approximately 25% of the main channel flow. Temp downstream of tributary: 63. Temp upstream of tributary: 65. Temp of tributary: 62. Tributary was not accessible to fish. No fish observed in the tributary.
44625	0329.00	Tributaries: The mouth to tributary #10 is located at the top of this unit (WP 001 (new GPS unit) Tributary was flowing and contributed approx 40% of downstream flow. Temp up from tributary: 63. Temp down from tributary: 63. Temp of tributary: 64. Checked up tributary 40', accessible to fish
45161	0333.00	Structures: culvert #7 is located at the top of this unit.
45280	0334.00	Access Points / Location: (Culvert) Culvert #7, private drive up Sonoma Mountain Rd. Aluminum pipe, smashed to H3.5', W5.5', L22'. Plunge height, 3.5'. Max water depth before culvert: 1.0'. Culvert slope 4.1%. Possible barrier to adults and juveniles.
45302	0335.00	Fish Passage: (Dam) There are two natural bedrock dams located in this unit; the first is located 532 feet into the unit and has a 7 foot bedrock drop. The second wall is 6 feet high and is located 557 feet into the unit.

Lichau Creek 2007

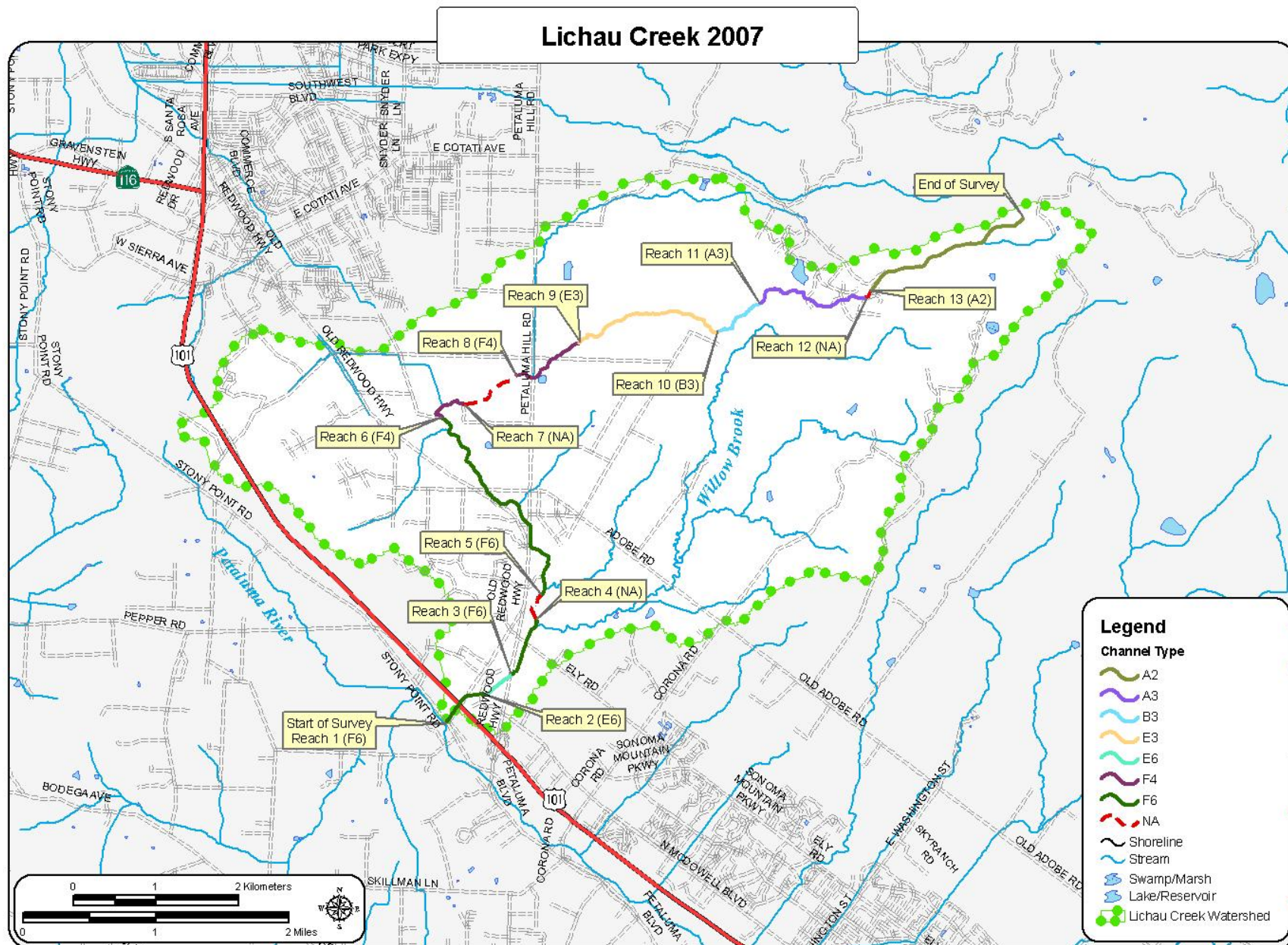
Position (ft)	Habitat Unit #	Comments
45962	0337.00	General Comment: Tributary checked 400' and concluded that it is not accessible to fish. No fish were observed. Tributary slope was approximately 6.2%. Mouth of tributary located at 38.32987, 122.60200.
45962	0337.00	Tributaries: Tributary # 11 is at the top of this unit (W.P. 004). There is a natural spring between tributary 11 and the mainstem. Tributary contributes nearly 100% of the downstream flow. Temp up from tributary: 65. Temp down from tributary: 66. Temp of tributary: 66.
45962	0337.00	Fish Passage: (Dam) There is a 9ft bedrock wall 22 feet into unit.
46064	0338.00	Tributaries: Tributary # 12 is located 288 feet into this unit. Tributary is dry and not accessible to fish. Slope of tributary: 5.2%. Located at 38.32995, 122.60095.
46879	0338.00	End of Survey: The survey ends at N38.33078, W122.59937

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: Lichau Creek

LLID: 1226762382742

Drainage: Petaluma River

Survey Dates: 6/20/2007 to 7/24/2007

Confluence Location: Quad: COTATI

Legal Description: T05NR07WS18

Latitude: 38:16:27.0N

Longitude: 122:40:34.0W

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
18	1	CULVERT	5.3	48	857	1.8	27.0	2.8	3.2	2700	48600	7560	136080		20
51	0	DRY	15.1	275	14003	29.9									
132	22	FLATWATER	39.1	151	19970	42.6	7.4	0.8	1.4	828	109358	1312	173197		26
3	0	NOSURVEY	0.9	1249	3747	8.0									
1	0	NOSURVEY_MARSH	0.3	151	151	0.3									
58	57	POOL	17.2	48	2756	5.9	9.9	1.2	2.1	674	39115	1724	100002	1584	25
75	20	RIFFLE	22.2	72	5395	11.5	4.8	0.2	0.5	255	19092	41	3060		3
Total Units	Total Units Fully Measured				Total Length (ft.)						Total Area (sq.ft.)		Total Volume (cu.ft.)		
338	100				46879						216166		412340		

Table 2 – Summary of Habitat Types and Measured Parameters

Stream Name: Lichau Creek

LLID: 1226762382742

Drainage: Petaluma River

Survey Dates: 6/20/2007 to 7/24/2007

Confluence Location: Quad: COTATI

Legal Description: T05NR07WS18

Latitude: 38:16:27.0N

Longitude: 122:40:34.0W

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 (%)
34	8	LGR	10.1	66	2230	4.8	6.0	0.2	0.7	406	13816	49	1683		4	69
36	10	HGR	10.7	78	2792	6.0	4.0	0.2	0.8	179	6431	41	1493		3	88
5	2	CAS	1.5	75	373	0.8	4.0	0.1	0.4	27	135	3	14		0	73
54	9	GLD	16.0	125	6748	14.4	10.0	1.3	3.8	1392	75150	2401	129674		44	74
22	6	RUN	6.5	167	3683	7.9	7.0	0.8	4.2	636	13991	1130	24866		11	50
56	7	SRN	16.6	170	9539	20.3	4.0	0.3	1.0	269	15085	67	3779		14	84
1	1	TRP	0.3	18	18	0.0	11.0	0.8	1.8	198	198	198	198	158	10	84
23	22	MCP	6.8	86	1980	4.2	12.0	1.5	4.8	1437	33045	3823	87936	3513	16	60
2	2	STP	0.6	38	77	0.2	6.0	0.6	1.2	169	337	138	277	95	35	75
4	4	CRP	1.2	30	119	0.3	14.0	2.1	4.4	420	1681	1052	4210	1021	38	81
3	3	LSL	0.9	51	152	0.3	10.0	1.8	6.5	584	1752	2017	6050	1918	55	82
3	3	LSR	0.9	38	115	0.2	6.0	1.6	5.1	268	805	625	1875	506	65	86
1	1	LSBk	0.3	6	6	0.0	4.0	1.0	1.6	23	23	25	25	23	0	94
3	3	LSBo	0.9	17	52	0.1	5.0	0.6	1.6	86	258	61	182	49	22	81
18	18	PLP	5.3	13	237	0.5	8.0	0.6	2.0	99	1779	75	1349	62	24	88
51	0	DRY	15.1	275	14003	29.9										56
18	1	CUL	5.3	48	857	1.8	27.0	2.8	3.2	2700	48600	7560	136080		20	
3	0	NS	0.9	1249	3747	8.0										
1	0	MAR	0.3	151	151	0.3										
Total Units	Total Units Fully Measured				Total Length (ft.)					Total Area (sq.ft.)		Total Volume (cu.ft.)				
338	100				46879					213086		399689				

Table 3 - Summary of Pool Types

Stream Name: Lichau Creek

LLID: 1226762382742

Drainage: Petaluma River

Survey Dates: 6/20/2007 to 7/24/2007

Confluence Location: Quad: COTATI

Legal Description: T05NR07WS18

Latitude: 38:16:27.0N

Longitude: 122:40:34.0W

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
26	25	MAIN	45	80	2075	75	11.8	1.4	1286	33429	3105	80728	17
32	32	SCOUR	55	21	681	25	8.4	1.0	197	6297	395	12652	32
Total Units	Total Units Fully Measured				Total Length (ft.)					Total Area (sq.ft.)		Total Volume (cu.ft.)	
58	57				2756					39726		93380	

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

Stream Name: Lichau Creek

LLID: 1226762382742

Drainage: Petaluma River

Survey Dates: 6/20/2007 to 7/24/2007

Confluence Location: Quad: COTATI

Legal Description: T05NR07WS18

Latitude: 38:16:27.0N

Longitude: 122:40:34.0W

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
22	MCP	39	0	0	11	50	5	23	2	9	4	18
3	LSL	5	0	0	1	33	1	33	0	0	1	33
3	LSR	5	0	0	0	0	2	67	0	0	1	33
4	CRP	7	0	0	1	25	0	0	2	50	1	25
18	PLP	32	4	22	13	72	1	6	0	0	0	0
3	LSBo	5	0	0	3	100	0	0	0	0	0	0
1	TRP	2	0	0	1	100	0	0	0	0	0	0
2	STP	4	0	0	2	100	0	0	0	0	0	0
1	LSBk	2	0	0	1	100	0	0	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
57			4	7	33	58	9	16	4	7	7	12

Mean Maximum Residual Pool Depth (ft.): 2.1

Table 5 - Summary of Mean Percent Cover by Habitat Type

Stream Name:		Lichau Creek		LLID:		1226762382742		Drainage:		Petaluma River	
Survey Dates:		6/20/2007 to 7/24/2007		Dry Units:		51		Confluence Location:		Quad: COTATI	
Legal Description:		T05NR07WS18		Latitude:		38:16:27.0N		Longitude:		122:40:34.0W	
Habitat Units	Units Fully Measured	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
34	8	LGR	0	0	0	0	0	0	0	38	0
36	10	HGR	0	0	0	0	0	0	0	20	0
5	2	CAS	0	0	0	0	0	0	0	0	0
75	20	TOTAL RIFFLE	0	0	0	0	0	0	0	25	0
54	9	GLD	0	9	4	0	23	18	0	23	0
22	6	RUN	0	17	0	0	12	38	0	0	0
56	7	SRN	0	0	0	0	1	0	0	70	0
132	22	TOTAL FLAT	0	8	0	0	18	18	0	32	0
1	1	TRP	0	33	0	0	33	0	0	34	0
23	23	MCP	11	8	0	1	13	24	7	15	13
2	2	STP	0	0	0	0	8	0	10	83	0
4	4	CRP	18	0	1	48	13	21	0	0	0
3	3	LSL	20	27	13	0	7	0	0	33	0
3	3	LSR	28	7	5	58	0	2	0	0	0
1	1	LSBk	0	0	0	0	0	0	0	0	0
3	3	LSBo	0	0	0	0	0	0	0	67	33
18	18	PLP	12	5	4	4	2	3	4	67	0
58	58	TOTAL POOL	12	7	2	8	8	12	4	35	7
18	1	CUL	0	0	0	0	60	40	0	0	0
3	0	NS									
1	0	MAR									
338	101	TOTAL	7	6	2	4	8	11	2	32	4

Table 6 - Summary of Dominant Substrates by Habitat Type

Stream Name: Lichau Creek		LLID: 1226762382742		Drainage: Petaluma River					
Survey Dates: 6/20/2007 to 7/24/2007		Dry Units: 51							
Confluence Location: Quad: COTATI			Legal Description: T05NR07WS18			Latitude: 38:16:27.0N		Longitude: 122:40:34.0W	
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
34	8	LGR	25	0	25	13	38	0	0
36	10	HGR	0	0	30	10	30	20	10
5	2	CAS	0	0	0	0	0	100	0
54	9	GLD	78	0	22	0	0	0	0
22	6	RUN	50	17	0	33	0	0	0
56	7	SRN	29	0	14	29	14	14	0
1	1	TRP	0	100	0	0	0	0	0
23	23	MCP	57	17	17	4	0	0	4
2	2	STP	0	50	0	0	0	50	0
4	4	CRP	25	50	0	0	25	0	0
3	3	LSL	33	0	0	33	0	0	33
3	3	LSR	67	0	0	33	0	0	0
1	1	LSBk	0	0	0	0	0	100	0
3	3	LSBo	67	0	33	0	0	0	0
18	18	PLP	11	11	39	39	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Lichau Creek

LLID: 1226762382742

Drainage: Petaluma River

Survey Dates: 6/20/2007 to 7/24/2007

Confluence Location: Quad: COTATI

Legal Description: T05NR07WS18

Latitude: 38:16:27.0N

Longitude: 122:40:34.0W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
74	1	99	7	69	73

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.

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 11

Channel Type: A3	Canopy Density (%): 84.6	Pools by Stream Length (%): 5.8
Reach Length (ft.): 6066	Coniferous Component (%): 0.0	Pool Frequency (%): 25.0
Riffle/Flatwater Mean Width (ft.): 6.1	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Hardwood Trees	< 2 Feet Deep: 81.3
Range (ft.): 7 to 22	Vegetative Cover (%): 62.4	2 to 2.9 Feet Deep: 18.8
Mean (ft.): 14.41	Dominant Shelter: Boulders	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 5.59	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0.0
Base Flow (cfs): 0	Occurrence of LWD (%): 1.0	Mean Max Residual Pool Depth (ft.): 1.41
Water (F): 57 - 62	Air (F): 64 - 73	LWD per 100 ft.:
Dry Channel (ft.): 172		Riffles: 1
		Pools: 1
		Flat: 0
Pool Tail Substrate (%): Silt/Clay: 0.0	Sand: 0.0	Gravel: 18.8
	Sm Cobble: 50.0	Lg Cobble: 18.8
	Boulder: 12.5	Bedrock: 0.0
Embeddedness Values (%):	1. 31.3	2. 31.3
	3. 25.0	4. 0.0
	5. 12.5	

STREAM REACH: 12

Channel Type: NA	Canopy Density (%):	Pools by Stream Length (%):
Reach Length (ft.): 238	Coniferous Component (%):	Pool Frequency (%):
Riffle/Flatwater Mean Width (ft.):	Hardwood Component (%):	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.):	Vegetative Cover (%):	2 to 2.9 Feet Deep:
Mean (ft.):	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.:	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs):	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F):	Air (F):	LWD per 100 ft.:
Dry Channel (ft.):		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: 13

Channel Type: A2	Canopy Density (%): 85.9	Pools by Stream Length (%): 2.2
Reach Length (ft.): 7442	Coniferous Component (%): 0.0	Pool Frequency (%): 20.0
Riffle/Flatwater Mean Width (ft.): 3.7	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Hardwood Trees	< 2 Feet Deep: 100.0
Range (ft.): 11 to 19	Vegetative Cover (%): 64.2	2 to 2.9 Feet Deep: 0.0
Mean (ft.): 15.05	Dominant Shelter: Boulders	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 3.17	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0.0
Base Flow (cfs): 0	Occurrence of LWD (%): 1.8	Mean Max Residual Pool Depth (ft.): 1.25
Water (F): 59 - 66	Air (F): 67 - 73	LWD per 100 ft.:
Dry Channel (ft.): 902	Riffles: 3	Mean Pool Shelter Rating: 19
	Pools: 3	
	Flat: 1	
Pool Tail Substrate (%): Silt/Clay: 0.0	Sand: 0.0	Gravel: 41.7
Embeddedness Values (%):	Sm Cobble: 33.3	Lg Cobble: 8.3
	Boulder: 16.7	Bedrock: 0.0
	1. 50.0	2. 16.7
	3. 8.3	4. 0.0
	5. 25.0	

STREAM REACH: 2

Channel Type: E6	Canopy Density (%): 52.0	Pools by Stream Length (%): 18.4
Reach Length (ft.): 1220	Coniferous Component (%): 30.0	Pool Frequency (%): 16.7
Riffle/Flatwater Mean Width (ft.): 11.0	Hardwood Component (%): 70.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Brush	< 2 Feet Deep:
Range (ft.): 13 to 13	Vegetative Cover (%): 88.8	2 to 2.9 Feet Deep:
Mean (ft.): 13	Dominant Shelter: Aquatic Vegetation	3 to 3.9 Feet Deep:
Std. Dev.: 0	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep:
Base Flow (cfs): 0	Occurrence of LWD (%): 0.0	Mean Max Residual Pool Depth (ft.):
Water (F): 64 - 64	Air (F): 68 - 68	LWD per 100 ft.:
Dry Channel (ft.): 864	Riffles:	Mean Pool Shelter Rating: 20
	Pools: 0	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay: 100.	Sand: 0.0	Gravel: 0.0
Embeddedness Values (%):	Sm Cobble: 0.0	Lg Cobble: 0.0
	Boulder: 0.0	Bedrock: 0.0
	1. 0.0	2. 0.0
	3. 0.0	4. 0.0
	5. 100.0	

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 3

Channel Type: F6	Canopy Density (%):	Pools by Stream Length (%): 0.0
Reach Length (ft.): 2389	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.): 13 to 13	Vegetative Cover (%): 0.0	2 to 2.9 Feet Deep:
Mean (ft.): 13	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.: 0	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs): 0	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): 64 - 64 Air (F): 68 - 68	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft.): 0	Riffles:	
	Pools:	
	Flat: 0	
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: NA	Canopy Density (%):	Pools by Stream Length (%):
Reach Length (ft.): 876	Coniferous Component (%):	Pool Frequency (%):
Riffle/Flatwater Mean Width (ft.):	Hardwood Component (%):	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.): to	Vegetative Cover (%):	2 to 2.9 Feet Deep:
Mean (ft.):	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.:	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs):	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): Air (F):	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft.):	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: 5

Channel Type: F6	Canopy Density (%): 73.2	Pools by Stream Length (%): 11.5
Reach Length (ft.): 9910	Coniferous Component (%): 0.0	Pool Frequency (%): 16.5
Riffle/Flatwater Mean Width (ft.): 10.7	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Brush	< 2 Feet Deep: 13.3
Range (ft.): 11 to 42	Vegetative Cover (%): 76.4	2 to 2.9 Feet Deep: 20.0
Mean (ft.): 18.97	Dominant Shelter: Undercut Banks	3 to 3.9 Feet Deep: 20.0
Std. Dev.: 8.347	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 46.7
Base Flow (cfs): 0	Occurrence of LWD (%): 4.2	Mean Max Residual Pool Depth (ft.): 3.65
Water (F): 58 - 64	Air (F): 58 - 77	LWD per 100 ft.:
Dry Channel (ft.): 2348	Riffles: 0	Mean Pool Shelter Rating: 35
	Pools: 1	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay: 66.7	Sand: 13.3	Gravel: 13.3
Embeddedness Values (%):	Sm Cobble: 0.0	Lg Cobble: 0.0
	Boulder: 0.0	Bedrock: 6.7
	1. 0.0	2. 0.0
	3. 6.7	4. 13.3
	5. 80.0	

STREAM REACH: 6

Channel Type: F4	Canopy Density (%): 89.0	Pools by Stream Length (%): 0.0
Reach Length (ft.): 1834	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.): 15 to 19	Vegetative Cover (%): 0.0	2 to 2.9 Feet Deep:
Mean (ft.): 17.4	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.: 1.96	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs): 0	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): 62 - 65	Air (F): 73 - 77	LWD per 100 ft.:
Dry Channel (ft.): 1789	Riffles:	Mean Pool Shelter Rating:
	Pools:	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay:	Sand:	Gravel:
Embeddedness Values (%):	Sm Cobble:	Lg Cobble:
	Boulder:	Bedrock:
	1.	2.
	3.	4.
	5.	

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 7

Channel Type: NA	Canopy Density (%):	Pools by Stream Length (%):
Reach Length (ft.): 2633	Coniferous Component (%):	Pool Frequency (%):
Riffle/Flatwater Mean Width (ft.):	Hardwood Component (%):	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.): to	Vegetative Cover (%):	2 to 2.9 Feet Deep:
Mean (ft.):	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.:	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs):	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): Air (F):	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft.):	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: 8

Channel Type: F4	Canopy Density (%): 41.7	Pools by Stream Length (%): 0.0
Reach Length (ft.): 3304	Coniferous Component (%): 0.0	Pool Frequency (%): 0.0
Riffle/Flatwater Mean Width (ft.): 7.5	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Grass	< 2 Feet Deep:
Range (ft.): 7 to 19	Vegetative Cover (%): 82.5	2 to 2.9 Feet Deep:
Mean (ft.): 14.5	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.: 5.81	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep:
Base Flow (cfs): 0	Occurrence of LWD (%): 0.0	Mean Max Residual Pool Depth (ft.):
Water (F): 60 - 61 Air (F): 57 - 60	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft.): 2870	Riffles:	
	Pools:	
	Flat: 0	
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: 9

Channel Type: E3	Canopy Density (%): 67.2	Pools by Stream Length (%): 0.4
Reach Length (ft.): 7036	Coniferous Component (%): 0.0	Pool Frequency (%): 5.6
Riffle/Flatwater Mean Width (ft.): 4.2	Hardwood Component (%): 100.0	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Grass	< 2 Feet Deep: 100.0
Range (ft.): 7 to 12	Vegetative Cover (%): 74.4	2 to 2.9 Feet Deep: 0.0
Mean (ft.): 10.72	Dominant Shelter: Boulders	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 1.37	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0.0
Base Flow (cfs): 0	Occurrence of LWD (%): 0.0	Mean Max Residual Pool Depth (ft.): 1.6
Water (F): 59 - 64	Air (F): 60 - 75	LWD per 100 ft.:
Dry Channel (ft.): 4782	Riffles: 0	Mean Pool Shelter Rating: 48
	Pools: 0	
	Flat: 0	
Pool Tail Substrate (%): Silt/Clay: 0.0	Sand: 0.0	Gravel: 50.0
	Sm Cobble: 50.0	Lg Cobble: 0.0
	Boulder: 0.0	Bedrock: 0.0
Embeddedness Values (%):	1. 100.0	2. 0.0
	3. 0.0	4. 0.0
	5. 0.0	

Table 9 -Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Lichau Creek **LLID:** 1226762382742 **Drainage:** Petaluma River
Survey Dates: 6/20/2007 to 7/24/2007
Confluence Location: Quad: COTATI **Legal Description:** T05NR07WS18 **Latitude:** 38:16:27.0N **Longitude:** 122:40:34.0W

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	5	1	3.0
Boulder	3	5	4.0
Cobble/Gravel	9	7	8.0
Sand/Silt/Clay	83	87	85.0

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	27	23	25.0
Brush	35	38	36.5
Hardwood Trees	38	39	38.5
Coniferous Trees	0	0	0.0
No Vegetation	0	0	0.0

Total Stream Cobble Embeddedness Values: 3

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

Stream Name: Lichau Creek

LLID: 1226762382742

Drainage: Petaluma River

Survey Dates: 6/20/2007 to 7/24/2007

Confluence Location: Quad: COTATI

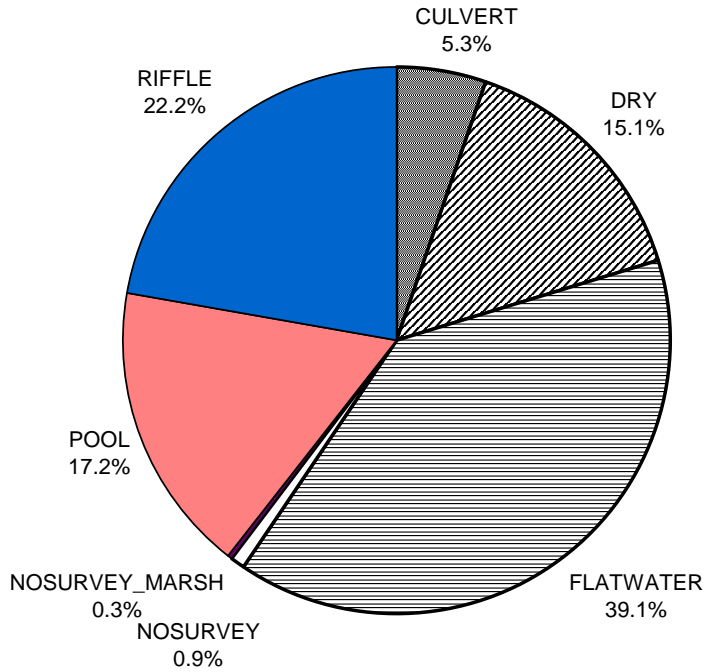
Legal Description: T05NR07WS18

Latitude: 38:16:27.0N

Longitude: 122:40:34.0W

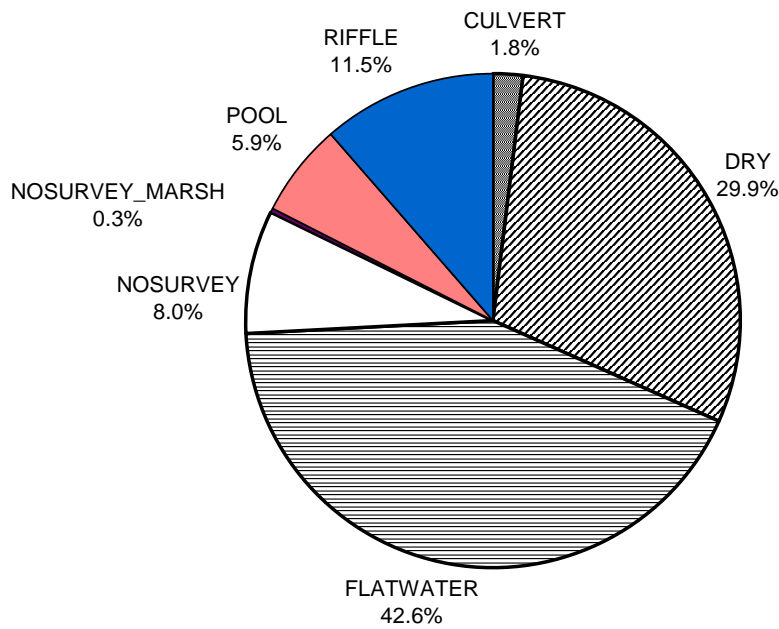
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	0	12
SMALL WOODY DEBRIS (%)	0	8	7
LARGE WOODY DEBRIS (%)	0	2	2
ROOT MASS (%)	0	0	8
TERRESTRIAL VEGETATION (%)	0	13	8
AQUATIC VEGETATION (%)	0	18	12
WHITEWATER (%)	0	0	4
BOULDERS (%)	25	32	35
BEDROCK LEDGES (%)	0	0	7

LICHAU CREEK 2007 HABITAT TYPES BY PERCENT OCCURRENCE



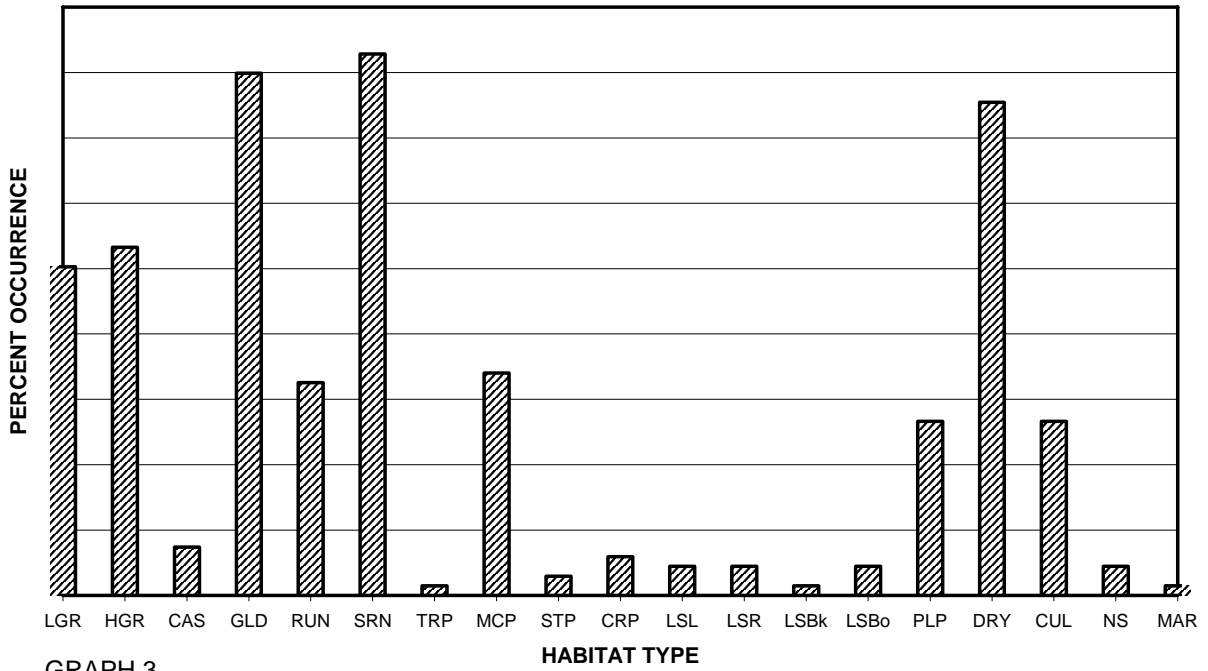
GRAPH 1

LICHAU CREEK 2007 HABITAT TYPES BY PERCENT TOTAL LENGTH

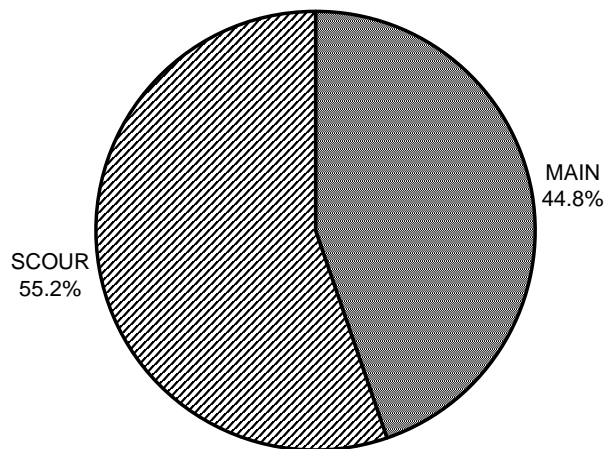


GRAPH 2

LICHAU CREEK 2007 HABITAT TYPES BY PERCENT OCCURRENCE

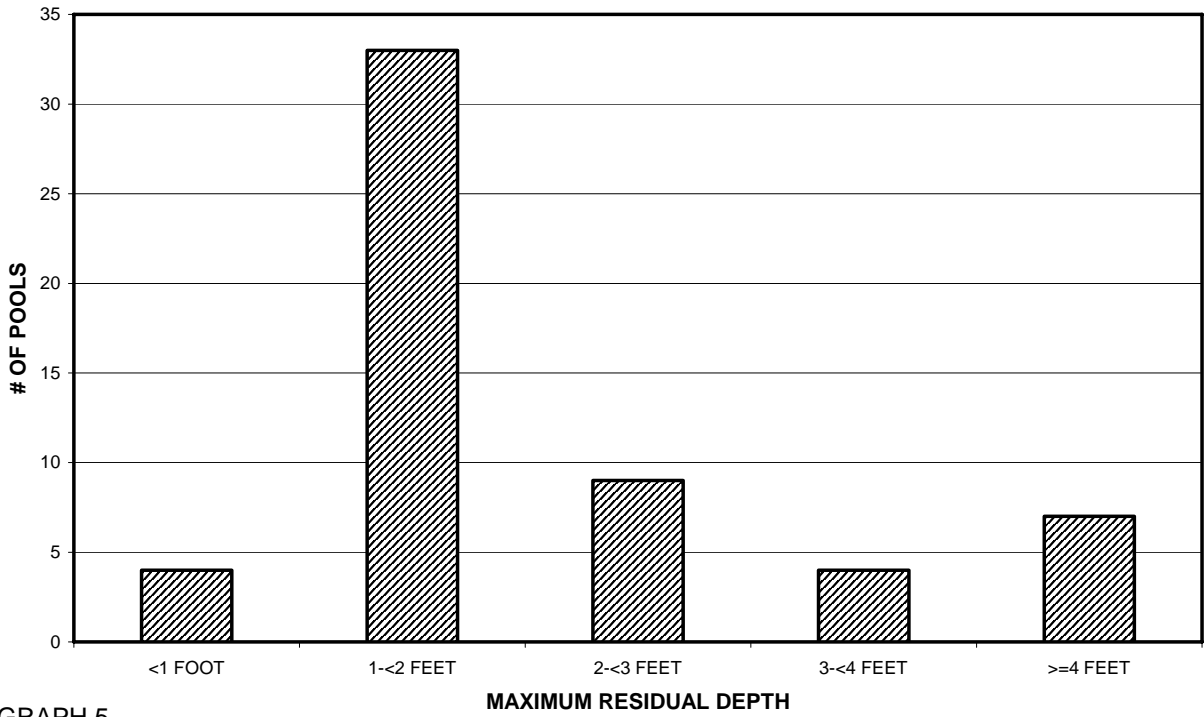


LICHAU CREEK 2007 POOL TYPES BY PERCENT OCCURRENCE



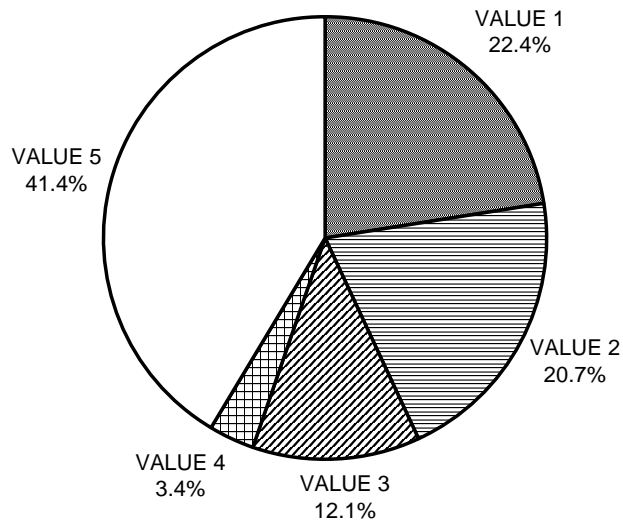
GRAPH 4

LICHAU CREEK 2007 MAXIMUM DEPTH IN POOLS



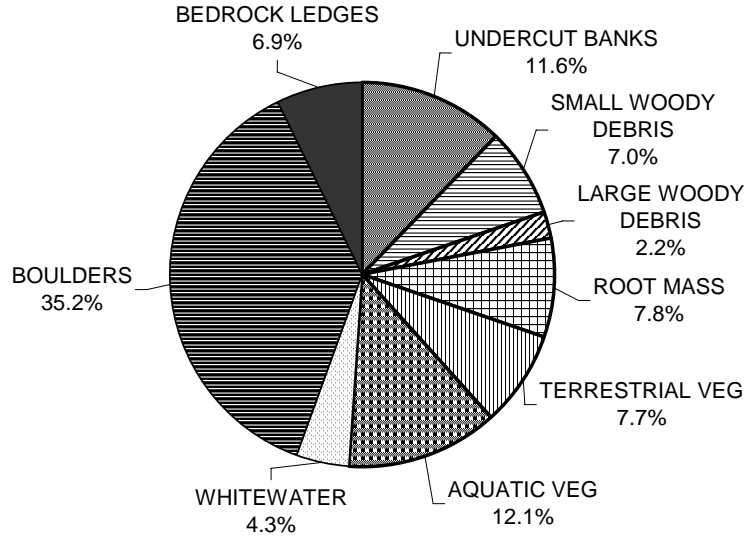
GRAPH 5

LICHAU CREEK 2007 PERCENT EMBEDDEDNESS



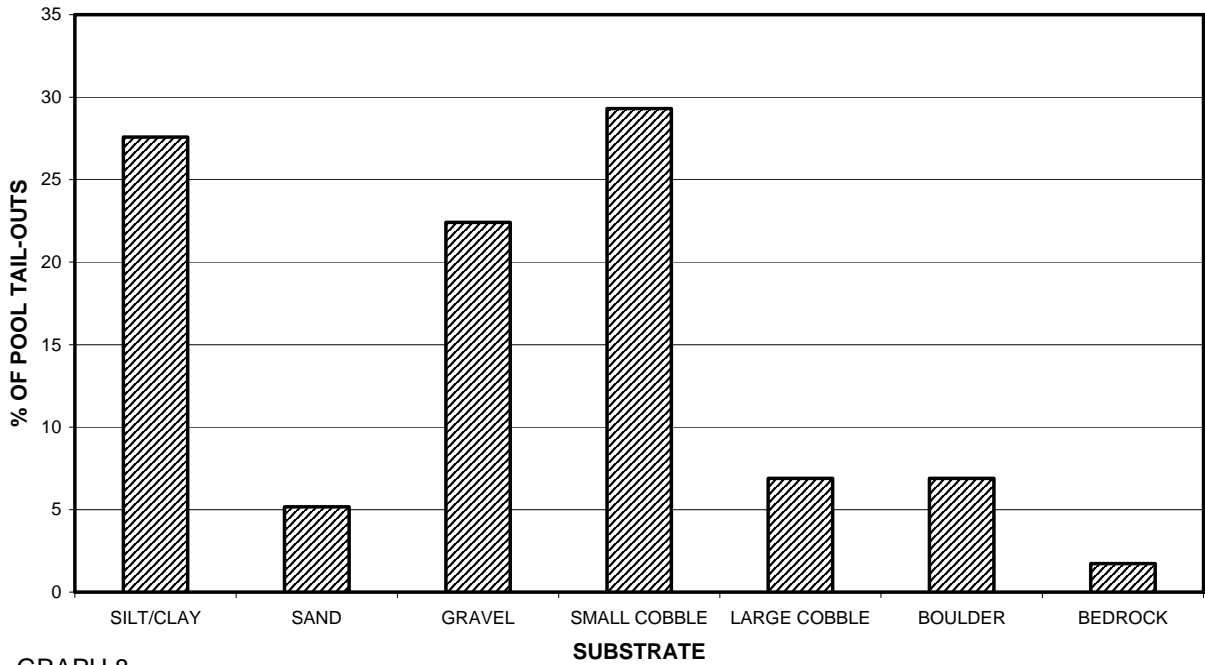
GRAPH 6

LICHAU CREEK 2007 MEAN PERCENT COVER TYPES IN POOLS



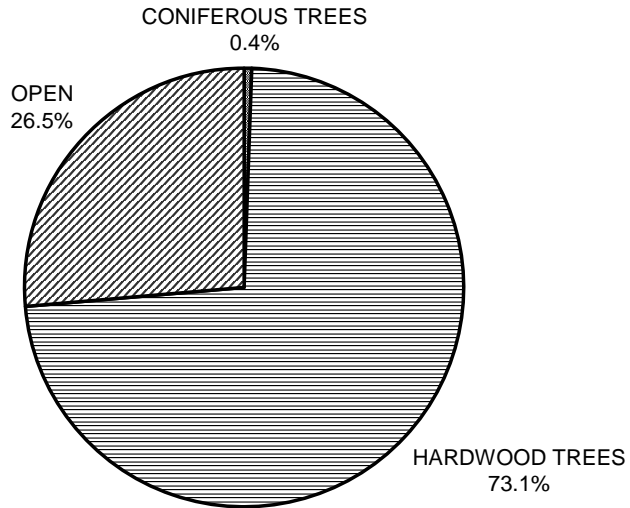
GRAPH 7

LICHAU CREEK 2007 SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



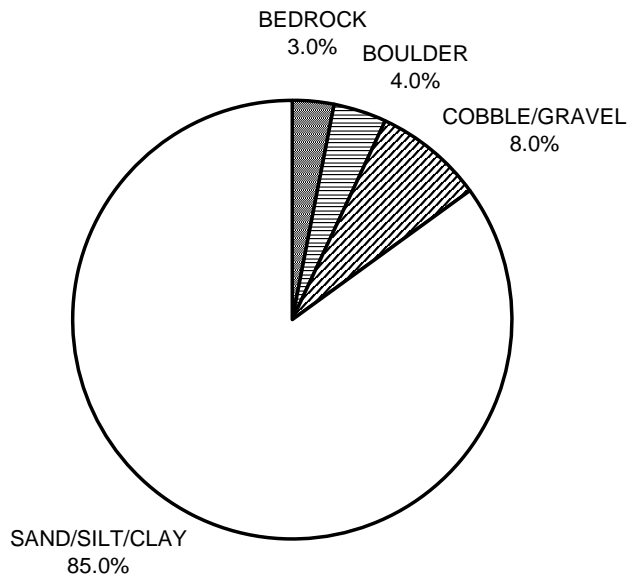
GRAPH 8

**LICHAU CREEK 2007
MEAN PERCENT CANOPY**



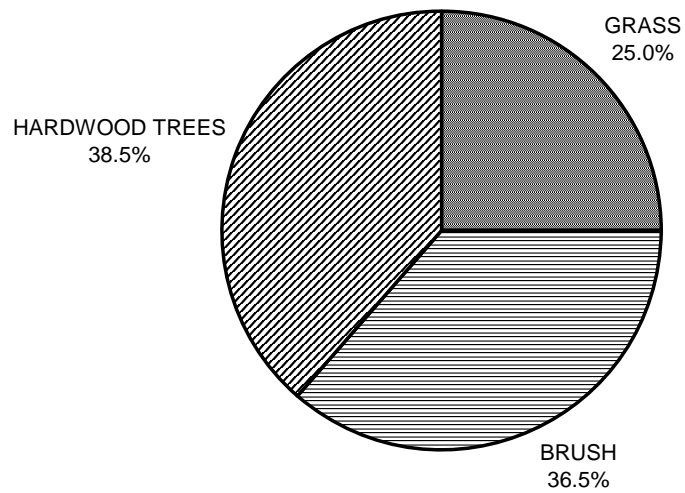
GRAPH 9

**LICHAU CREEK 2007
DOMINANT BANK COMPOSITION IN SURVEY REACH**



GRAPH 10

**LICHAU CREEK 2007
DOMINANT BANK VEGETATION IN SURVEY REACH**



GRAPH 11



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)

Willow Brook 2007

- 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.

Willow Brook 2007

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.

Willow Brook 2007

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

Willow Brook 2007

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.

Willow Brook 2007

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')

Willow Brook 2007

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.

Willow Brook 2007

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]	

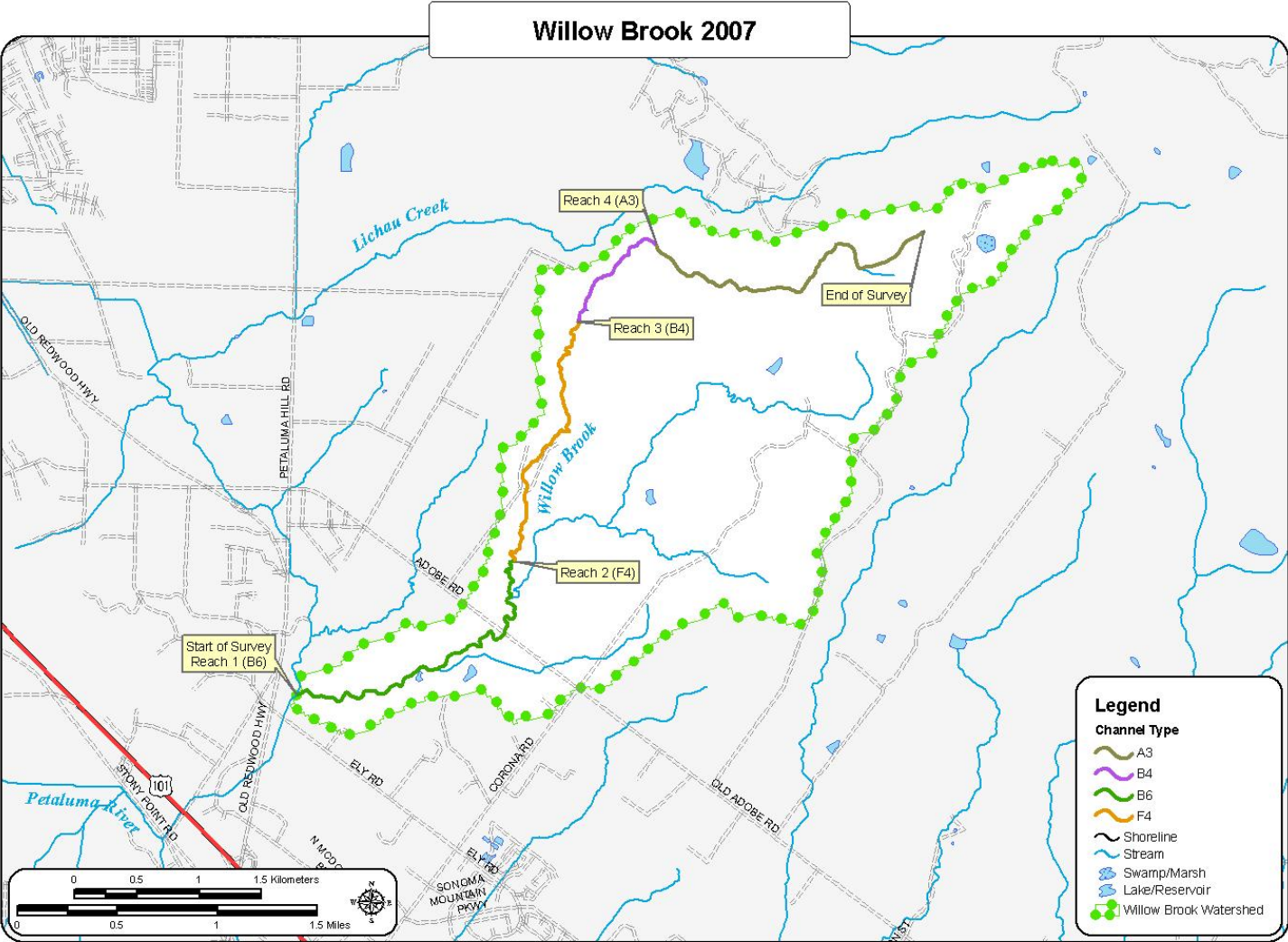


Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

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

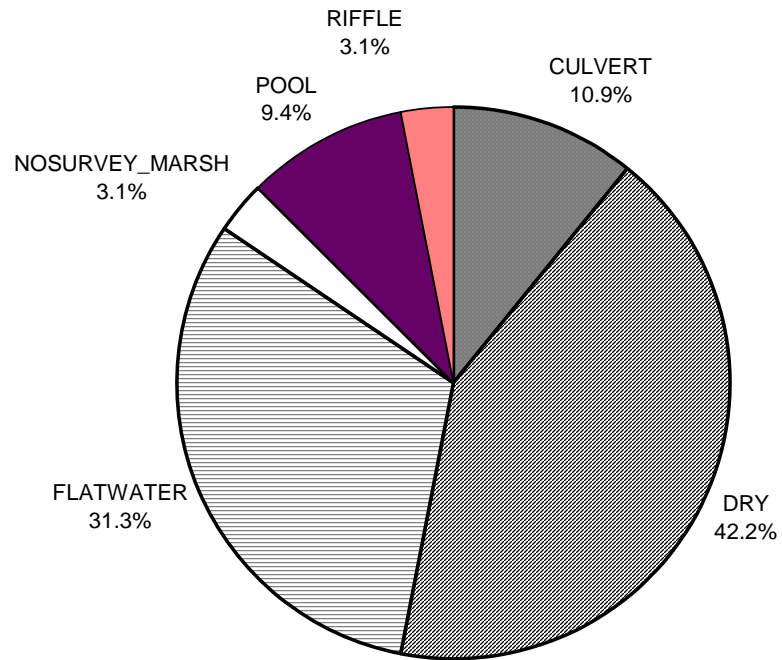
Legal Description: T005R007S07

Latitude: 38:17:06.0N

Longitude: 122:39:51.0W

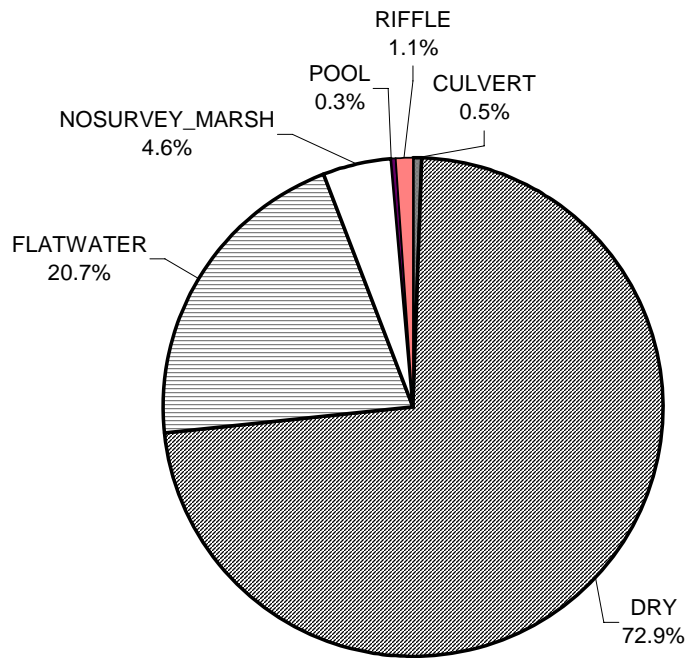
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	0	27
SMALL WOODY DEBRIS (%)	0	0	2
LARGE WOODY DEBRIS (%)	0	0	0
ROOT MASS (%)	0	0	0
TERRESTRIAL VEGETATION (%)	0	20	5
AQUATIC VEGETATION (%)	0	9	0
WHITEWATER (%)	0	0	0
BOULDERS (%)	0	14	50
BEDROCK LEDGES (%)	0	0	0

WILLOW BROOK 2007 HABITAT TYPES BY PERCENT OCCURRENCE



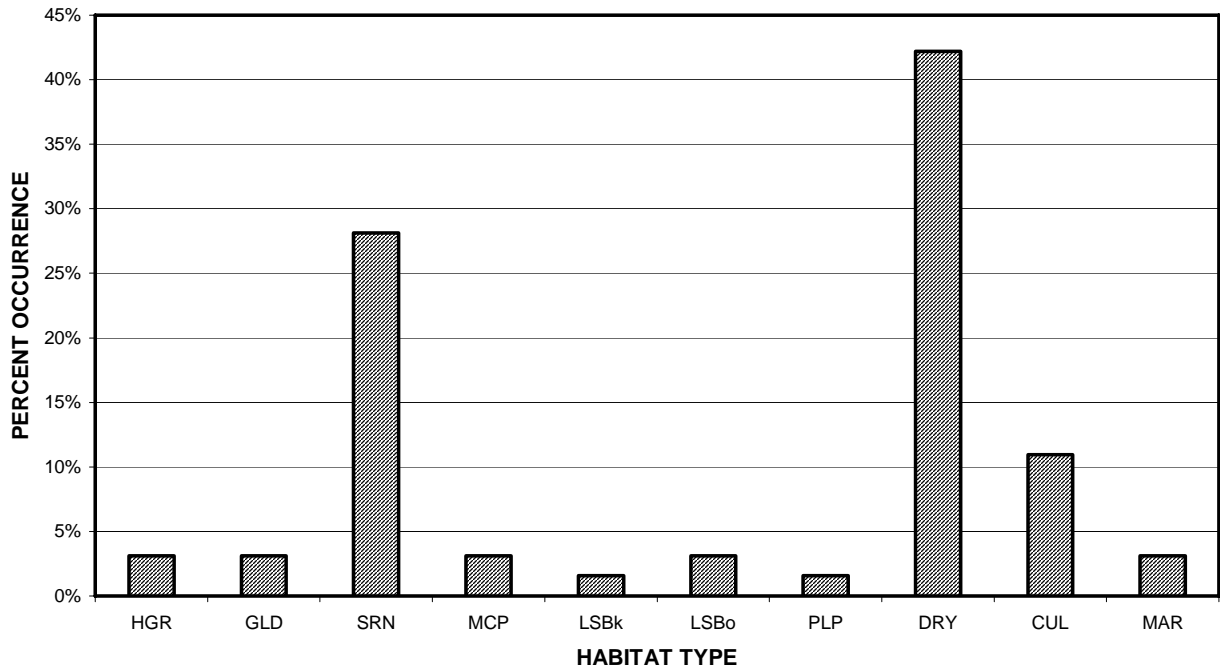
GRAPH 1

WILLOW BROOK 2007 HABITAT TYPES BY PERCENT TOTAL LENGTH



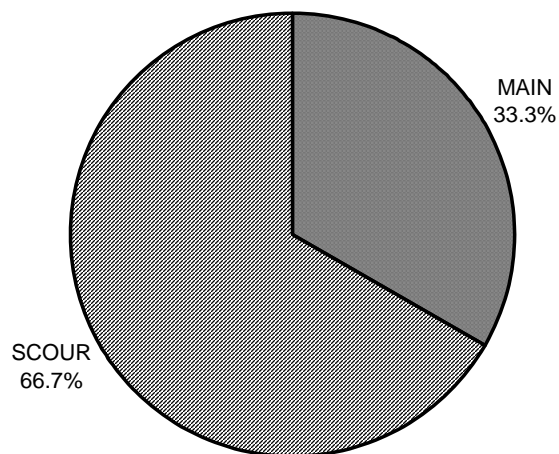
GRAPH 2

WILLOW BROOK 2007 HABITAT TYPES BY PERCENT OCCURRENCE



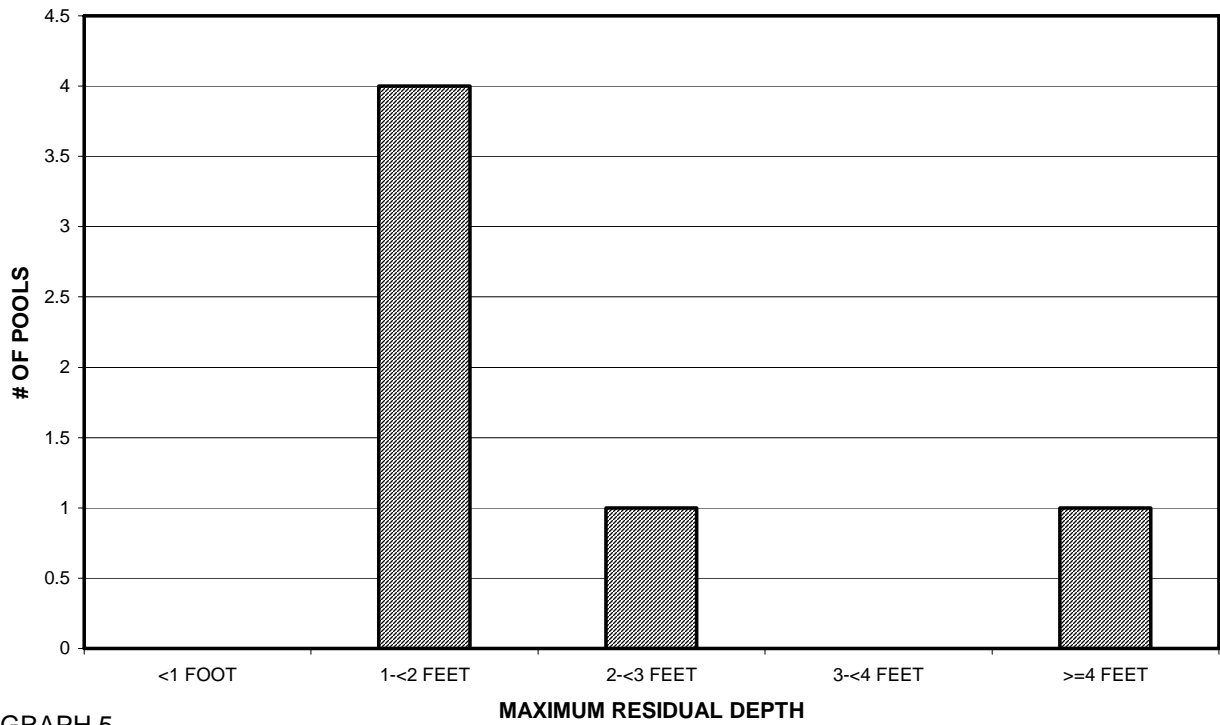
GRAPH 3

WILLOW BROOK 2007 POOL TYPES BY PERCENT OCCURRENCE



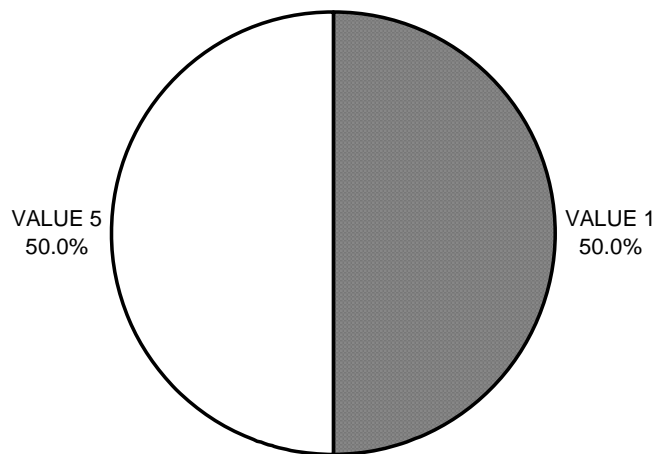
GRAPH 4

WILLOW BROOK 2007 MAXIMUM DEPTH IN POOLS



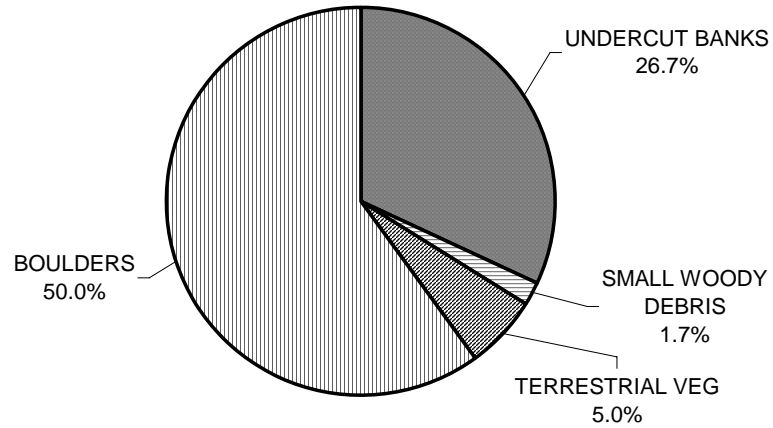
GRAPH 5

WILLOW BROOK 2007 PERCENT EMBEDDEDNESS



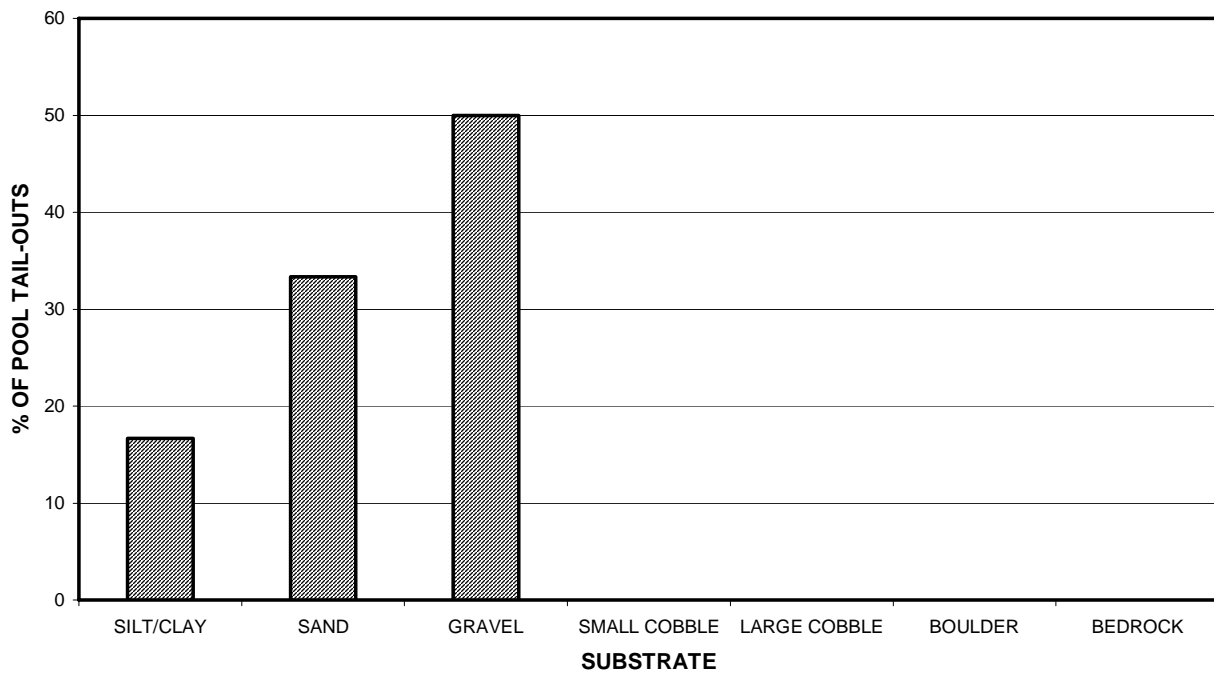
GRAPH 6

WILLOW BROOK 2007 MEAN PERCENT COVER TYPES IN POOLS



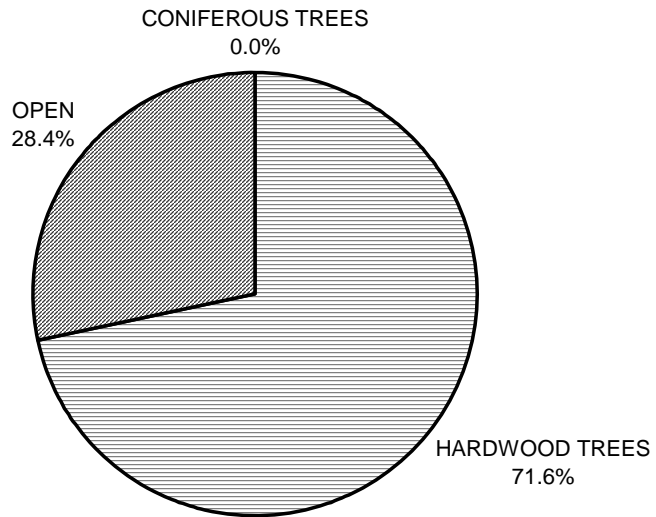
GRAPH 7

WILLOW BROOK 2007 SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



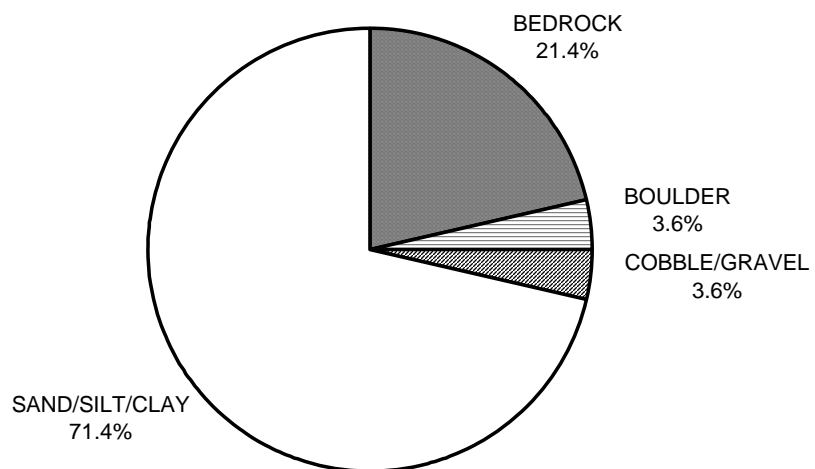
GRAPH 8

WILLOW BROOK 2007 MEAN PERCENT CANOPY



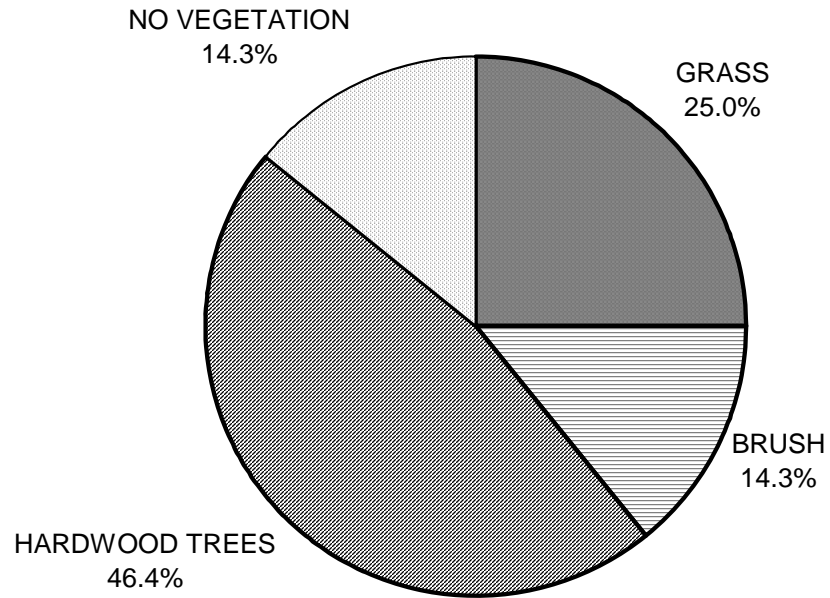
GRAPH 9

WILLOW BROOK 2007 DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 10

WILLOW BROOK 2007 DOMINANT BANK VEGETATION IN SURVEY REACH



GRAPH 11