Northern Napa River Tributary Streams Survey Report
May 2012

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Acknowledgments:
This report is the product of a joint effort by Napa County Resource Conservation District and Prunuske Chatham, Inc. We would like to thank the City of St. Helena for their generous support of the project. We also wish to acknowledge the residents of the Mill, Ritchey, Nash, Diamond Mountain, Blossom, Garnett, Simmons Canyon, and Selby Creek watersheds who generously provided access and to those landowners who provided valuable insight into the fisheries resources within the watersheds.

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1 INTRODUCTION

The northern portion of the Napa River contains some of the highest quality fisheries habitat within the watershed. Stream surveys of the eight most northerly streams, which represent a significant fraction of the overall existing and potential habitat within the basin, were completed to assess current steelhead populations within the watershed. Similar comprehensive stream surveys have been completed during the past 10 years within the southern and central portions of the Napa River watershed. In 2001, surveys were completed in the northern portion; however, they were limited in extent (NCRCD 2002). Inventories in the northern portion will complete the survey of current habitat conditions in all major tributaries and the mainstem of the Napa River. These stream survey results, in combination with the results of previous surveys, will allow resource managers to more fully understand the Napa River watershed steelhead populations and existing habitat conditions and to identify key locations for restoration and conservation actions. This study was funded by the City of St. Helena as part of an on-going mitigation settlement agreement with NOAA's National Marine Fisheries Service.

2 STUDY AREA

The study area includes eight tributaries in the northern portion of the Napa River watershed centered in and around the city of Calistoga. Blossom, Diamond Mountain, Nash, Ritchey, and Mill Creeks are located on the west side of the Napa Valley. These watersheds originate at the Sonoma-Napa County line. Blossom Creek flows from the Mayacamas Mountains into the Napa River at the upper boundary of Calistoga. Diamond Mountain, Nash, Ritchey, and Mill Creeks originate near Diamond Mountain and flow in an easterly direction towards the valley floor. On the east side of the valley are Garnett, Simmons Canyon, and Selby Creeks. Garnett Creek originates in The Palisades and Selby Creek along Rattlesnake Ridge through Dutch Henry Canyon. Nestled between Garnett and Selby is the Simmons Canyon Creek watershed.

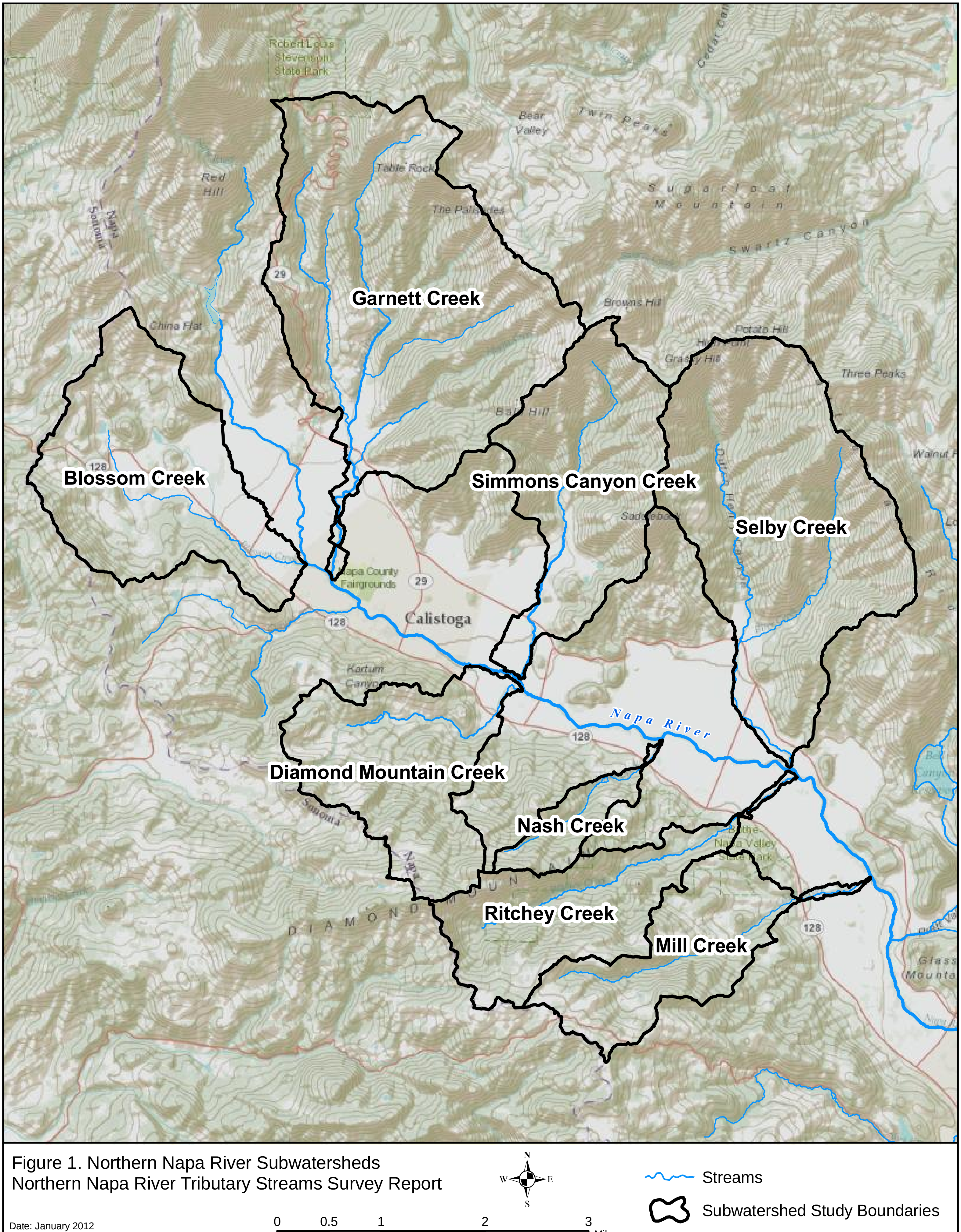

Figure 1. Northern Napa River Subwatersheds
Northern Napa River Tributary Streams Survey Report

Date: January 2012
Basemaps: ArcOnline Terrain

3 Methods

The following section includes a discussion of the landowner outreach completed prior to initiating field surveys and a description of the approaches used to collect and analyze fisheries habitat data on the eight target watersheds.

3.1 Landowner Outreach

Prior to beginning fieldwork, permission for property access was obtained from willing landowners along each stream. A cover letter outlining the goals of the project was sent to each landowner along with an access agreement beginning in summer 2010. Once sufficient access was obtained, the stream surveys were initiated in summer 2011. Letters were sent to owners of 227 parcels within the eight watersheds. Access was granted to 155 parcels. Only one watershed, Nash Creek, could not be fully evaluated due to insufficient access.

3.2 Methods

The habitat inventories were conducted in accordance with methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998)[1]. The inventories were conducted by a two-person team trained in standardized habitat inventory methods by the California Department of Fish and Game (CDFG). Jonathan Koehler from Napa County Resource Conservation District (NCRCD) led all of the habitat inventories. Paul Blank (NCRCD) or Jennifer Michaud (Prunuske Chatham, Inc.; PCI) assisted with the surveys.

The inventory uses a method that fully 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. 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. Pools are measured more frequently than other habitat units; approximately every third pool encountered is measured. Additional characteristics, such as flow, temperatures, vegetation community, in-stream habitat, and large woody debris, are also evaluated. Dry sections of stream bed are excluded from the inventory.

Initially, reconnaissance surveys were to be conducted on Blossom, Nash, and Diamond Mountain Creeks to identify fish resources. During 2011, reconnaissance survey methods consisted of stream bank observations. Underwater observations were not used as originally proposed due the lack of adequate water depths and/or dry stream bed conditions. Fish observations and resource potential within the watershed are described in the *Fisheries Resources and Field Observations* sections that follow.

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[1] Portions of this work plan appear verbatim from the California Salmonid Stream Habitat Restoration Manual (CDFG 1998).

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*. Methodology for the habitat inventory is based on a system developed by P.A. Bisson, et al. (1982) and refined by CDFG for use in California stream. This methodology was used for all stream surveys evaluated during this study to record measurements and observations. Ten components were collected for each of the streams surveyed. In addition to the following components, representative photographs were taken. GPS coordinates were taken at major obstacles and to demarcate the beginning and ending points of the survey. All of the data have been incorporated into a GIS layer and are available upon request.

1. Flow: Flow was visually estimated in cubic feet per second (cfs).

2. Temperatures: Both water and air temperatures were measured and recorded at every tenth habitat unit. The time of the measurement was also recorded. Both temperatures were taken in degrees Fahrenheit (F) at the middle of the habitat unit and within one foot of the water surface.

3. Habitat Type: Habitat typing uses the 24 habitat classification types (Type IV) defined by McCain et al. (1988). Habitat units were described according to location, orientation, and water flow. The attributes distinguishing the various habitat types include over-all channel gradient, velocity, depth, substrate, and the channel features responsible for the unit's formation. Channel dimensions were measured using tape measures and stadia rods. All measurements are in feet to the nearest tenth. Habitat type abbreviations, codes, and descriptions are provided in Appendix 1.

4. Embeddedness: The depth of embeddedness of the cobbles in pool tail-out reaches was measured by the percent of the cobble that is surrounded or buried by fine sediment. Embeddedness is visually estimated. Methodology and assigned values are based on protocols developed by CDFG and are standard for California streams. 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 particle size, presence of a bedrock tail-out, or other considerations.

5. Shelter Rating: In-stream shelter is composed of those elements within a stream channel that provide 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. 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 was made. All cover was then classified according to a list of 9 cover types. 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.

6. 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 visually estimated using a list of 7 size classes and recorded as a 1 and 2, respectively.

7. Canopy: Stream canopy density was estimated using a handheld spherical densiometer. Canopy density relates to the amount of stream shaded from the sun. An estimate of the percentage of the habitat unit covered by canopy was made from the end 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 visually into percentages of coniferous or deciduous trees.

8. Bank Composition and Vegetation: Bank composition elements range from bedrock to bare soil. These factors influence the ability of stream banks to withstand winter flows. The dominant composition type and the dominant vegetation type of both the right and left banks for each fully described unit that is selected from the habitat inventory form were described. Bank composition types included bedrock, boulder, cobble/gravel, and silt/clay/sand. Bank composition was measured from the existing water surface elevation to bankfull height. Additionally, the percent of each bank covered by vegetation was estimated and recorded. Bank vegetation types included grass, brush (small shrubs and understory vegetation), deciduous trees, coniferous trees, and no vegetation. Bank vegetation is measured from bankfull height to top of bank.

9. Large Woody Debris: Large Woody Debris (LWD) is important in the development of a stream's morphology and productivity. Large pieces of wood influence the physical form on the channel, movement of sediment, retention of gravel, and composition of the biological community. In each fully measured habitat unit, all pieces of LWD partially or entirely below the elevation of the bankfull discharge were counted and recorded. LWD is defined as a piece of wood having a minimum diameter of 12 inches and a minimum length of 6 feet. Rootwads were also classified.

10. 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 (10 habitat units), bankfull width was measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

Data Analysis

Data from the habitat inventory forms were 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. Tables for each stream inventoried are provided in Appendix 2.

- Table 1. Riffle, Flatwater, and Pool Habitat Types
- Table 2. Habitat Types and Measured Parameters
- Table 3. Pool Types
- Table 4. Maximum Residual Pool Depths by Pool
- Table 5. Mean Percent Cover by Habitat Type
- Table 6. Dominant Substrates by Habitat Type
- Table 7. Mean Percent Canopy for Entire Stream
- Table 8. Fish Habitat Inventory Data Summary by Stream Reach
- Table 9. Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Table 10. Mean Percent Shelter Cover Types for Entire Stream

Graphics are produced from the above-mentioned tables using Microsoft Excel. The following graphics were developed for each stream inventoried and are provided in the appropriate sections that follow:

- Graph 1. Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
- Graph 2. Riffle, Flatwater, Pool Habitat Types by Percent Total Length
- Graph 3. Total Habitat Types by Percent Occurrence
- Graph 4. Pool Types by Percent Occurrence
- Graph 5. Maximum Residual Depth in Pools
- Graph 6. Percent Embeddedness
- Graph 7. Mean Percent Cover Types in Pools
- Graph 8. Substrate Composition in Pool Tail-outs
- Graph 9. Mean Percent Canopy
- Graph 10. Dominant Bank Composition in Survey Reach
- Graph 11. Dominant Bank Vegetation in Survey Reach

4 STREAM SURVEY RESULTS

The following stream survey results are provided for the eight target watersheds – Mill, Ritchey, Nash, Diamond Mountain, Blossom, Garnett, Simmons Canyon, and Selby Creek. A brief overview of the watershed, historical fisheries data and field observations, results, and discussion are provided for each watershed. Graphics and representative photos are also included in each section. Detailed habitat inventory data tables are provided in Appendix 2.

4.1 MILL CREEK WATERSHED

Overview

Mill Creek flows into the Napa River south of Calistoga, Napa County, California. Mill Creek's location at the confluence with the Napa River is 38:32:39.0 north latitude and 122:29:42.0 west longitude, LLID number 1224951385441. It is mapped on the Calistoga USGS Quadrangle. Mill Creek is a second order stream and drains a watershed of approximately 2.2 square miles. Elevations range from approximately 240 feet at the confluence with the Napa River to 1,400 feet in the headwater areas. Mixed hardwood/mixed conifer forest dominates the watershed. Mill Creek flows through Bale Grist Mill State Historic Park upstream of Highway 29. Lower Mill Creek and surrounding lands are privately held. Vehicle access exists via Highway 29 between Calistoga and St. Helena.

Fisheries Resources and Field Observations

According to Leidy et al. (2005), there is a history of steelhead observations within the watershed. In 1965, 1966, and 1978, visual surveys of the watershed by CDFG noted steelhead in most of the stream reaches where water was present. In 2001 and 2002, surveys completed by Ecotrust and Friends of the Napa River (FONR) found steelhead in numerous Mill Creek reaches in varying densities (Ecotrust and FONR 2001 and 2002).

During the 2011 habitat inventory of Mill Creek, several steelhead/rainbow trout were observed scattered throughout the middle and upper reaches of the watershed. Most of these fish averaged 3 to 6 inches in length. In addition to steelhead/rainbow trout, signal crayfish and adult, non-native American bullfrog were observed.

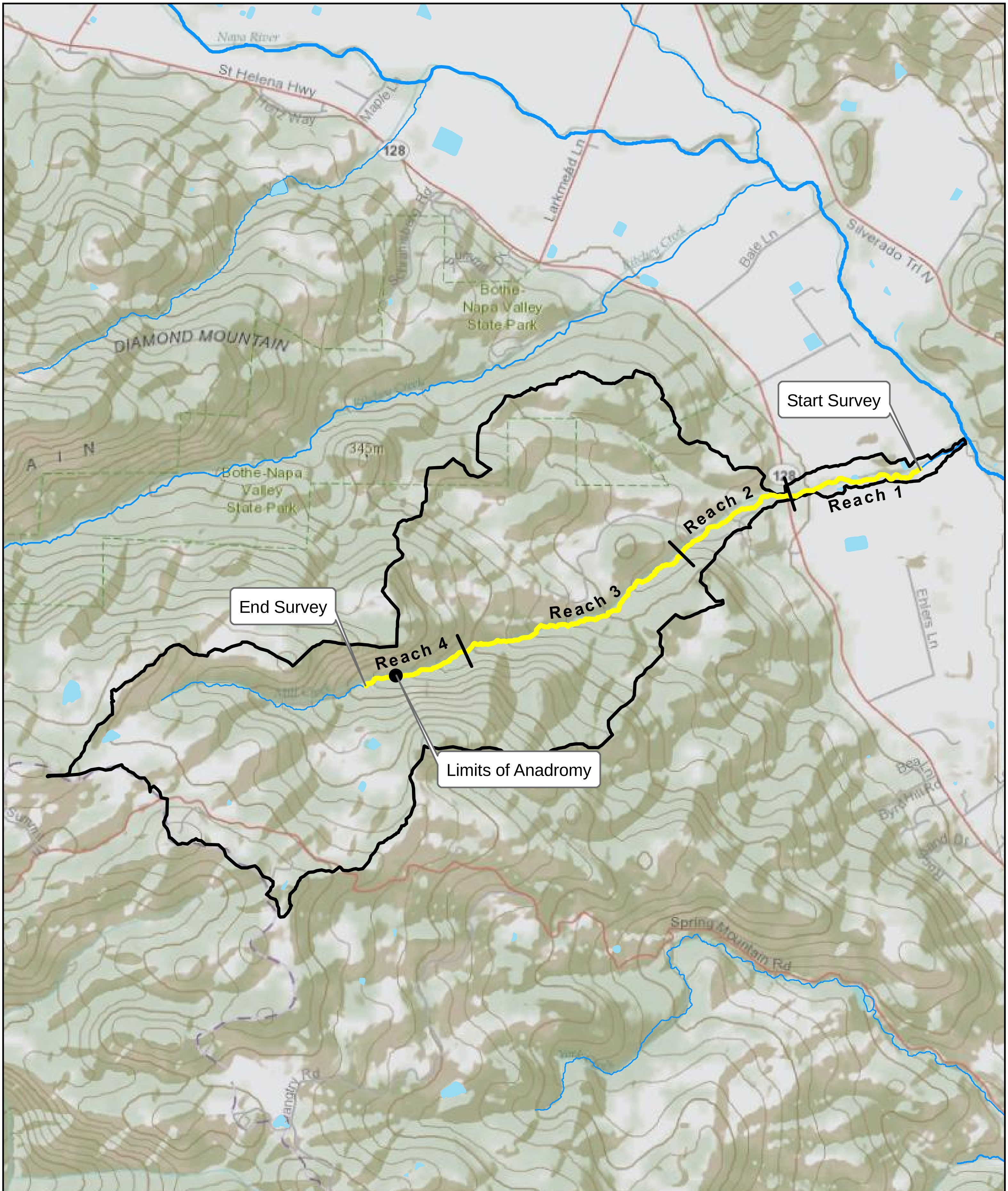

Figure 2. Mill Creek Watershed
Northern Napa River Tributary Streams Survey Report

Date: January 2012
Basemaps: ArcOnline Terrain

0 0.25 0.5 1 Miles

N S E W

Streams
Watershed Boundary
Mill Creek Survey

Habitat Inventory Results

The habitat inventory of Mill Creek was conducted on July 29, August 2, and August 9, 2011. The survey began at the confluence with the Napa River and extended upstream to the limits of anadromy. The total length of the stream surveyed was 13,763 feet (2.6 miles) with an additional 29 feet of side channel. Photos of the existing conditions are provided below (see Photos 4.1a to 4.1f).

Stream flow was visually estimated to be approximately 0.5 to 1 cfs during the survey period. Water temperatures taken during the survey period ranged from 56 to 63° F. Air temperatures ranged from 63 to 78° F.

Mill Creek was divided into 4 reaches. Reach 1 extended from the confluence with the Napa River to the Highway 29 crossing for 3,085 feet. Reach 2 extended from Highway 29 to the first major road crossing within Bale Grist Mill State Historic Park for 2,658 feet. Reaches 3 and 4 were 5,733 feet and 2,287 feet, respectively. Channel characteristic breaks were used to differentiate between Reaches 3 and 4.

Table 1 summarizes the Level II[2] riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 32% pool units, 39% riffle units, and 28% flatwater units, (Table 1; Graph 1). Based on total length of Level II habitat types, there were 14% pool units, 47% riffle units, and 39% flatwater units (Graph 2).

In total, 15 Level IV[3] habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were Mid-Channel Pool units (14%), Low Gradient Riffle units (17%), Step Run units (17%), and High Gradient Riffle units (15%) (Graph 3). Based on percent total length, the most frequent habitat types were Low Gradient Riffle units (26%), Step Run units (33%), and High Gradient Riffle units (15%) (Table 2).

A total of 74 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 66%, and comprised 68% 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, and 5 of the 37 fully measured pools (14%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 38 pool tail-outs measured, 21 had a value of 1 (55%), 13 had a value of 2 (34%), 4 had a value of 5 (11%) (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.

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[2] Level II habitat types include riffles, flatwaters, and pools.

[3] Level IV habitat types are broken down into 24 classification types. Level IV habitat type abbreviations, codes, and descriptions are provided in Appendix 1.

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 35, flatwater habitat types had a mean shelter rating of 23, and pool habitats had a mean shelter rating of 58 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 55, Scour pools had a mean shelter rating of 60, and Backwater pools had a mean shelter rating of 90 (Table 3).

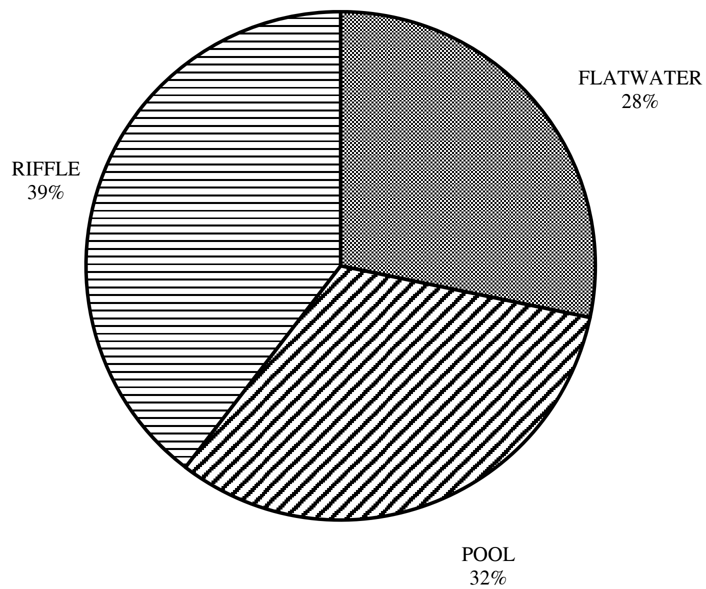
Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Mill Creek. Graph 7 describes the pool cover in Mill Creek. Boulders (52%) are the dominant pool cover type followed by root mass (22%) and whitewater (17%). Table 10 describes the shelter cover types for the entire system.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was observed in 37% of pool tail-outs, and small Cobble was observed in 45% of pool tail-outs.

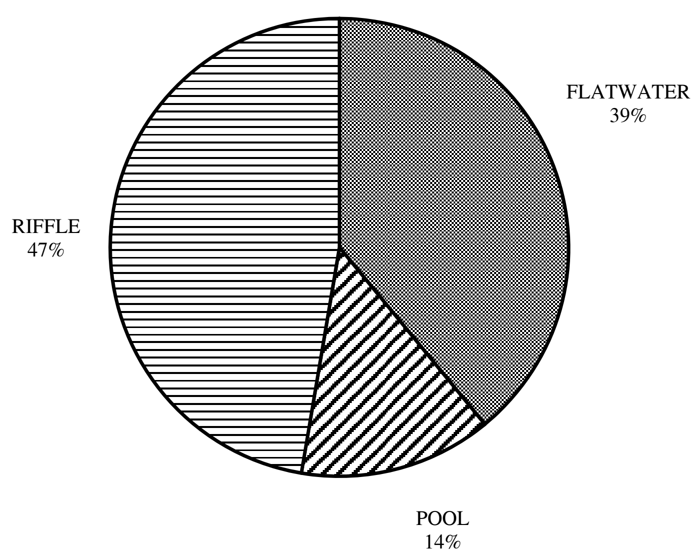
The mean percent canopy density for the surveyed length of Mill Creek was 87%. The mean percentages of hardwood and coniferous trees were 70% and 30%, respectively (Table 7). Thirteen percent of the canopy was open. Graph 9 describes the mean percent canopy in Mill Creek.

For the stream reaches surveyed, the mean percent right bank vegetated was 76%. The mean percent left bank vegetated was 78%. The structure of the stream banks consisted of 15% bedrock, 40% boulder, 34% cobble/gravel, and 11% sand/silt/clay (Table 9; Graph 10). Brush (small shrubs and understory vegetation) was the dominant vegetation type observed in 46% of the units surveyed. Additionally, 32% of the units surveyed had hardwood trees as the dominant vegetation type, and 13% had coniferous trees as the dominant vegetation (Table 9; Graph 11).

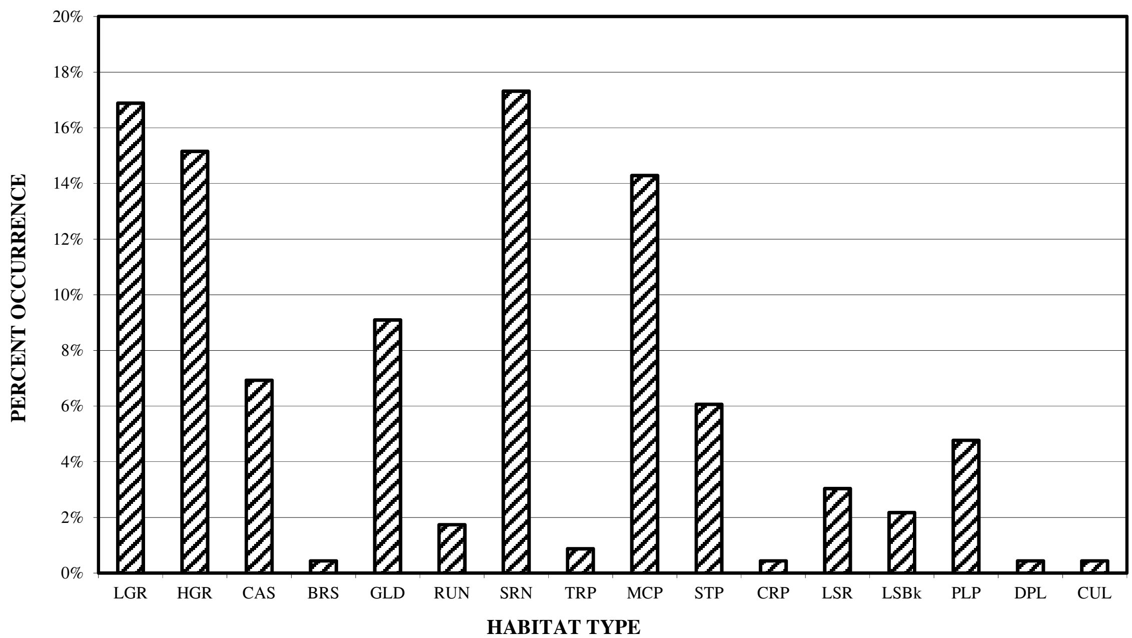
GRAPH 1 - MILL CREEK
HABITAT TYPES BY PERCENT OCCURRENCE



GRAPH 2 - MILL CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 3 - MILL CREEK
HABITAT TYPES BY PERCENT OCCURRENCE

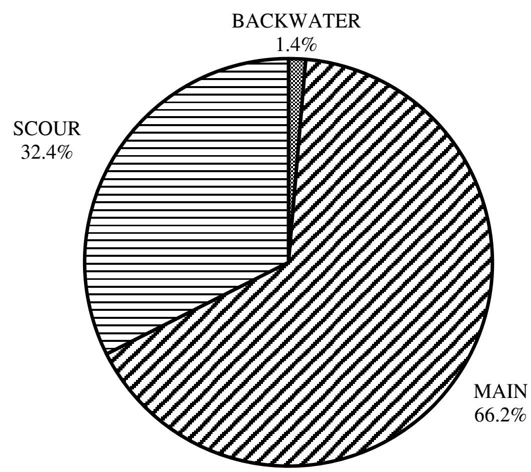


Level IV Habitat Types and Abbreviations

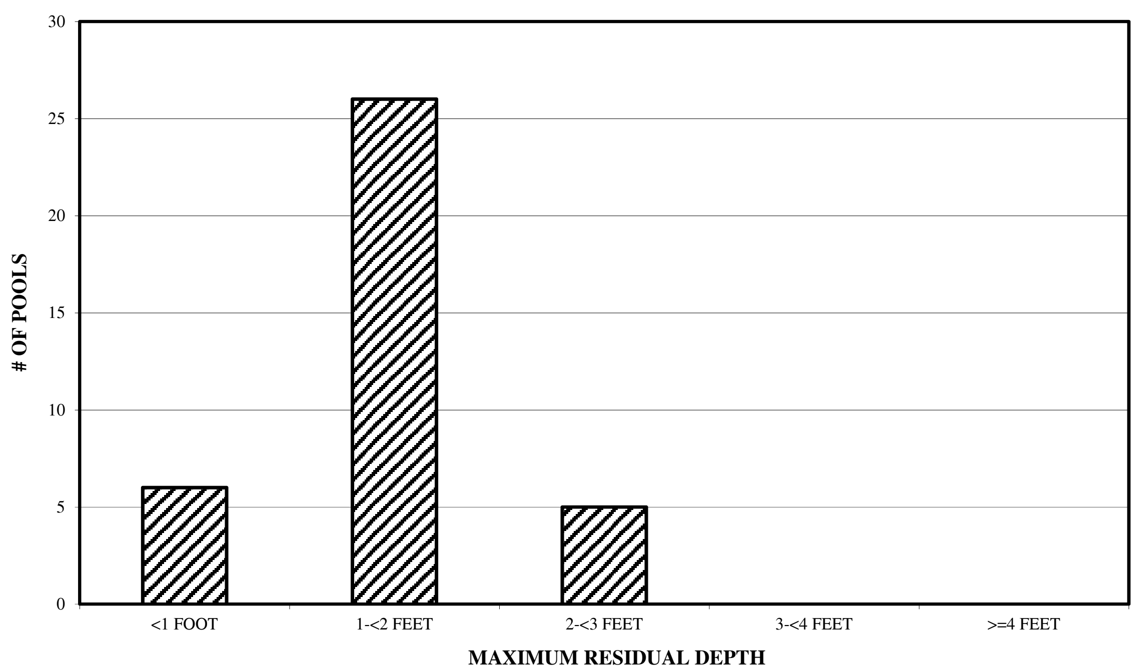
Low Gradient Riffle – LGR
High Gradient Riffle – HGR
Cascade – CAS
Bedrock Sheet – BRS
Glide – GLD
Run – RUN
Step Run – SRN
Trench Pool – TRP
Mid-Channel Pool – MCP
Step Pool – STP
Corner Pool – CRP
Lateral Scour Pool - Root Wad Enhanced – LSR
Lateral Scour Pool - Bedrock Formed – LSBk
Plunge Pool – PLP
Dammed Pool – DPL
Culvert – CUL

See Appendix 1 for more information.

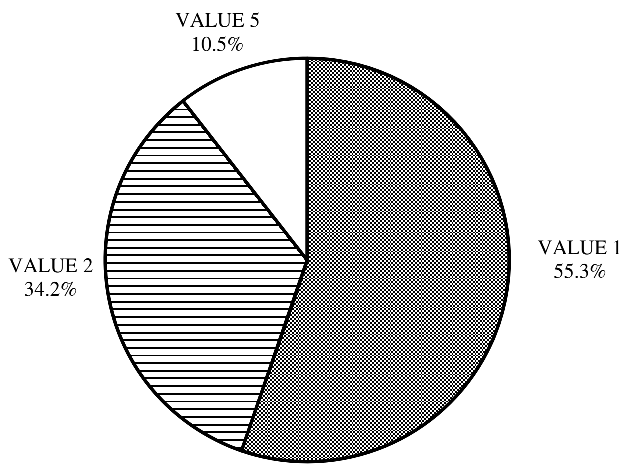
GRAPH 4 - MILL CREEK
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 5 - MILL CREEK
MAXIMUM DEPTH IN POOLS

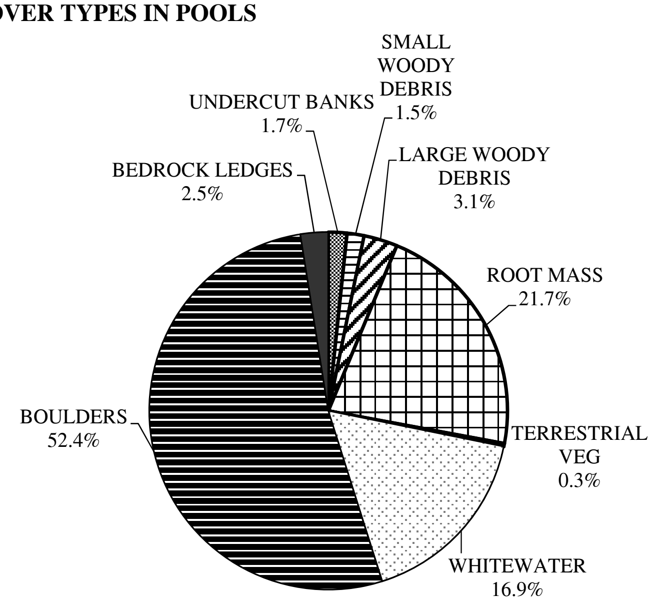


GRAPH 6 - MILL CREEK
PERCENT EMBEDDEDNESS

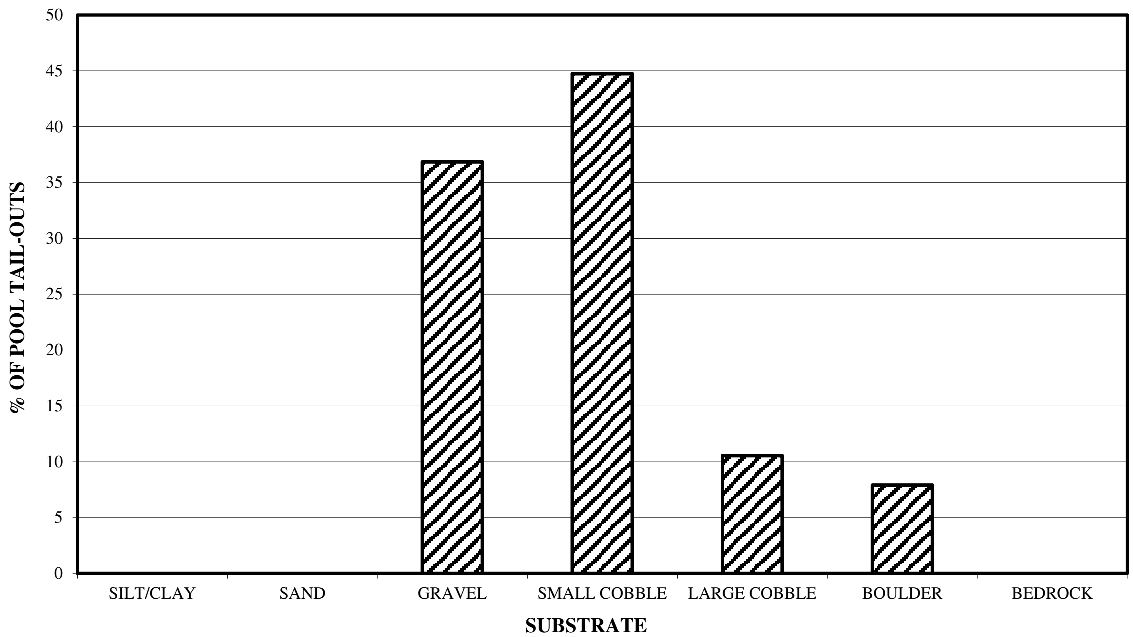


Embeddedness Values: 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

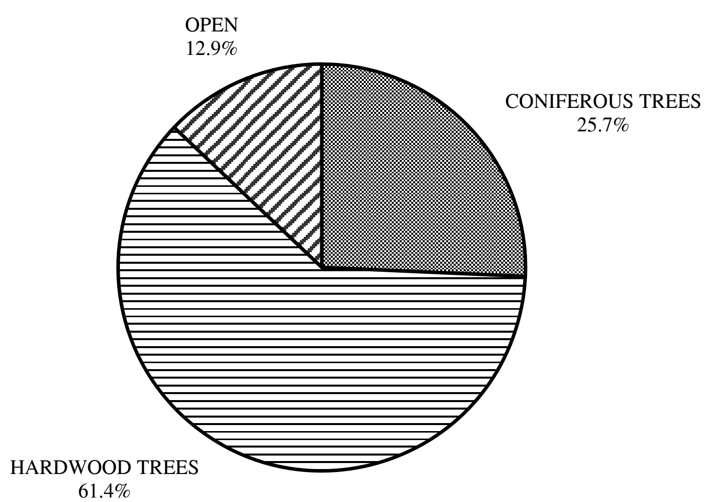
GRAPH 7 - MILL CREEK
MEAN PERCENT COVER TYPES IN POOLS



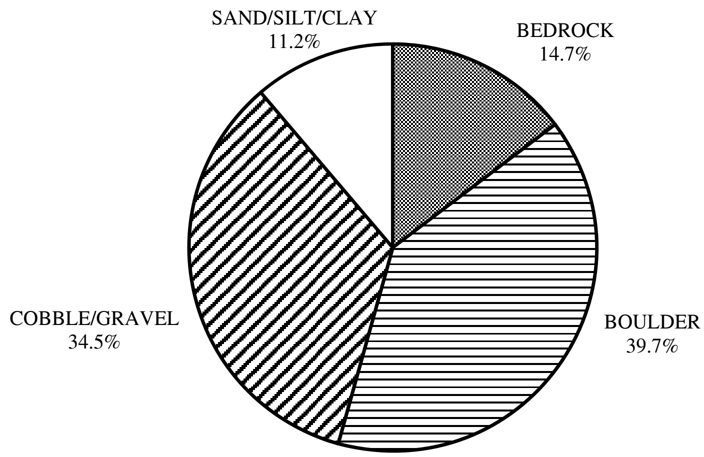
GRAPH 8 - MILL CREEK
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



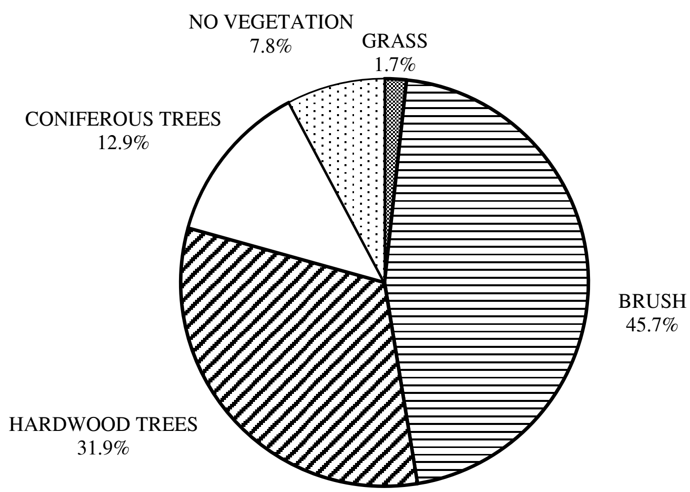
GRAPH 9 - MILL CREEK
MEAN PERCENT CANOPY



GRAPH 10 - MILL CREEK
DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 11 - MILL CREEK
DOMINANT BANK VEGETATION IN SURVEY REACH

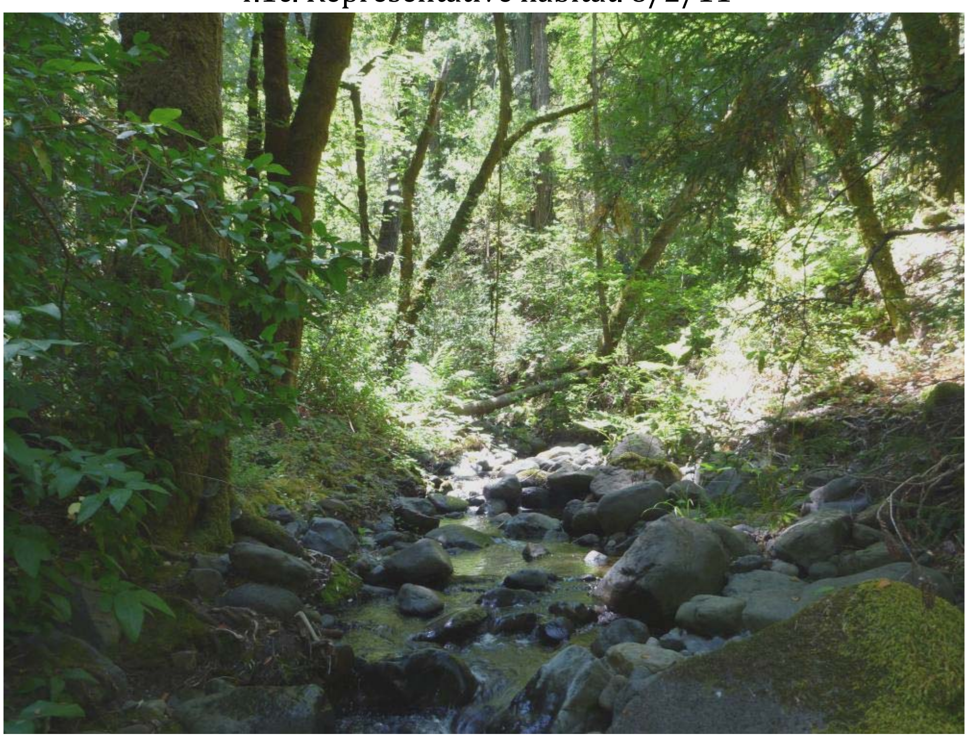


Mill Creek Photographs

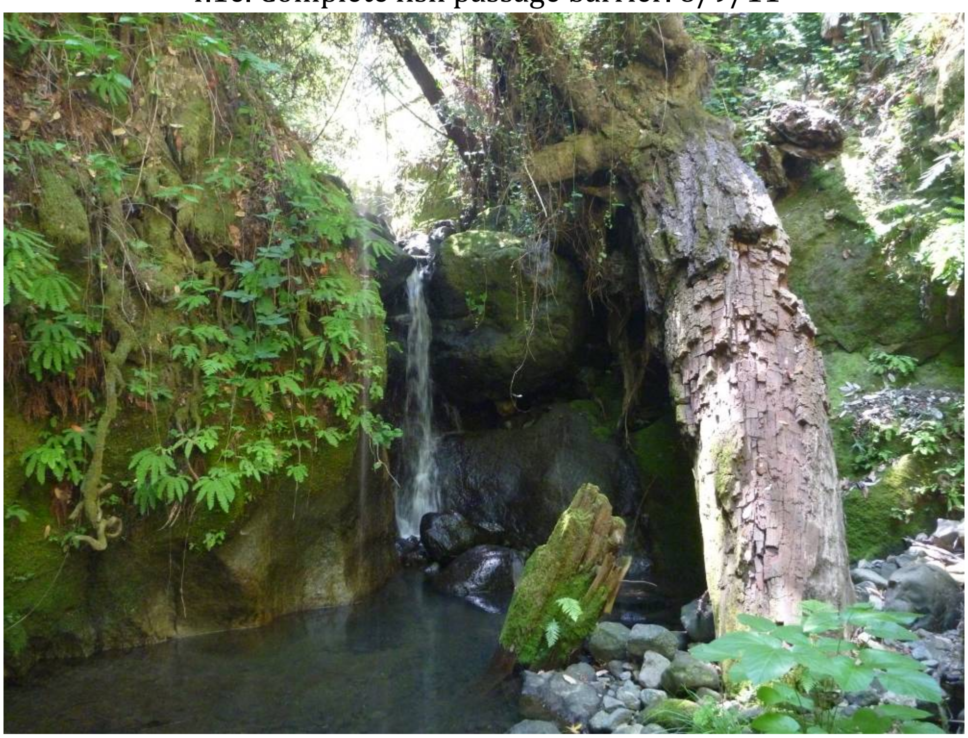
4.1a. Stream conditions in the lower reach of Mill Creek. 7/29/11

4.1b. In-stream stone wall. 8/2/11


4.1c. Representative habitat. 8/2/11


4.1d. Representative habitat. 8/2/11

4.1e. Complete fish passage barrier. 8/9/11



4.1f. Waterfall above limits of survey. 8/9/11

Discussion

During July and August 2011, 2.6 miles of stream channel were surveyed within the Mill Creek watershed. The water temperatures recorded on the survey days ranged from 56 to 63° F. Air temperatures ranged from 63 to 78° F. In-stream water temperatures were within the tolerable limits for steelhead (optimal range is 50 to 59° F). However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months.

Flatwater habitat types comprised 39% of the total length of this survey, riffles 47%, and pools 14%. The pools are relatively shallow with only 5 of the 37 (14%) 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.

Thirty-four of the 38 pool tail-outs measured had embeddedness ratings of 1 or 2. None of the pool tail-outs had embeddedness ratings of 3 or 4. 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 Mill Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Thirty-one of the 38 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 58. The shelter rating in the flatwater habitats was 23. A pool shelter rating of approximately 100 is desirable. Boulders are the dominant cover type in pools followed by root mass. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover 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 87%. Reach 1 had a canopy density of 86%, Reach 2 had a canopy density of 85%, Reach 3 had a canopy density of 87%, and Reach 4 had a canopy density of 90%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was high at 76% and 78%, 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.

Overall, Mill Creek provides high quality habitat for steelhead and/or resident rainbow trout (Photos 4.1a, 4.1c, and 4.1d). During the survey period, flows were adequate to support year-round rearing. Pool frequency and depth were below optimal levels for high quality steelhead habitat. However, pool tail-outs supported good quality spawning substrate, and canopy coverage over the channel was within acceptable levels. Three artificial barriers to fish passage were documented during the course of these surveys. From downstream to upstream, they include the Highway 29 culvert crossing, a small in-stream concrete wall just upstream of the Bale Grist Mill (Photo 4.1b), and a second small concrete wall (weir) approximately 500 feet upstream. All of these sites are partial barriers, which limit passage at low flows. The RCD is working with State Parks and Caltrans to secure funds to improve fish passage at these sites. At the upper limits of the watershed, there is an approximately 8-foot bedrock drop at the end of the survey limits that is impassable to fish and is the limit of anadromy (Photo 4.1e). Further upstream, there is also a 10-foot waterfall that would be a complete barrier (Photo 4.1f).

4.2 Ritchey Creek Watershed

Overview
Ritchey Creek flows into the Napa River south of Calistoga, Napa County, California. Ritchey Creek's location at the confluence with the Napa River is 38:33:30.0 north latitude and 122:30:30.0 west longitude, LLID number 1225084385582. It is mapped on the Calistoga USGS Quadrangle. Ritchey Creek is a second order stream and drains a watershed of approximately 2.4 square miles. Elevations range from approximately 270 feet at the confluence with the Napa River to 1,400 feet in the headwater areas. Mixed hardwood/mixed conifer forest dominates the watershed. Ritchey Creek flows through Bothe-Napa Valley State Park upstream of Highway 29. Lower Ritchey Creek and surrounding lands are privately held. Vehicle access exists via Highway 29 between Calistoga and St. Helena.

Fisheries Resources
According to Leidy et al. (2005), there is a history of steelhead observations within the watershed. In 1964, CDFG observed numerous adults attempting to jump a diversion dam within Bothe-Napa Valley State Park; adult fish were later found upstream of the dam. The diversion dam was removed in 2003, improving fish passage into the upper watershed. Additional observations by CDFG of juvenile steelhead are reported from 1967 to 1989 throughout the watershed. In 2001 and 2002, surveys completed by Ecotrust and FONR found steelhead in numerous Ritchey Creek reaches in varying densities.

During the 2011 habitat inventory of Ritchey Creek, several steelhead/rainbow trout were observed scattered throughout the middle and upper reaches of the watershed. Most of these fish averaged 2 to 6 inches in length. In addition to steelhead/rainbow trout, signal crayfish were observed in Ritchey Creek.

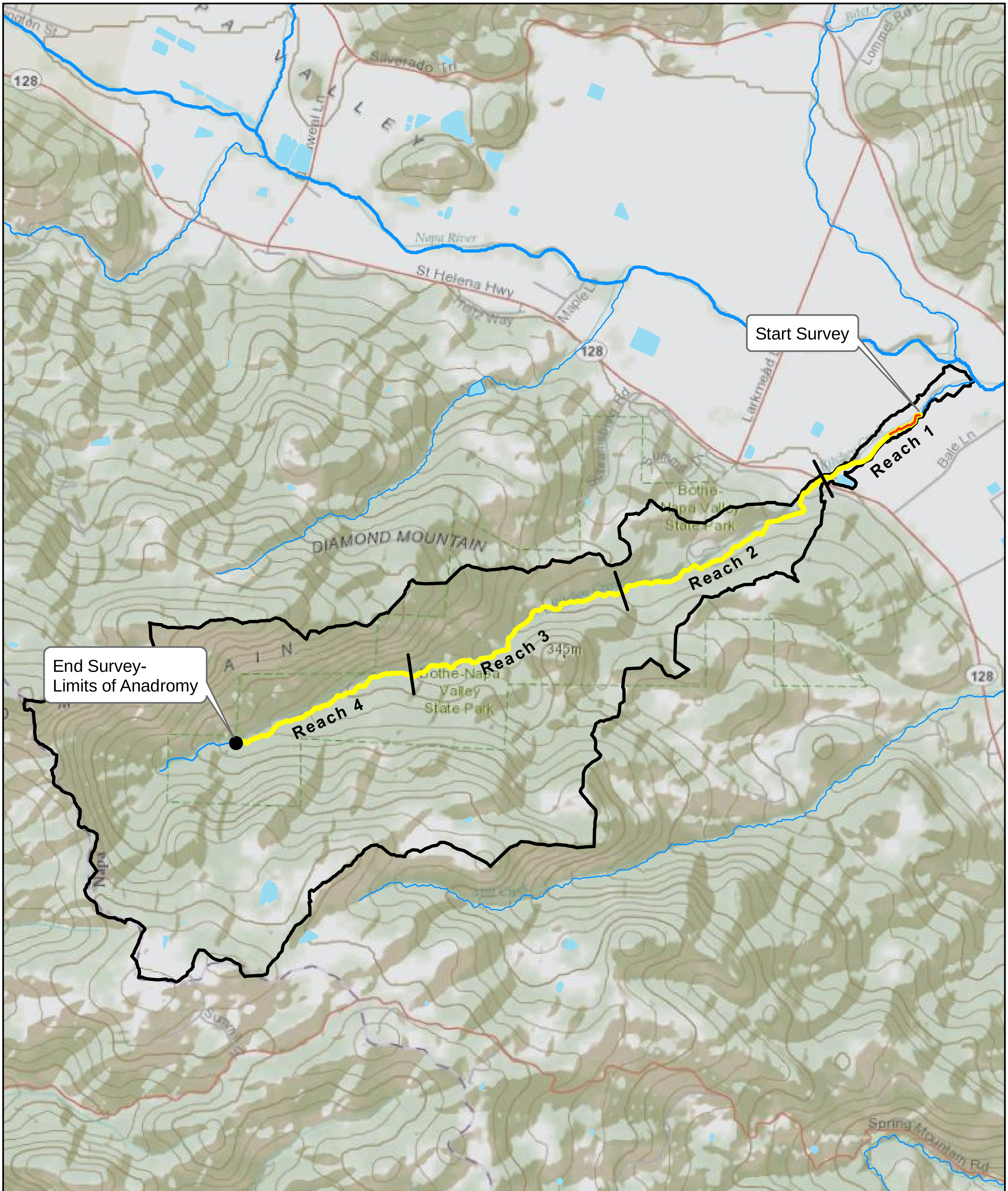


Figure 3. Ritchey Creek Watershed
Northern Napa River Tributary Streams Survey Report

Streams
Watershed Boundary
Dry Channel
Ritchey Creek Survey

0 0.25 0.5 1 Miles

Date: January 2012
Basemaps: ArcOnline Terrain

Habitat Inventory Results

The habitat inventory of Ritchey Creek was conducted on August 10, 11, and 12, 2011. The survey began at the confluence with the Napa River and extended upstream to the limits of anadromy. The total length of the stream surveyed was 17,808 feet (3.4 miles). Photos of the existing conditions are provided below (see Photos 4.2a to 4.2l).

Average stream flow was visually estimated to be 0.3 cfs during the survey period in areas with flowing water. Water temperatures taken during the survey period ranged from 57 to 63° F. Air temperatures ranged from 57 to 70° F.

Ritchey Creek was divided into 4 reaches. Reach 1 extended from the confluence with the Napa River to the Highway 29 crossing for 2,553 feet. Reaches 2, 3, and 4 were 5,291 feet, 5,373 feet, and 4,590 feet, respectively. Channel characteristic breaks were used to differentiate between Reaches 2, 3, and 4.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence, there were 42% riffle units, 30% flatwater units, and 27% pool units (Table 1; Graph 1). Based on total length of Level II habitat types, there were 44% riffle units, 38% flatwater units, and 12% pool units (Graph 2).

In total, 17 Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were High Gradient Riffle units (23%), Step Run units (17%), Low Gradient Riffle units (16%), Glide units (12%), and Mid-Channel Pool units (12%) (Graph 3). Based on percent total length, the most frequent habitat types were Step Run units (31%), High Gradient Riffle units (22%), and Low Gradient Riffle units (21%) (Table 2).

A total of 75 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 64%, and comprised 73% 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, and 6 of the 30 pools (20%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 31 pool tail-outs measured, 24 had a value of 1 (77%); 4 had a value of 2 (13%); 1 had a value of 3 (3%); 2 had a value of 5 (7%) (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 31, flatwater habitat types had a mean shelter rating of 53, and pool habitats had a mean shelter rating of 64 (Table 1). Of the pool types, the Scour pools had a mean shelter rating of 74; Main Channel pools had a mean shelter rating of 53 (Table 3).

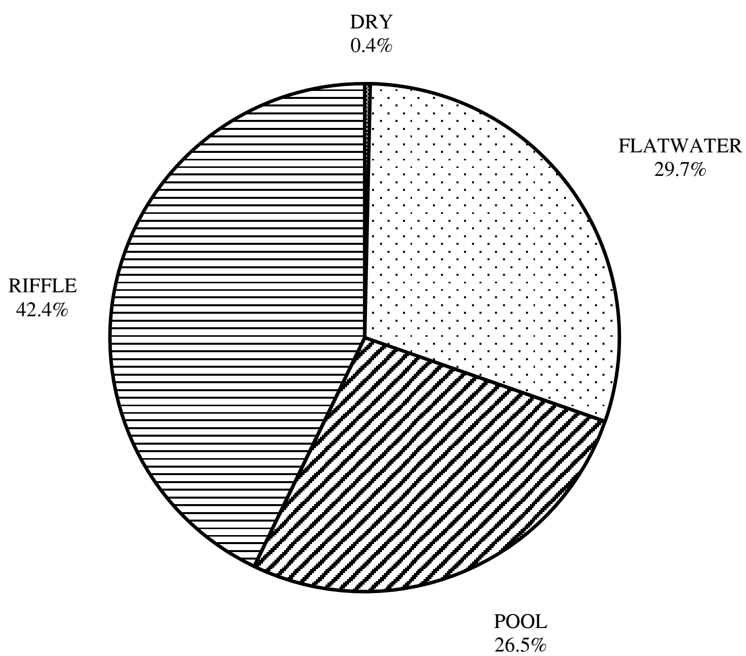
Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Ritchey Creek. Graph 7 describes the pool cover in Ritchey Creek. Boulders (51%) are the dominant pool cover type followed by root mass (15%) and whitewater (10%). Table 10 describes the shelter cover types for the entire system.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was observed in 39% of pool tail-outs, small Cobble observed in 26% of pool tail-outs, and large Cobble observed in 26% of pool tail-outs.

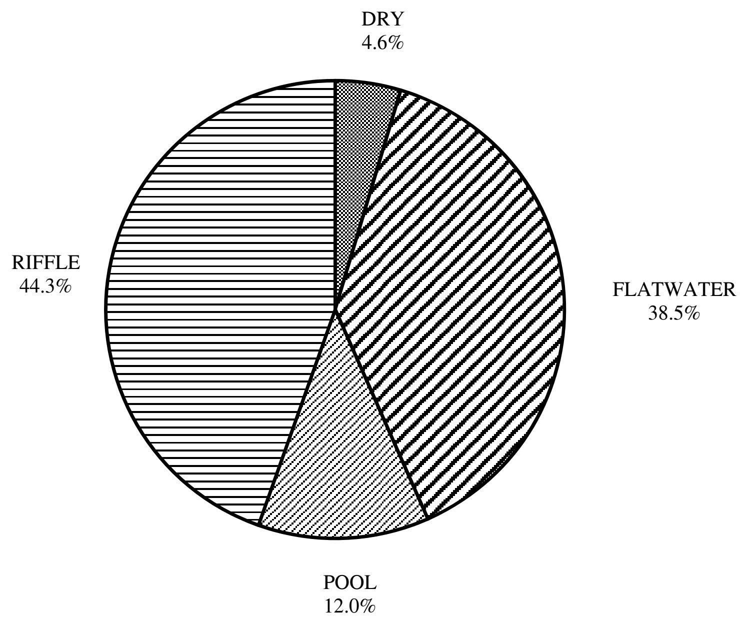
The mean percent canopy density for the surveyed length of Ritchey Creek was 81%. The mean percentages of hardwood and coniferous trees were 50% and 50%, respectively (Table 7). Nineteen percent of the canopy was open. Graph 9 describes the mean percent canopy in Ritchey Creek.

For the stream reaches surveyed, the mean percent right bank vegetated was 69%. The mean percent left bank vegetated was 68%. The structure of the stream banks consisted of 60% boulder and 22% cobble/gravel (Table 9; Graph 10). Brush (small shrubs and understory vegetation) was the dominant vegetation type observed in 46% of the units surveyed. Additionally, 24% of the units surveyed had deciduous trees as the dominant vegetation type, and 20% had coniferous trees as the dominant vegetation (Table 9; Graph 11).

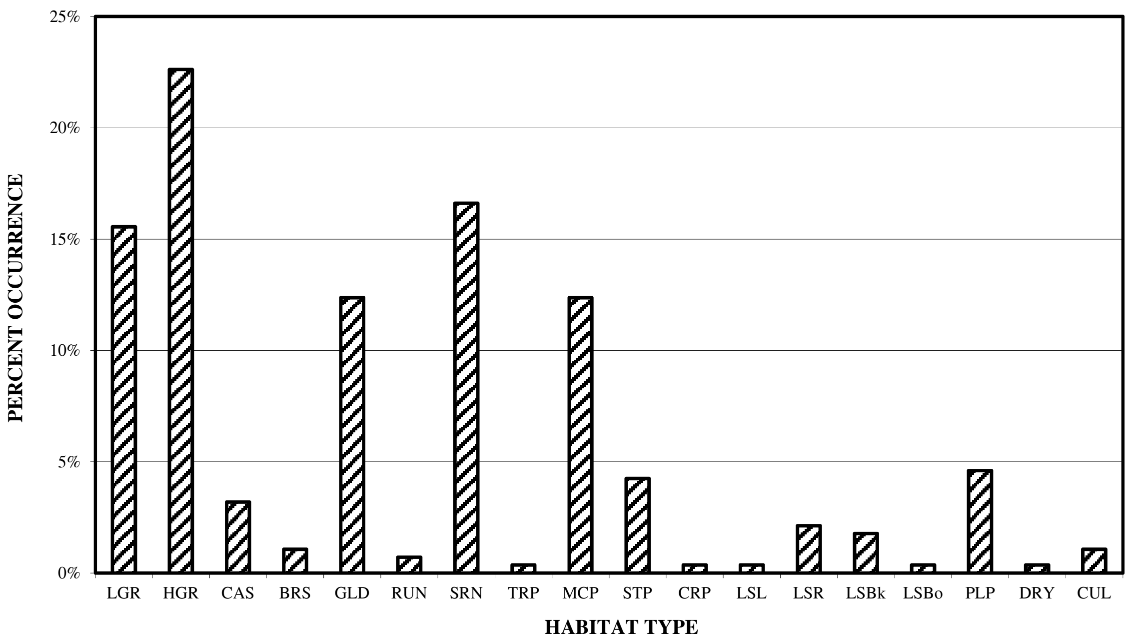
GRAPH 1 - RITCHEY CREEK
HABITAT TYPES BY PERCENT OCCURRENCE



GRAPH 2 - RITCHEY CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 3 - RITCHEY CREEK
HABITAT TYPES BY PERCENT OCCURRENCE

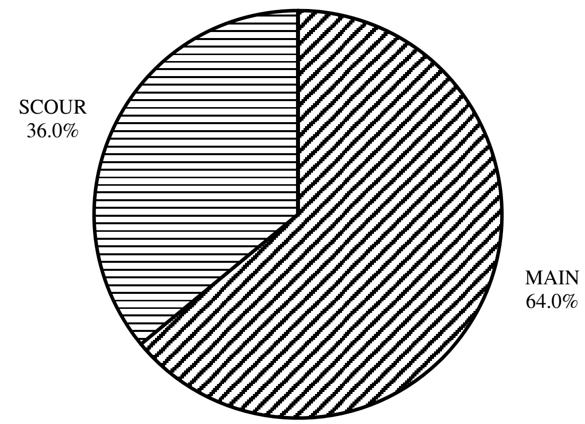


Level IV Habitat Types and Abbreviations

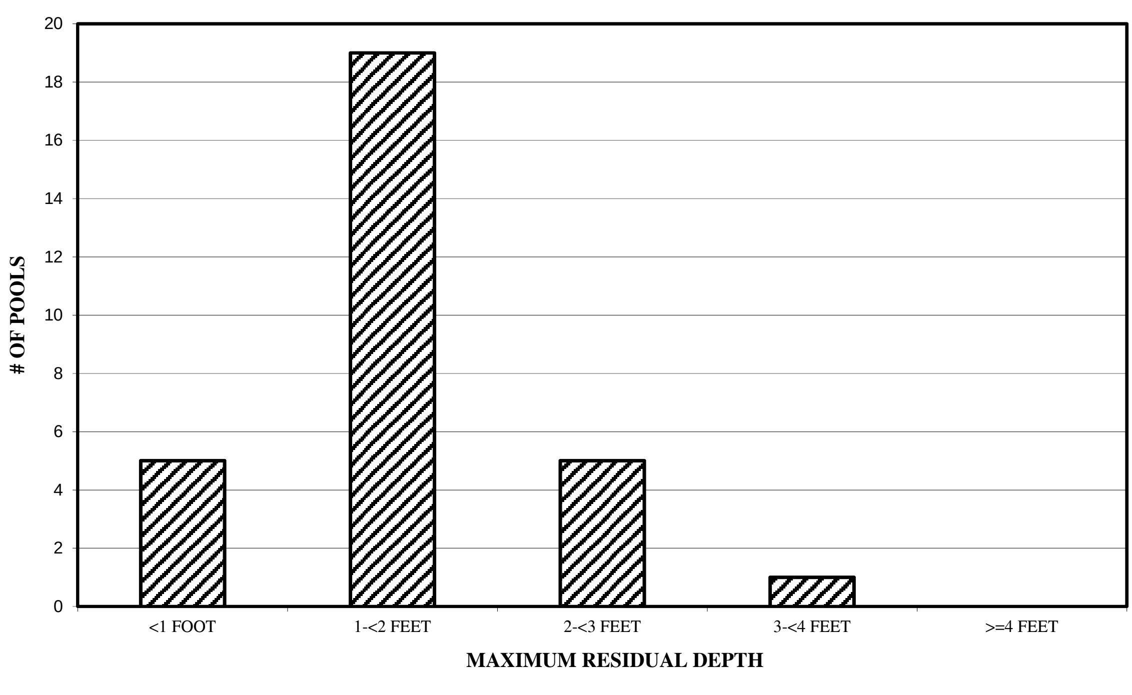
Low Gradient Riffle – LGR
High Gradient Riffle – HGR
Cascade – CAS
Bedrock Sheet – BRS
Glide – GLD
Run – RUN
Step Run – SRN
Trench Pool – TRP
Mid-Channel Pool – MCP
Step Pool – STP
Corner Pool – CRP
Lateral Scour Pool - Log Enhanced – LSL
Lateral Scour Pool - Root Wad Enhanced – LSR
Lateral Scour Pool - Bedrock Formed – LSBk
Lateral Scour Pool - Boulder Formed – LSBo
Plunge Pool – PLP
Dry – DRY
Culvert – CUL

See Appendix 1 for more information.

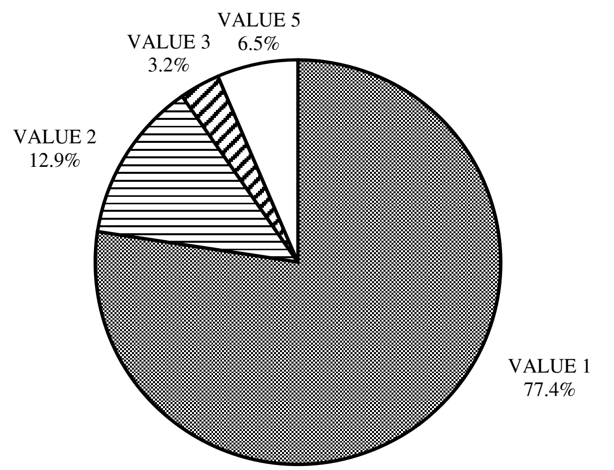
GRAPH 4 - RITCHEY CREEK
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 5 - RITCHEY CREEK
MAXIMUM DEPTH IN POOLS

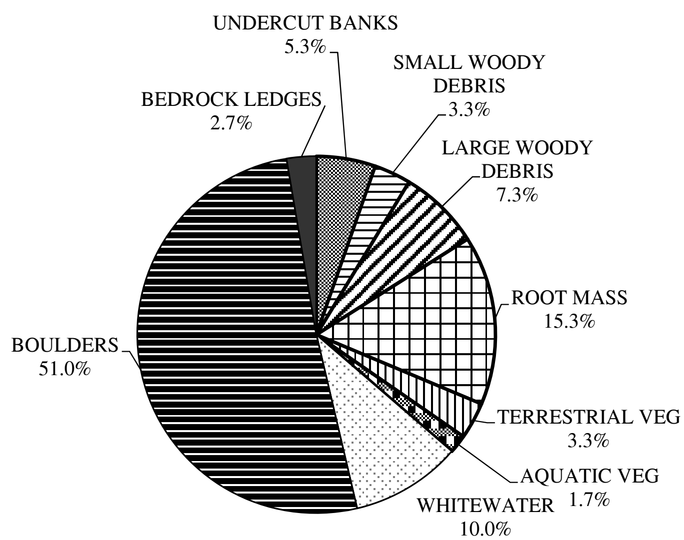


GRAPH 6 - RITCHEY CREEK 2011
PERCENT EMBEDDEDNESS

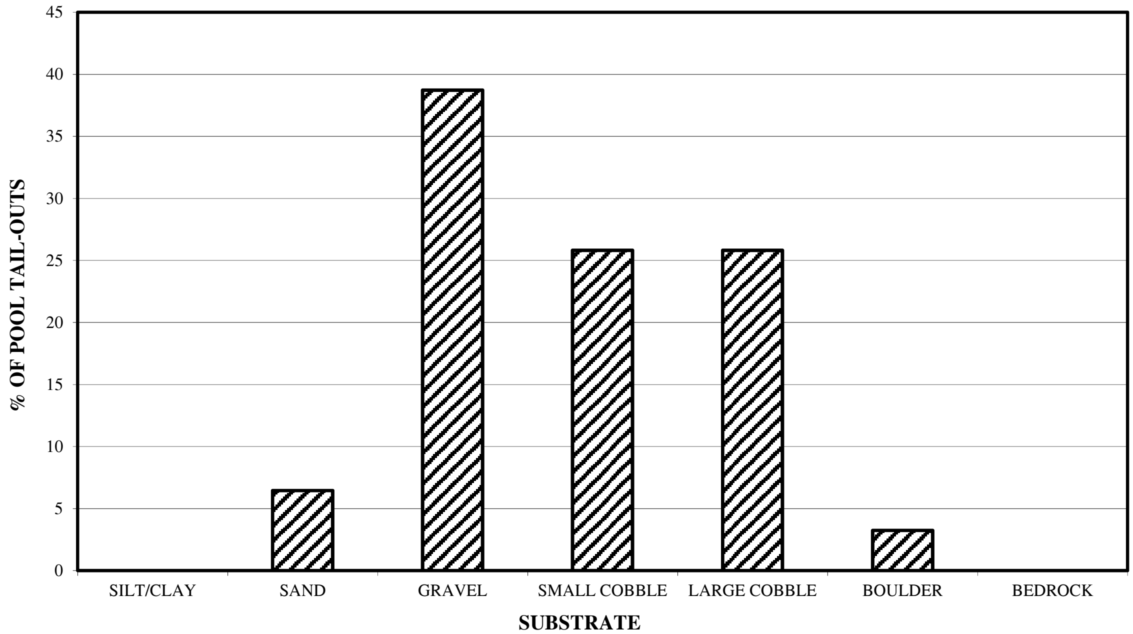


Embeddedness Values: 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

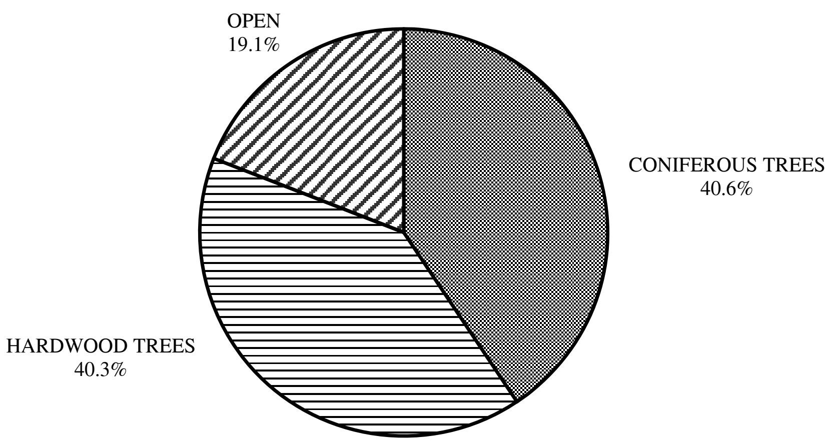
GRAPH 7 - RITCHEY CREEK
MEAN PERCENT COVER TYPES IN POOLS



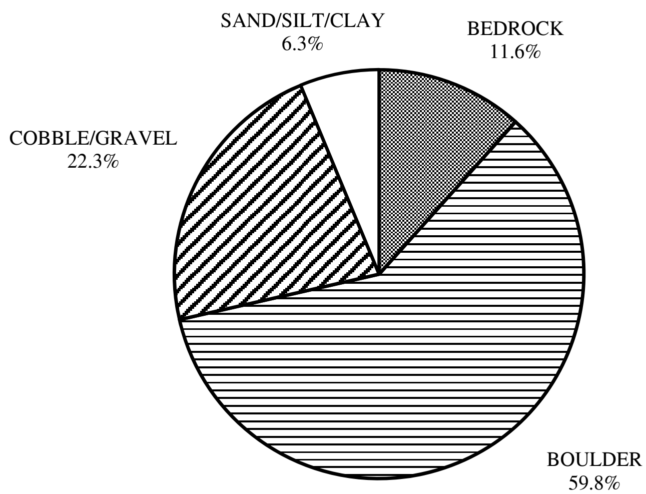
GRAPH 8 - RITCHEY CREEK
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



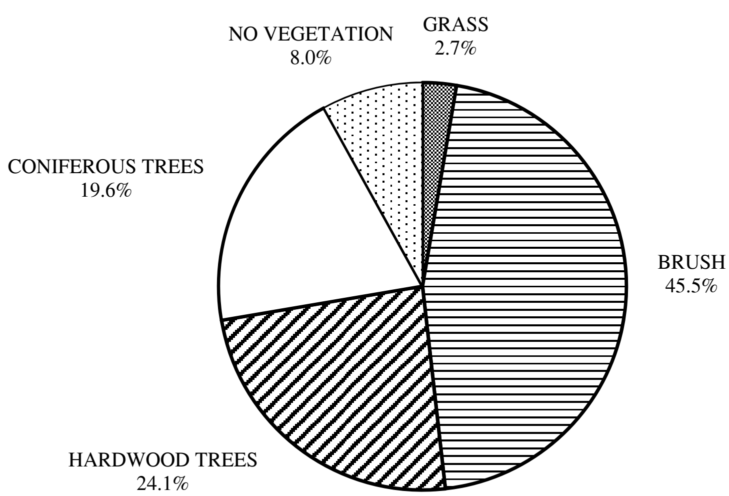
GRAPH 9 - RITCHEY CREEK
MEAN PERCENT CANOPY



GRAPH 10 - RITCHEY CREEK
DOMINANT BANK COMPOSITION IN SURVEY REACH

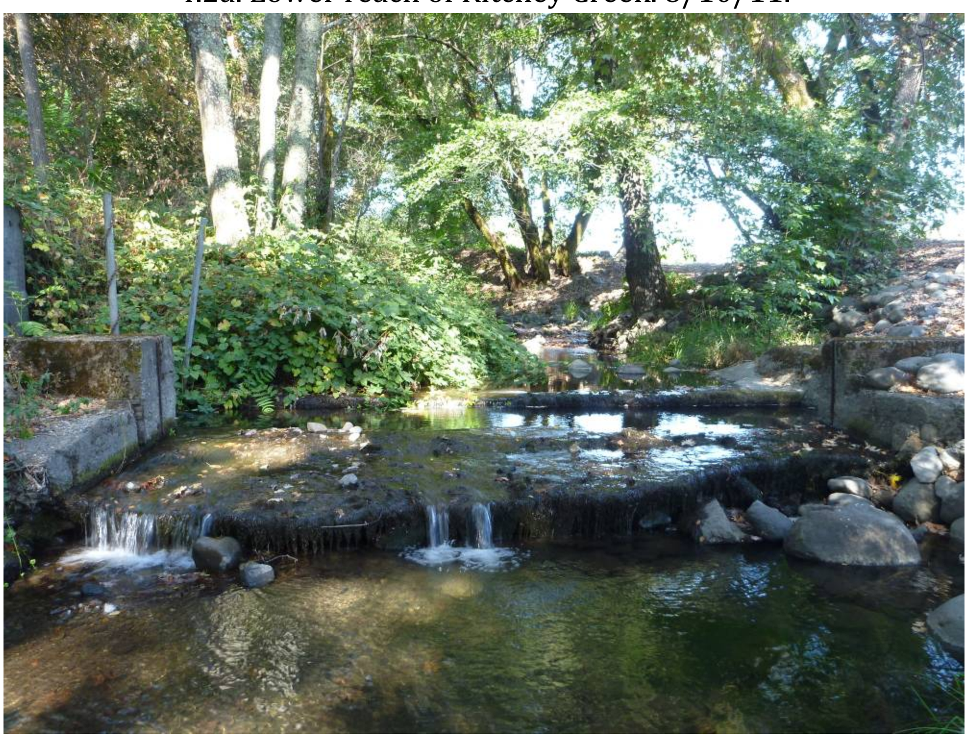


GRAPH 11 - RITCHEY CREEK
DOMINANT BANK VEGETATION IN SURVEY REACH

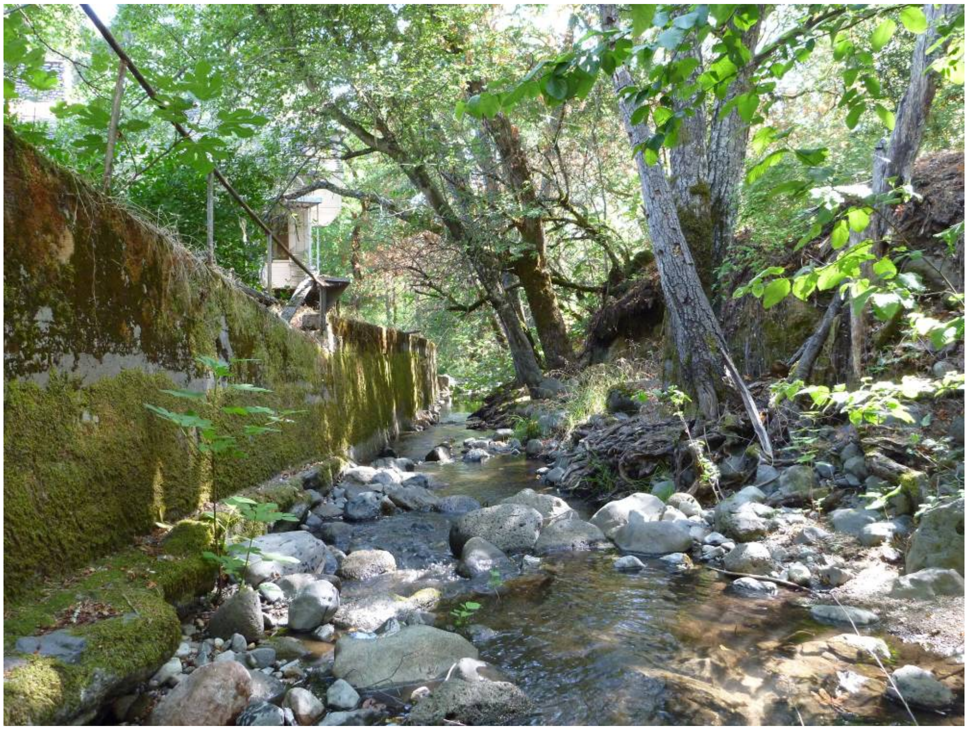


Ritchey Creek Photos

4.2a. Lower reach of Ritchey Creek. 8/10/11.



4.2b. In-stream concrete sill downstream of Highway 29. 8/10/11

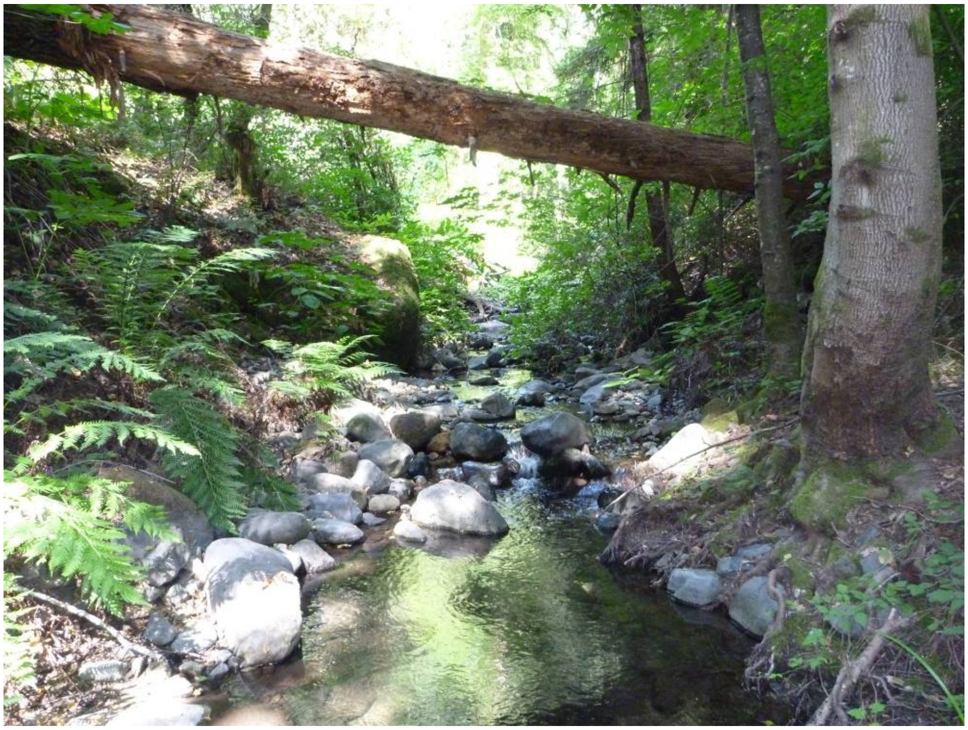


4.2c. Remnants of the diversion dam removed in 2003. 8/10/11

4.2d. Remnants of the diversion dam removed in 2003. 8/10/11

4.2e. Road crossing within Bothe-Napa Valley State Park. 8/10/11

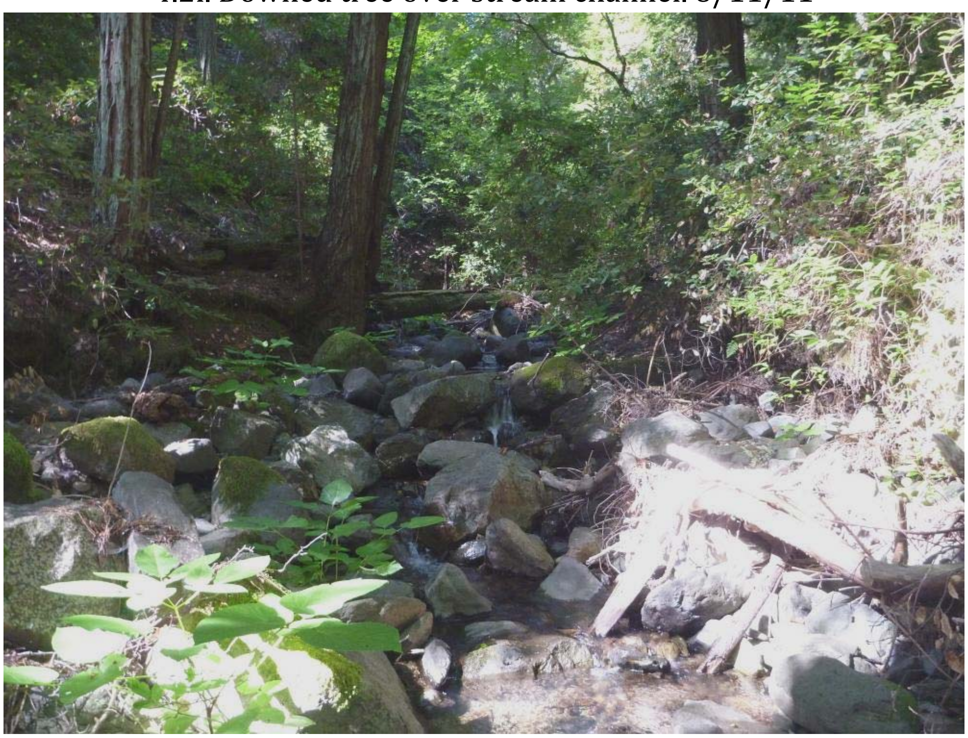
4.2f. Representative habitat. 8/10/11

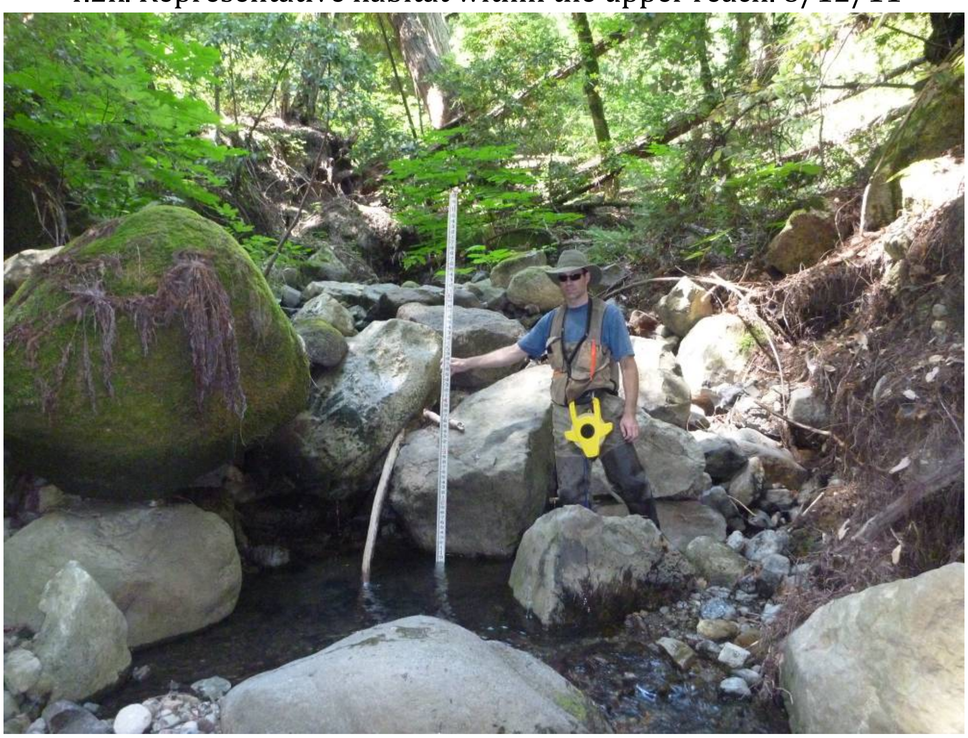


4.2g. Representative habitat. 8/11/11

4.2h. Culvert crossing under dirt road within Bothe-Napa Valley State Park. 8/11/11


4.2i. Downed tree over stream channel. 8/11/11


4.2j. Representative habitat. 8/12/11


4.2k. Representative habitat within the upper reach. 8/12/11

4.2l. Boulder cascade in upper reach. 8/12/11

Discussion

During August 2011, 3.4 miles of stream channel were surveyed within the Ritchey Creek watershed. The water temperatures recorded on the survey days ranged from 57 to 63° F. Air temperatures ranged from 57 to 70° F. In-stream water temperatures were at the upper tolerable limits for steelhead (optimal range is 50 to 59° F). However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months.

Flatwater habitat types comprised 38% of the total length of this survey, riffles 44%, and pools 12%. The pools are relatively shallow, with only 6 of the 30 (20%) 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.

Twenty-eight of the 31 pool tail-outs measured had embeddedness ratings of 1 or 2. One of the pool tail-outs had embeddedness ratings of 3. Two 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 Ritchey Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Twenty of the 31 pool tail-outs measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids. Eleven of the pool tail-outs had substrate considered unsuitable for spawning salmonids.

The mean shelter rating for pools was 64. The shelter rating in the flatwater habitats was 53. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Ritchey Creek. Boulders are the dominant cover type in pools, followed by root mass. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover 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 81%. Reach 1 had a canopy density of 55%, Reach 2 had a canopy density of 83%, Reach 3 had a canopy density of 82%, and Reach 4 had a canopy density of 86%. In general, revegetation projects are considered when canopy density is less than 80%; this would be advisable for Reach 1.

The percentage of right and left bank covered with vegetation was moderate at 69% and 68%, 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.

Overall, Ritchey Creek provides high quality habitat for steelhead and/or resident rainbow trout (see Photos 4.2f, 4.2g, 4.2i, and 4.2j). During the survey period, flows were adequate to support year-round rearing. Pool frequency and depth was below optimal levels for high quality steelhead habitat. However, pool tail-outs supported good quality spawning substrate, and canopy coverage over the channel was good.

In 2003, a diversion dam upstream of Highway 29 within park properties was removed. Large sections of concrete still remain in the channel (Photos 4.2c and 4.2d). Three artificial fish passage barriers were documented during the course of this survey. In downstream to upstream order, they include the Highway 29 culvert crossing, the Bothe State Park main entrance road culvert crossing (Photo 4.2e), and the Bothe State Park upper dirt road culvert crossing (Photo 4.2h). All three of these sites have been evaluated by RCD, State Parks, and/or other agencies and groups, who collectively are seeking funds to improve passage. At the upper limits of the watershed, the stream channel becomes very steep and dominated by large boulder cascades. These areas are unsuitable for fish and pose a significant barrier (Photos 4.2k and 4.2l).

4.3 Nash Creek Watershed

Overview

Nash Creek flows into the Napa River south of Calistoga, Napa County, California. Nash Creek's location at the confluence with the Napa River is 38:33:47.0 north latitude and 122:32:1.36 west longitude, LLID number 1225330385633. It is mapped on the Calistoga USGS Quadrangle. Nash Creek is a first order stream and drains a watershed of 0.63 square miles. Approximately 0.5 miles upstream of Highway 29, there is an in-stream reservoir, which fully blocks passage to the upper reaches of the watershed. Elevations range from approximately 280 feet at the confluence with the Napa River to 1,100 feet in the headwater areas. Mixed hardwood/mixed conifer forest dominates the watershed. The watershed is primarily privately owned and used for residential and agricultural development. Vehicle access exists via Highway 29 between Calistoga and St. Helena and private roads.

Fisheries Resources and Field Observations

According to Leidy et al. (2005), there are no records of fish observations within the watershed. In July 1965, a visual survey of the watershed was completed by CDFG. The entire two-mile length of stream was found to be dry. In May 1974, another survey was completed by CDFG. Again, with the exception of intermittent reaches near springs, the stream was dry, and no fish were observed. CDFG speculates that prior to the building of the in-stream reservoir; the creek may have been capable of supporting steelhead runs.

During the 2011 habitat reconnaissance survey of Nash Creek, the accessible channel was completely dry, and no aquatic species were observed.

Results and Discussion

In August and September 2011, limited field surveys of Nash Creek were completed. Access was limited to parcels downstream of the Highway 29 crossing to the confluence with the Napa River. Conditions during the surveys were dry. Comprehensive habitat inventory data was not collected due to dry conditions. No habitat for steelhead or other aquatic species was observed. As indicated in Leidy et al. (2005), fisheries resources within the watershed are limited due a lack of stream flows and presence of the in-stream reservoir. Photos of the existing conditions in the vicinity of Highway 29 are provided below (Photos 4.3a to 4.3d).

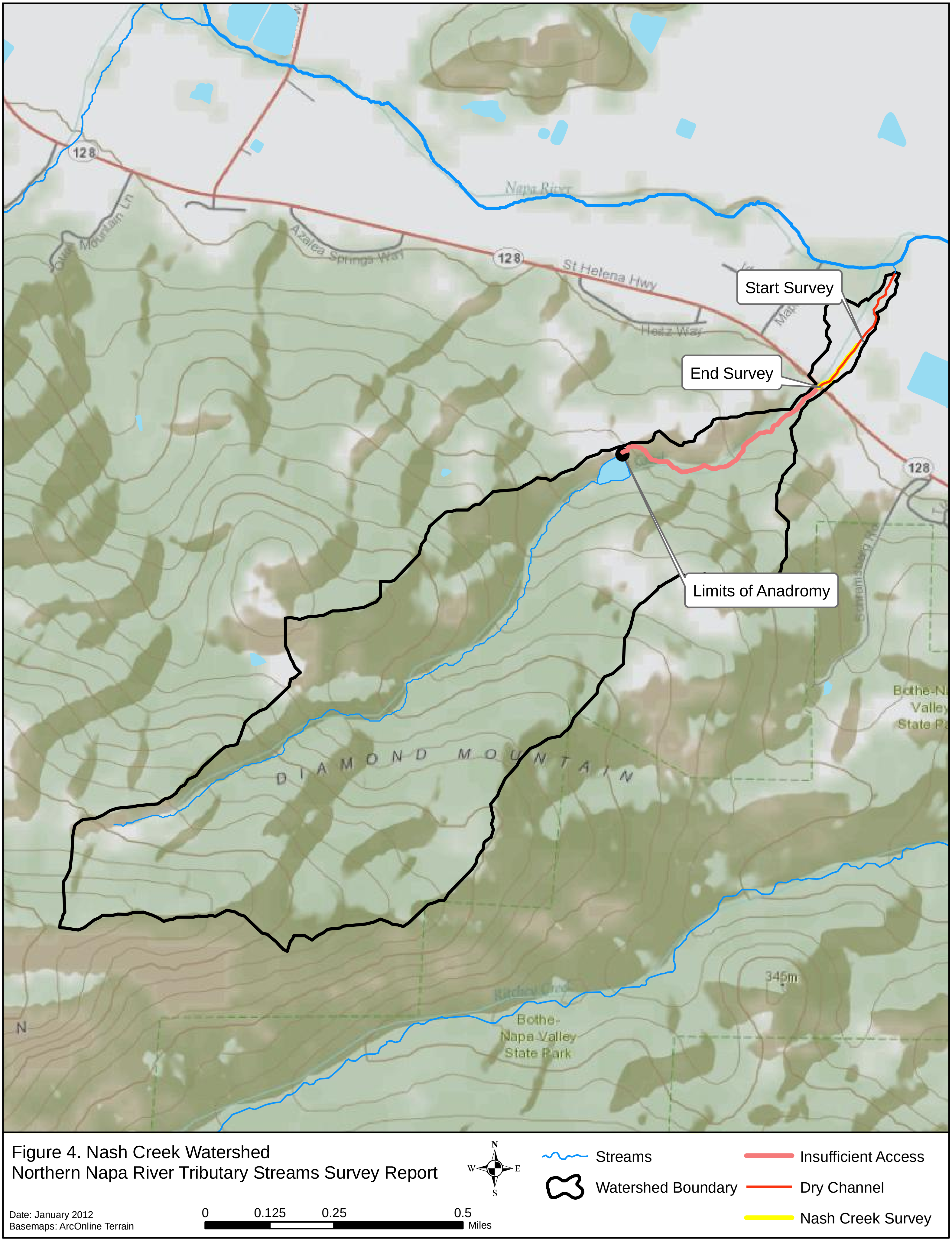


Figure 4. Nash Creek Watershed
Northern Napa River Tributary Streams Survey Report

Date: January 2012
Basemaps: ArcOnline Terrain

Nash Creek Photos

4.3a. Nash Creek downstream of Highway 29 crossing. 9/29/11

4.3b. In-stream habitat downstream of Highway 29 crossing. 9/29/11

4.3c. Culvert crossing under Highway 29. 9/29/11

4.3d. In-stream habitat immediately upstream of Highway 29. 9/29/11

4.4 DIAMOND MOUNTAIN CREEK WATERSHED

Overview
Diamond Mountain Creek flows into the Napa River south of Calistoga, Napa County, California. Diamond Mountain Creek's location at the confluence with the Napa River is 38:34:12.0 north latitude and 122:33:26.0 west longitude, LLID number 1225573385700. It is mapped on the Calistoga USGS Quadrangle. Diamond Mountain Creek is a second order stream and drains a watershed of approximately 2.9 square miles. Approximately 1.4 miles upstream of Highway 29, there is an in-stream reservoir, which fully blocks passage to the upper reaches of the watershed. Elevations range from approximately 310 feet at the confluence with the Napa River to 675 feet in the headwater areas. Mixed hardwood/mixed conifer forest dominates the watershed. The watershed is primarily privately owned and used for residential and agricultural development. Vehicle access exists via Highway 29 between Calistoga and St. Helena and Diamond Mountain Road.

Fisheries Resources and Field Observations
According to Leidy et al. (2005), there is one record of fish observations within the watershed. In 2001, surveys completed by Ecotrust and FONR found steelhead in small numbers. In field notes prepared by CDFG in 1965, spawning and rearing habitat was identified within the watershed; however, there is no record of whether or not fish were observed.

During the 2011 habitat inventory/reconnaissance surveys of Diamond Mountain Creek, no steelhead/rainbow trout were observed. Stream reaches with water present supported a small number of native sculpin (*Sculpin* sp.). Non-native green sunfish and American bullfrog tadpoles and adults were also observed. The survey team spoke with one landowner who observed a small group of approximately 6-inch steelhead/rainbow trout in a pool near her house in summer 2010.

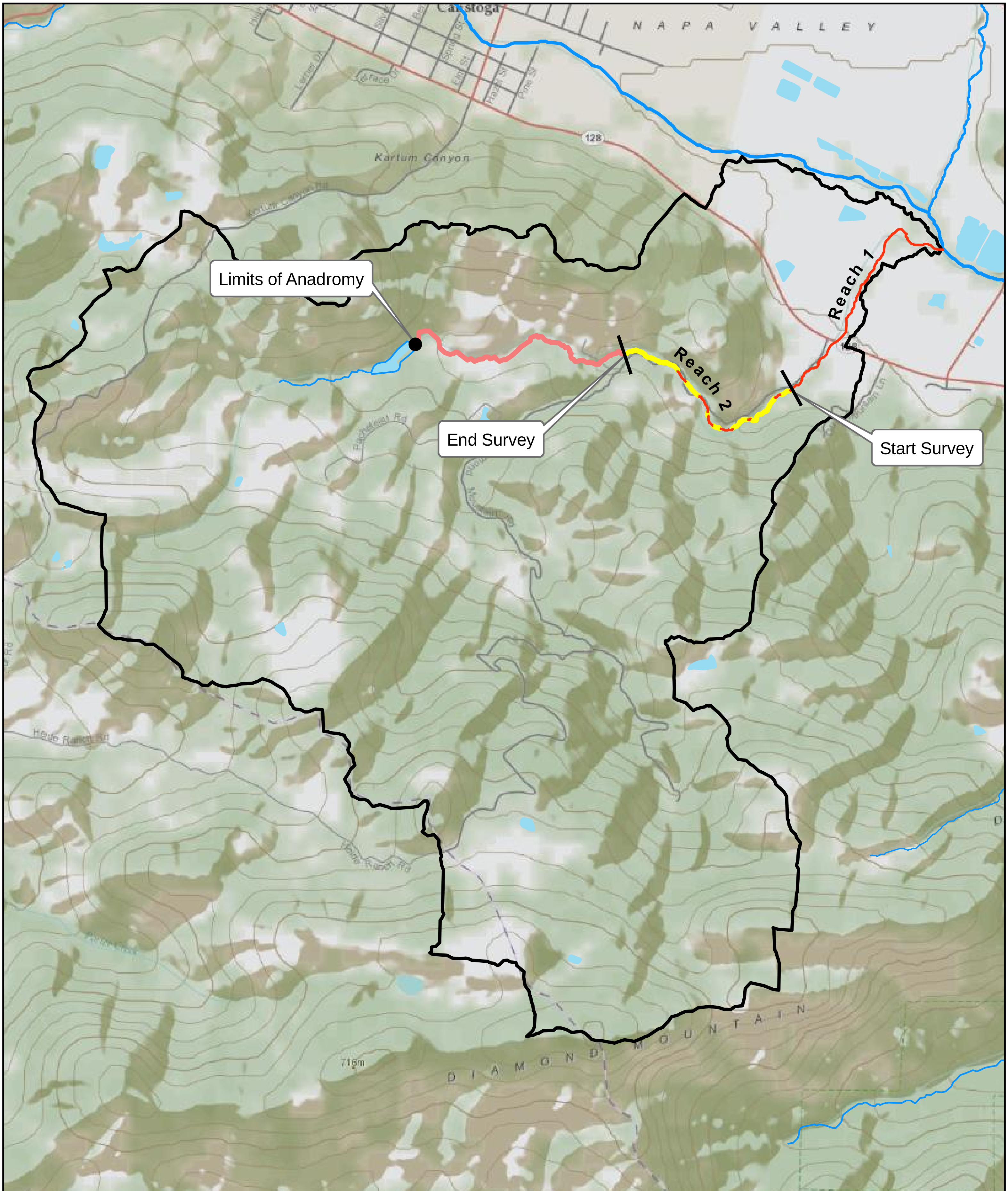


Figure 5. Diamond Mountain Creek Watershed
Northern Napa River Tributary Streams Survey Report

Date: January 2012
Basemaps: ArcOnline Terrain

Habitat Inventory Results

The habitat inventory of Diamond Mountain Creek was conducted on August 16, 2011. The survey began upstream of the Highway 29 road crossing to the limits of access. The total length of the stream evaluated was 6,872 feet (1.3 miles). The total length of stream habitat typed was 3,192 feet. Photos of the existing conditions are provided below (see Photos 4.4a to 4.4h).

Average stream flow was visually estimated to be 0.3 cfs during the survey period in areas with flowing water. Water temperatures taken during the survey period ranged from 61 to 63° F. Air temperatures ranged from 67 to 74° F.

Diamond Mountain Creek was divided into two reaches. Reach 1 extended from the confluence with the Napa River upstream of Highway 29 for 3,680 feet. Reach 2 extended to the limits of access 3,192 feet. The presence of water was used to differentiate the two stream reaches.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 38% riffle units, 25% flatwater units, and 22% pool units (Table 1; Graph 1). Based on total length of Level II habitat types, there were 69% dry units, 14% riffle units, 11% flatwater units, and 5% pool units (Graph 2).

In total, 12 Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were Low Gradient Riffle units (22%), Glide units (15%), High Gradient Riffle units (15%), Dry units (12%), and Mid-Channel Pool units (12%) (Graph 3). Based on percent total length, the most frequent habitat types were Dry units (69%), High Gradient Riffle units (6%), and Low Gradient Riffle units (7%) (Table 2).

A total of 13 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 62%, and comprised 60% 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, and three of the 7 pools (43%) had a residual depth of two feet or greater (Graph 5). One of the 7 pools (14%) had a residual depth of three feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 7 pool tail-outs measured, all had a value of 1 (100%) (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 is 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 50, flatwater habitat types had a mean shelter rating of 25, and pool habitats had a mean shelter rating of 63 (Table 1). Of the pool types, Scour pools had a mean shelter rating of 50, and Main Channel pools had a mean shelter rating of 80 (Table 3).

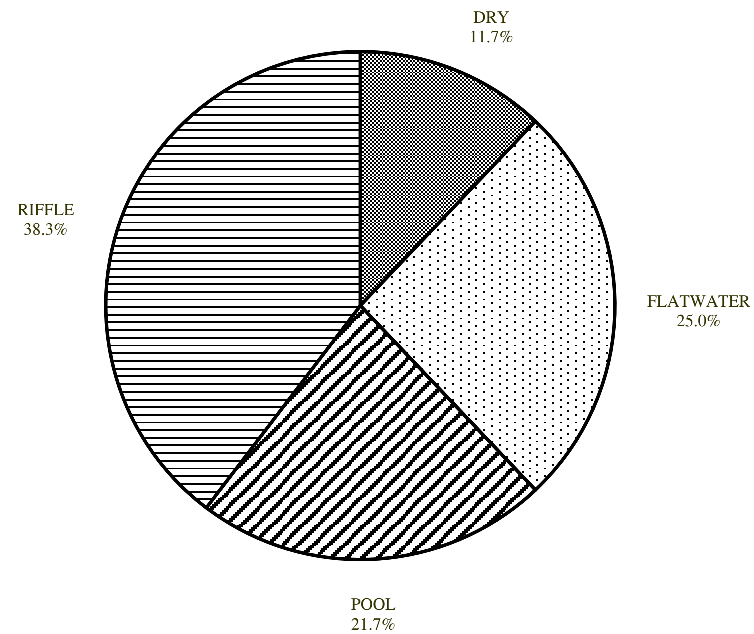
Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Diamond Mountain Creek. Graph 7 describes the pool cover in Diamond Mountain Creek. Boulders (51%) are the dominant pool cover type, followed by undercut banks (23%). Table 10 describes the shelter cover types for the entire system.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was observed in 43% of pool tail-outs and small Cobble observed in 57% of pool tail-outs.

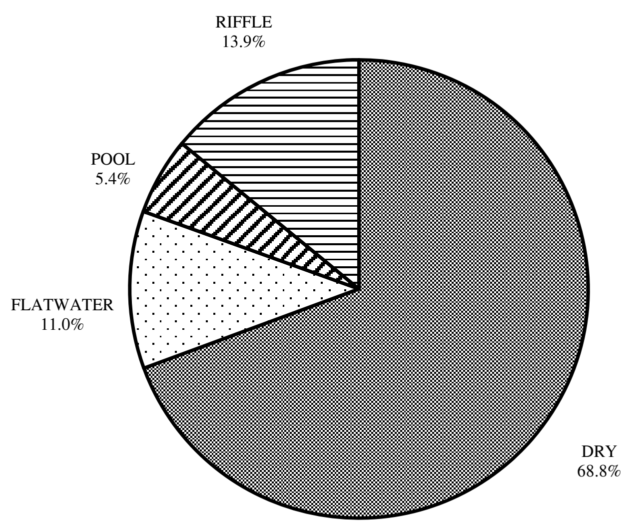
The mean percent canopy density for the surveyed length of Diamond Mountain Creek was 75%. The mean percentages of hardwood and coniferous trees were 74% and 26%, respectively. Twenty-five percent of the canopy was open. Graph 9 describes the mean percent canopy in Diamond Mountain Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 76%. The mean percent left bank vegetated was 84%. The structure of the stream banks consisted of 94% boulder, 3% cobble/gravel, and 3% bedrock (Table 9; Graph 10). Brush (small shrubs and understory vegetation) was the dominant vegetation type observed in 88% of the units surveyed. Additionally, 6% of the units surveyed had hardwood trees as the dominant vegetation type, and 6% had no vegetation (Table 9; Graph 11).

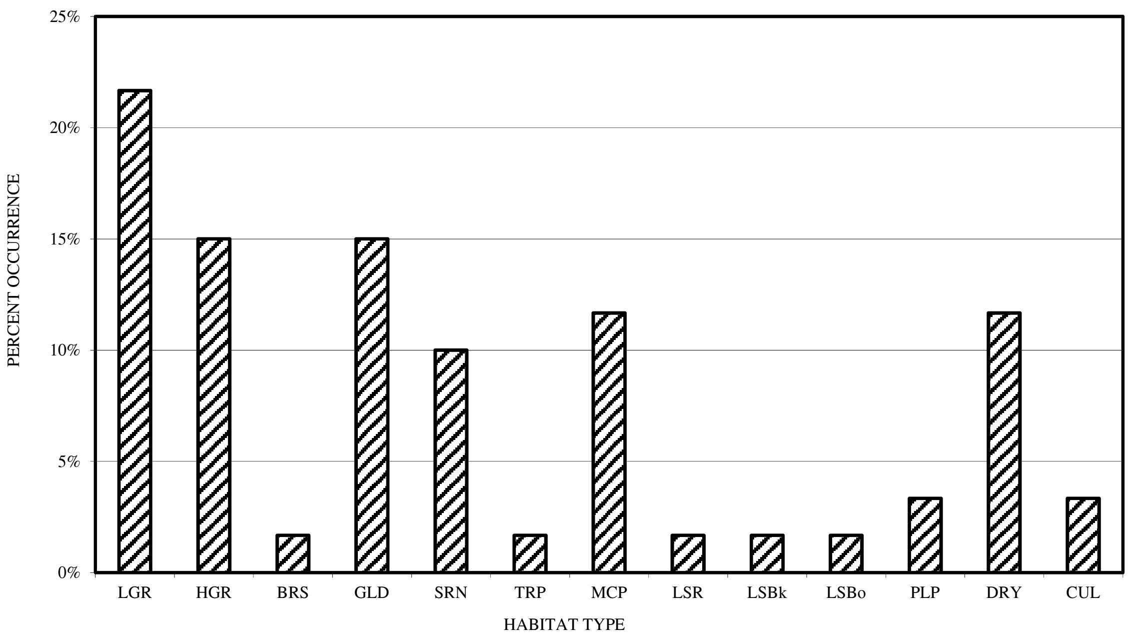
GRAPH 1 - DIAMOND MOUNTAIN CREEK
HABITAT TYPES BY PERCENT OCCURRENCE



GRAPH 2 - DIAMOND MOUNTAIN CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 3 - DIAMOND MOUNTAIN CREEK
HABITAT TYPES BY PERCENT OCCURRENCE

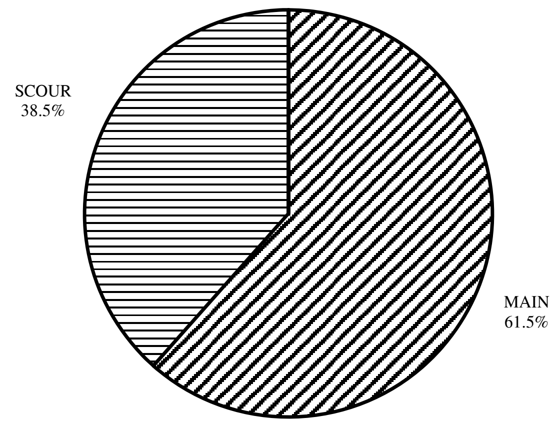


Level IV Habitat Types and Abbreviations

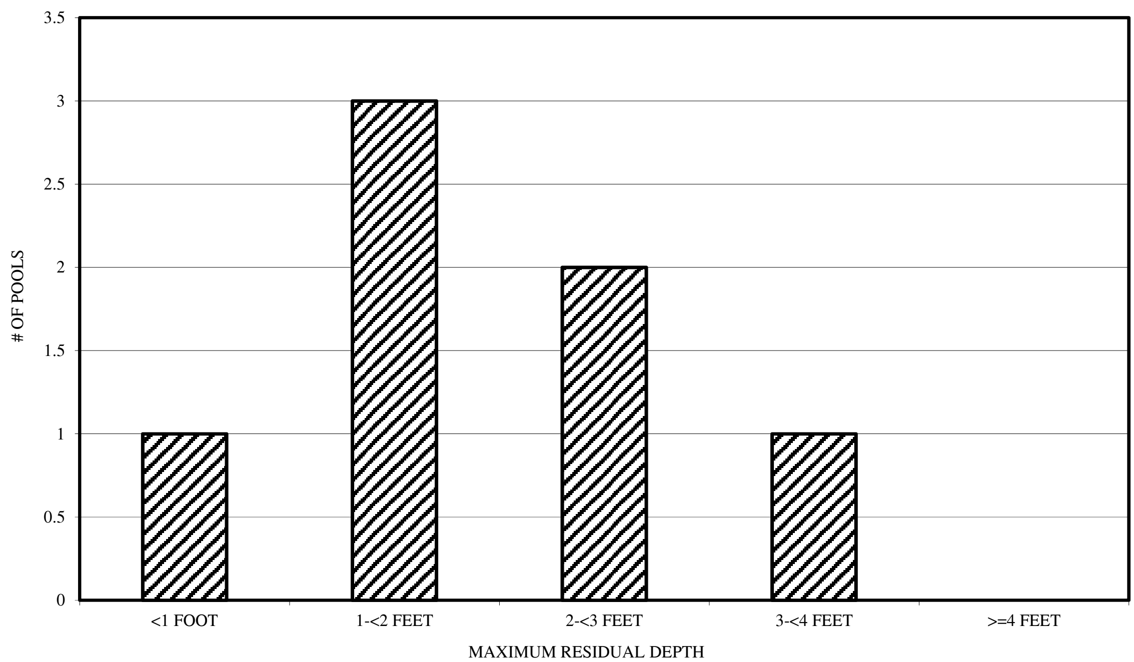
Low Gradient Riffle – LGR
High Gradient Riffle – HGR
Bedrock Sheet – BRS
Glide – GLD
Step Run – SRN
Trench Pool – TRP
Mid-Channel Pool – MCP
Lateral Scour Pool - Root Wad Enhanced – LSR
Lateral Scour Pool - Bedrock Formed – LSBk
Lateral Scour Pool - Boulder Formed – LSBo
Plunge Pool – PLP
Dry – DRY
Culvert – CUL

See Appendix 1 for more information.

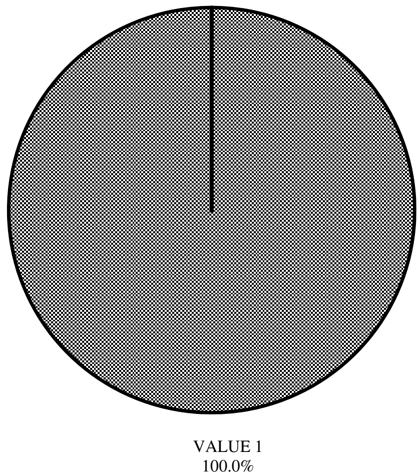
GRAPH 4 - DIAMOND MOUNTAIN CREEK
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 5 - DIAMOND MOUNTAIN CREEK
MAXIMUM DEPTH IN POOLS

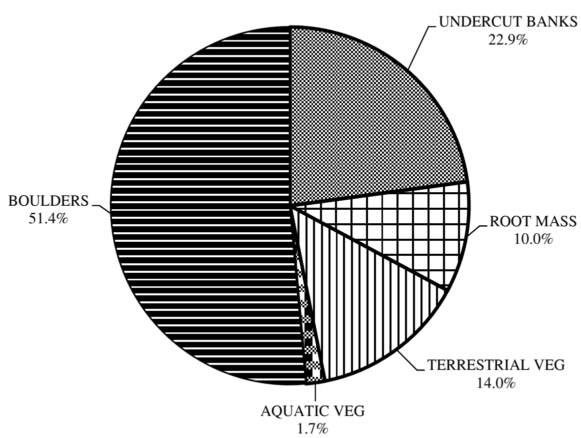


GRAPH 6 - DIAMOND MOUNTAIN CREEK
PERCENT EMBEDDEDNESS

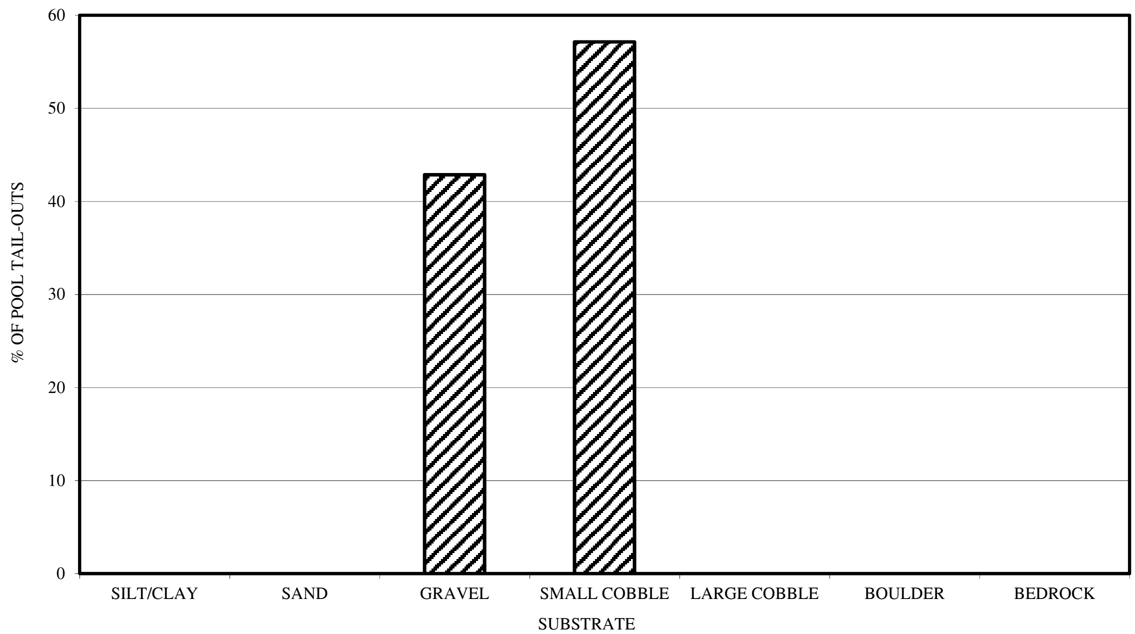


Embeddedness Values: 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

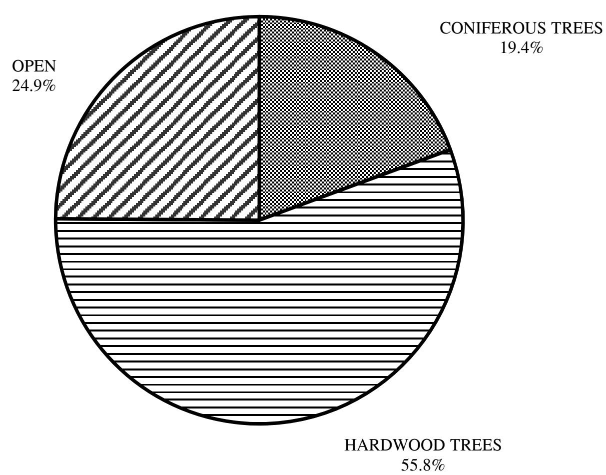
GRAPH 7 - DIAMOND MOUNTAIN CREEK
MEAN PERCENT COVER TYPES IN POOLS



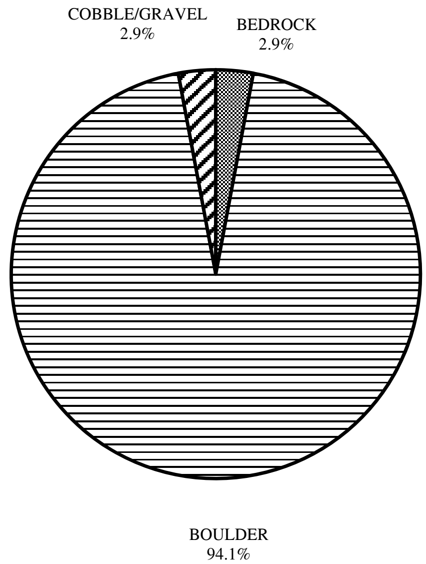
GRAPH 8 - DIAMOND MOUNTAIN CREEK
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



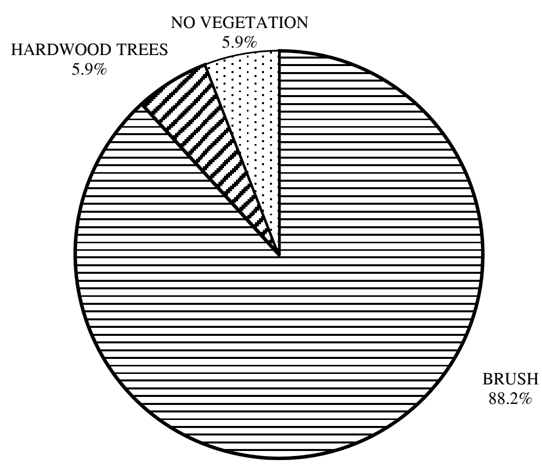
GRAPH 9 - DIAMOND MOUNTAIN CREEK
MEAN PERCENT CANOPY



GRAPH 10 - DIAMOND MOUNTAIN CREEK
DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 11 - DIAMOND MOUNTAIN CREEK
DOMINANT BANK VEGETATION IN SURVEY REACH



Diamond Mountain Creek Photos

4.4a. Lower reach of Diamond Mountain Creek. 8/16/11

4.4b. Lower reach of Diamond Mountain Creek. 8/16/11

4.4c. Pool habitat downstream of artificial, low-flow barrier. 8/16/11

4.4d. Representative habitat. 8/16/11


4.4e. Representative habitat. 9/28/11


4.4f. Culvert crossing under Diamond Mountain Road. 8/16/11

4.4g. High quality riffle habitat near end of survey limits. 8/16/11

4.4h. High quality riffle/pool habitat near end of survey limits. 8/16/11

Discussion
During August and September 2011, 1.3 miles of stream channel were surveyed within the Diamond Mountain Creek watershed. The water temperatures recorded on the survey days ranged from 61 to 63° F. Air temperatures ranged from 67 to 74° F. In-stream water temperatures were at the upper tolerable limits for steelhead (optimal range is 50 to 59° F). However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months.

Flatwater habitat types comprised 11% of the total length of this survey, riffles 14%, and pools 5%. The pools are relatively shallow with only three of the 7 (43%) pools having a maximum residual depth greater than two 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.

All of the 7 pool tail-outs measured had embeddedness ratings of 1 or 2. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. All of the pool tail-outs measured had gravel or small cobble as the substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools was 63. The shelter rating in the flatwater habitats was 25. A pool shelter rating of approximately 100 is desirable. Boulders are the dominant cover type in pools, followed by undercut banks. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover 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 75%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was high at 76% and 84%, 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.

Overall, Diamond Mountain Creek provides suitable habitat for steelhead and/or resident rainbow trout. During the survey period, flows were adequate to support year-round rearing in portions of the creek. However, the lower reach (Reach 1) was completely dry (Photos 4.4a and 4.4b). In the reaches surveyed, pool frequency and depth was below optimal levels for high quality steelhead habitat. However, pool tail-outs supported good quality spawning substrate, and canopy coverage over the channel was near acceptable levels (Photos 4.4g and 4.4h). The stream channel upstream of Reach 2 may support additional habitat for steelhead and/or resident trout; however, these areas were not surveyed due to insufficient access. There are several small, low-flow barriers at road crossings within the watershed (Photos 4.4c and 4.4f). Fisheries resources within the watershed may be limited due a lack of stream flows and presence of the in-stream reservoir that fully blocks passage into the upper reaches.

4.5 Blossom Creek Watershed

Overview

Blossom Creek flows into the Napa River at the north end of Calistoga, Napa County, California. Blossom Creek's location at the confluence with the Napa River is 38:35:13.12 north latitude and 122:35:48.76 west longitude, LLID number 1225955385872. It is mapped on the Calistoga and Mark West Springs USGS Quadrangles. Blossom Creek is a second order stream and drains a watershed of 3.89 square miles. There are two in-stream reservoirs in the upper watershed, one on mainstem Blossom Creek and another on Bennett Creek, a tributary to Blossom Creek. Elevations range from approximately 380 feet at the confluence with the Napa River to 700 feet in the headwater areas. Mixed hardwood and shrubland dominate the watershed. The watershed is primarily privately owned and used for residential and agricultural development. Vehicle access exists via Highway 128 northwest of Tubbs Lane, Bennett Lane, and private roads.

Fisheries Resources and Field Observations

According to Leidy et al. (2005), there are no records of fish observations within the watershed. No other resources were found documenting the occurrence of fish within the watershed.

During the 2011 habitat inventory/reconnaissance surveys of Blossom Creek, the accessible channel was largely dry or had only isolated, stagnant pools, especially along the lower reach where the channel parallels Highway 128. Isolated pools supported a small number of native California roach and non-native bluegill. No steelhead/rainbow trout were observed in the reaches surveyed, and conditions were unfavorable.

Results and Discussion

In August and September 2011, limited field surveys of Blossom Creek were completed. In the lower reach, dry conditions or isolated, stagnant pools were observed (see Photos 4.5a, 4.5b, and 4.5c). The upper reaches of both mainstem Blossom Creek and Bennett Creek were highly channelized and dry (see Photos 4.5e and 4.5f). No habitat for steelhead/rainbow trout was observed within the watershed. At the upper limits of the watershed, two in-stream reservoirs are present. There are no historical reports of fish within the watershed available. Photos of the existing conditions in the lower and upper reaches of the watershed are provided below.

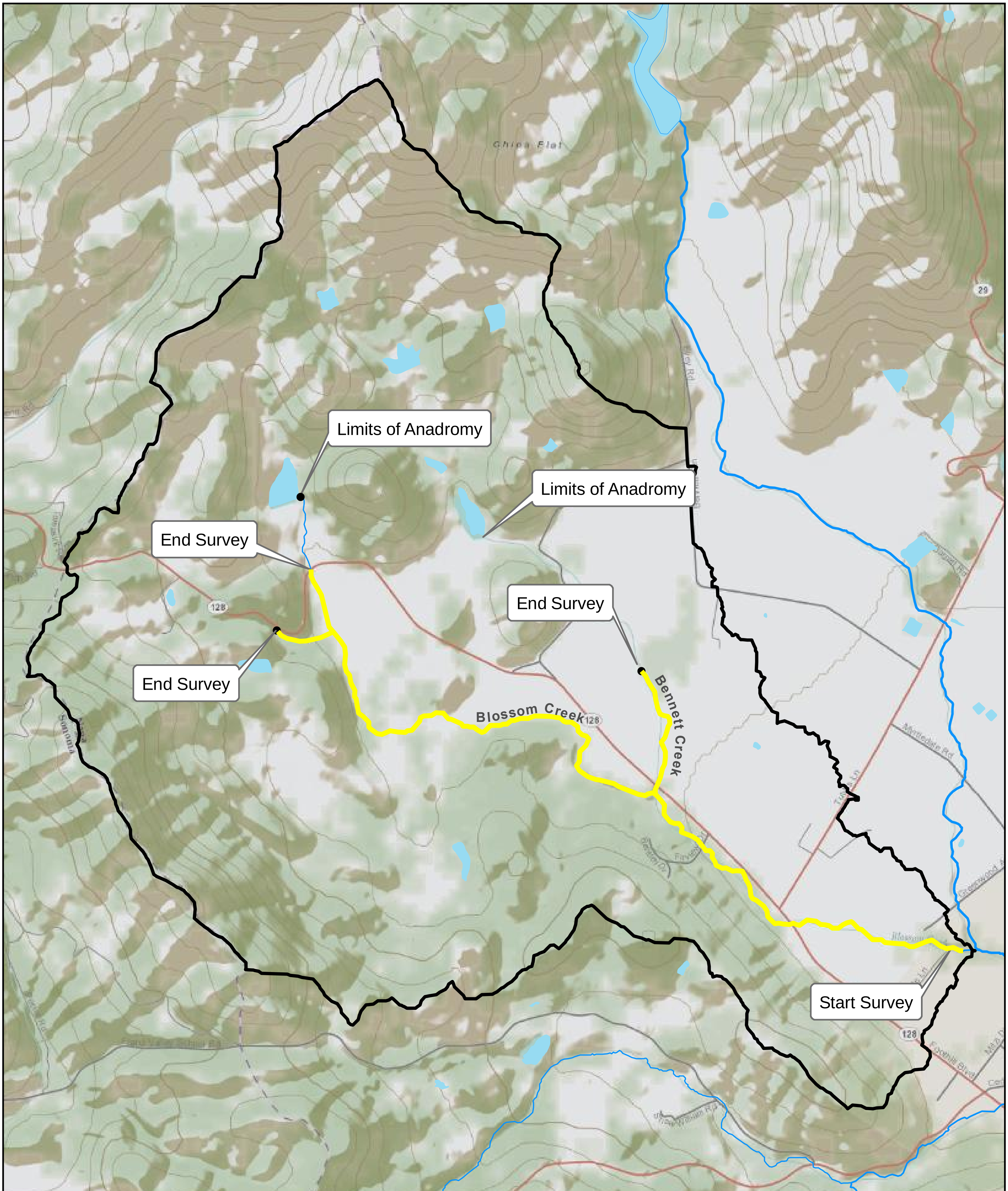


Figure 6. Blossom Creek Watershed
Northern Napa River Tributary Streams Survey Report

N
W E
S

Streams
Watershed Boundary
Blossom Creek Survey (mostly dry or stagnant pools with no habitat value)

0 0.25 0.5 1 Miles

Date: January 2012
Basemaps: ArcOnline Terrain

Blossom Creek Photos

4.5a. Dry stream bed in lower Blossom Creek. 8/22/11

4.5b. Stagnant, isolated pool in lower Blossom Creek. 8/22/11

4.5c. Stagnant, isolated pool in lower Blossom Creek. 8/22/11

4.5d. Road crossing over Bennett Creek. 8/22/11

4.5e. Representative dry stream bed in upper Blossom Creek. 8/22/11

4.5f. Representative dry stream bed in Bennett Creek. 9/28/11

4.6 GARNETT CREEK WATERSHED

Overview
Garnett Creek flows into the Napa River north of Calistoga, Napa County, California. There are several named tributaries to Garnett Creek – Horns, Hoisting Works Canyon, and Jericho Creeks. Downstream of Silverado Trail, Garnett Creek forks to the south, forming Horns Creek along Palisades Road. On the northwest side of Silverado Trail, the largest tributary, Jericho Creek, joins mainstem Garnett Creek. Further upstream, the last tributary, Hoisting Works Canyon Creek, joins the mainstem to the northeast. Garnett Creek's location at the confluence with the Napa River is 38:35:07.0 north latitude and 122:35:30.0 west longitude, LLID number 1225916385853 (mainstem) and 1225887386064 (Jericho Creek). It is mapped on the Calistoga and Detert Reservoir USGS Quadrangles. Garnett Creek is a third order stream and drains a watershed of approximately 7.5 square miles. Elevations range from approximately 360 feet at the confluence with the Napa River to 1,200 feet in the headwater areas above Jericho Creek. Mixed hardwood and shrubland dominate the watershed. The watershed is primarily privately owned and used for residential and agricultural development. Vehicle access exists via Silverado Trail and Old Lawley Toll Road, Palisades Road, and Greenwood Avenue.

Due to the size of the watershed and habitat characteristics, data on Garnett Creek (including mainstem, Horns Creek, and Hoisting Works Canyon Creek) and Jericho Creek were collected separately. Therefore, the following results and discussions have been broken down into Garnett Creek and Jericho Creek, respectively.

Fisheries Resources and Field Observations
According to Leidy et al. (2005), there is a history of steelhead observations within the watershed. In 1970, CDFG found steelhead in both mainstem Garnett Creek and Jericho Creek. In 1981, CDFG rescued 1,189 young-of-the year steelhead from mainstem Garnett Creek. In 1984, CDFG observed steelhead in all sites with water on the mainsteam and up to an impassable barrier (a 15-foot chute) on Jericho Creek. This is likely referring to the bedrock cascade at the limits of anadromy (see Photo4.6o). In 2001 and 2002, surveys completed by Ecotrust and FONR found steelhead in mainstem Garnett Creek and Jericho Creek in varying densities.

During the 2011 habitat inventory surveys, no steelhead/rainbow trout were observed in the watershed. However, several native aquatic species were found in the lower and upper reaches of the mainstem with persistent water. These included California roach, three-spine stickleback, Sacramento sucker, California species of special concern foothill yellow-legged frog (juveniles and adults), and Sierran tree frog (adults and tadpoles). Two additional aquatic species (possibly American bullfrog and unknown salamander larvae) were observed in the mainstem Garnett; however, identification was not definitive. Within Jericho Creek, native California roach, foothill yellow-legged frog, and California giant salamander were observed, along with non-native green sunfish and brown bullhead catfish.

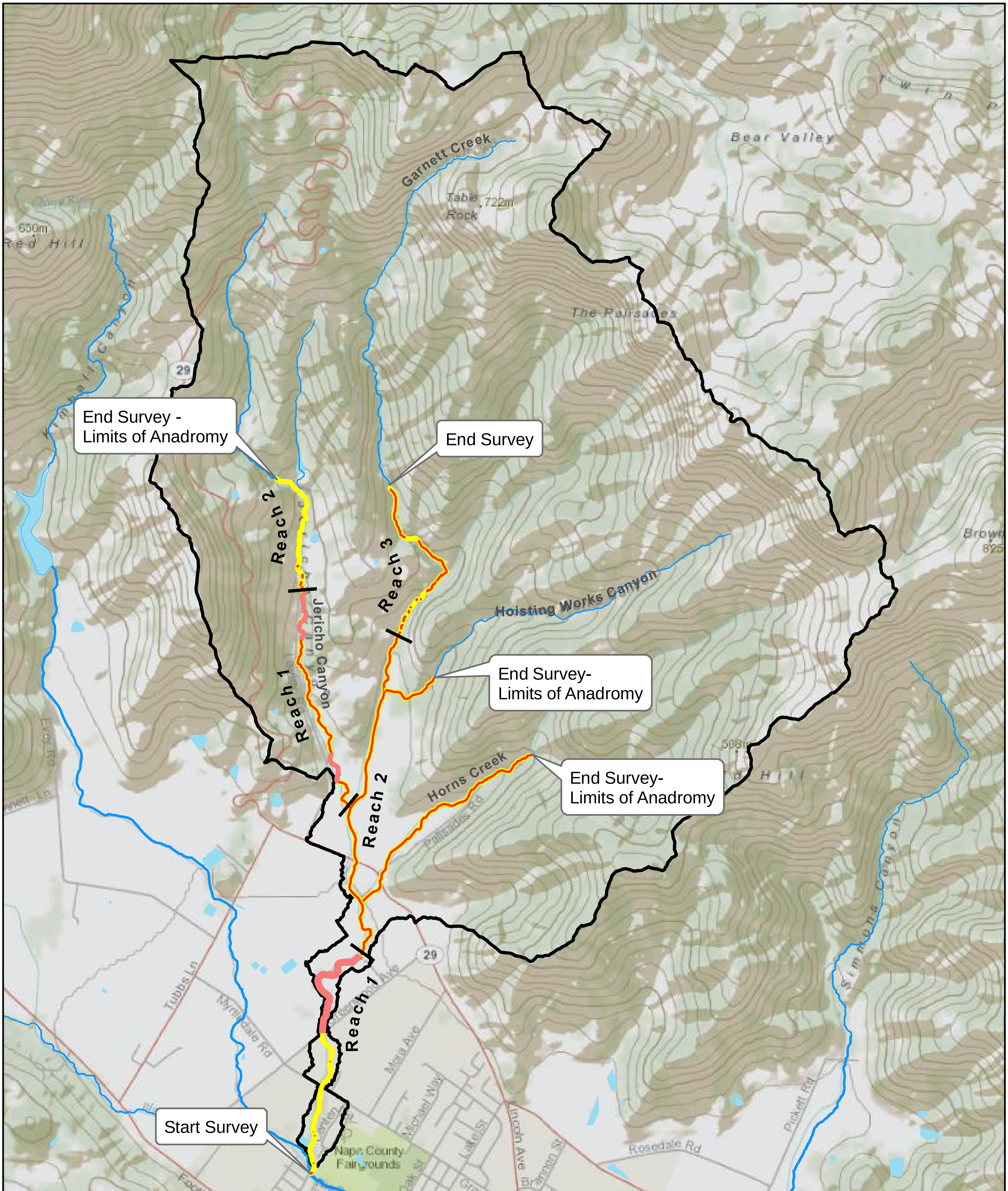


Figure 7. Garnett Creek Watershed
Northern Napa River Tributary Streams Survey Report

N E S W

Streams
Watershed Boundary
Dry Channel
Garnett Creek Survey
Insufficient Access

Date: January 2012
Basemaps: ArcOnline Terrain

0 0.25 0.5 1 Miles

Habitat Inventory Results – Garnett Creek

The habitat inventory of mainstem Garnett Creek and its tributaries, Horns Creek and Hoisting Works Canyon Creek, was conducted on August 25, 29, 31, and September 1, 2011. The survey began at the confluence with the Napa River and continued upstream to the limits of anadromy. The total length of stream surveyed was 17,746 feet (3.4 miles). Photos of the existing conditions are provided below (see Photos 4.6a to 4.6l).

Average stream flow was visually estimated to be 0.1 cfs during the survey period in areas with flowing water. Water temperatures taken during the survey period ranged from 61 to 63° F. Air temperatures ranged from 58 to 67° F.

Garnett Creek was divided into 3 reaches. Reach 1 extended from the confluence with the Napa River upstream to mid-way between Greenwood Avenue and Horns Creek for 6,225 feet. Reach 2 extended from the upstream end of Reach 1 to just upstream of the confluence with Hoisting Work Canyon Creek for 7,824 feet. Reach 3 extended from the upstream end of Reach 2 to the limits of access for 3,697 feet. The presence of water and physical channel characteristics were used to differentiate the 3 stream reaches.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence, there were 28% pool units, 28% riffle units, 27% flatwater units, and 16% dry units (Table 1; Graph 1). Based on total length of Level II habitat types, there were 60% dry units, 10% flatwater units, 10% pool units, and 5% riffle units (Graph 2).

In total, 10 Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 24% Mid-Channel Pool units, 24% Low Gradient Riffle units, and 17% Glide units (Graph 3). Based on percent total length, the most frequent habitat types were Dry units (60%) and Mid-Channel Pool units (9%) (Table 2).

A total of 28 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 89%, and comprised 91% 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. Seven of the 11 pools (64%) had a residual depth of two feet or greater (Graph 5). The remaining three pools (27%) had residuals depths between three feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 11 pool tail-outs measured, 5 had a value of 1 (46%); three had a value of 2 (27%); one had a value of 3 (9%); two had a value of 5 (18%) (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 13, and pool habitats had a mean shelter rating of 60 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 53, and Scour pools had a mean shelter rating of 90 (Table 3).

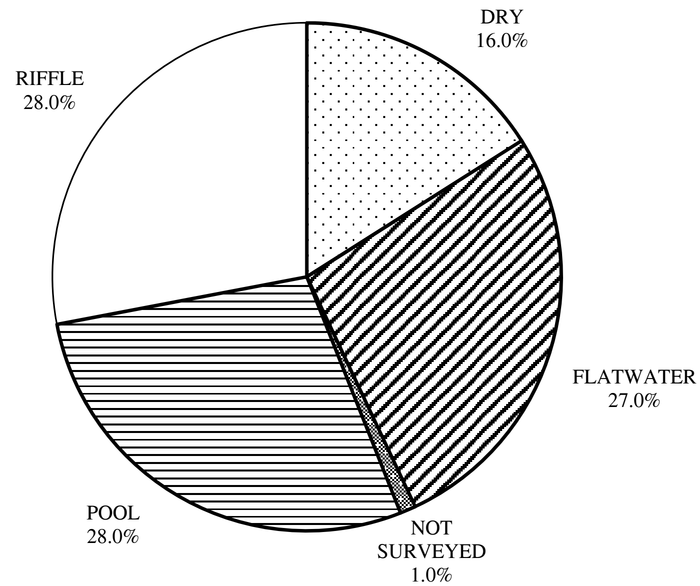
Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Garnett Creek. Graph 7 describes the pool cover in Garnett Creek. Terrestrial vegetation is the dominant pool cover type followed by root mass. Table 10 describes the shelter cover types for the entire system.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was observed in 60% of pool tail-outs, small Cobble observed in 30% of pool tail-outs, and sand observed in 10% of pool tail-outs.

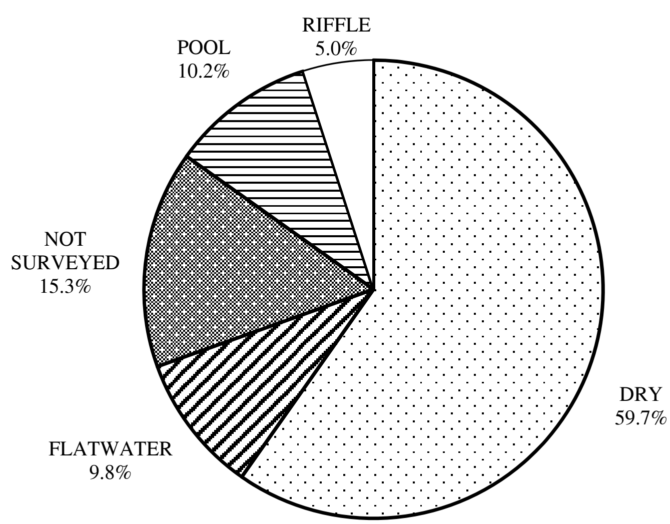
The mean percent canopy density for the surveyed length of Garnett Creek was 75%. The mean percentages of hardwood and coniferous trees were 94% and 6%, respectively. Twenty-five percent of the canopy was open. Graph 9 describes the mean percent canopy in Garnett Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 87%. The mean percent left bank vegetated was 70%. The structure of the stream banks consisted of 38% sand/silt/clay, 26% boulder, and 26% cobble/gravel (Graph 10). Brush (small shrubs and understory vegetation) was the dominant vegetation type observed in 71% of the units surveyed. Additionally, 19% of the units surveyed had deciduous trees as the dominant vegetation type, and 10% had grass as the dominant vegetation (Table 9; Graph 11).

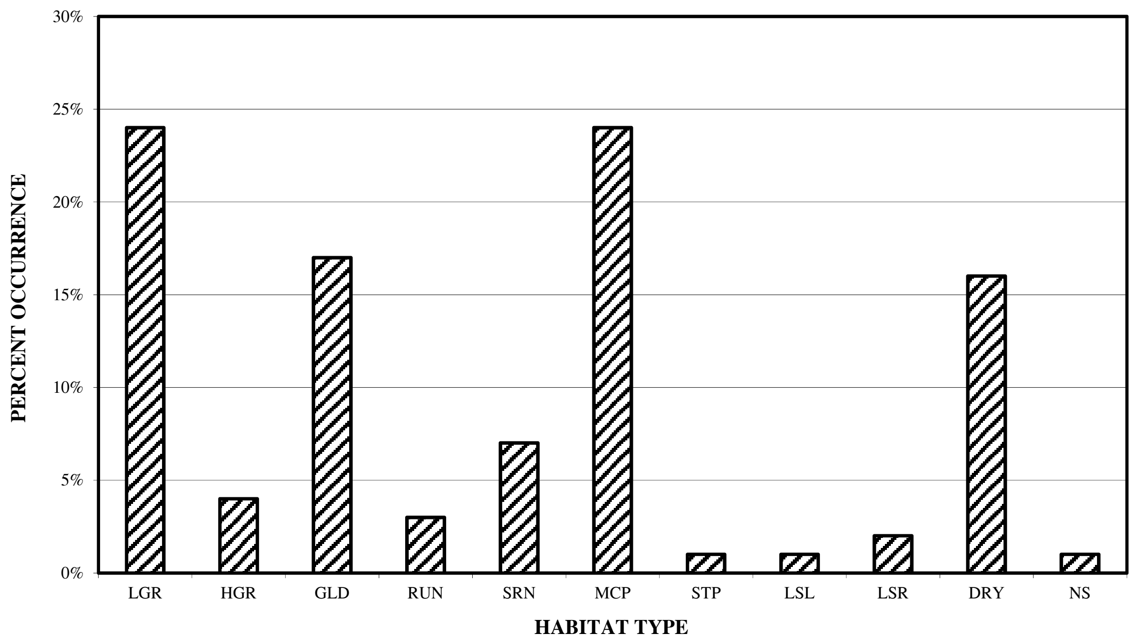
GRAPH 1 - GARNETT CREEK
HABITAT TYPES BY PERCENT OCCURRENCE



GRAPH 2 - GARNETT CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 3 - GARNETT CREEK
HABITAT TYPES BY PERCENT OCCURRENCE

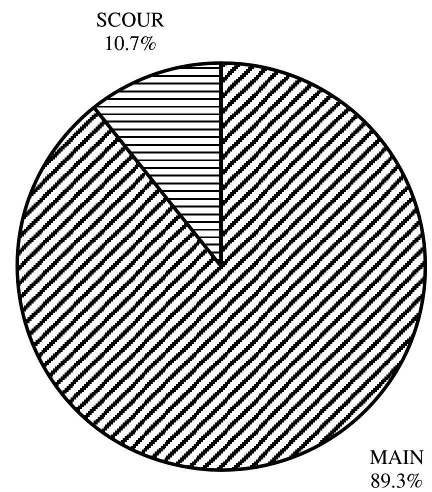


Level IV Habitat Types and Abbreviations

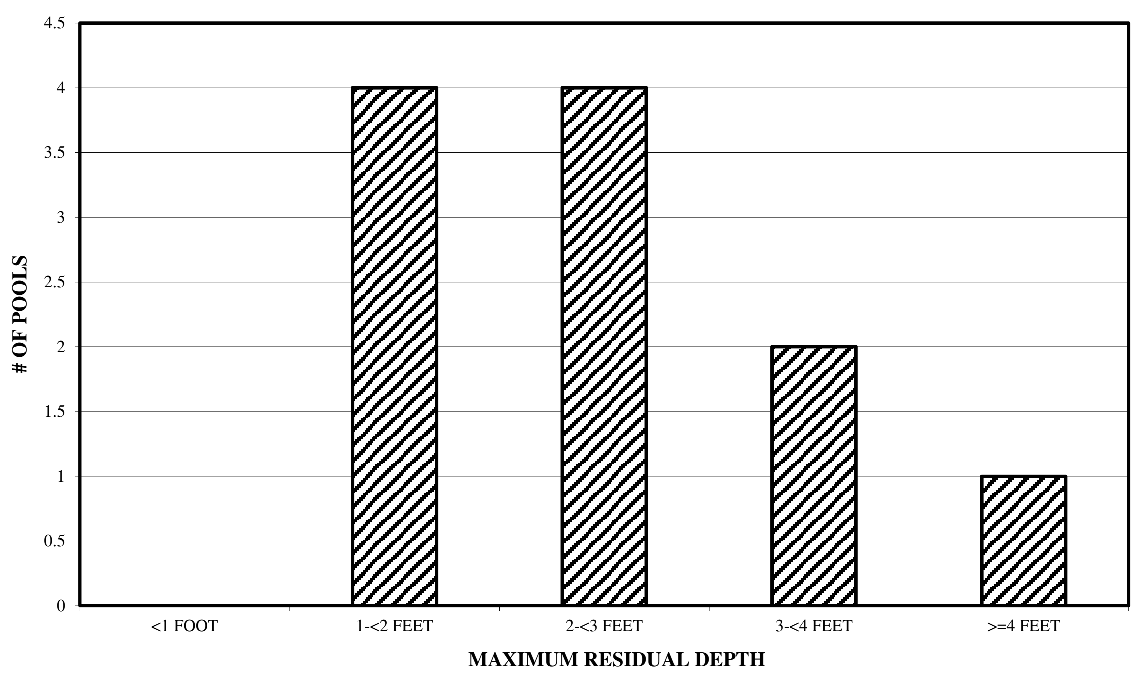
Low Gradient Riffle – LGR
High Gradient Riffle – HGR
Glide – GLD
Run – RUN
Step Run – SRN
Mid-Channel Pool – MCP
Step Pool – STP
Lateral Scour Pool - Log Enhanced – LSL
Lateral Scour Pool - Root Wad Enhanced – LSR
Dry – DRY
Not Surveyed – NS

See Appendix 1 for more information.

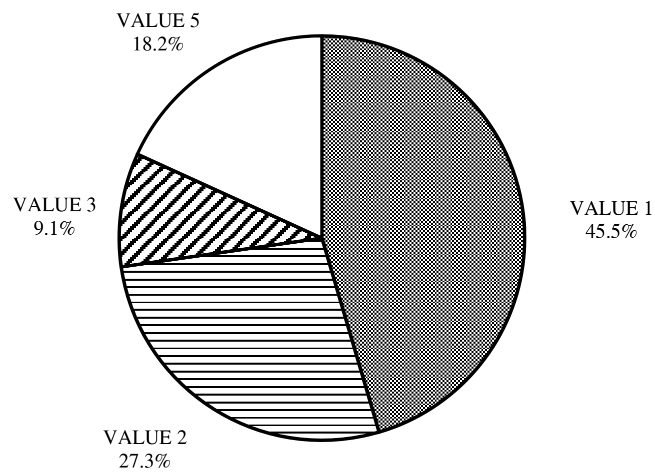
GRAPH 4 - GARNETT CREEK
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 5 - GARNETT CREEK
MAXIMUM DEPTH IN POOLS

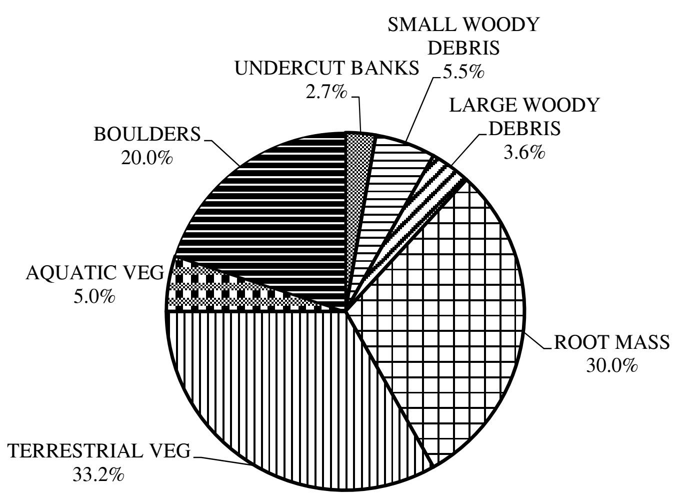


GRAPH 6 - GARNETT CREEK
PERCENT EMBEDDEDNESS

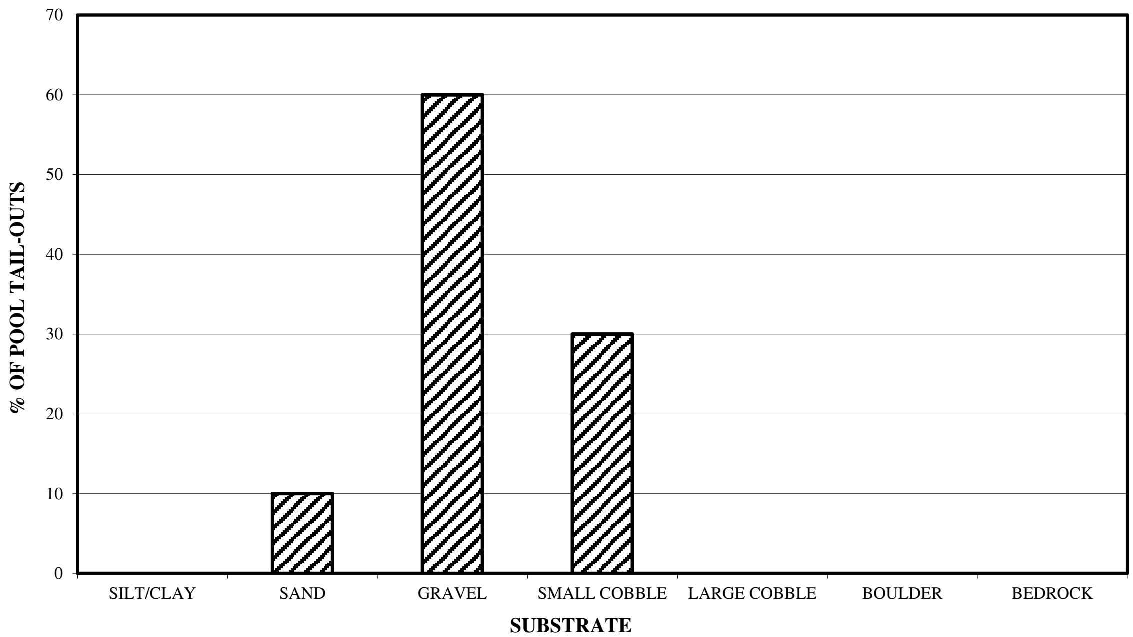


Embeddedness Values: 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

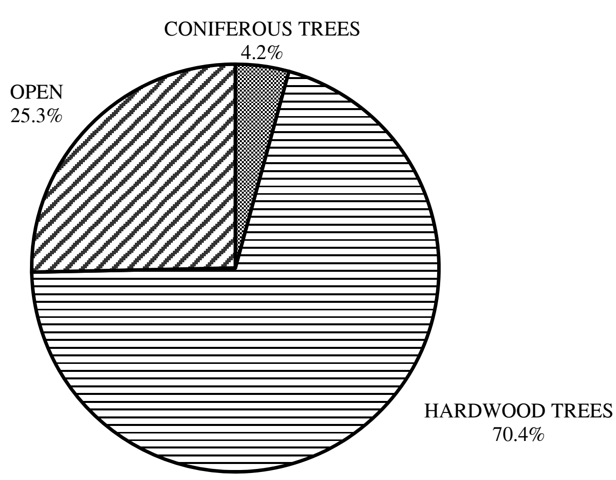
GRAPH 7 - GARNETT CREEK
MEAN PERCENT COVER TYPES IN POOLS



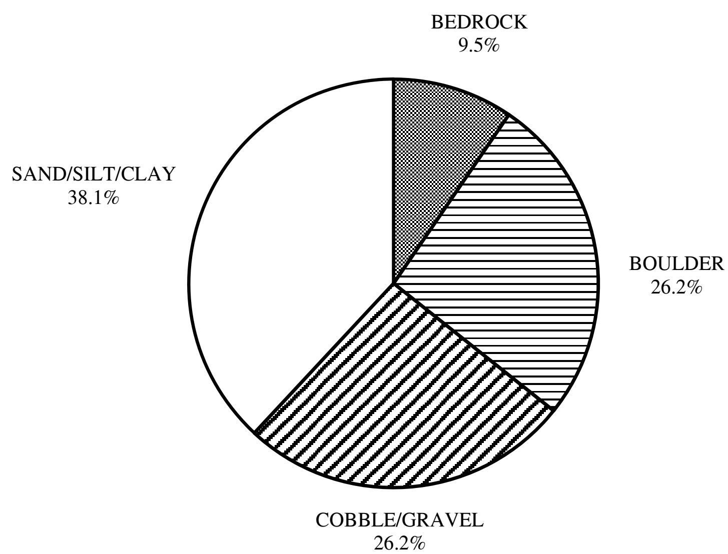
GRAPH 8 - GARNETT CREEK
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



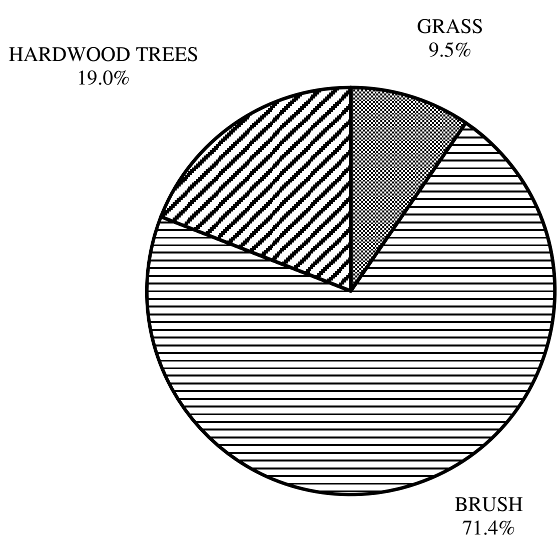
GRAPH 9 - GARNETT CREEK
MEAN PERCENT CANOPY



GRAPH 10 - GARNETT CREEK
DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 11 - GARNETT CREEK
DOMINANT BANK VEGETATION IN SURVEY REACH



Habitat Inventory Results – Jericho Creek

The habitat inventory of Jericho Creek was conducted on August 31 and September 1 and 12, 2011. The survey began at the confluence with mainstem Garnett Creek and continued upstream to the limits of anadromy. The total length of stream surveyed was 8,946 feet (1.7 miles). Photos of the existing conditions are provided below (Photos 4.6m to 4.6o).

Stream flow was visually estimated to be approximately 0 to 0.1 cfs during the survey period. Water temperatures taken during the survey period ranged from 60 to 68° F. Air temperatures ranged from 63 to 86° F.

Jericho Creek was divided into 2 reaches. Reach 1 extended from the confluence with mainstem Garnett Creek for 5,812 feet. Reach 2 extended from the upstream end of Reach 1 to the limits of access and anadromy for 3,134 feet. The presence of water and physical channel characteristics were used to differentiate the 2 stream reaches.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence, there were 24% pool units, 26% riffle units, and 39% flatwater units (Table 1; Graph 1). Based on total length of Level II habitat types, there were 61% dry units, 18% flatwater units, 5% pool units, and 8% riffle units (Graph 2).

In total, 11 Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 20% Glide units, 19% Step Run units, 17% Mid-Channel Pool units, and 15% Low Gradient Riffle units (Graph 3). Based on percent total length, the most frequent habitat types were Dry units (61%) and Step Run units (14%) (Table 2).

A total of 13 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 92%, and comprised 96% 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. Three of the 6 pools (50%) had a residual depth of two feet or greater (Graph 5). The remaining pools had residuals depths of less than two feet (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 6 pool tail-outs measured, three had a value of 1 (50%); two had a value of 3 (33%); and one had a value of 5 (17%) (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 7, flatwater habitat types had a mean shelter rating of 52, and pool habitats had a mean shelter rating of 32 (Table 1). Of the pool types, the Scour pools had a mean shelter rating of 60, and Main Channel pools had a mean shelter rating of 27 (Table 3).

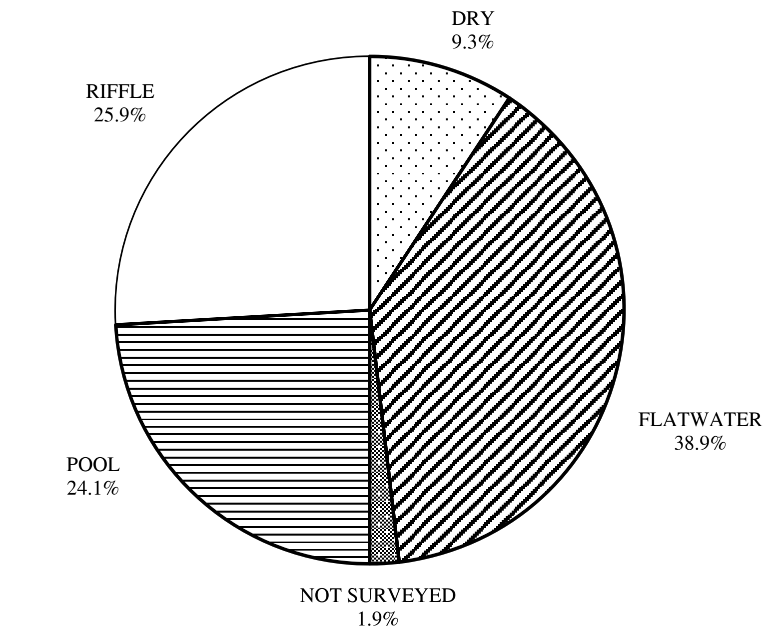
Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Jericho Creek. Graph 7 describes the pool cover in Jericho Creek. Boulders are the dominant pool cover type followed by terrestrial vegetation. Table 10 describes the shelter cover types for the entire system.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel and small Cobble were observed in 33%, respectively, and sand and bedrock were observed in 17% of pool tail-outs, respectively.

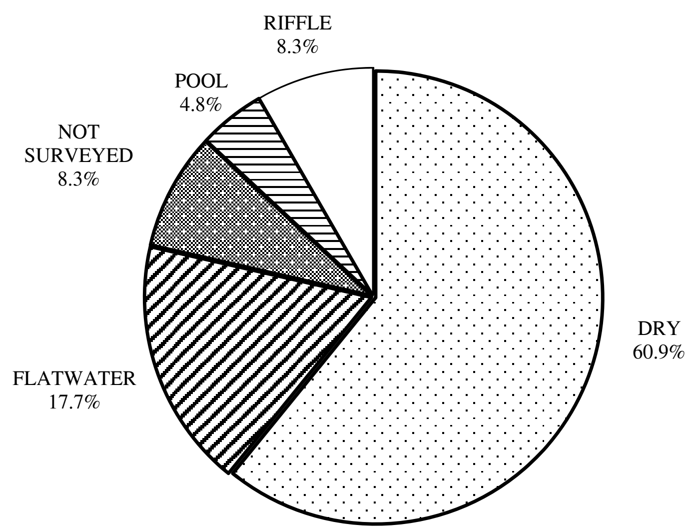
The mean percent canopy density for the surveyed length of Jericho Creek was 77%. The mean percentages of hardwood and coniferous trees were 93% and 7%, respectively. Twenty-three percent of the canopy was open. Graph 9 describes the mean percent canopy in Jericho Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 81%. The mean percent left bank vegetated was 85%. The structure of the stream banks consisted of 61% boulder, 21% bedrock, and 11% sand/silt/clay (Graph 10). Brush (small shrubs and understory vegetation) was the dominant vegetation type observed in 54% of the units surveyed. Additionally, 36% of the units surveyed had deciduous trees as the dominant vegetation type, and 11% had grass as the dominant vegetation (Table 9; Graph 11).

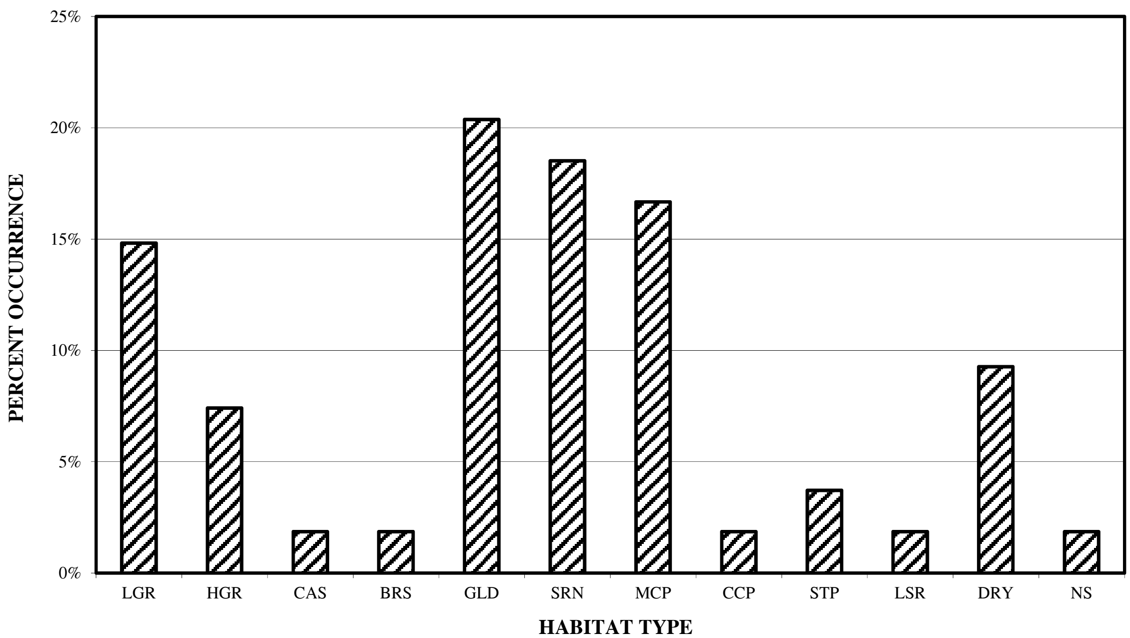
GRAPH 1 - JERICHO CREEK
HABITAT TYPES BY PERCENT OCCURRENCE



GRAPH 2 - JERICHO CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 3 - JERICHO CREEK
HABITAT TYPES BY PERCENT OCCURRENCE

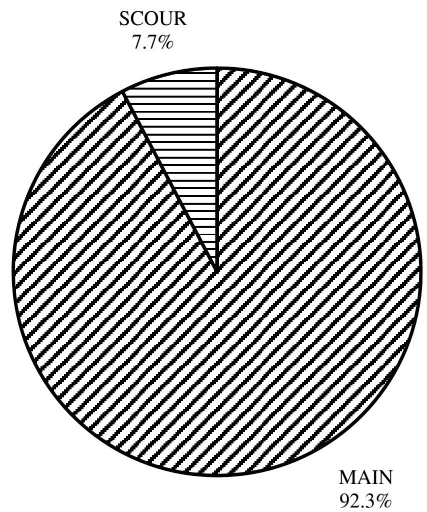


Level IV Habitat Types and Abbreviations

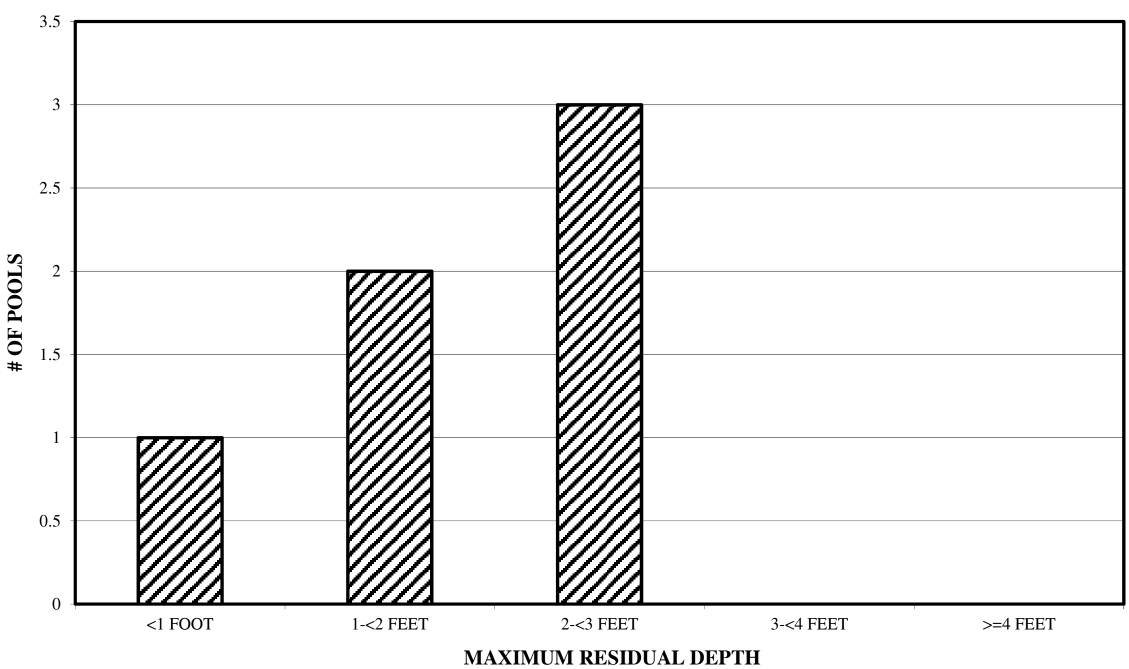
Low Gradient Riffle – LGR
High Gradient Riffle – HGR
Cascade – CAS
Bedrock Sheet – BRS
Glide – GLD
Step Run – SRN
Mid-Channel Pool – MCP
Channel Confluence Pool – CCP
Step Pool – STP
Lateral Scour Pool - Root Wad Enhanced – LSR
Dry – DRY
Not Surveyed – NS

See Appendix 1 for more information.

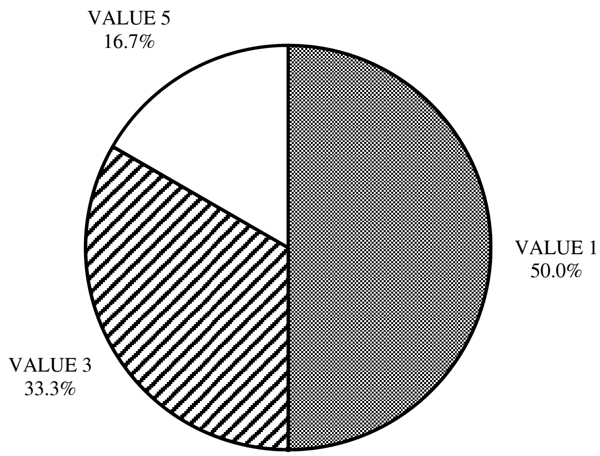
GRAPH 4 - JERICHO CREEK
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 5 - JERICHO CREEK
MAXIMUM DEPTH IN POOLS

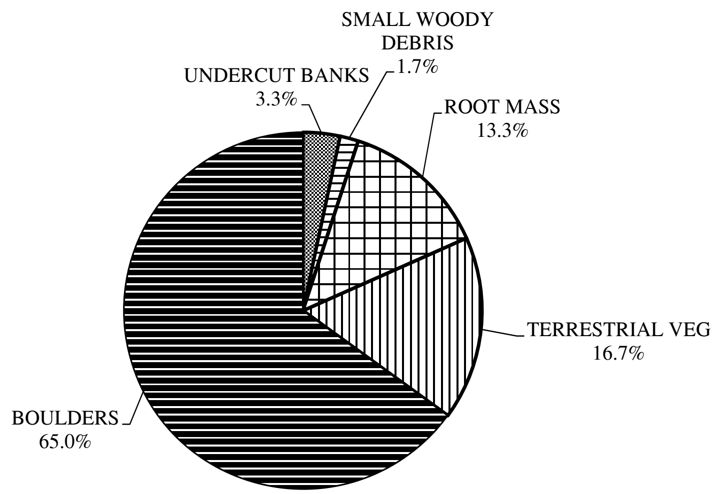


GRAPH 6 - JERICHO CREEK
PERCENT EMBEDDEDNESS

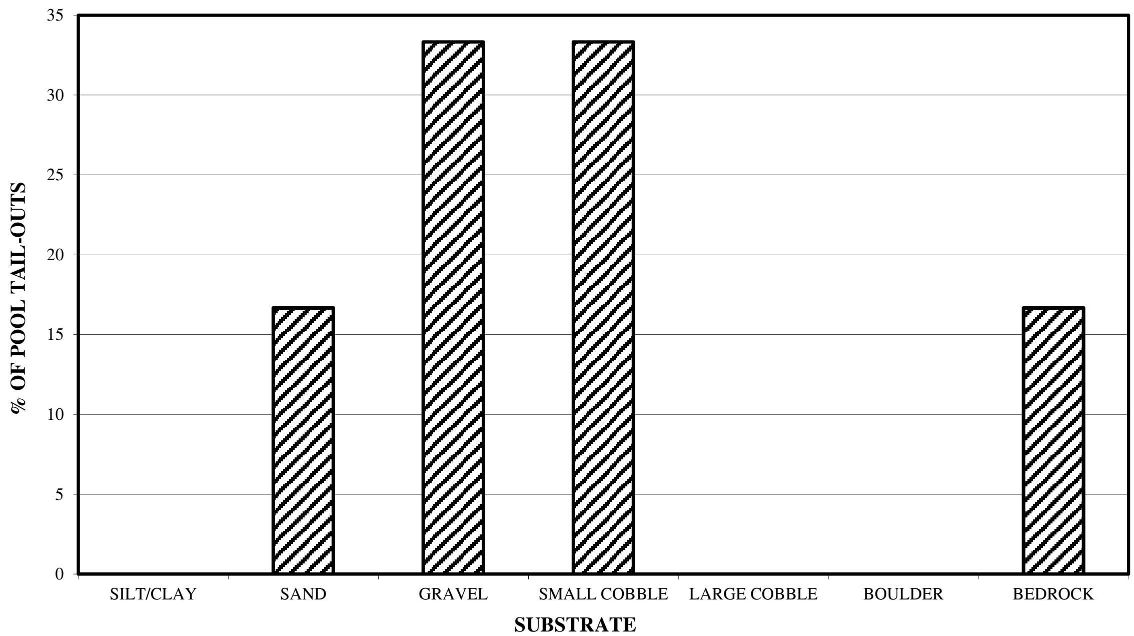


Embeddedness Values: 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

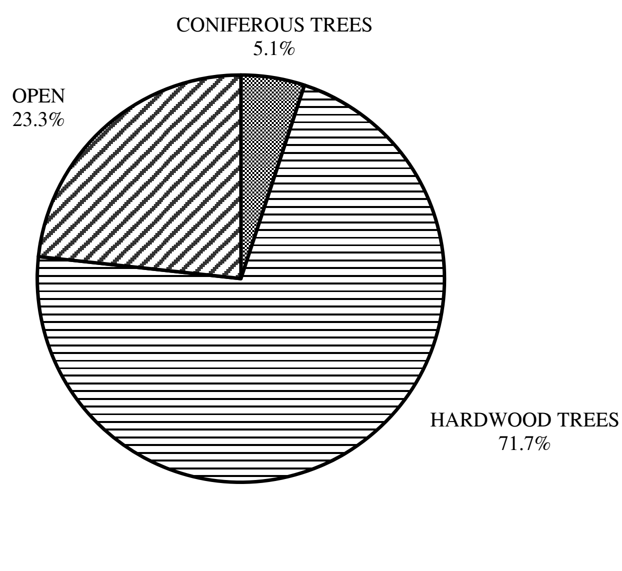
GRAPH 7 - JERICHO CREEK
MEAN PERCENT COVER TYPES IN POOLS



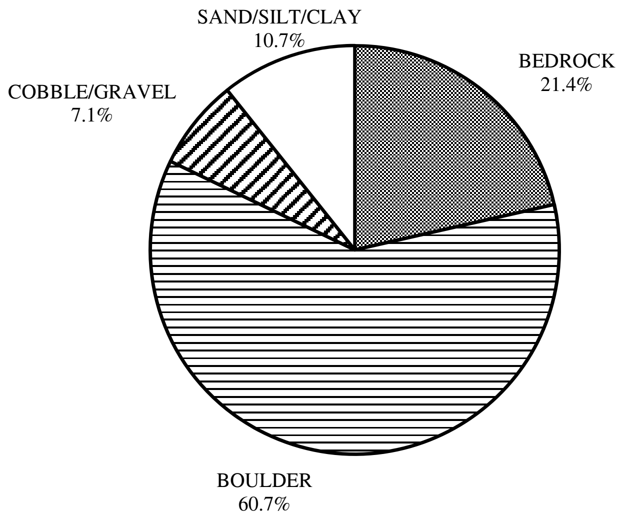
GRAPH 8 - JERICHO CREEK
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



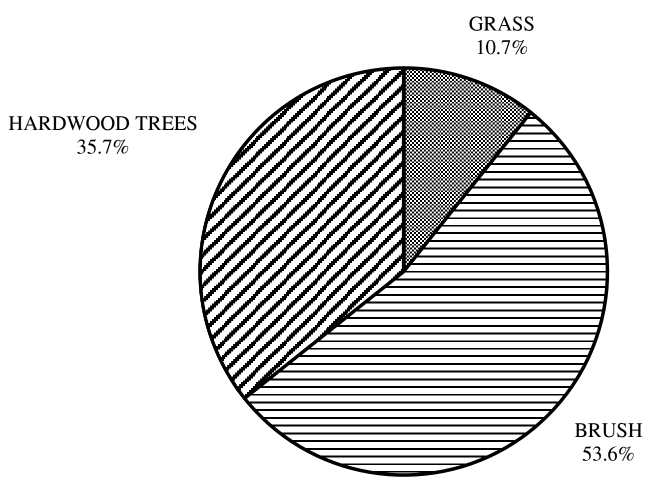
GRAPH 9 - JERICHO CREEK
MEAN PERCENT CANOPY



GRAPH 10 - JERICHO CREEK
DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 11 - JERICHO CREEK
DOMINANT BANK VEGETATION IN SURVEY REACH



Mainstem Garnett Creek Photos

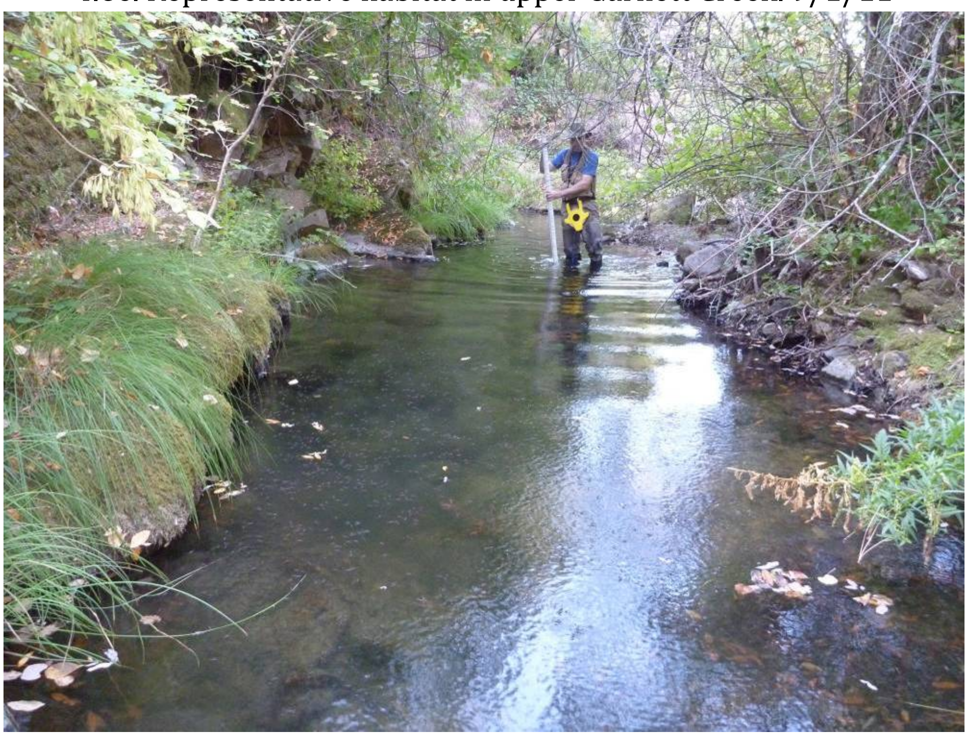
4.6a. Representative habitat in lower Garnett Creek near the confluence with the Napa River. 8/25/11

4.6b. Representative habitat in lower Garnett Creek below Greenwood Avenue. 8/25/11

4.6c. Dry stream bed conditions in the middle reach of Garnett Creek. 8/29/11

4.6d. Four barrel culvert crossing on Garnett Creek. 8/29/11

4.6e. Representative habitat in upper Garnett Creek. 9/1/11



4.6f. Representative habitat in upper Garnett Creek. 9/1/11


4.6g. Dry stream bed conditions in the upper reach of Garnett Creek. 9/1/11


4.6h. Steep boulder cascade at upper limits of survey. 9/1/11

Hoisting Works Canyon Creek Photos

4.6i. Hoisting Works Canyon Creek with characteristic dry stream bed and steep boulder cascade. 8/29/11

4.6j. Concrete road crossing on Hoisting Works Canyon Creek. 8/29/11

Horns Creek Photos

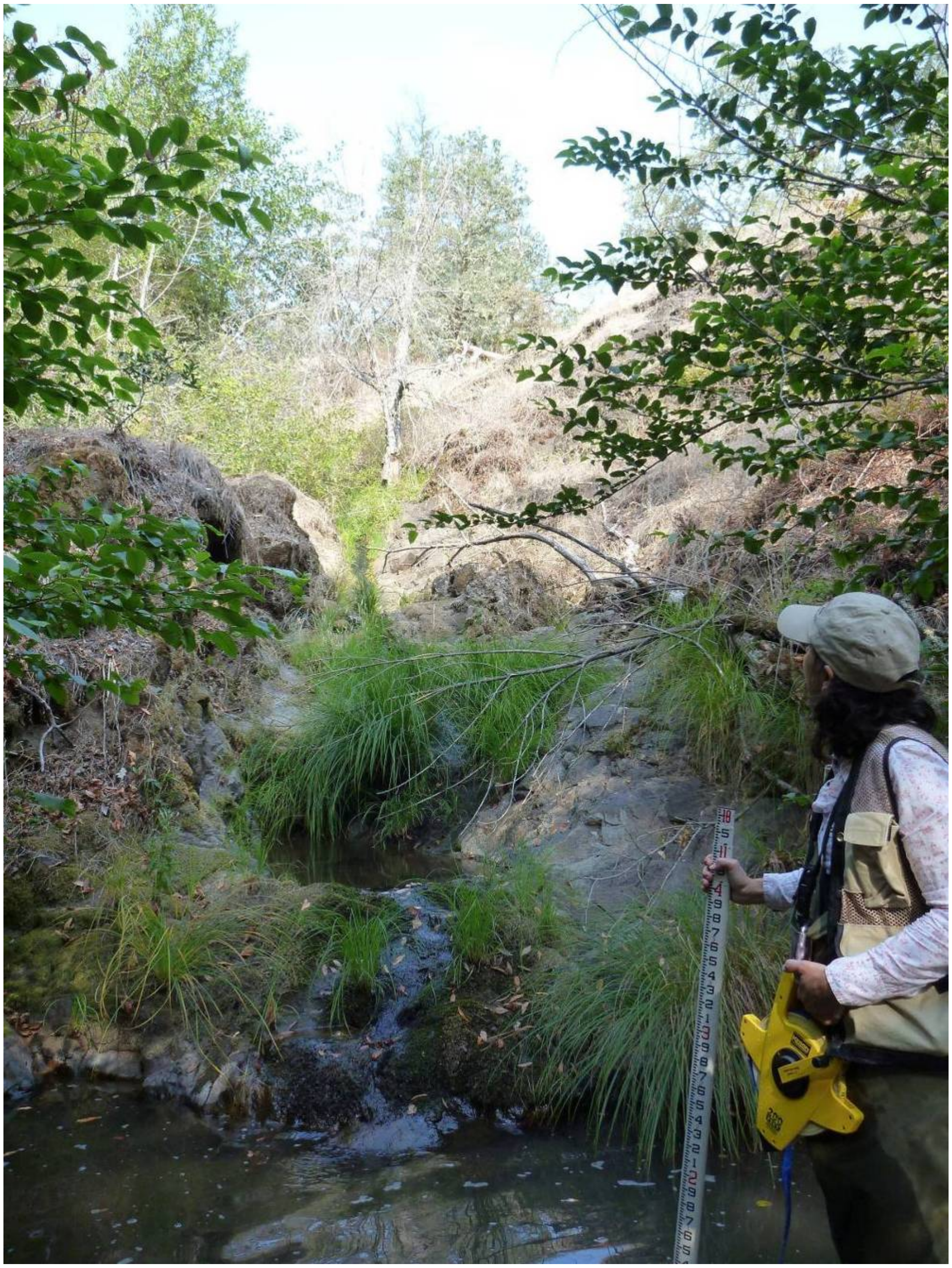
4.6k. Horns Creek with characteristic dry stream bed and steep boulder cascade. 8/31/11

4.6l. Steep boulder cascade at upper limits of survey. 8/31/11

Jericho Creek Photos

4.6m Representative habitat in lower Jericho Creek. 9/1/11

4.6n. Representative habitat in upper Jericho Creek. 9/1/11



4.6o. Limits of anadromy on Jericho Creek. 9/12/11

Discussion – Garnett Creek

During August and September 2011, 3.4 miles of stream channel were surveyed within the Garnett Creek watershed (excluding Jericho Creek). The water temperatures recorded on the survey days ranged from 61 to 63° F. Air temperatures ranged from 58 to 67° F. In-stream water temperatures were at the upper tolerable limits for steelhead (optimal range is 50 to 59° F). However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months.

Flatwater habitat types comprised 10% of the total length of this survey, riffles 5%, and pools 10%. The pools are relatively shallow, with only 7 of the 11 (64%) pools having a maximum residual depth greater than two 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 three feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy.

Eight of the 11 pool tail-outs measured had embeddedness ratings of 1 or 2. One of the pool tail-outs had an embeddedness rating of 3 or 4. Two 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. Nine of the 10 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 60. The shelter rating in the flatwater habitats was 13. A pool shelter rating of approximately 100 is desirable. Terrestrial vegetation is the dominant cover type in pools followed by root mass. 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 75%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was high at 87% and 70%, 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.

Overall, mainstem Garnett Creek provides suitable habitat for steelhead and/or resident rainbow trout. No habitat for steelhead/rainbow trout was observed within Horns and Hoisting Works Canyon Creeks due to dry stream bed conditions and steep topography (Photos 4.6i, 4.6j, 4.6k, and 4.6l).

During the survey period, flows were adequate to support year-round rearing in the upper reach of the mainstem and the lower reach near the confluence with the Napa River. In the reaches surveyed, pool frequency and depth were below optimal levels for high quality steelhead habitat. However, pool tail-outs supported good quality spawning substrate, and canopy coverage over the channel was near acceptable levels. There are numerous accounts of steelhead rearing and spawning within the watershed (Leidy et al. 2005); however, they were not observed during the 2011 surveys. Despite the presence of in-stream habitat and reported observations, fisheries resources within the watershed are limited due to a lack of stream flows, especially along the middle reaches (Photos 4.6a, 4.6b, 4.6c and 4.6d). The most suitable instream habitat conditions were noted in the upper watershed (Photos 4.6e and 4.6f). At the upper limits of mainstem Garnett Creek, the stream channel is very steep and dominated by large boulder cascades. These areas are unsuitable for fish and pose a significant barrier (Photos 4.6g and 4.6h).

Discussion – Jericho Creek

During August and September 2011, 1.7 miles of stream channel were surveyed within the Jericho Creek watershed. The water temperatures recorded on the survey days ranged from 60 to 68° F. Air temperatures ranged from 63 to 86° F. In-stream water temperatures were at the upper tolerable limits for steelhead (optimal range is 50 to 59° F). However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months.

Flatwater habitat types comprised 18% of the total length of this survey, riffles 8%, and pools 5%. The pools are relatively shallow, with only three of the 6 (50%) pools having a maximum residual depth greater than two 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 three feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy.

Three of the 6 pool tail-outs measured had embeddedness ratings of 1 or 2. Two of the pool tail-outs had embeddedness ratings of 3 or 4. One 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. Four 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 32. The shelter rating in the flatwater habitats was 52. A pool shelter rating of approximately 100 is desirable. 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 77%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was high at 81% and 85%, 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.

Overall, Jericho Creek provides a limited amount of suitable habitat for steelhead and/or resident rainbow trout (Photos 4.6m and 4.6n). During the survey period, flows were adequate to support year-round rearing in the upper reach of the watershed. However, pool frequency and depth were below optimal levels for high quality steelhead habitat. In addition, only a few of the pool tail-outs supported good quality spawning substrate. Canopy coverage over the channel was near acceptable levels. The stream channel immediately downstream of Reach 2 may support additional habitat for steelhead and/or resident trout; however, this area was not surveyed due to insufficient access. There are numerous accounts of steelhead rearing within the watershed (Leidy et al. 2005); however, steelhead/rainbow trout were not observed during 2011 surveys. Despite the presence of in-stream habitat and reported observations, fisheries resources within the watershed are limited due to a lack of stream flows, especially along the lower reach. At the upper limits of Jericho Creek, there is an approximately 50-foot bedrock cascade that is a complete barrier to upstream habitat (Photo 4.6o).

4.7 SIMMONS CANYON CREEK WATERSHED

Overview

Simmons Canyon Creek flows into the Napa River approximately 1.0 mile south of Calistoga, Napa County, California. Simmons Canyon Creek's location at the confluence with the Napa River is 38:34:16.6 north latitude and 122:33:32.0 west longitude, LLID number 1222457380787. It is mapped on the Calistoga USGS Quadrangle. Simmons Canyon Creek is a second order stream and drains a watershed of 3.3 square miles. Elevations range from approximately 310 feet at the confluence with the Napa River to 850 feet in the headwater areas. Mixed hardwood and shrubland dominate the watershed. The watershed is primarily privately owned and used for residential and agricultural development. The City of Calistoga operates a wastewater treatment facility near the confluence with the Napa River. Vehicle access exists via Silverado Trail and Pickett Road.

Fisheries Resources and Field Observations

According to Leidy et al. (2005), there are limited records of fish observations within the watershed. In November 1958, a visual and foot survey of the watershed was completed by CDFG, and no fish were observed. A memo prepared by CDFG in 1958 reported Simmons Canyon Creek typically goes dry by late April. In 1981, a fish salvage effort was completed by CDFG. A small number of fish were salvaged in pools 0.5 miles upstream of the confluence with the Napa River.

During the 2011 habitat inventory of Simmons Canyon Creek, the accessible channel was largely dry. Isolated pools near the confluence with the Napa River supported a small number of California roach. Black bear scat was observed in the dry stream bed near the end of the survey. No steelhead/rainbow trout were observed in the reaches surveyed.

Results and Discussion

On September 12, 2011, a visual and foot survey of Simmons Canyon Creek was completed. Isolated pools were observed in the vicinity of the City of Calistoga's wastewater treatment facility near the confluence with the Napa River (Photos 4.7a and 4.7b). Although a few stagnant, isolated pools were present in this lowest reach, no suitable rearing habitat for steelhead was observed. In-stream habitat was evaluated at multiple locations upstream, and the upper reaches of the watershed were surveyed on foot. The remainder of the watershed was dry. At the upper limits of the watershed, the stream channel becomes very steep and dominated by large boulder cascades (Photo 4.7c). As indicated in Leidy et al. (2005), fisheries resources within the Simmons Canyon Creek watershed are limited due a lack of stream flows.

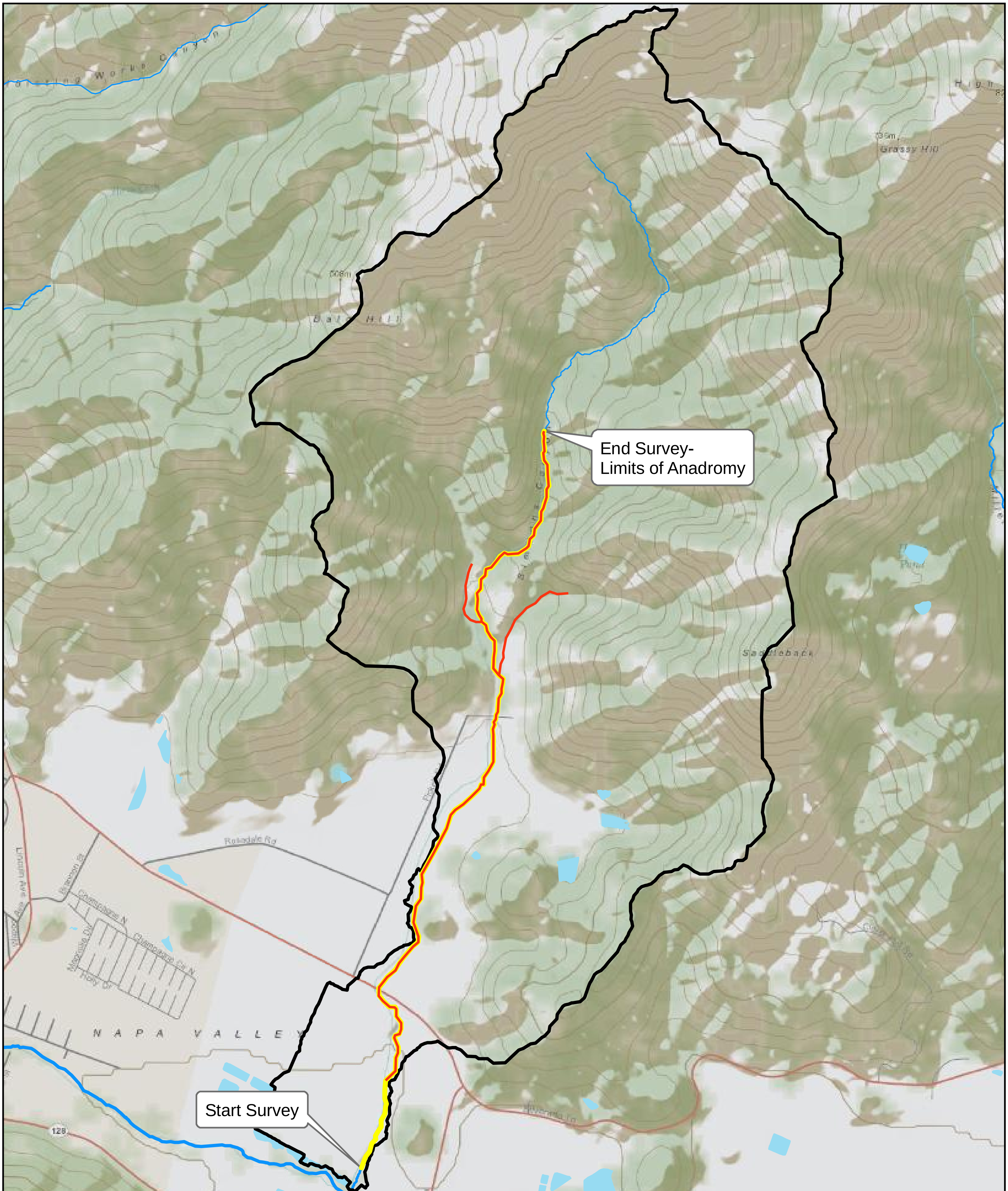


Figure 8. Simmons Canyon Creek Watershed
Northern Napa River Tributary Streams Survey Report

N
W E
S

Streams
Watershed Boundary
Simmons Canyon Survey
Dry Channel

Date: January 2012
Basemaps: ArcOnline Terrain

0 0.25 0.5 1 Miles

Simmons Canyon Creek Photos

4.7a. Dry stream bed conditions near the confluence with the Napa River. 9/12/11

4.7b. Isolated pools in the lower reach of Simmons Canyon Creek. 9/12/11

4.7c. Upper reach of Simmons Canyon Creek with characteristic dry stream bed and steep boulder cascade. 9/12/11

4.8 SELBY CREEK WATERSHED

Overview

Selby Creek (aka Dutch Henry Creek) flows into the Napa River south of Calistoga, Napa County, California. Mainstem Selby Creek runs from the confluence of the Napa River upstream to approximately Silverado Trail. At this location, it forks to the south and north, forming Dutch Henry Creek and Biter Creek, respectively. Selby Creek's location at the confluence with the Napa River is 38:33:32.87 north latitude and 122:30:39.78 west longitude, LLID number 1225188385770. It is mapped on the Calistoga and St. Helena USGS Quadrangles. Selby Creek is a third order stream and drains a watershed of approximately 5.9 square miles. Elevations range from approximately 265 feet at the confluence with the Napa River to 1,200 feet in the headwater areas above Dutch Henry Creek. Mixed hardwood and shrubland dominate the watershed. It is primarily privately owned and used for residential and agricultural development. There is a large private resort on Biter Creek. Vehicle access exists via Silverado Trail and Larkmead Lane, Dutch Henry Canyon Road, and Lommel Road.

Fisheries Resources and Field Observations

According to Leidy et al. (2005), there have been limited fish observations within the watershed. In November 1958, a visual survey was completed by CDFG. Fish were present in intermittent, spring-fed pools in the middle and upper reaches of the watershed. The lower reach was completely dry. A memo prepared by CDFG in 1958 reported that Selby Creek typically goes dry in the summer-fall months. In 1981, a CDFG survey of the entire watershed found dry conditions and no fish. A small number of steelhead were observed in 1987 near the Silverado Trail crossing. In June 2001, NCRCD observed abundant juvenile steelhead ranging from 2-6 inches in Selby and Dutch Henry Creeks. NCRCD also found two adult steelhead carcasses near the Larkmead Lane Bridge on February 29, 2008. The channel was completely dry at the time.

During the 2011 habitat inventory surveys of Selby Creek, no steelhead/rainbow trout were observed. Downstream of Larkmead Lane, isolated pools supported a small number of native threespine stickleback and freshwater leech and non-native signal crayfish and American bullfrog. In Dutch Henry Creek, juvenile California giant salamander and western toad were observed.

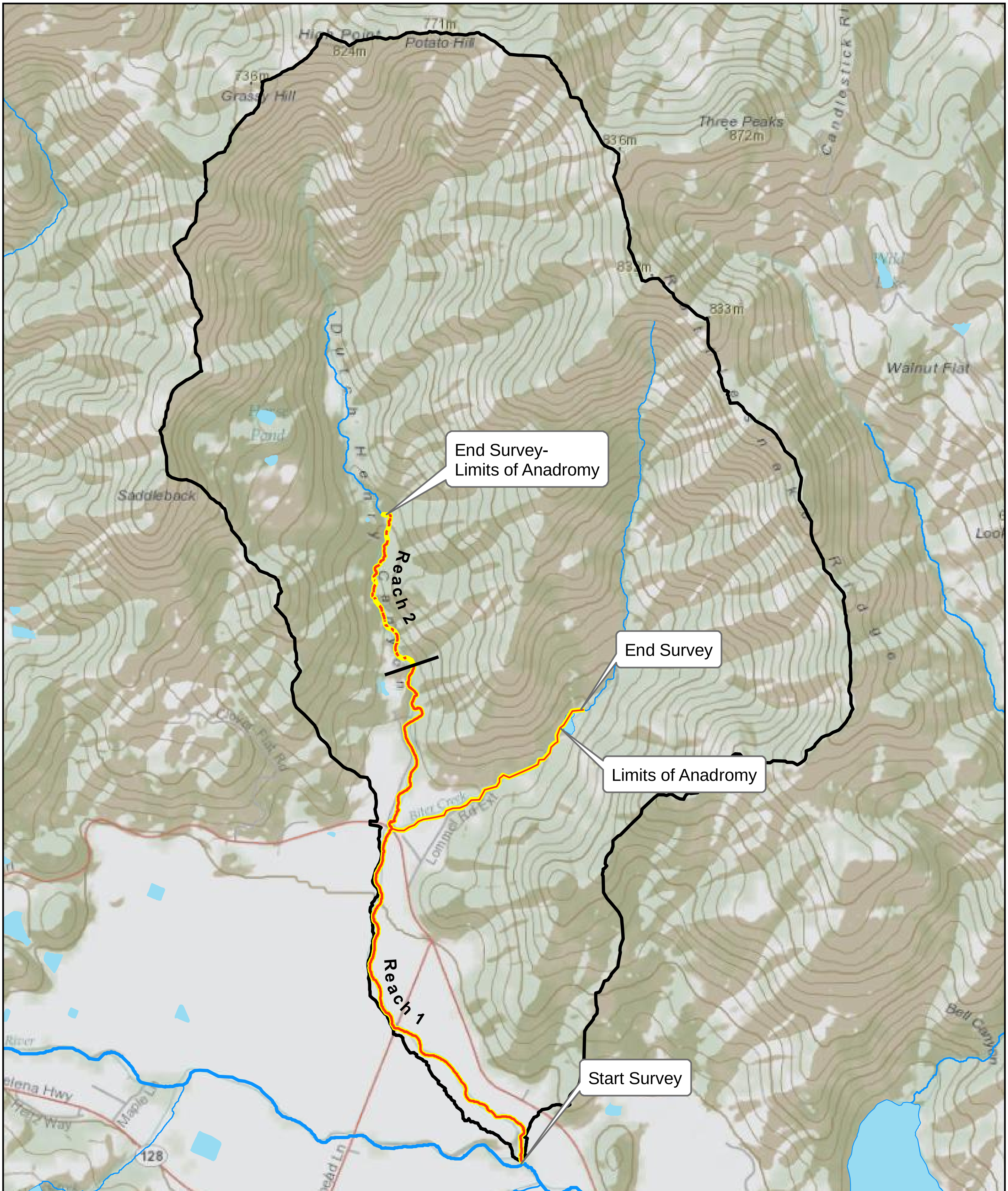


Figure 9. Selby Creek Watershed
Northern Napa River Tributary Streams Survey Report

Date: January 2012
Basemaps: ArcOnline Terrain

0 0.25 0.5 1 Miles

N E S W

Streams
Watershed Boundary
Selby Creek Survey
Dry Channel

Habitat Inventory Results

The habitat inventory of Selby Creek was conducted on September 13 and October 11, 2011. The survey began at the confluence with the Napa River and continued upstream to the limits of anadromy. The total length of stream surveyed was 16,976 feet (3.2 miles). Photos of the existing conditions are provided below (Photos 4.8a to 4.8l).

Average stream flow was visually estimated to be 0.1 cfs during the survey period in areas with flowing water. Water temperatures taken during the survey period ranged from 61 to 63° F. Air temperatures ranged from 67 to 72° F.

Selby Creek was divided into two reaches. Reach 1 extended from the confluence with the Napa River upstream to the Silverado Trail for 13,217 feet. Reach 2 extended 3,759 feet upstream of Reach 1 to the limits of access. The presence of water and physical channel characteristics were used to differentiate the two stream reaches.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence, there were 35% dry units, 29% flatwater units, 20% pool units and 16% riffle units (Table 1; Graph 1). Based on total length of Level II habitat types there were 92% dry units, 2% riffle units, 4% flatwater units, and 2% pool units (Graph 2).

In total, 10 Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were Dry units (35%), Mid-Channel Pool units (13%), Step Run units (18%), and Glide units (11%) (Graph 3). Based on percent total length, the most frequent habitat types were Dry units (92%) and Step Run units (3%) (Table 2).

A total of 11 pools were identified (Table 3). Main Channel pools were the most frequently encountered, at 82%, and comprised 77% 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. One of the 5 pools (20%) had a residual depth of two feet or greater (Graph 5). The remaining 4 pools had residuals depths between one and two feet.

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 5 pool tail-outs measured, one had a value of 1 (20%); two had a value of 2 (40%); one had a value of 3 (20%); one had a value of 5 (20%) (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 35, flatwater habitat types had a mean shelter rating of 32, and pool habitats had a mean shelter rating of 66 (Table 1). Of the pool types, the Main Channel pools had a mean shelter rating of 57 and Scour pools had a mean shelter rating of 80 (Table 3).

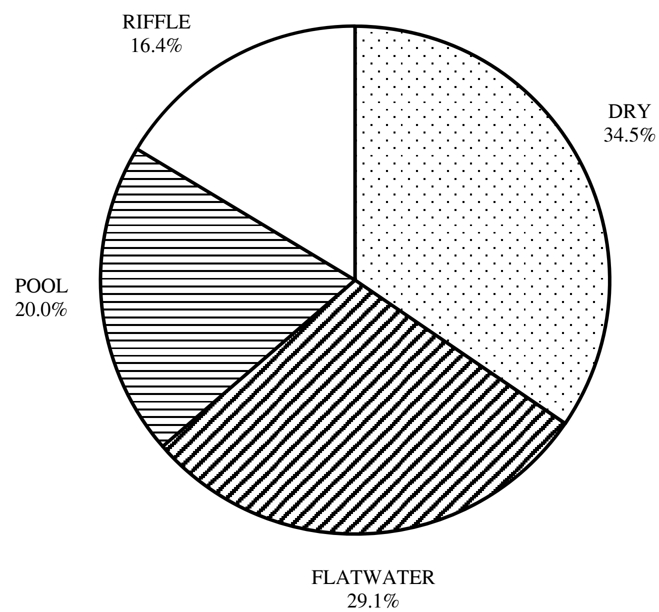
Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Selby Creek. Graph 7 describes the pool cover in Selby Creek. Boulders (56%) are the dominant pool cover type followed by aquatic vegetation (28%). Table 10 describes the shelter cover types for the entire system.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Large Cobble was observed in 60% of pool tail-outs, boulders observed in 20% of pool tail-outs, and gravel in 20% of pool tail-outs.

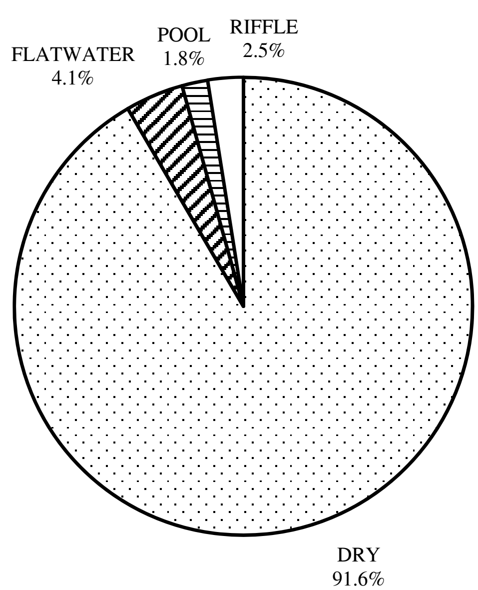
The mean percent canopy density for the surveyed length of Selby Creek was 75%. The mean percentages of hardwood and coniferous trees were 96% and 4%, respectively. Twenty-five percent of the canopy was open. Graph 9 describes the mean percent canopy in Selby Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 50%. The mean percent left bank vegetated was 60%. The structure of the stream banks consisted of 86% boulder, 5% cobble/gravel, and 9% bedrock (Table 9; Graph 10). Hardwood trees were the dominant vegetation type observed in 50% of the units surveyed. Additionally, 36% of the units surveyed had brush (small shrubs and understory vegetation) as the dominant vegetation type, and 14% had no vegetation (Table 9; Graph 11).

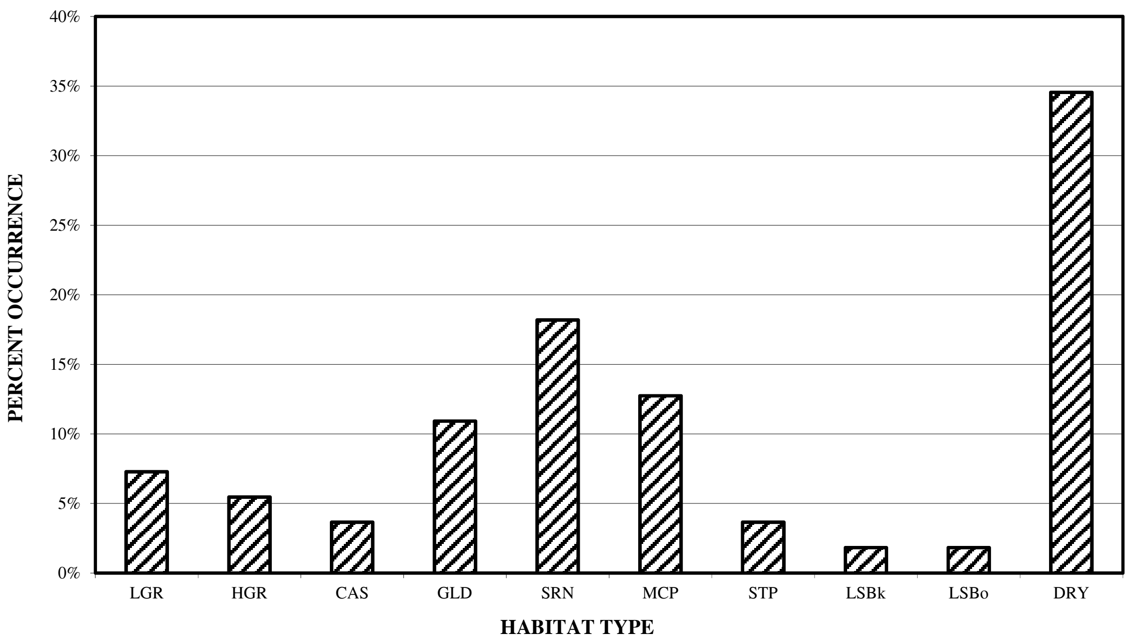
GRAPH 1 - SELBY CREEK
HABITAT TYPES BY PERCENT OCCURRENCE



GRAPH 2 - SELBY CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 3 - SELBY CREEK
HABITAT TYPES BY PERCENT OCCURRENCE

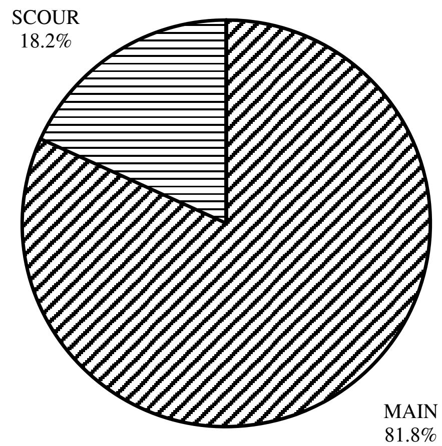


Level IV Habitat Types and Abbreviations

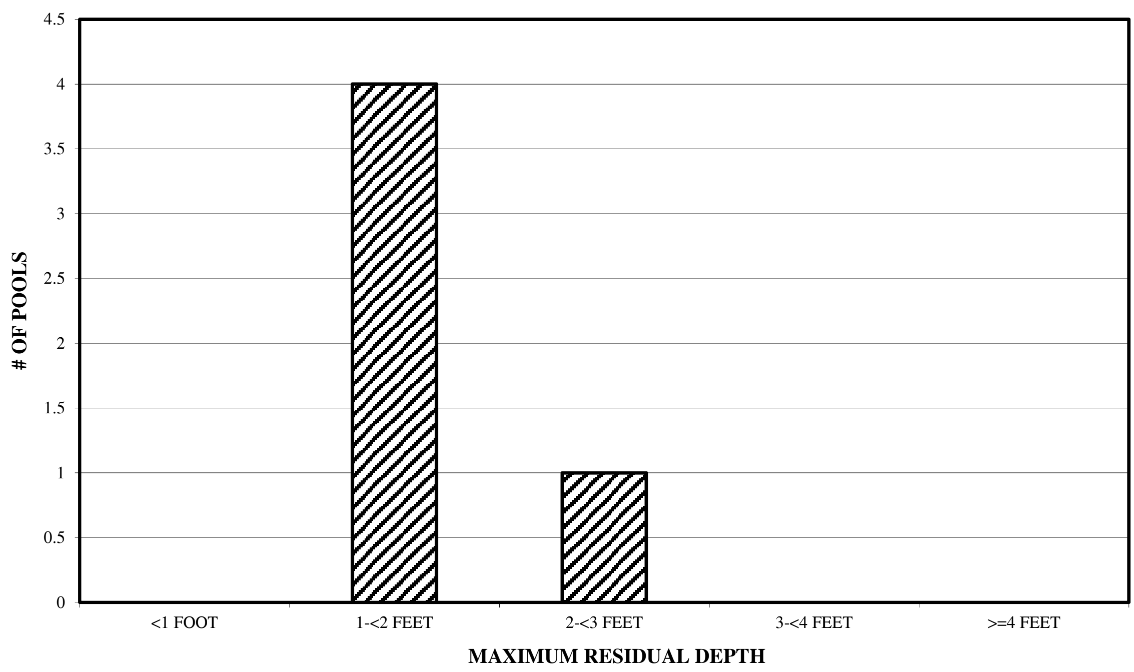
Low Gradient Riffle – LGR
High Gradient Riffle – HGR
Cascade – CAS
Glide – GLD
Step Run – SRN
Mid-Channel Pool – MCP
Step Pool – STP
Lateral Scour Pool - Bedrock Formed – LSBk
Lateral Scour Pool - Boulder Formed – LSBo
Dry – DRY

See Appendix 1 for more information.

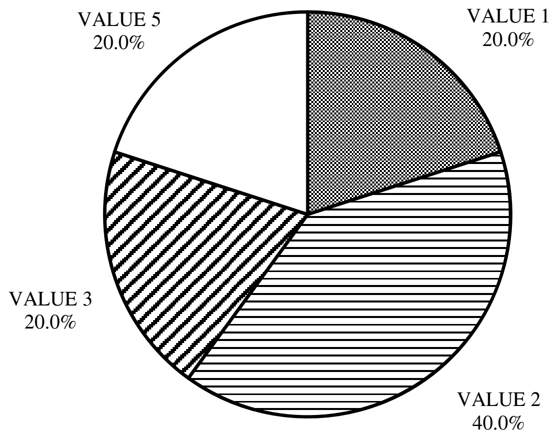
GRAPH 4 - SELBY CREEK
POOL TYPES BY PERCENT OCCURRENCE



GRAPH 5 - SELBY CREEK
MAXIMUM DEPTH IN POOLS

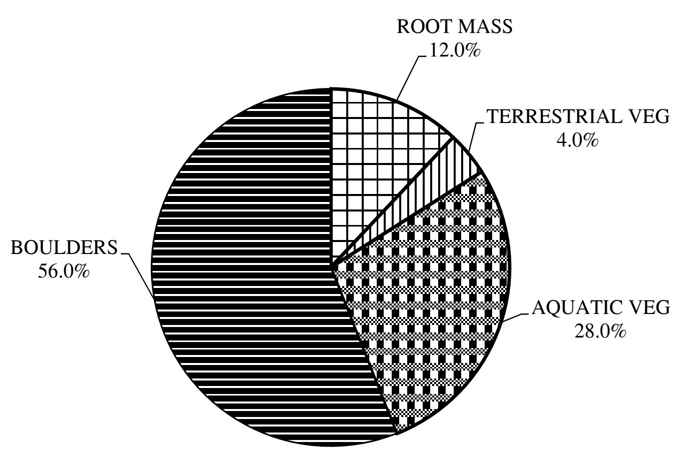


GRAPH 6 - SELBY CREEK
PERCENT EMBEDDEDNESS

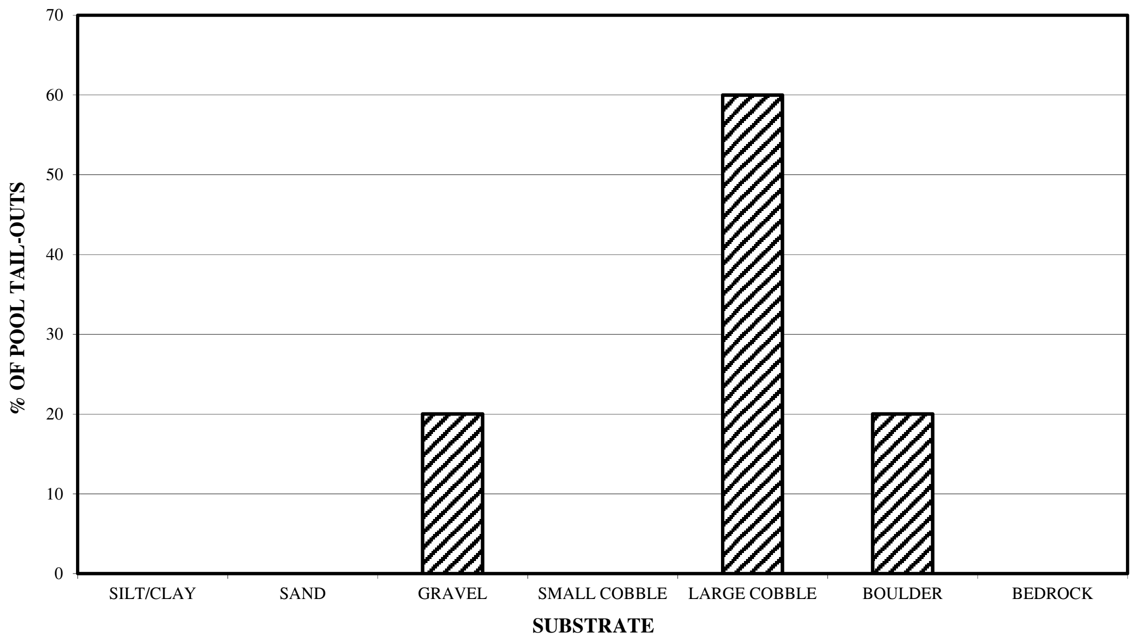


Embeddedness Values: 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.

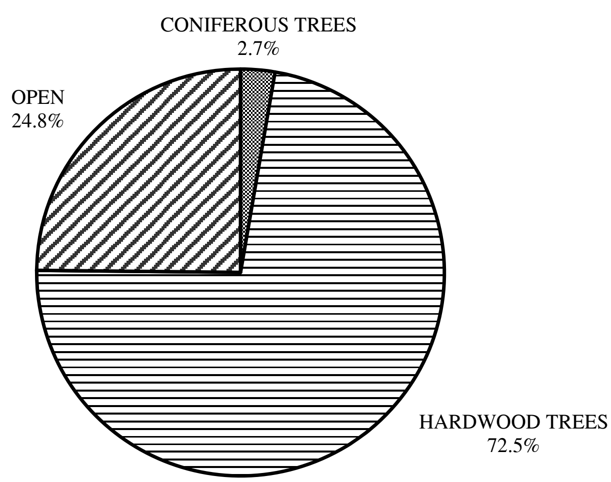
GRAPH 7 - SELBY CREEK
MEAN PERCENT COVER TYPES IN POOLS



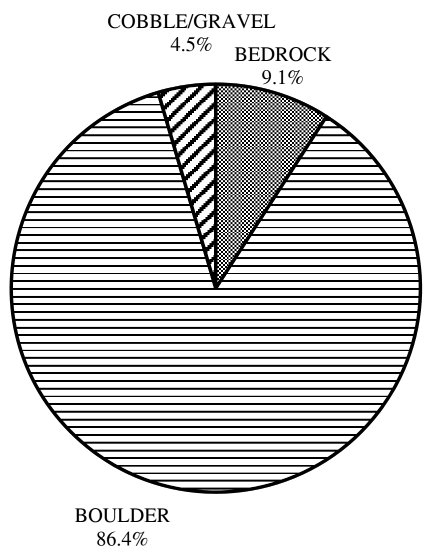
GRAPH 8 - SELBY CREEK
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



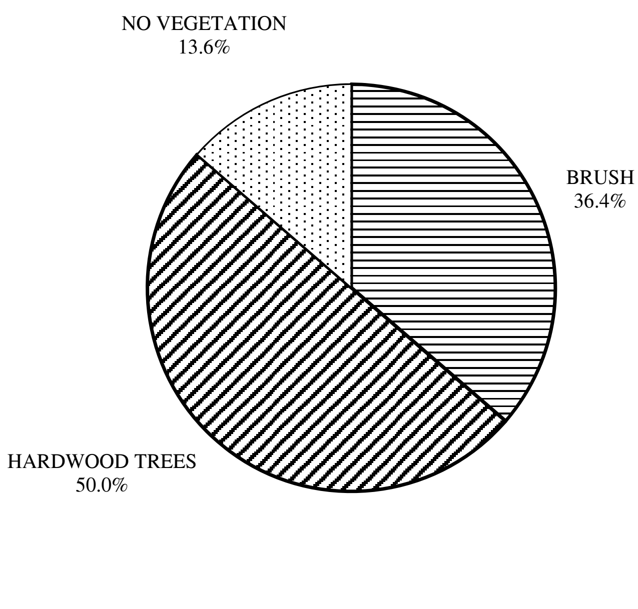
GRAPH 9 - SELBY CREEK
MEAN PERCENT CANOPY



GRAPH 10 - SELBY CREEK
DOMINANT BANK COMPOSITION IN SURVEY REACH



GRAPH 11 - SELBY CREEK
DOMINANT BANK VEGETATION IN SURVEY REACH



Selby Creek Photos

4.8a. Isolated pool in lower reach of Selby Creek. 10/11/11

4.8b. Isolated pool in lower reach of Selby Creek. 10/11/11

4.8c. Representative habitat in lower Selby Creek. 10/11/11

4.8d. Dry stream bed conditions downstream of Silverado Trail. 10/11/11

Biter Creek Photos

4.8e. Representative habitat in Biter Creek. 9/13/11

4.8f. Steep boulder cascade in Biter Creek. 9/13/11

4.8g. Steep boulder cascade in Biter Creek. 9/13/11

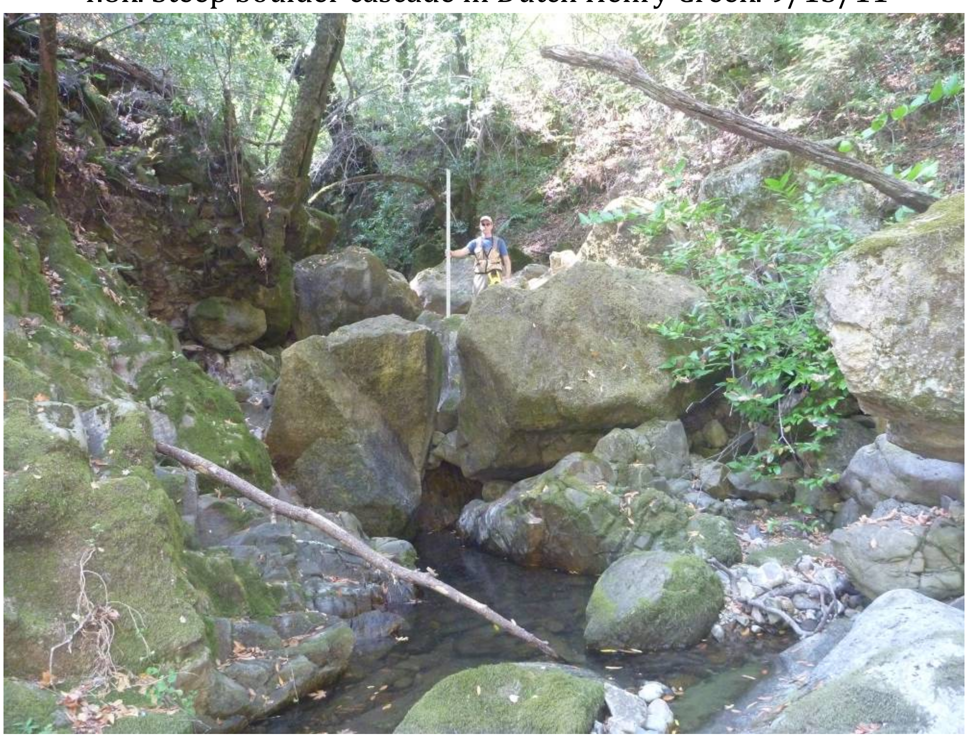
4.8h. Representative habitat in Biter Creek. 9/13/11

Dutch Henry Creek Photos

4.8i. Open water habitat in Dutch Henry Creek. 9/13/11

4.8j. Dry stream bed conditions in Dutch Henry Creek. 9/13/11

4.8k. Steep boulder cascade in Dutch Henry Creek. 9/13/11



4.8l. Steep boulder cascade and pool in Dutch Henry Creek. 9/13/11

Discussion
During September and October 2011, 3.2 miles of stream channel were surveyed within the Selby Creek watershed. The water temperatures recorded on the survey days ranged from 61 to 63° F. Air temperatures ranged from 67 to 72° F. In-stream water temperatures were at the upper tolerable limits for steelhead (optimal range is 50 to 59° F). However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months.

Flatwater habitat types comprised 4% of the total length of the survey, riffles 2%, dry 92%, and pools 2%. The pools were relatively shallow with only one of the 5 (20%) pools having a maximum residual depth greater than two 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 three 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.

Three of the 5 pool tail-outs measured had embeddedness ratings of 1 or 2. The remaining pool tail-outs had embeddedness ratings of 3 and 5, respectively. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Five is considered unsuitable for spawning. One of the 5 pool tail-outs measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids. The remaining pool tail-outs were unsuitable for spawning salmonids due to the presence of sand, silts, boulders, etc.

The mean shelter rating for pools was 66. The shelter rating in the flatwater habitats was 32. A pool shelter rating of approximately 100 is desirable. Boulders are the dominant cover type in pools followed by aquatic vegetation. Log and root wad cover structures in the pool and flatwater habitats supporting salmonids enhances both summer and winter salmonid habitat. Log cover 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 75%. 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 at 50% and 60%, 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.

Overall, Selby Creek provides limited habitat for steelhead and/or resident rainbow trout. During the survey period, the majority of the stream channel was dry. The lower reach of Selby Creek supported isolated pools with no habitat value for salmonids (Photos 4.8a, 4.8b, 4.8c, and 4.8d). Biter Creek was completely dry during the survey, and there is an in-stream reservoir that fully blocks passage to the upper reaches of the watershed (Photos 4.8e, 4.8f, 4.8g, and 4.8h). Dutch Henry Creek supported approximately 1,400 feet of perennial flatwater, riffle, and pool habitat (Photos 4.8i and 4.8j). In this reach, pool frequency and depth were below optimal levels for high quality steelhead habitat and areas suitable for spawning were limited. However, canopy coverage was near acceptable levels. At the upper limits of Dutch Henry Creek, the stream channel became very steep and dominated by large boulder cascades. These areas are unsuitable for fish and pose a significant barrier (Photos 4.8k and 4.8l). As summarized in Leidy et al. (2005), fisheries resources within the watershed are limited due to lack of stream flows.

5 Conclusions and Recommendations

Streams in the northern Napa River watershed flow through steep terrain in their headwaters onto the gentle slopes of the valley floor and enter the Napa River near Calistoga, at the north end of the Napa Valley. Many of these upper Napa River tributaries remain forested with complex communities of redwoods, firs, and oaks shading the streams and stabilizing the creek, while others are highly developed. In the lower reaches, streams have been narrowed and channelized. Historic and current land-use practices in these watersheds have contributed to impaired riparian-zone habitat conditions and altered channel processes. Water extractions from instream and groundwater sources appear to have decreased summer dry-season flows. Although little empirical data exists to fully analyze this trend, several long-time residents have noted significant changes in the availability of water in recent times. Despite these changes, several streams still support a variety of native fish and wildlife species.

Impairment of the stream channels and riparian corridors make certain conservation and restoration activities imperative for preserving and enhancing steelhead populations within the Napa River basin. The following measures are needed to protect/restore self-sustaining fish populations:

- Instream habitat complexity in the form of large wood structures, vegetated gravel bars, and inset floodplains need to be created to provide high-flow refugia, deep pools, and sediment sorting.

- Riparian forests must be protected and enhanced to provide shade, bank stability, and sources of large wood.

- Grasses and small shrubs in the riparian corridor must be protected, and be of sufficient extent, to provide bank stability and pollutant filtration.

- Delivery of fine sediment from upland sources must be inventoried and reduced.

- Water quality conditions should be monitored to meet or exceed all regulatory targets and support fish and other aquatic organisms at all life stages.

- Summer base flows must be maintained, and increased if possible, to supply instream habitats with cool, oxygenated water and support fish and other aquatic organisms at all life stages.

Comprehensive habitat inventories of eight watersheds were conducted in the northern Napa River watershed in accordance with current California Department of Fish and Game protocols (Flosi et al. 1998). Following the habitat typing analysis, the streams were ranked by current habitat quality, steelhead occurrence, and restoration priority level (see Table 1 below). This ranking is meant to guide future restoration planning and implementation projects to provide the greatest benefit to steelhead populations and other aquatic resources.

Based on the survey findings and historical fisheries data, Mill and Ritchey Creek are the highest priority watersheds. These watersheds support habitat elements and stream flows that provide both spawning and year-round rearing habitat for salmonids. Both watersheds are largely undeveloped and much of the lands are owned by State Parks. These watersheds should be managed as anadromous, natural production streams and restoration efforts undertaken to enhance the existing resources.

Diamond Mountain, Garnett, and Selby Creek support potentially suitable habitat for salmonids; however, aquatic resources within these watersheds are limited due a lack of stream flows, complex habitat elements, and the presence of an in-stream reservoir that restricts access on Diamond Mountain Creek. These streams could be viable resources for local fish populations with the improvement of summer base flows in conjunction with habitat enhancement projects.

Nash, Blossom and Simmons Canyon Creek do not currently support salmonids and appear to have limited potential to support sustainable populations in the future. During the survey, Blossom Creek had only stagnant pools, and Simmons Canyon Creek was completely dry. Only a small portion of the Nash Creek watershed was accessible due to difficulties in obtaining landowner agreements. Where access was obtained in Nash Creek, the stream channel was completely dry.

Following Table 1 are monitoring and enhancement recommendations for Mill Creek, Ritchey Creek, Diamond Mountain Creek, Garnett Creek (mainstem and Jericho Creek), and Selby Creek (mainstem and Dutch Henry Creek). Many of the recommendations are interrelated and should be considered in conjunction with the measures discussed at the beginning of this section.

Table 1. Ranking of evaluated streams based on current habitat quality, steelhead occurrence, and restoration priority level.

Stream	Current Habitat Quality	Steelhead Occurrence	Restoration Priority Level
Mill	High	Numerous historical observations; Present during survey	High
Ritchey	High	Numerous historical observations; Present during survey	High
Nash	Low	No records/ observations	Not warranted
Diamond Mountain	Moderate	Limited historical observations; None observed during survey	Low
Blossom	Low	No records/ observations	Not warranted
Garnett	Moderate	Numerous historical observations; None observed during survey	Moderate
Simmons Canyon	Low	Limited historical observations; None observed during survey	Not warranted
Selby	Moderate	Limited historical observations; None observed during survey	Moderate

Mill Creek Recommendations

- Manage the watershed as a self-sustaining, salmonid-bearing stream,
- Increase pool frequency and depth with the installation of instream wood enhancement projects,
- Map active and potential sediment sources and develop control measures, as feasible,
- Increase pool shelter with instream wood enhancement projects,
- Increase streambank vegetated cover in association with other restoration efforts, and
- Improve fish passage at three artificial barriers within the watershed. From downstream to upstream, these include the Highway 29 culvert crossing, a small in-stream concrete wall just upstream of the Bale Grist Mill, and a second small concrete wall (weir) approximately 500 feet upstream.

Ritchey Creek Recommendations

- Manage the watershed as a self-sustaining, salmonid-bearing stream,
- Increase pool frequency and depth with the installation of instream wood enhancement projects,
- Map active and potential sediment sources and develop control measures, as feasible,
- Increase pool shelter with instream wood enhancement projects,
- Increase streambank vegetated cover in association with other restoration efforts, and
- Improve fish passage at several artificial barriers within the watershed. In downstream to upstream order, they include an instream concrete sill downstream of Highway 29, the Highway 29 culvert crossing, remnants of the diversion dam upstream of Highway 29, the Bothe State Park main entrance road culvert crossing, and the Bothe State Park upper dirt road culvert crossing.

Diamond Mountain Creek Recommendations

- Continue outreach to the landowners in the upper limits of the watershed where access was not obtained,
- Protect and enhance summer streamflow,
- Increase pool frequency and depth with the installation of instream wood enhancement projects,
- Increase pool shelter with instream wood enhancement projects,
- Increase streambank vegetated cover in association with other restoration efforts, and
- Improve fish passage at several artificial barriers within the watershed. In downstream to upstream order, they include an artificial low-flow barrier

approximately 1,000 feet upstream of Highway 29 and the culvert crossing under Diamond Mountain Road. Habitats upstream of the limits of the survey should also be evaluated for the presence of additional fish barriers, as well as the instream barrier located approximately 1.4 miles upstream of Highway 29.

Garnett Creek (mainstem and Jericho Creek) Recommendations

- Protect and enhance summer streamflow,
- Map active and potential sediment sources and develop control measures, as feasible,
- Increase pool frequency and depth with the installation of instream wood enhancement projects,
- Increase pool shelter with instream wood enhancement projects, and
- Increase canopy coverage over the stream channel and streambank vegetated cover in association with other restoration efforts.

Selby Creek (mainstem and Dutch Henry Creek) Recommendations

- Protect and enhance summer streamflow,
- Map active and potential sediment sources and develop control measures, as feasible,
- Increase pool frequency and depth with the installation of instream wood enhancement projects,
- Increase pool shelter with instream wood enhancement projects, and
- Increase canopy coverage over the stream channel and streambank vegetated cover in association with other restoration efforts.

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