SELBY CREEK – SILVERADO TRAIL CULVERT FISH PASSAGE ASSESSMENT

NAPA COUNTY, CALIFORNIA

PREPARED BY

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INTRODUCTION

Selby Creek is formed by the junction of Dutch Henry Creek and Biter Creek, which join at the Silverado Trail (Figure 1). The Dutch Henry and Biter Creek watersheds cover an area of 5.19 square miles of primarily steep terrain dominated by oak woodland and chaparral with extensive rock outcroppings. The upper watershed that drains to the Silverado Trail culvert is largely undeveloped, with approximately 2.8% of its land area covered with vineyards and the remainder as open space and rural residential land.

This report addresses fish passage conditions for steelhead (*Oncorhynchus mykiss*) at two potential impediments in Selby Creek and Dutch Henry Creek (Figure 2). The Silverado Trail crossing consists of a four-barrel concrete box culvert with a two-lane highway on top. Immediately upstream of this site is another culvert on Dutch Henry Road, a single lane road that crosses Dutch Henry Creek. The Dutch Henry crossing consists of a primary single-bore round steel culvert in the low flow channel and a secondary corrugated steel pipe arch at a slightly higher elevation. Both sites have been identified as potential fish migration barriers warranting thorough analysis of their severity.

Steelhead are known to spawn and rear in Dutch Henry and Biter Creeks (Ecotrust & FONR 2002, NCRCD 2002). Juvenile steelhead densities appear to be relatively high in upper reaches that maintain perennial pools and high-quality habitat. Selby Creek is intermittent and goes completely dry every year by June. Due to this seasonal drying, Selby Creek acts primarily as a migration corridor for adult steelhead moving upstream to spawn in winter and juvenile steelhead migrating to the ocean (smolts) during spring. Partial migration barriers in this corridor could delay spawning by days or weeks and have negative effects on spawning success.

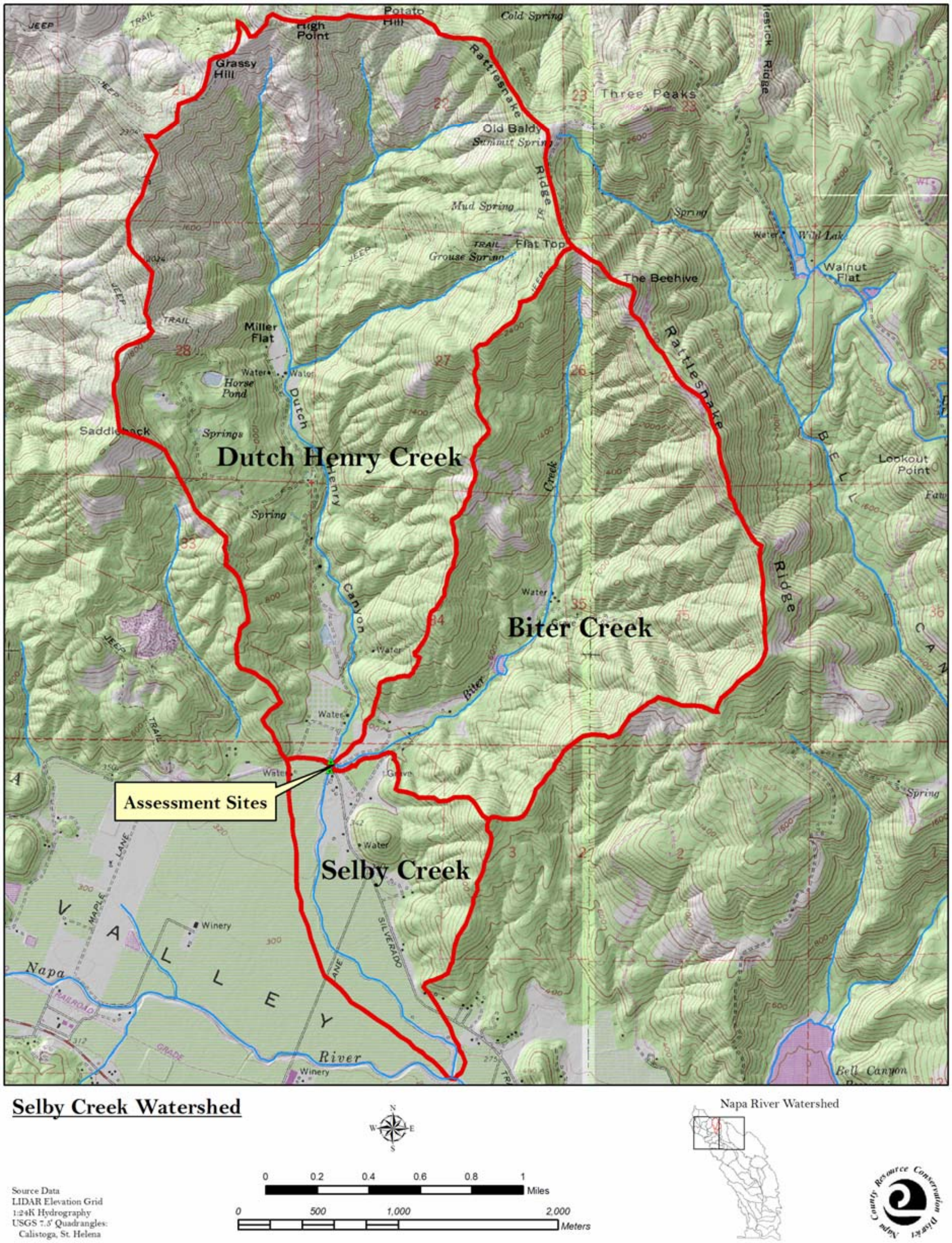


Figure 1. Selby Creek subwatershed map.

Figure 2. Fish passage assessment sites.

METHODS

Fish passage was assessed following California Department of Fish & Game (DFG) protocols as described in the California Salmonid Stream Habitat Restoration Manual, Part IX. Field observations were made during late spring, 2006 with flows ranging from approximately 50 cubic feet per second (cfs) until the stream went dry in mid May.

No streamgage or rainfall data were available for Selby Creek. Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected flow data from the former USGS streamgaging station on the Napa River in Calistoga. This was the gage nearest to Selby Creek with at least 5 years of daily average flows (8 years) and with a drainage area less then 50 square miles (22 square miles). Calculated fish passage flows were adjusted for Selby Creek by multiplying them by the ratio of the two drainage areas. The passage period was Dec 1 – March 31, which corresponds with published and observed data for upstream steelhead migration timing. Downstream passage by adults and juveniles may extend into May, but the culvert does not hinder downstream movement.

A TR-55 model was constructed to estimate discharge at standard return intervals. The model was built from GIS data on landuse, topography, and vegetation and rainfall data from NOAA Atlas 2. Natural Resource Conservation Service (NRCS) Agricultural Engineer, Carolyn Jones, constructed a simplified HEC-RAS model using visual estimates for channel geometry and roughness to calculate culvert capacity.

In July 2006, Paul Blank and Jonathan Koehler surveyed the culvert sites and conducted thalweg surveys of Biter, Dutch Henry, and Selby Creeks. A cross-section survey of the downstream tailwater control for the Silverado Trail culvert was conducted by Paul Blank and Chad Edwards in August 2006.

Hydraulic and topographic survey data were analyzed with Fish X-ing v3.0.1. This software is intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage (http://www.stream.fs.fed.us/fishxing/).

High and low passage flows were based on percent exceedance calculations. The low passage flow was three (cfs) and the high passage flow was 258 cfs. The low passage flow (3 cfs) represents the lowest expected flow during the migration period for adult steelhead. The high passage flow (258 cfs) represents the daily average flow that has a 1% chance of being exceeded between December and March in any given year. This range of flows encompasses the majority of flows that a migrating steelhead would encounter between December and March in Selby Creek.

Swimming capabilities and minimum depth requirements for adult and juvenile steelhead were based on Table IX-6 in the California Salmonid Stream Habitat Restoration Manual and NOAA Fisheries Guidelines for Salmonid Passage at Stream Crossings.

RESULTS AND DISCUSSION

Dutch Henry Culvert

Based on field observations and Fish X-ing analysis, this culvert does not represent a significant obstacle to steelhead migration. The culvert was given a “GREEN” value based on DFG criteria, which indicates that conditions are adequate for passage of all salmonid life stages.

The main culvert is installed slightly below streambed level, maintains sufficiently low velocities during a wide range of flows, and is relatively short. The passage window analyzed was 3–70 cfs with Fish X-ing. The results of this analysis suggest that the culvert is passable during all but the lowest passage flows (< 5 cfs) for adults and passable during all passage flows for juveniles. Shallow conditions with water depths less than 0.5 feet in the culvert exist during low flows, which may slightly hinder fish passage. However, such shallow water depths are also expected in the natural channel above and below the culvert during such flows.

Silverado Trail Culvert

Fish X-ing analysis of the Silverado Trail culvert suggests that it is not passable for upstream migration by adult or juvenile steelhead. Based on our inputs, the culvert scored 0%, which is an impassable barrier. The culvert was given a “RED” value based on DFG criteria including excessive slope (greater than 3%) and an excessive outlet drop (greater than two feet). This indicates that this culvert does not meet current fish passage requirements and would be given a high priority ranking for modification or replacement.

Our analysis was based on conservative swimming capabilities and minimum depth requirements from the DFG guidelines. Additionally, this analysis uses average water velocities to determine passage, which may not account for hydraulic variations, including velocity breaks near the culvert’s edges. Margin areas with lower velocities may facilitate passage for juveniles and smaller adults under certain moderate to high flow conditions. Given these assumptions, the culvert is likely passable by some unknown fraction of the steelhead population with stronger swimming abilities during certain flows. However, DFG and NOAA Fisheries guidelines are designed to allow passage of all fish in the population, not just the strongest swimmers.

The main obstacles for fish passage are lack of water depth within the culvert and high velocities from the steep slope (3.7%). The culvert is relatively wide, which promotes sheet flow (shallow, fast moving water) during most low to moderate flows. Under all conditions, the culvert is a complete barrier to juvenile upstream movement due to high velocities and the excessively high jump into the culvert outlet (Table 1).

Fish Passage Summary	
Low Passage Design Flow	3 cfs
High Passage Design Flow	258 cfs
Percent of Flows Passable	0.0 %
Passable Flow Range	None
Depth Barrier	0 to 226 cfs
Leap Barriers	83 cfs and above
Velocity Barrier - EB	27 cfs and above
Pool Depth Barrier	0 to 40 cfs

Table 1. Silverado Trail culvert fish passage summary.

The Silverado Trail culvert outlet is perched above the downstream pool, requiring a substantial leap into the culvert. Leap heights range from approximately 3.1 feet at the low passage flow (3 cfs) to about 2.1 feet at the high passage flow (258 cfs). These leap heights are well within documented adult steelhead leaping abilities of six feet or greater. However, the downstream jump pool is not deep enough to allow for efficient leaping. If a perched outlet is unavoidable, the downstream jump pool depth should be at least 1.25 times the leap height to create favorable hydraulic conditions for leaping. NOAA Fisheries and DFG guidelines recommend that all culverts be installed slightly below grade to eliminate leaping at the outlet. Repeated leap attempts cause exhaustion, injury, and even mortality to migrating fish.

Results of our simplified HEC-RAS hydraulic model suggest that the culvert's capacity is approximately 1,600 cfs, which corresponds roughly to a 2 year return interval (Table 2). Flows above 1,600 cfs would be expected to cause flooding and ultimately overtopping of the roadway. The DFG and NOAA Fisheries guidelines recommend designing culverts to accommodate the 100 year flow to prevent failure and subsequent delivery of sediment downstream.

Based on our hydraulic analysis, the culvert appears to be undersized to handle frequent flood flows. However, our qualitative observations of the site indicate that the culvert has roughly the same dimensions as the upstream and downstream channels. Due to the lack of rainfall and streamgage data for this watershed, all capacity and flow estimates should be interpreted to reflect these limitations.

Year Storm (Return Interval)	Peak Flow (cfs)
2	1,542
5	2,498
10	3,520
25	4,076
50	4,637
100	5,399

Table 2. Estimated discharges and return intervals at the Silverado Trail culvert.

RECOMMENDATIONS

The culvert on Dutch Henry Creek does not warrant further action to improve fish passage. The current two-pipe configuration allows full passage during all expected steelhead migration flows and the structures appear to be in good physical condition.

The Silverado Trail culvert represents a major obstacle for steelhead migration, and likely has a significant impact on fish movement to high quality upstream habitat. The culvert should be either replaced or modified to reduce water velocities, concentrate flows into a deeper low-flow lane, and eliminate the leap at the outlet. Since the culvert appears to be undersized, it is not advisable to improve passage by installing roughness elements (e.g. boulders, baffles, concrete berms, etc.) inside the culvert to decrease velocities and create resting areas.

The channel downstream of the Silverado Trail culvert shows evidence of incision, and is characterized by steep, unstable banks. The culvert is currently providing grade control to the channel, preventing incision from traveling upstream into Dutch Henry and Biter Creeks. Restoration efforts in this downstream reach could include elements that sequentially raise the bed elevation over several hundred feet of channel. This may include a series of constructed step pools or other instream structures that promote bed aggradation. If the culvert remained in place and an improved approach route was created, the culvert itself would still remain a significant barrier, requiring modification to reduce velocities and increase depth. This may be partially accomplished by creating a notched lane in the concrete that concentrates flow through the culvert. This lane would likely only be effective at lower flows when velocities are lowest.

REFERENCES

California Department of Fish and Game. 2001. *Culvert Criteria for Fish Passage*.

Ecotrust, and FONR. 2002. Results of Hankin-Reeves standard uncalibrated *O. mykiss* survey of Napa River tributaries, Portland, OR.

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

Napa County Resource Conservation District. 2002. Northern Napa River Watershed Plan. Napa, CA.

NOAA Fisheries. 2001. Guidelines for Salmonid Passage at Stream Crossings.

APPENDICES

SILVERADO TRAIL CULVERT SUMMARY DATA

Adult Fish Length: 40 cm
Minimum Water Depth: 0.6 ft
Prolonged Swimming Speed: 6 ft/s
Prolonged Time to Exhaustion: 30 min
Species: Oncorhynchus mykiss (Steelhead)
Temp: 10 to 19 Deg C
Fish Body Depth: 0.29 ft

Burst Swimming Speed: 10 ft/s
Burst Time to Exhaustion: 5 s
Burst Swimming Speed: 10 ft/s
Burst Time to Exhaustion: 5 s
Species: Oncorhynchus mykiss (Steelhead)
Length: 10.3 to 81.3 cm
Temp: 7 to 19 Deg C
Swim Time: 1 - 20 s
Fish Body Depth: 0.29 ft
Fish Metrics Calculated

Leaping Speed: 15 ft/s
Velocity Reduction Factors:
Inlet: 1.00
Barrel: 1.00
Outlet: 1.00

Crossing Installation Data

Culvert Type: 32 X 5.95 ft Box
Material: Concrete
Installation: Not Embedded
Culvert Length: 43 ft
Culvert Slope: 3.72%
Culvert Roughness Coefficient: 0.013
Inlet Invert Elevation: 93.04 ft
Outlet Invert Elevation: 91.44 ft
Inlet Headloss Coefficient (Ke): 0.5

Design Flows

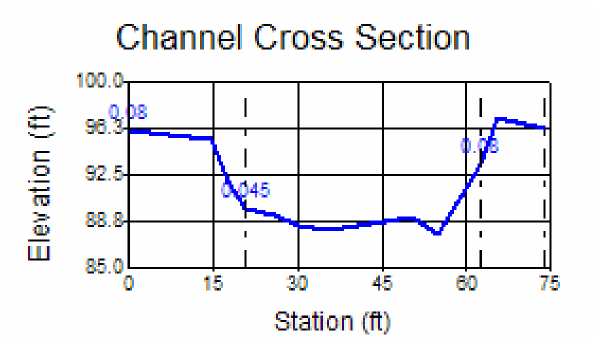
Low Passage Flow: 3 cfs
High Passage Flow: 258 cfs

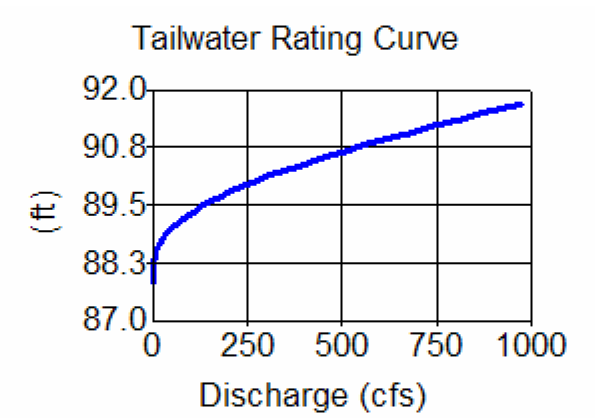
Tailwater Information

Tailwater Option: Tailwater Channel Cross-Section
Channel Bottom Slope: 2%
Outlet-Pool Bottom Elevation: 86.2 ft

Tailwater Cross Section Data.

Station (ft)	Elevation (ft)	Roughness Coefficient
0.00	95.98	0.080
14.49	95.37	
17.67	91.94	
20.84	89.72	0.045
25.98	89.30	
29.93	88.31	
35.72	88.07	
50.30	89.02	
55.00	87.78	
62.29	93.24	0.080
65.26	97.07	
73.74	96.24	

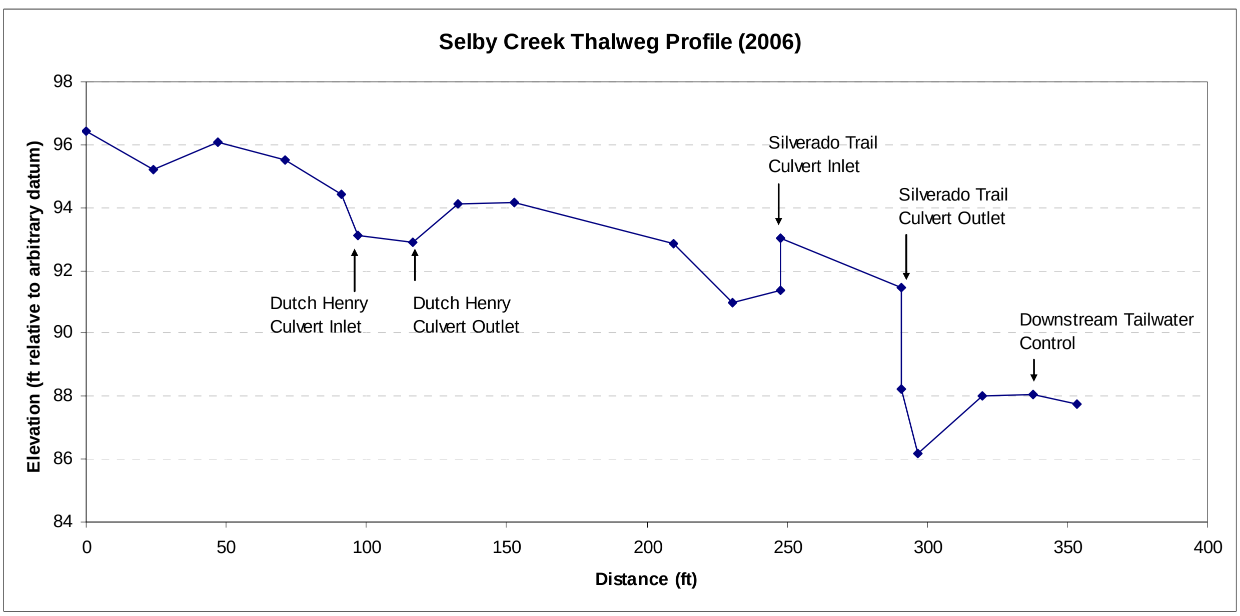




SELBY CREEK EXCEEDENCE FLOW CALCULATIONS (DEC 1 – MAR 31)

Stream of Interest:	Selby Creek	Drainage Area (A_{ug}):	5.19 mi^2
Gaged Stream:	Napa R at Calistoga	Drainage Area (A_g):	21.9 mi^2
		Period of Daily Q Record:	1976 to 1983
		Passage Period:	Dec1 – Mar 31
		No of records (n):	970

Exceedance Flow (%)	Rank (m)	Q_{gaged} (cfs)	A_{ug}/A_g	$Q_{ungaged}$ (cfs)
1	10	1090	0.237	258
5	49	419	0.237	99.3
10	97	223	0.237	52.8
50	486	16.0	0.237	3.792
90	874	0.430	0.237	0.102
95	922	0.190	0.237	0.045




Silverado Trail culvert facing upstream (5-17-2006)


Silverado Trail culvert inlet facing downstream (5-17-2006)

Selby Creek downstream of Silverado Trail facing downstream (5-17-2006)

Silverado Trail culvert downstream standing on left bank (3-10-2006)


Silverado Trail culvert downstream standing right bank (3-10-2006)


Dutch Henry Culvert inlet facing downstream (5-17-2006)