Stonybrook Creek
Fish Passage Assessment

Prepared for

Alameda County
Public Works Agency

BY

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1.0 Introduction

This report summarizes the assessment of fish passage at road-crossings on Stonybrook Creek, a small tributary to Alameda Creek, California. The assessment was conducted for Alameda County Public Works Agency (ACPWA). The primary objectives were:

1. To identify State and County maintained road-crossings that hinder upstream migration of juvenile and adult steelhead and rainbow trout;

2. Develop a project-scheduling document containing a prioritized list of actions that will improve fish passage at road-crossings within historically fish bearing portions of Stonybrook Creek; and

3. Provide conceptual treatment alternatives for each fish migration barrier.

This report does not directly address the biological significance of eliminating identified road-crossing barriers as part of overall steelhead restoration efforts in the Alameda Creek watershed. Actions listed in this report for barrier removal should be placed into a larger watershed context before proceeding towards implementation.

2.0 Background

Fish passage through road-crossings is an important component in the recovery of depleted stocks of anadromous salmonids throughout their range. Although culverts and other types road-crossing structures that typically hinder upstream fish passage tend to be located on smaller streams with relatively short reaches of habitat, these streams often consist of the best spawning and rearing habitat for steelhead.

These small streams often contain steeper channel gradients than larger streams, resulting in the formation of a pool-riffle-run sequence. Also, the stream bed material in these streams is typically larger than that found in the larger mainstem. The larger gravels combined with well-defined riffles create ideal spawning grounds for steelhead and resident trout.

Small streams also provide some of the highest quality habitat for rearing of juvenile salmonids. During summer flow conditions water temperatures within larger streams and rivers often become elevated to fatal levels for juvenile salmonids. Typically the smaller tributaries produce cooler water than the mainstem throughout the summer through inflow from cold springs and dense tree canopy over the channel. Sometimes these smaller tributaries provide the only viable summer habitat for rearing juveniles. Additionally, during high flows the larger streams may lack suitable over-wintering habitat for juvenile steelhead and rainbow trout due to limited shelter from high water velocities and persistently elevated turbidity levels. The smaller tributaries often provide more shelter from high flows and better water quality conditions than larger streams.

Combining the amount of habitat lost above each road-crossing barrier with the thousands of existing crossings on public and private roads creates a cumulative loss of habitat that is likely significant to the long term survival of steelhead and other salmonids in California.

2.1 Types of Road-Crossing Barriers

Typical passage problems created by culverts and other road-crossings are:

- Excessive drop at the downstream end of the crossing (perched outlet);
- Water velocities within the crossing greater than the swimming ability of the fish;
- Constriction of the flow as it enters the crossing causing excessive water velocities and turbulence at the inlet;
- Lack of sufficient depth in the culvert for the fish to swim; and
- Debris accumulation across the inlet or within the culvert.

All fish migration barriers, including road-crossings, can be placed into three categories: temporal, partial, and total. As described in Table 2.1, some barriers may only block upstream migration of adult fish at certain flows, allowing them to eventually negotiate the culvert as flows change. For steelhead and other fish attempting to reach spawning grounds, this delay can cause excessive energy expenditure by the fish, potentially resulting in death prior to spawning or the reduction in viability of eggs and offspring. Additionally, both temporal and total blockages of adult fish can greatly limit the distribution of spawning: causing the upper portions of the basin to remain unseeded, increasing the likelihood of superimposition of redds, and creating high densities of juveniles within lower stream reaches leading to increased competition for food and shelter.

Table 2.1 - Types of fish migration barriers and potential impacts (Taylor and Love, 2001)

Barrier Category	Definition	Potential Impacts
Temporal	Impassable to all fish some of the time.	Delay in movement beyond the barrier for some period of time.
Partial	Impassable to some fish at all times.	Exclusion of certain species and lifestages from portions of a watershed.
Total	Impassable to all fish at all times.	Exclusion of all species from portions of a watershed.

Partial barriers are often crossings that prevent upstream juvenile passage but allow adult passage at some or all flows. Although not well understood, awareness has developed among the fisheries community regarding the importance of upstream movement within the life history of juvenile and resident fish. Juvenile steelhead spend up to four years in freshwater (typically one to two years in California) prior to out-migrating to the ocean. During this period they will often migrate up smaller streams to find more suitable habitat and better food sources (Cederholm and Scarlett, 1981). Recent studies of culverts in Northern California have documented numerous juvenile salmonids, including steelhead, leaping at culvert outlets seemingly attempting to migrate upstream (Lang *et al.,* 2000, Taylor 2000). Because of the perceived importance of upstream migration in salmonid life history, existing State and Federal guidelines require most road-crossings on anadromous streams to accommodate upstream passage of juveniles.

2.2 Site Description

Stonybrook Creek is a tributary to Alameda Creek, which drains into San Francisco Bay (Figure 2.1). The Stonybrook Creek watershed lies within Alameda County, about 7 miles east of Hayward. The watershed runs north to south and has a drainage area of 6.9 square miles. Elevations within the basin range from 160 feet at its mouth to 2,191 feet. Its mouth joins Alameda Creek in Niles Canyon, approximately 13 river miles upstream from San Francisco Bay.

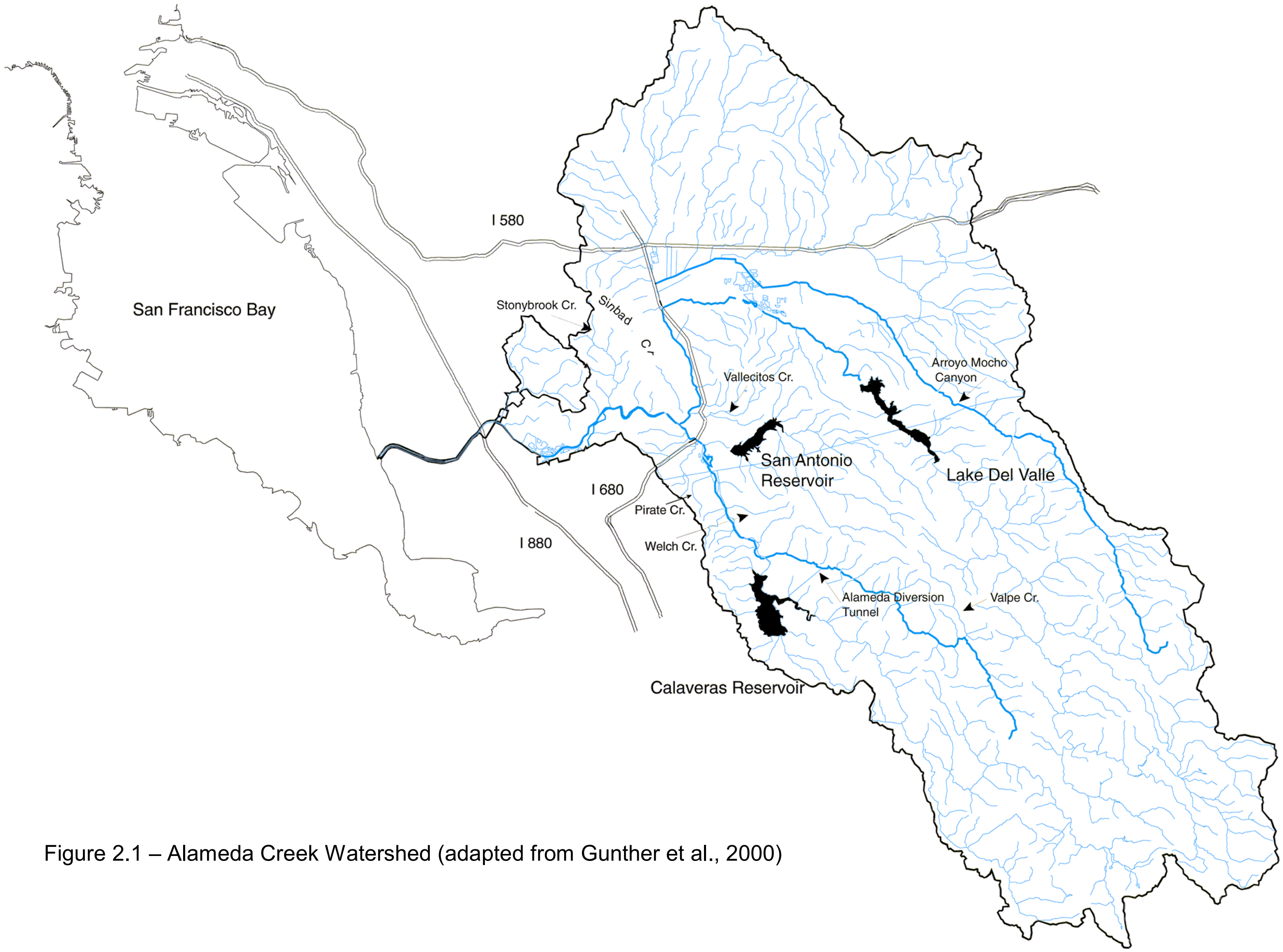

Figure 2.1 – Alameda Creek Watershed (adapted from Gunther et al., 2000)

2.3 Fisheries Habitat

2.3.1 San Francisco Bay to the Mouth of Stonybrook Creek

A fisheries restoration planning report was prepared for the Alameda Creek Fisheries Restoration Workgroup. It documents the historic and current status of the salmonid fisheries, current habitat conditions, and migrational barriers within the mainstem of Alameda Creek and its lager tributaries (Gunther *et al.,* 2000). The document cites both anecdotal and published reports that affirm the presence of historic rainbow trout and steelhead populations (*Onchorhynchus mykiss*) within Alameda Creek. Watershed conditions cited in the report prepared by *Gunther et al*., as they relate to Stonybrook Creek, are summarized in this section.

Alameda Creek downstream of the confluence with Stonybrook Creek contains several migration barriers and little spawning and rearing habitat. The lower 12 miles of Alameda Creek has been converted into a flood control channel with little viable habitat. Additionally, the stream reach contains three inflatable dams and a sloping eight-foot high concrete structure. Commonly referred to as the BART weir, this concrete structure is owned and operated by the Alameda County Flood Control and Water Conservation District (ACFC&WCD). Although the inflatable dams allow upstream passage of steelhead when lowered, the BART weir has is assumed to be complete barrier to all upstream migration (da Costa, per. comm.). Since 1999, the ACFC&WCD has lead efforts to capture and transport blocked steelhead to suitable habitat upstream of the weir. Actions are currently underway to design and install a fish passage structure for the BART weir.

Above the flood control channel Alameda Creek enters Niles Canyon. This reach contains several low flow barriers and the Sunol Valley dam, a complete barrier, at the upstream end of the canyon. Although this reach offers some suitable spawning grounds, summer daytime water temperatures within Niles Canyon have been reported to frequently exceed 22^{o}C, reaching levels which stress salmonid populations and can be fatal to rearing juveniles.

2.3.2 Stonybrook Creek

The Niles Canyon reach includes Stonybrook Creek, which serves as the only potentially viable salmonid tributary below Sunol Valley dam. Water temperatures were measured within Stonybrook Creek during the summer of 1999. Temperatures showed only minor fluctuation and were consistently below 18^{o}C in pools. In contrast to the Niles Canyon reach of Alameda Creek, these temperature conditions are suitable for rearing of juvenile salmonids (Gunther et al. 2000).

A preliminary habitat assessment of Stonybrook Creek was conducted by the East Bay Regional Park District (Alexander, 1999). Further habitat characteristics were noted for reaches adjacent to Palomares Road while inventorying road-crossings as part of this project.

The lower 2,000-feet of Stonybrook Creek has a moderate gradient. The stream substrate consists mostly of large cobbles, with some gravels. The lower end of this reach is depositional, causing flow to go subsurface during late summer. This reach of stream contains potential spawning grounds but poor summer rearing habitat do to the lack of pools and surface water in late-summer.

The lower-middle reach contains about 8,500-feet of channel and is characterized by a steep gradient (average of 6.5%) with boulder-controlled morphology and numerous deep pools. Tree canopy is dense and canyon walls are steep, providing ample shade. The substrate throughout the reach is comprised mostly of boulders and large cobbles, not suitable for spawning. Many of the pools become isolated during late summer months but maintain cool surface water, providing good rearing habitat for rainbow trout and juvenile steelhead.

The middle-portion of Stonybrook Creek is characterized by a low gradient fluvial channel containing numerous riffles and runs, but few pools and limited surface water during late summer. This reach is approximately 10,300-feet in length and ends as the stream forks and the mainstem heads up a canyon to the east. The presence of numerous low gradient riffles containing gravel characterizes this reach as potentially suitable spawning habitat for rainbow trout and steelhead. Streamside canopy is less than in the lower reaches of the creek. Residential and agricultural water withdrawals further reduce the small amount of surface water available. These factors combine to result in elevated summer water temperatures, which would force young-of-the-year fish to migrate downstream for summer rearing.

The upper reach of Stonybrook Creek lies in a canyon east of Palomares Road. Although much of this reach is low gradient, during summer months it appears to be heavily impacted by grazing and has no surface water. Because no stream surveys have been conducted within this reach, the upper extent of steelhead habitat is unknown. To roughly estimate the amount of potential available habitat within the reach, a continuous channel gradient greater than 10% was assumed to be the upper extent of steelhead migration. Using a 1:24,000 topographic map the upper reach contains an estimated 9,800-feet of low quality habitat.

2.4 Historic Fish Observations

The first documented observations of salmonids in Stonybrook Creek occurred in 1955 (Leidy, 1984). Since then, several other observations have been reported. In 1999 two female steelhead were radio-tagged and released into the Niles Canyon reach of Alameda

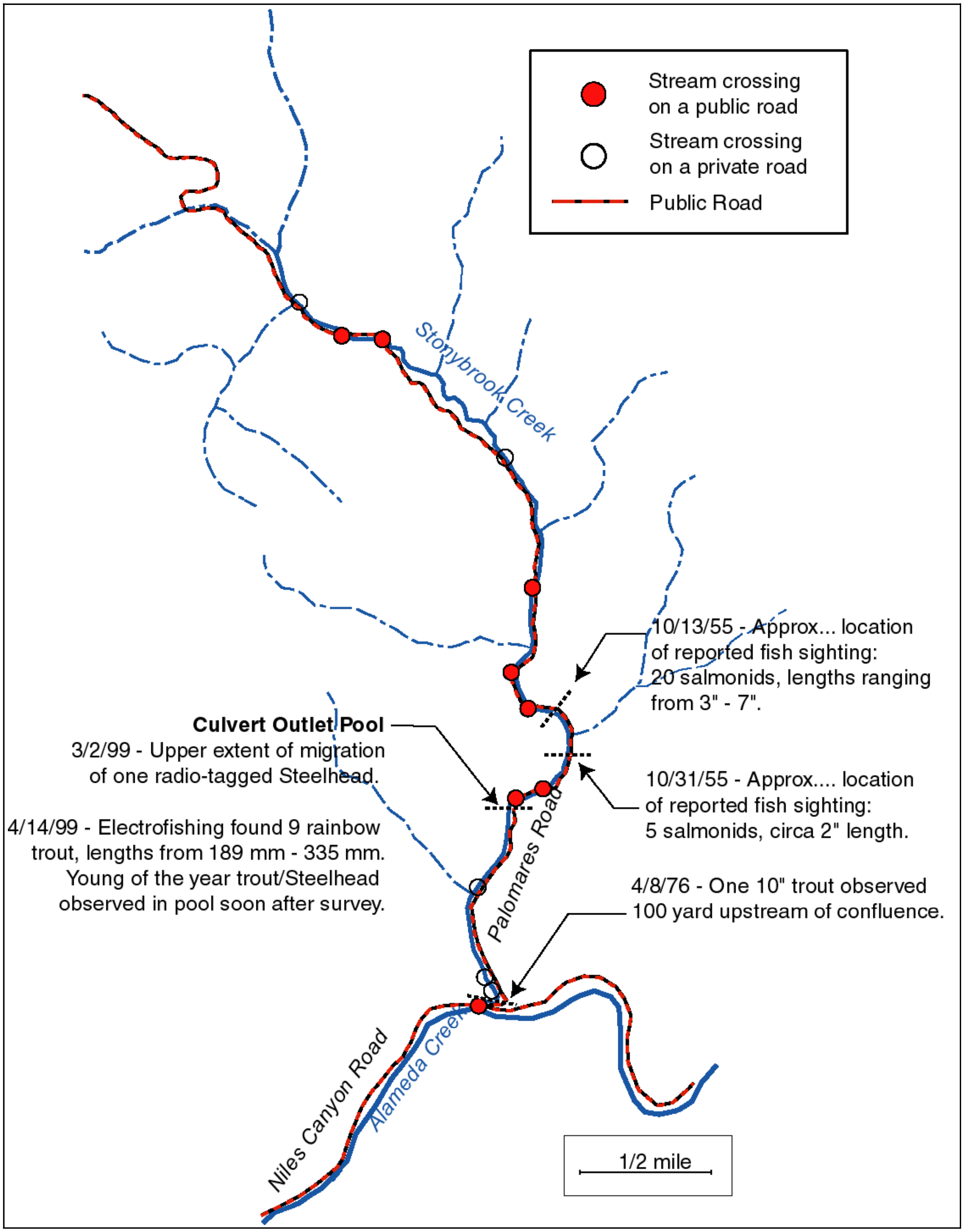

Figure 2.2 – Locations of observed salmonids in Stonybrook Creek.

Creek after being transported over the BART weir. One of the tagged steelhead migrated up Stonybrook Creek. Over a four-day period the fish migrated 4,800 feet upstream, ending in the outlet pool of a culvert located on Palomares Road, milepost 8.75 (EBRPD, 1999). Figure 2.2 shows the approximate location of reported fish observations along Stonybrook Creek.

In 1999 a total of eight adult rainbow trout were captured in the lower section of Stonybrook Creek. Tissue samples were taken and analyzed. Results from genetic tests indicated that the fish were from native stocks of rainbow trout/steelhead (Alexander, 1999).

3.0 Activities

3.1 Field Surveys

The field inventory of road-crossings was conducted in October 2000. A total of eight road-stream crossings were surveyed, one on State Highway 84 and seven on County maintained Palomares Road. Privately maintained road-crossings on Stonybrook Creek were not inventoried as part of this project, although their locations were recorded.

At each site a longitudinal profile was surveyed through the stream crossing. The profile included a minimum of 50-feet of upstream and downstream channel. Additionally, a cross-section was surveyed at the tailwater control (location in the channel controlling the elevation of the outlet pool) for use in the hydraulic analysis. Details about the crossing were recorded on a datasheet, including:

- Location of the road-crossing using both road/milepost and latitude/longitude obtained from GPS;
- Construction materials;
- Overall structural condition of each crossing;
- Inlet and outlet configuration and alignment with the channel;
- Width of the active channel upstream of the crossing;
- Ocular estimate of substrate size and distribution below the road-crossing; and
- Description of habitat above and below the crossing.

See Appendix A for sample data sheet.

3.2 Hydrologic Analysis

When examining fish passage at road-crossings, three specific flows are considered: (1) peak flow capacity of the crossing, (2) the upper fish passage flow, and (3) the lower fish passage flow. Because flows are not gaged on Stonybrook Creek, estimates were made based on hydrologic records from nearby gaged streams.

3.2.1 Magnitude and Frequency of Peak Flows

Current Federal guidelines for passage of threatened and endangered salmonids recommend road-crossings accommodate the flow associated with the 100-year flood without damage to the crossing (NMFS, 2000). Additionally, infrequently maintained crossings should accommodate the 100-year flood without overtopping the culvert's inlet.

Determination of a road-crossing's flood capacity can assist in ranking sites for remediation. Undersized crossings have a higher risk of failure, which often results in the immediate delivery of road-derived sediment to the downstream channel. Undersized crossings can adversely effect sediment transport and channel stability through frequent upstream ponding of water and downstream channel scour, creating conditions that hinder fish passage and degrade habitat.

Due to the lack of stream-flow gaging on Stonybrook Creek, flow records from nearby streams were used to estimate peak flow events on Stonybrook Creek. A search was conducted to identify stream gages on tributaries to Alameda Creek and adjacent drainages operated by the U.S. Geological Survey (USGS) with the following characteristics:

- Peak flow record greater than 10-years in length;
- Unregulated flows during storm events; and,
- A drainage area less than 100 square miles.

A total of seven gage sites were identified, four are tributaries to Alameda Creek and three drain portions of adjacent San Lorenzo Creek watershed (Table 3.1).

Using the annual peak flow data, the flow associated with various recurrence intervals was calculated for each gaging station using procedures outlined by the USGS (1982). Mean annual precipitation (MAP) was estimated for the contributing drainage area above each gaging station using an isohyetal map developed by Rantz (1971). For estimating flows at road-crossings on Stonybrook Creek, relationships were developed between peak flow, drainage area, and MAP for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events (Appendix B).

3.2.2 Upper and Lower Fish Passage Flows

It is widely agreed that designing stream crossings to pass fish at all flows is impractical (Robison et al., 2000; SSHEAR, 1998). Although anadromous salmonids typically migrate upstream during higher flows triggered by hydrologic events, it is presumed that migration is naturally delayed during larger flood events. Conversely, during low flow periods on many smaller streams, water depths within the channel can become impassable for both adult and juvenile salmonids. To identify the range of flows that

Table 3.1 – Magnitude and frequency of peak-flow events for gaged streams within the Alameda Creek and San Lorenzo Creek watersheds, calculated using Log Pearson type III distribution.

Gaging Station		Drainage Area	Record Length	Discharge for indicated recurrence intervals					
				2-years		50-years		100-years	
Number	Name	(mi^2)	(years)	(cfs)	(cfs/mi^2)	(cfs)	(cfs/mi^2)	(cfs)	(cfs/mi^2)
18050004	Dry C A Union City	9.39	43	181	19	2,716	289	3,392	361
11179005	Alameda C Trib Nr Niles	0.28	14	2.9	10	146	522	226	809
11180960	Cull C Ab Cull C Res Nr Castro Valley	5.79	20	340	59	2,733	472	3,251	562
11180825	San Lorenzo C Ab Don Castro Res	18.00	14	481	27	5,472	304	8,037	447
11181000	San Lorenzo C A Hayward [1]	37.5	18	3,631	97	10,013	267	11,507	307
11174000	San Antonio C Nr Sunol	37.0	37	345	9.3	4,390	119	6,051	164
11173200	Arroyo Hondo Nr San Jose	77.1	17	3,572	46	9,952	129	10,117	131

[1] Pre-regulated flows (1940–1942, 1947–1962) were used for San Lorenzo Creek A Hayward.

road-crossings should accommodate for fish passage, lower and upper flow limits have been defined specifically for streams within California (NMFS, 2000).

The upper fish passage flow for adult anadromous salmonids (Q_{hp}) is defined as the 2% excedence flow (the flow equaled or exceeded 2% of the time) during the period of migration. The lower fish passage flow (Q_{lp}) is the 95% excedence flow for the migration period. Between the lower and upper passage flows road-crossings should allow unimpeded passage of all adult steelhead and salmon. Additionally, at the lower passage flow road-crossings should accommodate upstream juvenile passage.

Identifying the 2% and 95% excedence flows at various locations in Stonybrook Creek requires obtaining daily average stream flow data for the period of fish migration from nearby gage sites. November through April was assumed to encompass the migration period for adult and juvenile steelhead and rainbow trout. Table 3.2 lists nine steam-gaging sites that reportedly have unregulated flows between November and April.

Flow duration curves were developed for all nine stations. Details are located in Appendix B. Unfortunately, only four of these gage sites have been operational for more than five years. The remainder were installed between 1995 and 1998 and have flow records representing a wetter than average period. Additionally, further analysis suggests Dry Creek flows are regulated during winter base-flow conditions and unrepresentative of conditions in Stonybrook Creek.

Table 3.2 – USGS stream gaging stations recording daily average streamflow on unregulated stream in close proximity to Stonybrook Creek.

Gaging Station		Drainage Area (mi^2)	Record Length (years)	Coverage (WY)
Number	Name			
11172945	Alameda C Ab Div Dam Nr Sunol	33.29	5	1995 – '99
11173200	Arroyo Hondo Nr San Jose	77.10	5	1995 – '99
11180500	Dry C A Union City	9.39	44	1917– '19 1959 – '99
11180810	Palomares C Nr Hayward	9.08	2	1998 – '99
11180825	San Lorenzo C Ab Don Castro Res	18.00	19	1981– '99
11180900	Crow C Nr Hayward	10.51	2	1998 – '99
11180960	Cull C Ab Cull C Res Nr Castro Valley	5.79	21	1979 – '99
11181004	Castro Valley C A Castro Valley	0.98	2	1979 – '80
11181008	Castro Valley C A Hayward	5.51	22	1978 – '99

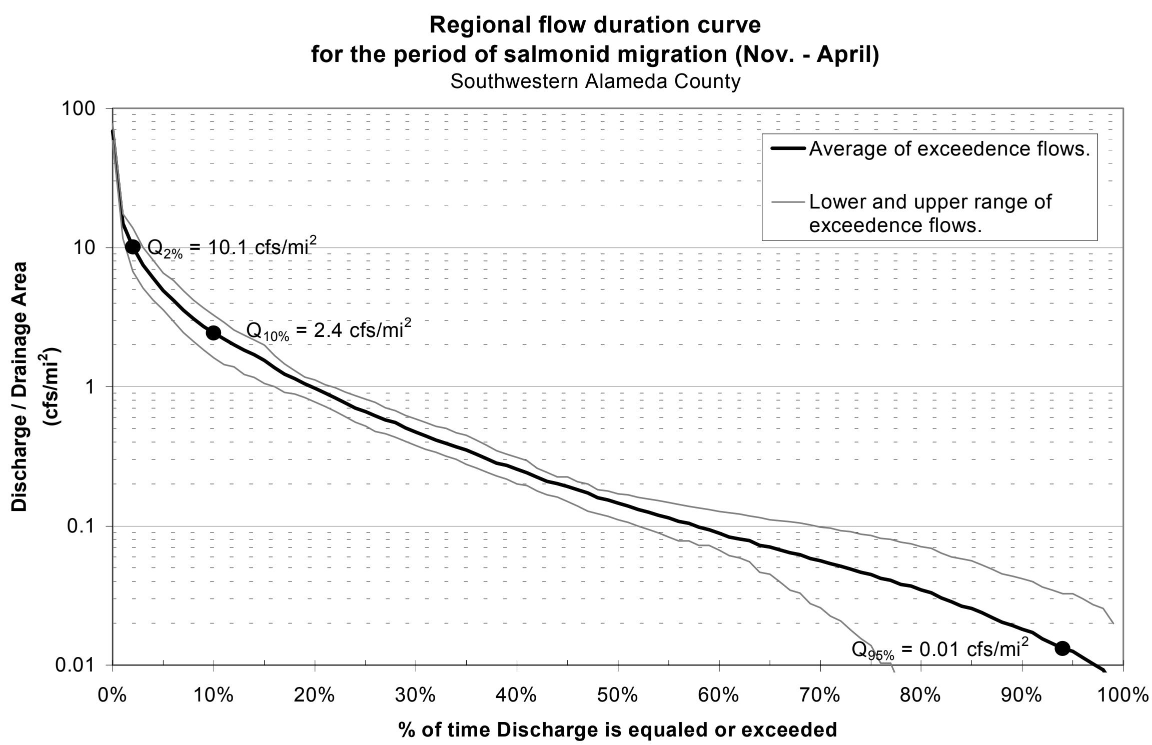

Figure 3.1 – Regional flow duration curve constructed by averaging the exceedence flows from three stream gaging stations: San Lorenzo Creek above Don Castro Reservoir, Cull Creek above Cull Creek Reservoir, and Castro Valley Creek at Hayward. Error bars represent the minimum and maximum flow associated with the indicated exceedence value.

A regional flow duration curve was then created using flow records from the three long-term gaged streams: San Lorenzo Creek above Don Castro Reservoir, Cull Creek above Cull Creek Reservoir, and Castro Valley Creek at Hayward. This regional flow duration curve became the basis for estimating fish passage flows at inventoried road-crossings on Stonybrook Creek (Figure 3.1).

Indirect Observation of Steelhead Migration Flows in Stonybrook Creek

As discussed in Section 2.4, a radio tagged female steelhead was tracked migrating up Stonybrook Creek during a four-day period in 1999. Estimating the flows in which the fish migrated upstream can be useful for both assessing and designing road-crossings for fish passage within the watershed. Although no streamflow gages exist on Stonybrook Creek, the flows can be estimated with reasonable accuracy using flow records from Palomares Creek and scaling by drainage area. The Palomares Creek watershed lies immediately north of Stonybrook Creek and has a similar basin shape, orientation, and size.

Based on daily average flows from Palomares Creek, adjusted by drainage area, the female steelhead moved into Stonybrook Creek at approximately 12 cfs and migrated upstream as the flow receded. It reached the road-crossing barrier at milepost 8.75 four days later at flows near 6.5 cfs. Using the regional flow duration curve in Figure 3.2, the tagged steelhead appears to have moved upstream between the 15% and 20% exceedence flows, which lies within the range of typical steelhead migration flows (Lang *et al*., 2000).

3.3 Fish Passage Assessment

For each of the eight inventoried sites, a detailed profile of the crossing was plotted and slopes were calculated for the crossing, inlet and outlet aprons, and channel. Road-crossing specifications were entered into a spreadsheet and inputted into hydraulic software to determine its ability to accommodate fish passage and flood flows.

3.3.1 Fish Passage Criteria

The analysis used surveyed elevations and culvert specifications to evaluate passage for each species and lifestages of salmonids known to historically reside in Stonybrook Creek. The swimming abilities and passage criteria used for each species and lifestage are listed Table 3.3. Although many individual fish will have swimming abilities surpassing those listed, swim speeds were selected to ensure stream crossings accommodate passage of weaker individuals within each age class.

3.3.2 Culvert Hydraulic Models and Fish Passage

Two software packages were used to model water velocities and depths through the eight road-crossings on Stonybrook Creek: FishXing and HydroCulv. FishXing Version 2.2 is designed for analyzing fish passage through common culvert types. FishXing identifies the range of flows that meet the depth, velocity, and leaping criteria for each lifestage. For six of the eight crossings an alternative software package, named Hydroculv, was utilized due to their unique shape and construction.

Table 3.3 - Fish species and lifestages used in the fish passage analysis along with associated swimming abilities and passage criteria. Passage flows are based on current adult salmonid criteria (NMFS, 2000) combined with observational data from northern California coastal streams (Lang *et al.*, 2000).

Fish Species/Age Class	Adult Steelhead	2+year Rainbow Trout	1+year Rainbow Trout	Young of the Year (YoY)
Fish Length	500 mm	200 mm	130 mm	80 mm
Migration Period	Nov. - April	Nov. - April	Nov. - April	Nov. - April
Prolonged Mode				
Swim Speed	6.0 ft/s	2.8 ft/s	2.4 ft/s	2.0 ft/s
Time to Exhaustion[1]	30 min	30 min	30 min	30 min
Burst Mode				
Swim Speed	10.0 ft/s	6.4 ft/s	4.5 ft/s	3.0 ft/s
Time to Exhaustion[1]	5 s	5 s	5 s	5 s
Maximum Leaping Speed	12.0 ft/s	6.4 ft/s	4.5 ft/s	3.0 ft/s
Minimum Required Water Depth	0.8 ft	0.5 ft	0.3 ft	0.2 ft
Upper Passage Flow (November – April)	2% flow	10% flow	10% flow	10% flow
Lower Passage Flow (November – April)	95% flow	95% flow	95% flow	95% flow

[1] The "time to exhaustion" is the length of time a fish can maintain the associated swim speed without being required to rest for an extended period.

The hydraulic environment at each road-crossing was modeled to determine the range of flows meeting the passage criteria. They were then compared to the lower and upper fish passage flows to determine the percentage of migrational flows meeting the criteria. Additionally, the model output was used to identify individual passage problems and potential solutions.

3.3.3 Hydraulic Capacity of Road-Crossings

The hydraulic capacity of each crossing was estimated to determine the size of flood it could effectively accommodate. Capacity was calculated for two different headwater elevations: water ponded to the top of the inlet opening (HW/D = 1) and water ponded to the top of the road surface (HW/F = 1). For the lower two road-crossings nomographs published by the Federal Highways Administration were used to determine capacity (Normann *et al.*, 1985). Capacity was calculated for the remaining six crossings using the Hydroculv software.

4.0 Findings

A total of eight road-crossings were inventoried for fish passage on Stonybrook Creek in October 2000. Table 4.1 lists the name, location, and basic characteristics of each crossing. Figure 4.1 shows their relative position in the watershed and notes locations of privately maintained road-crossings that were identified but not inventoried as part of this project. The ability of these privately maintained crossings to allow unimpeded fish passage is unknown.

Table 4.1 – Site name and description of inventoried road-crossings on Stonybrook Creek.

Site Name	Road Name	Posted Mile	Crossing End-section Shape	Material	Culvert Inlet Dimensions width (base/top) x height	Culvert Length (including aprons)	Average Slope through Culvert (including aprons)
Stobk#1	Hwy 84	12.9	Box	Concrete	10' x 7'	57.5'	4.02%
Stobk#2	Palomares Road	8.75	Box	Concrete	8' x 9'	89'	6.98% 7.42% (culvert only)
Stobk#3	Palomares Road	8.60	Trapezoid	Stone masonry with rough concrete floor	(9'/14.5') x 8'	77'	4.46%
Stobk#4	Palomares Road	8.16	Trapezoid	Stone with gabion outlet apron	(8'/12.5') x 8'	86'	4.25% 3.5% (culvert only) 6.6% (outlet apron)
Stobk#5	Palomares Road	8.00	Trapezoid	Stone masonry and bedrock	(8.5'/14.5') x 8.5'	101'	11.2% 7.1% (inlet & culvert) 19.5% (outlet apron)
Stobk#6	Palomares Road	7.57	Trapezoid	Stone masonry	(7'/28') x 10'	56'	0.49% 0.2% (inlet & culvert) 8.0% (outlet apron)
Stobk#7	Palomares Road	6.28	Trapezoid	Stone masonry	(10.5'/15') x 7'	47'	5.79% 0.2% (culvert only) 30% (outlet apron)
Stobk#8	Palomares Road	6.18	Trapezoid	Stone masonry walls/open bottom with cobbles	(7'/14') x 10.5'	33'	No Slope

Palomares Road parallel Stonybrook Creek, crossing the stream at seven different locations. Six of these road-crossings were originally built between 1938 and 1939. The invert and sides of these crossings were constructed of stone. More recently, new bridge decks have been placed onto the original abutments and some of the inverts have been lined with a concrete slurry.

Descriptions and specifications for each road-crossing accompanied by a plotted profile and cross-section are located in Appendix C.

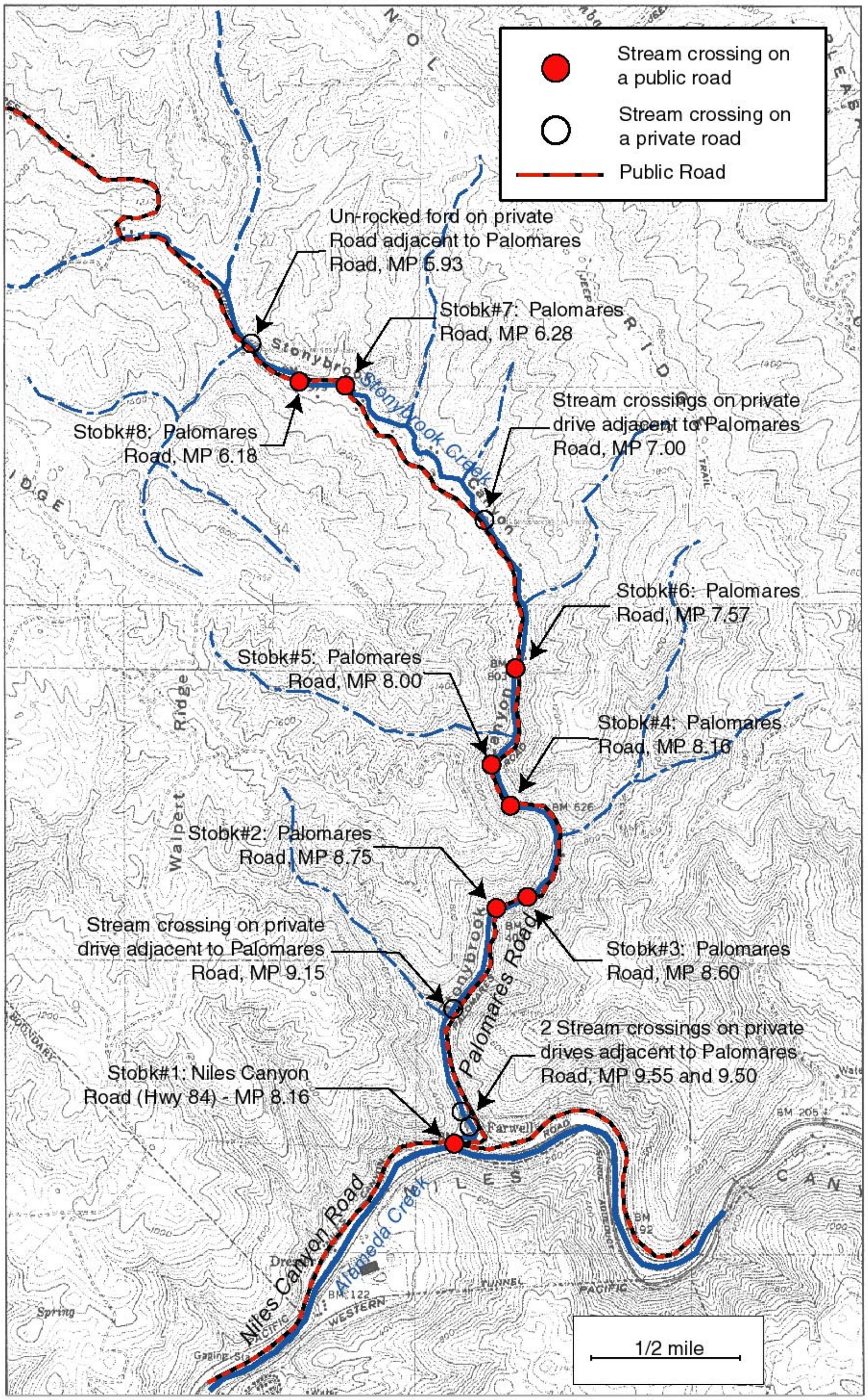

Figure 4.1 – Map of State, County, and privately maintained road-crossings on Stonybrook Creek.

4.1 Hydraulic Capacity of Road-Crossings

The hydraulic capacity of each crossing was calculated and compared to the peak flows predict with the flood estimation equations developed for the surrounding region. The risk of water overtopping the road-crossing is also reported as a recurrence interval in Table 4.2 and Appendix C.

Of the eight inventoried road-crossings, three are unable to accommodate passage of the 10-year flow without overtopping the road. Three road-crossings, Stobk#3 through Stobk#5, fail to pass the 25-year flow and will divert water down a steep section of Palomares road when overtopped. Diverting flow down the road or inboard drainage ditch for extended lengths often causes substantial damage to the road and receiving stream channel (Flannagan *et al.*, 1998).

Table 4.2 – Peak flow capacity of inventoried road-crossings on Stonybrook Creek.

Road Crossing	Flow Diverts if Overtopped?	MAP (in/yr)	Hydraulic Capacity (cfs) Overtop Inlet	Hydraulic Capacity (cfs) Overtop Road	**Return Interval (years) Overtop Inlet**	**Return Interval (years) Overtop Road**
Stobk#1 (Hwy 84)	No	23	520	950	**4.9**	**9.2**
Stobk#2 MP 8.75	Yes	23	590	1500	**6.3**	**29.1**
Stobk#3 MP 8.60	Yes	23	600	600	**6.4**	**6.4**
Stobk#4 MP 8.16	Yes	23	530	700	**6.6**	**9.1**
Stobk#5 MP 8.00	Yes	23	586	850	**7.4**	**12.2**
Stobk#6 MP 7.57	Yes	24	1100	1400	**25**	**46**
Stobk#7 MP 6.28	No	24	530	700	**13.9**	**23**
Stobk#8 MP 6.18	No	24	800	1100	**41**	**114**

4.2 Existing Fish Passage Conditions

Results from the fish passage analysis revealed seven of the eight road-crossings are total barriers; failing to comply with the passage criteria shown in Table 3.3 at all migration flows for all lifestages of rainbow tout and steelhead.

Stobk#8, the furthest most upstream crossing, accommodates passage of all fish do to its open bottom and outlet weir that creates sufficient water depths and reduces velocities. It complies with adult steelhead, 2+year and 1+year rainbow trout, and juvenile salmonid passage criteria at all migration flows. Table 4.3 summarizes the results of the fish passage analysis for each inventoried road-crossing.

Table 4.3 – Result from the fish passage analysis of road-crossings on Stonybrook Creek. The reported upper fish passage flows ($Q_{2\%}$) are for adult Steelhead.

Crossing Name	*Lower Passage Flow*			*Steelhead Upper Passage Flow*			Description of Conditions
	Lower Passage Flow, $Q_{95\%}$ (cfs)	Leap Height from Pool to Outlet (ft)	Water Depth [1] (ft)	Upper Passage Flow, $Q_{2\%}$ (cfs)	Water Depth [1] (ft)	Water Velocity (ft/s)	
Stobk#1	0.22	1.2	0.02	94.8	0.86	11.0	Complete barrier to all upstream migrating juvenile and resident salmonids. Insufficient water depth and excessive water velocities at most migration flows. Fails to meet adult passage criteria at all flows, BUT individual adult steelhead with strong than average swimming abilities have small window for passage.
Stobk#2	0.19	0.2	0.02	78.9	0.45	14.0	Insufficient water depth and excessive water velocities at all migration flows makes this crossing a complete barrier to all fish. Additionally, 11-foot drop in channel at culvert inlet prevents upstream fish movement.
Stobk#3	0.19	4.8	0.02	78.4	0.79	10.7	Drop at outlet combined with excessive outlet velocities and shallow water depths creates complete upstream migration barrier.
Stobk#4	0.16	0.0	0.00	66.0	0.83	9.6	Insufficient water depth and excessive water velocities at most migration flows. Complete barrier to all upstream migrating juvenile and resident salmonids. Individual steelhead with stronger swimming abilities have small window for passage. Lower flows travel subsurface through gabions.
Stobk#5	0.15	1.1	0.00	65.4	0.69	10.8	Insufficient water depth and excessive water velocities at all migration flows makes this crossing a complete barrier to all fish.
Stobk#6	0.14	2.8	0.04	57.1	1.49 barrel 0.78 outlet apron	4.4 barrel 8.0 outlet apron	Perched outlet and steep outlet apron makes crossing complete barrier to juvenile and resident salmonids. Additionally adult steelhead depth criteria for fish passage is insufficient along apron at all migration flows. Some stronger swimming steelhead would likely be able to negotiate the shallow depths at moderate flows.
Stobk#7	0.08	0.0	0.00	32.2	1.01 barrel 0.29 outlet apron	2.9 barrel 10.5 outlet apron	Insufficient water depth and excessive water velocities across the outlet apron creates a complete barrier to all fish. Some stronger adult steelhead may be able to negotiate the crossing at moderate flows.
Stobk#8	0.07	0.0	0.80	28.0	1.03	4.5	100% passable all steelhead and rainbow trout lifestages due to concrete weir at crossing outlet.

[1] Reported water depths and velocities occur at midpoint in the crossing.

[2] To account for the natural substrate in Stobk#8, velocities encountered by resident and juvenile trout were assumed to be 60% of the average water velocity (adapted from Belke *et. al*, 1991).

Because of the occasional presence of chinook salmon in lower Alameda Creek, fish passage of this species was also considered. Adult chinook salmon are generally larger than steelhead and spawn in rivers and larger streams. Compared to adult steelhead, their swimming abilities are slightly less and leaping ability substantially less. Additionally, they require more depth to swim and typically do not spawn in smaller steep channels. Their potential habitat range in Stonybrook Creek was considered not to extend beyond the second road-crossing (Stobk#2) due to the steepness of the channel (greater than 10%). The only crossing assessed for passage of Chinook salmon was Stobk#1, the road-crossing at the mouth of Stonybrook Creek. Because Stobk#1 fails to meet adult steelhead passage criteria at all flows, it follows that it is also a complete barrier to chinook salmon.

4.3 Road-Crossings and Geomorphic Conditions

As Palomares Road winds through Stonybrook Canyon, it encroaches on the original floodplain. The canyon is inherently narrow, and the stream was undoubtedly further confide when the road was constructed. The confinement has likely decreased the overall channel length and thus further increased the naturally steep gradient.

The steep canyon walls provide the stream with large amounts of boulder sized colluvium. Over the last sixty years the undersized road-crossings on Stonybrook Creek have slowed the transport of bedload, resulting in large deposits of boulders upstream of most crossings and locally increased channel gradients at the crossing entrances. These regions of steep channel have created potential fish barriers.

Replacement of the existing crossing with new structures that span the active channel will not only eliminate the individual barrier, but will also allow for unimpeded transport of bedload leading to increased habitat quality and easier access for fish to upstream habitat.

5.0 Recommendations for Providing Fish Passage

This section presents recommendations for treating identified fish passage barriers in an effort to provide access to currently blocked habitat on Stonybrook Creek. Since only the mainstem of Stonybrook Creek appears to contain viable fish habitat, barrier removal efforts must be approached systematically, beginning at the furthest downstream barrier and proceeding upstream. Actions to remove existing barriers should occur in conjunction with efforts to identify and addressing other potential limit factors to fish production within the Stonybrook Creek watershed and the lower portions of Alameda Creek.

5.1 Actions for Removing Fish Migration Barriers

Actions essential to opening access to upstream habitat on Stonybrook Creek are listed in the order they should be addressed based on current knowledge of fish barriers within the watershed. Additional actions may be added to this list as more information is made available concerning both natural barriers and migration barriers created by privately maintained road-crossings and other structures within the stream channel.

At five of the eight crossings, full replacement is the preferred alternative. As shown in Table 5.1, cost associated with replacement can be substantial and limited restoration funds need to be prioritized throughout the entire Alameda Creek watershed. The actions listed below only address possible options for eliminating existing barriers. For each road-crossing considered for retrofit or replacement, larger issues should be addressed concerning whether opening additional upstream habitat on Stonybrook Creek will be advantageous to the restoration of a viable steelhead population within the Alameda Creek watershed.

1. **Provide upstream passage for adult and juvenile steelhead/rainbow trout at Stobk#1 (Highway 84, milepost 12.90).**

The road-crossing on Highway 84 lies at the confluence of Stonybrook Creek with Alameda Creek and is maintained by the California Department of Transportation (CalTrans). Currently, the road-crossing fails to meet passage criteria at all flows. Steelhead are known to have successfully negotiate this culvert under limited flow conditions. Action should be taken to ensure this crossing does not impede migration of steelhead. Additionally, providing access for juvenile and resident steelhead/rainbow trout to Stonybrook Creek should be considered when selecting an alternative due to the cold water refugia the stream provides during summer months.

Two options exist for remediate the fish passage barrier, each having varying degrees of project cost and effectiveness: retrofitting the existing crossing or full replacement with a bridge or arch culvert on footings. Retrofitting the existing crossing requires constructing a weir downstream of the outlet pool to raise the tailwater elevation between 0.5-feet and 1-foot. Since the outlet pool lies on an active gravel bar of Alameda Creek and is inundated during large flood events, the weir would need to be constructed of concrete and keyed into the upstream banks. A small notched beam at the culvert outlet combined with corner baffles spaced evenly along the left side of the barrel would create suitable hydraulic conditions to allow for passage of adult steelhead and larger resident trout during most migration flows.

Although retrofitting the crossing would be less costly than a full replacement, it fails to provide for upstream juvenile passage and will reduce the hydraulic capacity of the culvert, further exacerbating adverse geomorphic conditions produced by the existing road-crossing. Currently, the crossing is severely undersized, constricting the channel and causing frequent ponding of water upstream of the culvert. This has resulted in sediment deposition and aggradation of the channel bed extending at least 100-feet upstream. The aggradation has created a steep drop in the channel bed as it enters the culvert, which likely hinders fish passage at most flows. Additionally, the channel aggradation appears to have led to the construction of a hardened levee along the left bank upstream of the crossing to prevent water from flowing onto the highway.

Replacement of the existing concrete box culvert with a bridge or open-bottom arch spanning the active channel (approximately 20-feet) combined with removing deposited sediment and regrading the upstream channel bed to its natural slope will allow for unimpeded passage of all salmonid lifestages and the efficient transport of stream bed material through the crossing.

2. Inventory and assessment of privately maintained road-crossings and other potential barriers on Stonybrook Creek.

At least three privately maintained roads cross over Stonybrook Creek between Stobk#1 and Stobk#2. Before attempting to eliminate fish passage barriers at crossings on Palomares Road, an inventory of potential barriers on private lands should be completed. If landowner cooperation in the upper watershed is difficult to obtain, the inventory could be limited to the lower portions of the watershed (between Stobk#1 and Sobk#6) where habitat quality is highest and the likelihood of encountering additional barriers is greatest due to the steepness of the channel. Future barrier inventories should also include habitat surveys focusing on identification of potential natural upstream barriers to adult and juvenile steelhead and rainbow trout.

3. Replace culvert at Stobk#2 (Palomares Road, milepost 8.75).

The furthest most downstream culvert on Palomares Road is Stobk#2. It is a total barrier based on both the analyses performed as part of this inventory and direct observations made in 1999 (Alexander, 1999). The existing concrete box culvert is undersized, which has caused upstream ponding of water, extreme channel aggradation, and the creation of an 11-foot drop in the channel bed at the inlet. Full replacement of this road-crossing is the only feasible option for providing fish passage.

A pre-fabricated concrete arch placed on concrete footings may be the most suitable replacement structure. Due to the height of the road above the existing crossing, replacement with a bridge would require an extremely long span and likely be cost-prohibited. The new crossing should have a span of at least 20-foot to allow unimpeded transport of bedload, comprised primarily of boulders. To eliminate the 11-foot drop above the existing culvert inlet, the stream should be recontoured at an average channel slope of approximately 8.5%. Although the channel would be relatively steep, using an open bottom arch containing natural boulder substrate should encourage the formation of pools throughout the reach and create suitable fish passage and habitat conditions.

Treating the existing barrier at Stobk#2 will only open approximately 600-feet of upstream habitat for steelhead/rainbow trout before encountering the next road-crossing barrier. Plans to provide fish passage at Stobk#2 should be made in conjunction with treatment of the barrier at Stobk#3, opening up access to more than 3,000-feet of upstream habitat.

4. Retrofit or replace Stobk#3 road-crossing (Palomares Road, milepost 8.60).

The road-crossing at milepost 8.60 is extremely undersized, causing scour of the downstream channel through excessive outlet water velocities at high flows. As a result the channel has locally degraded approximately 5-feet at the culvert outlet. The most suitable solution for eliminating the fish passage barrier is full replacement of the crossing with a bridge or open bottom arch with a span of approximately 20-feet.

Because Stobk#3 through Stobk#8 are historic structures constructed in the 1930's, replacement may be difficult. For Stobk#3, an interim solution may be installing a fishway at the culvert outlet combined with fish weirs within the crossing to provide for upstream passage of adult steelhead and possibly larger rainbow trout. A steep-pass or denial fish ladder leading from the outlet pool to the apron could be mounted onto the bedrock wall along the left side of the channel. Weirs would need to be installed throughout the crossing to provide adequate water depth and reduced velocities. As part of the retrofit, the existing floor throughout the crossing should be relined with concrete and a headwall installed below the outlet apron.

Although installing a fishway would be less costly than replacing the road-crossing, it will require extensive modification to the existing structure and would only provide passage for larger fish under a limited range of flows. Additionally, fishways are inherently susceptible to clogging and damage by debris and large bedload.

5. Replace road-crossings at Stobk#4 and Stobk#5 (Palomares Road, mileposts 8.16 and 8.00).

Stobk#4 and Stobk#5 are both total barriers due to their steep slopes. Less than 800-feet of habitat lies between the two crossings, with an additional 1,900-feet of potentially unblocked habitat above Stobk#5. Because of the small length of unblocked channel between the two crossings, they should be considered for barrier remediation at the same time. The preferred option for providing fish passage at both of these road-crossings is to replace them with bridges or open bottom arches spanning the active channel.

The outlet apron on Stobk#4 has recently been rebuilt with a gabion floor and retaining wall. The gabion floor has already failed in several locations and creates an upstream migration barrier to all fish due to its steepness (greater than 6%). Alternatives for achieving passage of steelhead and large rainbow trout at Stobk#4 could involve replacing the gabion floor with concrete and installing a series of weirs throughout the entire crossing.

The outlet apron on Sobk#5 produces shallow sheeting flow due to its steepness (19.5%) and 15-foot width. Also, the upper potion of the crossing has a steep slope and narrow width, constricting the flow at the entrance. Because of the steepness of the outlet apron, retrofitting would require constructing a fishway up the left edge of the apron and installing a series of weirs within the crossing.

Although retrofitting both of these crossings is less costly than replacement, it will further reduce their hydraulic capacity and their ability to transport sediment. Additionally, due to the steep channel gradient through these crossings, retrofitting will only create marginal fish passage conditions suitable solely for passage of adult steelhead over a small range of flows.

6. Retrofit the Stobk#6 road-crossing (Palomares Road, mileposts 7.57).

Currently Stobk#6 does not meet adult and juvenile fish passage criteria but at higher flows some steelhead would likely be able to negotiate the outlet drop and shallow water depths. Moderate modifications to the crossing could create suitable passage conditions for both adult and juvenile steelhead/rainbow trout, opening up access to potentially 7,000-feet of upstream habitat.

Installation of three boulder weirs downstream of the crossing would raise the tailwater approximately two feet, eliminating the perched outlet. Placement of a one foot high notched beam on the edge of the outlet apron combined with two to three additional baffles across the lower portion of the crossing could create suitable hydraulic conditions for adult and juvenile fish passage.

7. Retrofit the Stobk#7 road-crossing (Palomares Road, mileposts 6.28).

The existing outlet apron on Stobk#7 drops steeply about 1.5-feet before being submerged by the outlet pool. The remaining portions of the crossing meet the fish passage depth and velocity criteria at most flows for both adult and juvenile steelhead/rainbow trout.

Placement of a one-foot high notched beam at the upstream edge of the outlet apron combined with raising the outlet pool one to two feet by constructing three boulder weirs downstream of the crossing would submerge the outlet apron and create suitable fish passage conditions. If downstream barriers are removed, retrofitting this crossing for fish passage could potentially provide access to the remaining 10,000-feet of upstream habitat.

5.2 Estimated Cost of Treatments

Rough cost estimates were developed for the treatment alternatives described in section 5.1. The estimates are based on final costs for recently implemented fish passage improvement projects in Northern California. As detailed plans are developed for retrofit or replacement of existing road-crossings along Stonybrook Creek, actual implementation costs may vary dramatically from those listed in Table 5.1.

Table 5.1 – Fish passage treatment options and estimated implementation costs based on final costs of similar projects.

Site	Treatment	Preliminary Cost Estimate
Stobk#1 – Hwy 84	Retrofit (1-concrete weir at outlet; corner baffles in culvert)	$30,000 - $40,000
	Replacement (20' span concrete arch)	$300,000 - $400,000
Stobk#2 – Palomares Road, MP 8.75	Replacement (20' span concrete arch)	$400,000 - $500,000
Stobk#3 – Palomares Road, MP 8.60	Retrofit (fish-ladder at outlet; weirs in culvert)	$30,000 - $40,000
	Replacement	$250,000
Stobk#4 – Palomares Road, MP 8.16	Retrofit (rebuild outlet apron; off channel fishway at outlet; series of weirs within crossing)	$60,000
	Replacement	$300,000
Stobk#5 – Palomares Road, MP 8.00	Retrofit (rebuild outlet apron; series of weirs within crossing)	$60,000
	Replacement	$250,000 - $300,000
Stobk#6 – Palomares Road, MP 7.57	Retrofit (3-boulder weirs; 3 sets of baffles)	$15,000 – $20,000
Stobk#7 – Palomares Road, MP 6.28	Retrofit (3-boulder weirs; outlet beam)	$15,000 – $20,000

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Personal Communications

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Appendix A

Field Data Sheet and Instructions

Surveyors: Scope: _________ Rod:___________ Date: ___________

Culvert ___ of ___ (from Left Bank to Right Bank)

Fish Passage Inventory Data Sheet

Road:	Mile Post:	Cross Road:
Named Stream:		Watershed:
USGS Quad:		Lat/Long:
Fisheries Information		
Fish Species/Age Classes of Concern:		Presence observed during survey? ˜ upstream ˜ downstream ˜ none Species/age class: ____________________________
Length of upstream habitat (ft) – Historical:		Currently Accessible:
Upstream Culverts: ˜ yes ˜ no No. of culverts: Barrier(s): ˜ yes ˜ no Distance to 1st culvert barrier (ft):		**Downstream Culverts:** ˜ yes ˜ no No. of culverts: Barrier(s): ˜ yes ˜ no Distance to 1st culvert barrier (ft):
Culvert Information		
Culvert Type: ˜ Circular ˜ Pipe Arch ˜ Box ˜ Open Arch ˜ Other: Height (ft): ___________ Width (ft): ___________ Length (ft):___________		
Material: ˜ SSP ˜ CSP ˜ Aluminum ˜ Plastic ˜ Concrete ˜ Log/wood ˜ Other: Corrugations (*width x depth*) (in): ______________ ˜ Spiral Rustline Height (ft): _____________ Pipe Condition: ˜ good ˜ abraded ˜ rust-through ˜ Other:		
Embedded: ˜ yes ˜ no Depth (ft)- Inlet: _______ Outlet: _______ Location (beginning/end) (ft): ________ Describe substrate:		
Barrel Retrofit (weirs/baffles): ˜ yes ˜ no Type: Sketch on back ˜ Description:		
Inlet type: ˜ projecting ˜ headwall ˜ wingwalls ˜ mitered Inlet/Channel Alignment (deg): _________ Inlet Apron: ˜ yes ˜ no Describe:		**Outlet configuration:** ˜ At stream grade ˜ freefall into pool ˜ Cascade over riprap Outlet Apron: ˜ yes ˜ no Describe:
Tailwater Control: ˜ pool tailout ˜ log weir ˜ boulder weir ˜ concrete weir ˜ channel x-section(no pool)		
Upstream Channel Widths (ft): (1) (2) (3) (4) (5)		

Surveyed Elevations Use inlet as datum when possible	STATION (ft)	ELEVATION (ft)	Station Description (**bold font = required**)
			TW control of 1st resting hab. u/s of inlet
			Bed Elev. 2-culvert widths. u/s of inlet
			Inlet invert
			Outlet invert
			Inlet/outlet apron or riprap
			Max depth w/in 5-ft of outlet
			Max. pool depth
			TW control
			OHW elevation at TW control

Breaks in Slope: ˜ yes ˜ no No. ______

(1) Dist. from inlet (ft): _______ Elev. at Break (ft): _______

(2) Dist. from inlet (ft): _______ Elev. at Break (ft): _______

(3) Dist. from inlet (ft): _______ Elev. at Break (ft): _______

Fill Volume:

Lu (ft):________ Su (%):________ Road Width(ft):________

Ld (ft):_______ Su(%):________Top Fill width(ft):________

Base Fill Width (ft):___________

Tailwater Cross-Section (optional) Use culvert inlet bottom as datum

Station (ft)								
Elev. (ft)								
Notes								

Channel Roughness – Describe substrate size/shape:

Channel Slope at Tailwater Control

Length (ft):

Upstream Rod Ht (ft):

Downstream Rod Ht (ft):

Calculate Channel Slope (ft/ft):

Add site sketches and qualitative habitat comments below:

Field Guide

Explanations and Instructions for Inventory and Assessment of Culverts on Fish Bearing Streams

Michael Love
July 14, 2000

This document is intended to provide general instructions and explanations for how to use the accompanying fish passage field data sheet. The data sheet and field guide were developed for collecting information required for inventory and assessment of culverts on fish bearing streams, with the specific purpose of using the FishXing software as an analysis tool.

The field guide and data sheet are only one component of a culvert assessment for fish passage. Once the general stream crossing data has been collected the sites need to be categorized by whether or not they are an obvious barrier, passable, or undeterminable. If it is not readily apparent whether a culvert is a fish barrier, further hydraulic analysis should be performed using FishXing. The Help system within FishXing should assist in guiding you through the analysis.

Once the fish barriers are identified, priorities must be assigned to develop a clear strategy for remediating the passage problems. Priorities are often assigned based on the cost of the fix and the quantity and quality of the habitat that would become accessible. This requires some degree of habitat assessment and identification of additional barriers upstream and downstream of the stream crossing. The Fish Passage Barrier Assessment and Prioritization Manual produced by Washington Department of Fish & Wildlife covers these issues in detail and is available at:

http://www.wa.gov/wdfw/hab/engineer/fishbarr.htm.htm

Header Information

Surveyors: You and your partner's name.

Culvert # of Total #: If a stream crossing contains more than one culvert, each culvert must be surveyed separately. Start with surveying the culvert closest to the left bank (looking downstream). Fill out a separate data sheet for each culvert.

Road , Mile post , and Cross Road: Road name and the mile post were the stream crossing is located. If there are no posted miles, note location where you began (i.e. intersection of a road) and use your odometer to estimate the mile post. Also enter the name of the nearest cross road.

Named Stream: From USGS 7.5' quad or other local sources.

Watershed: Enter the name of the watershed or sub-watershed.

Fisheries Information

Fish Species/Age Class of Concern: List all the species and associated age classes of fish that the stream crossing should pass in both directions.

Presence observed during survey?: If fish are observed during the survey, check the box appropriate to where you observed them and note the species and age class or size.

Length of upstream habitat (ft):

Historical – The total length of stream channel upstream of the culvert that was accessible by fish prior to the existence of any constructed barriers (i.e. upstream culverts or small dams). If the surveyed culvert is a barrier, this will assist in quantifying the amount of potential habitat that can be made accessible if the upstream barriers are also removed.

Currently Accessible – Length of stream channel that is, or would be accessible to fish assuming no barrier exists downstream. If the culvert is a barrier, this will assist in quantifying the amount of habitat that will be made accessible by correcting the problem.

Upstream Culverts: Check the yes box if any culverts exist upstream within the range of historical habitat. Do not count culverts that are on historically non-fish bearing portion of the stream.

No. of Culverts: Number of upstream culverts.

Barriers: Check yes if any of these culverts are barriers to upstream fish movement. To answer this question, a complete analysis of the upstream culverts may be required.

Distance: If there are upstream culvert barriers, measure the stream distance from the culvert inlet to the first upstream culvert barrier. This is best done using a hip-chain, but can be estimated using air photos or USGS topographic maps. If your not sure if an upstream culvert is a barrier, a hydraulic analysis may have to be preformed in the office before filling out this field.

Downstream Culverts: Check the yes box if any culverts exist downstream of the stream crossing.

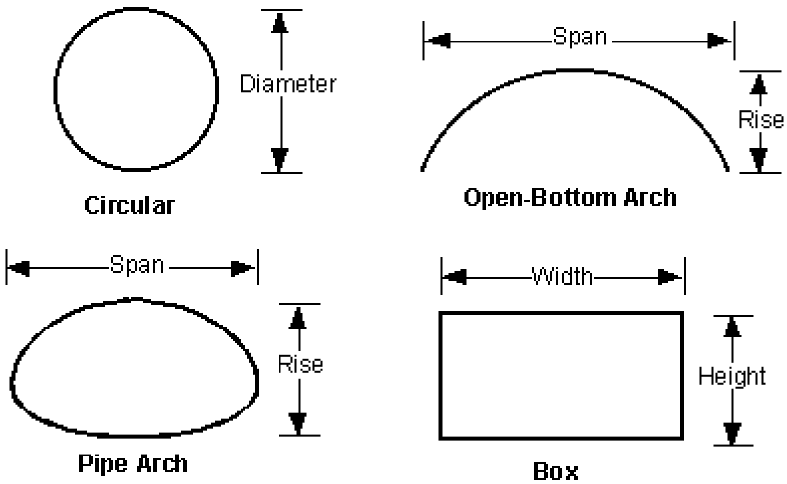
No. of Culverts: Number of downstream culverts.

Barriers: Check yes if any of these culverts are barriers to upstream fish movement. To answer this question, a complete analysis of the downstream culverts may be required.

Distance: If there are culvert barriers downstream, measure the stream distance from the culvert outlet to the first downstream culvert barrier.

Culvert Information

Culvert Type: Choose appropriate type of culvert. Depicted below are the end-sections of common culvert types.



Height- The height, rise, or diameter (measured vertically) of the culvert, measured from the inside of the corrugations. If the culvert bottom is completely covered with bedload (embedded) estimate the culvert height based on the shape (e.g. assume the height = width for circular culverts). For Open-Bottom Arches, measure the height from the streambed to the top of the culvert.

Width- The maximum width, span, or diameter (measured horizontally) of the culvert, measured from the inside of the corrugations. It is important to measure both the height and width on circular culverts since they often become squashed after installation.

Length- Culvert length measured from the inlet to the outlet. Do not include inlet and outlet aprons.

Material: If the culvert material does not fall into one of the following categories, give a brief description characterizing the roughness of the material.

> SSP = Structural Steel Plate pipes are constructed of multiple plates of corrugated galvanized steel bolted together.
>
> CSP = Corrugated Steel Pipes are constructed of a single sheet of corrugated galvanized steel.
>
> Aluminum = Corrugated aluminum, no rust line.
>
> Plastic = Often has corrugations.
>
> Concrete = Most box and some circular and arch culverts are constructed of concrete.
>
> Log/Wood = Includes log stringer (Humboldt) crossings. Also includes some older box and circular culverts that are constructed of wood.

Corrugations: Measure the width and depth of the corrugations in inches. Most CSP have 2 2/3 in. x ½ in. corrugations. SSP pipes often have 6 in. x 2 in. corrugations. The size of the corrugations determines the culvert roughness.

Spiral: Spiral culverts have helical corrugations, reducing the culvert roughness.

Rustline Height: Measure the height of the rustline (at the peak) above the culvert bottom. The rustline height should be measured two to three diameters downstream of the inlet. The rustline can be used both as a field indicator for undersized culverts and as a check for the accuracy of the calculated fish passage flow for that specific stream. Rustlines greater than 1/3 the culvert height (diameter) are often considered hydraulically undersized. Also, the flow associated with the rustlines height (normal depth = rustline height) can sometimes be correlated to the basin hydrology (i.e. flow at rustline is approximately the 20% exceedence flow).

Pipe Condition: The categories below apply primarily to steel culverts. When appropriate, give a brief description of other observed problems with the stream.

good = slightly rusted

abraded = culvert worn thin by rust and passing sediment

rust-through = a portion of the water flows through holes in the culvert bottom

Embedded: Check the yes box if the culvert has stream substrate retained within at least a third of the culvert. Estimate the depth of the substrate at the inlet and outlet. Estimating the culvert height and substrate depth can be difficult with pipe arch and box culverts that contain sediment throughout. Best estimates will suffice.

Location (beginning/end): If the culvert has only partial substrate coverage, measure the distance from the inlet to where the substrate either begins or ends. Enter the distance and circle whether the substrate begins or ends at that location.

Barrel Retrofit: If the culvert contains baffles or weirs record the type and give a brief description. Since baffle designs are often not standardized, a sketch of the retrofit along with dimensions is extremely useful. In particular, note the height and shape of the baffle/weir at the culvert outlet.

Inlet Types: Select the appropriate culvert inlet type.

Inlet/Channel Alignment: The approach angle of the upstream channel. Standing at the inlet looking upstream estimate the approach angle of the channel with respect to culvert centerline.

Channel approach angles greater than 30 degrees can increase the likeliness of culvert plugging which results in blockage of both upstream and downstream fish movement and can result in catastrophic failure of the stream crossing. Additionally, in some situations poor channel alignment can create adverse hydraulic conditions for fish passage.

Outlet Configuration:

At stream grade = A swim through culvert that has no drop at the outlet.

Freefall into pool = The culvert outlet is perched directly over the outlet plunge pool.

Cascade over riprap = Culvert outlet is perched above the downstream channel and exiting water sheets over riprap or bedrock making it difficult for fish to swim or leap into the culvert.

Inlet / Outlet Apron: Aprons are commonly constructed of concrete or grout and extend upstream from the culvert inlet or downstream from the outlet. Inlet aprons are used to increase a culvert capacity, stabilize the channel bed or for other structural purposes. Outlet aprons are typically designed to prevent erosion at the toe of the stream crossing fill. Check the yes box if the culvert has an outlet apron and give a brief description. Note if the end of the apron has a weir or influences the flow within the culvert. Include a sketch on the back of the data sheet if needed.

Tailwater Control: The tailwater is the water surface immediately downstream of the culvert outlet. The location controlling the elevation of the tailwater is referred to as the tailwater control.

Pool tailout = Commonly referred to as the riffle crest. Deposition downstream of the outlet pool controls the pool elevation.

Log weir/Boulder weir/Concrete weir = Different weir types placed downstream of the outlet pool to control tailwater elevation.

Channel cross-section = No outlet pool has formed allowing the water to flow unimpeded downstream of the culvert.

Upstream channel widths: Measure the width of the channel at the ordinary high water (OHW) level, sometimes referred to as the height of the active channel. The OHW location can be identified by locating the height of annual scour along the banks (typically devoid of vegetation or moss). Take five channel width measurements at locations upstream of the culvert influence. Space the measurements out over a 100-foot reach.

Undersized culverts can influence channel morphology and the OHW level for several hundred feet upstream as a result of frequent ponding and siltation. Avoid taking channel width measurements within the culvert influence. The maximum extent of the upstream influence can be assumed to be located where the channel bed elevation is the same as the road surface elevation at the stream crossing.   In most situations the extent of influence is far less.

Surveyed Elevations

For accurately determining the culvert slope(s) and elevation of the tailwater at varying flows a survey must be performed. The minimum equipment required for surveying is a stadia rod, measuring tape, and either an auto level mounted on a tripod or a hand level placed on a monopod. When surveying breaks-in-slope within the culvert a flashlight and pocket stadia rod may also be required.

It is convenient to set up your level at a location that allows a clear line-of-sight to all the required survey points. This will avoid the need to move the instrument and keep the survey calculations simple. Often the easiest location to set up your level is in the channel directly downstream of the culvert. At crossings with small fills, the level can also be located on the road above the culvert if no slope breaks exist within the culvert. The site characteristics will generally dictate where you can set up the level.

It is important to tie all surveyed points to a common datum. The center of the culvert inlet bottom is often used, but any point that can be reoccupied in the future will suffice. An elevation must be assigned to the datum (100ft is commonly used). Then rod heights surveyed with the level are converted to elevations relative to the datum and entered on the data sheet. This may require a piece of scratch paper or calculator.

TW control of 1st resting habitat upstream of inlet: Identify the first potential resting location upstream of the culvert inlet, such as a pool. Then survey and record the station and elevation of the streambed at the pool tailwater, typically at the beginning of the riffle leading to the culvert inlet. This measurement will assist in determining if there is ample resting habitat for fish that successfully negotiate the culvert.

Bed Elev. 2-culvert widths upstream of inlet: Move two culvert widths upstream of the inlet and survey the stream bed thalwag elevation. Often undersized culverts interfere in the transport of sediment, depositing streambed material upstream of the inlet. This can cause a steep drop in the channel profile as it enters the culvert, hindering fish passage. This measurement can assist in identifying these sites.

Inlet Invert (Bottom Elev.): Survey the point at the center of the culvert inlet. In embedded culverts this may not be the deepest point. The culvert length should be measured between the surveyed inlet and outlet points.

Outlet Invert (Bottom Elev.): Located at the center of the culvert outlet.

Inlet/Outlet apron or riprap: If the culvert has apron(s), survey the beginning point the inlet apron and the ending point of the outlet apron. This will be used to determine the length and slope of the apron. If either the inlet or outlet has riprap within the channel survey the beginning/ending point of the placed rock.

Max depth within 5-feet of outlet: Survey the deepest point within five feet of the culvert outlet. If the fish must leap to enter the culvert, this elevation will be used to determine if the pool has sufficient depth.

Max pool depth: Survey the deepest point within the outlet pool. If there is no pool, survey the thalwag (lowest point in the channel) immediately downstream of the culvert.

TW Control: Survey the thalwag at the tailwater control. This defines the residual pool depth downstream of the culvert (see Tailwater Control for description).

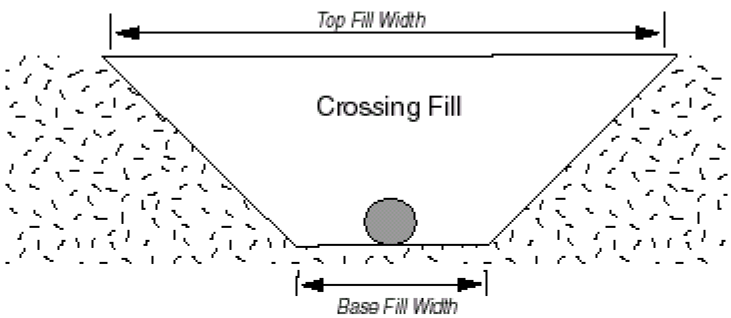
OHW elevation at TW control: Survey the elevation of the ordinary high water mark between the culvert outlet and the tailwater control. This will assist in identifying the elevation of the tailwater during fish migration flows (see Upstream Channel Widths for description of OHW).

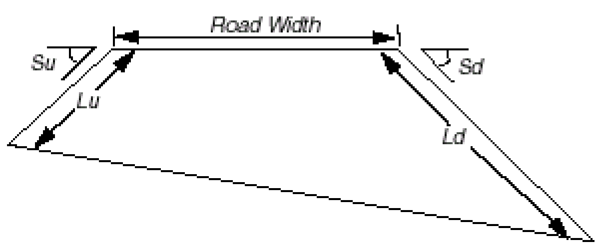
Breaks-in-Slope: In addition to measuring the average slope of the culvert, it is important to survey each change in slope within the culvert. Culverts often settle and become bowed through time. Typically the upper portion of the culvert becomes steeper than the lower section. When a culvert consists of compound slopes these steeper sections may become fish barriers. Be mindful that fish passage assessment using the average culvert slope instead of analyzing each compound slope independently may mistakenly suggest the stream crossing is not a barrier.

If the culvert contains observable breaks in slope, record the number of breaks (note that a culvert consisting of two compound slopes has only one break). Measure the distance from the inlet to the break and survey the elevation of the break point. Often a flashlight will be required to illuminate the stadia rod. In small culverts you may need to use a pocket stadia rod.

Fill Volume

Estimating the fill volume is useful when attempting to prioritize stream crossing replacements. Excavation of existing fill can add substantial cost to a project. Conversely, when stream crossings with large fill volumes fail they can deliver greater amounts of sediment directly into adjacent streams. Dramatically undersized stream crossings with large fill volumes, even if they are not fish barriers, may need to be replaced.





Crossing fill measurements. Note that Ld, the downstream fill slope length often extends below the culvert outlet. These measurements are for obtaining a rough estimate of the fill volume and not intended for use in contract specifications.

Lu: Upstream fill slope length, measured from toe of the fill at the culvert inlet to inboard edge of road surface.

Su: Upstream fill slope, measured with clinometer.

Ld: Downstream fill slope length, measured from toe of the fill near the culvert outlet to outer edge of road surface.

Sd: Downstream fill slope, measured with clinometer.

Road Width: Width of the road above the stream crossing, measured perpendicular to the road centerline.

Top Fill Width: Width of the fill measured along the road centerline and perpendicular to culvert axis.

Base Fill Width: Width at the base of the fill (original channel width) measured perpendicular to culvert axis.

For a description of how to calculate the fill volume refer to Flanagan et al. (1998), which can be downloaded at:

http://watershed.org/wmc/pdf/xing_handbook.pdf

Tailwater Cross-Section

This section of the data sheet is optional. The tailwater cross-section is used to estimate the tailwater elevation at different flows by constructing a flow verses tailwater elevation rating curve. This method is most appropriate for stream crossings with unimpeded flow downstream of the outlet and possessing little or no outlet pool. It can also be used successfully when the tailwater control is the pool tailout. Although cross-sections of downstream weirs can not be used explicitly in FishXing, they can be informative when attempting to estimate water elevations at various flows.

The cross-section should be located at the tailwater control perpendicular to the stream channel. Cross-sections typically start on the left bank looking downstream. String a measuring tape across the channel from left to right. Make sure the first survey point is well out of the channel. Proceed to survey along the tape, taking points at each break in slope. Record the station (distance across the channel as indicated on the tape) and survey the rod height. The rod heights must then be converted to elevations relative to the datum. Also record points of interest, such as the locations of the OHW and bank full.

Channel Roughness: Describe the substrate at, and immediately downstream of the cross-section. This information will be used to estimate a Manning's roughness coefficient. For boulder or log weirs, describe the size of the boulders or the diameter of the logs.

Channel Slope at Tailwater Control: The slope of the channel reach leading downstream from the tailwater cross-section. The change in elevation of the channel thalwag over a measured length will be used to calculate the channel slope.

Select the length of channel to measure. The channel reach should begin at the cross-section and continue until the channel slope or width noticeably changes, typically 20 to 30 feet. Survey the thalwag near the tailwater control and record the rod height. Then proceed to survey the thalwag at the downstream end of the selected reach. Record the rod height and measure the distance between the two points. The change in the rod height divided by the length will give you the channel slope downstream of the tailwater control.

Appendix B

Hydrologic Analysis

Table B-1. Predicted peak flows and associated recurrence intervals for gaging stations on streams located in close proximity to Stonybrook Creek. Peak flows were estimated using the Log Pearson Type III distribution and the methods described by the USGS (1982). Regional skew coefficients appeared not to be representative of the peak flow distribution skew within the study area. Thus, only station skew was employed.

Gaging Station		Mean Annual Precipitation	Drainage Area	Record Length	Discharge for recurrence intervals indicated below					
					2-years		5-years		10-years	
Number	Name	(inches)	(mi^2)	(years)	(cfs)	(cfs/mi^2)	(cfs)	(cfs/mi^2)	(cfs)	(cfs/mi^2)
18050004	Dry C A Union City	21	9.39	43	181	19	699	74	1,233	131
11179005	Alameda C Trib Nr Niles	20	0.28	14	2.9	10	16.6	59	38.2	137
11180960	Cull C Ab Cull C Res Nr Castro Valley	26	5.79	20	340	59	957	165	1,481	256
11180825	San Lorenzo C Ab Don Castro Res	23	18.00	14	481	27	1,183	66	1,996	111
11181000	San Lorenzo C A Hayward[1]	23	37.5	18	3,631	97	5,463	146	6,790	181
11174000	San Antonio C Nr Sunol	23	37.0	37	345	9	1,005	27	1,732	47
11173200	Arroyo Hondo Nr San Jose	27	77.1	17	3,572	46	7,271	94	8,711	113

Gaging Station		Mean Annual Precipitation	Drainage Area	Record Length	Discharge for recurrence intervals indicated below					
					25-years		50-years		100-years	
Number	Name	(inches)	(mi^2)	(years)	(cfs)	(cfs/mi^2)	(cfs)	(cfs/mi^2)	(cfs)	(cfs/mi^2)
18050004	Dry C A Union City	21	9.39	43	2,051	218	2,716	289	3,392	361
11179005	Alameda C Trib Nr Niles	20	0.28	14	87.9	314	146	522	226	809
11180960	Cull C Ab Cull C Res Nr Castro Valley	26	5.79	20	2,197	379	2,733	472	3,251	562
11180825	San Lorenzo C Ab Don Castro Res	23	18.00	14	3,632	202	5,472	304	8,037	447
11181000	San Lorenzo C A Hayward[1]	23	37.5	18	8,589	229	10,013	267	11,507	307
11174000	San Antonio C Nr Sunol	23	37.0	37	3,059	83	4,390	119	6,051	164
11173200	Arroyo Hondo Nr San Jose	27	77.1	17	9,632	125	9,952	129	10,117	131

[1] Pre-regulated flows (1940 - 1962) were used for San Lorenzo Creek A Hayward, station number 11181000.

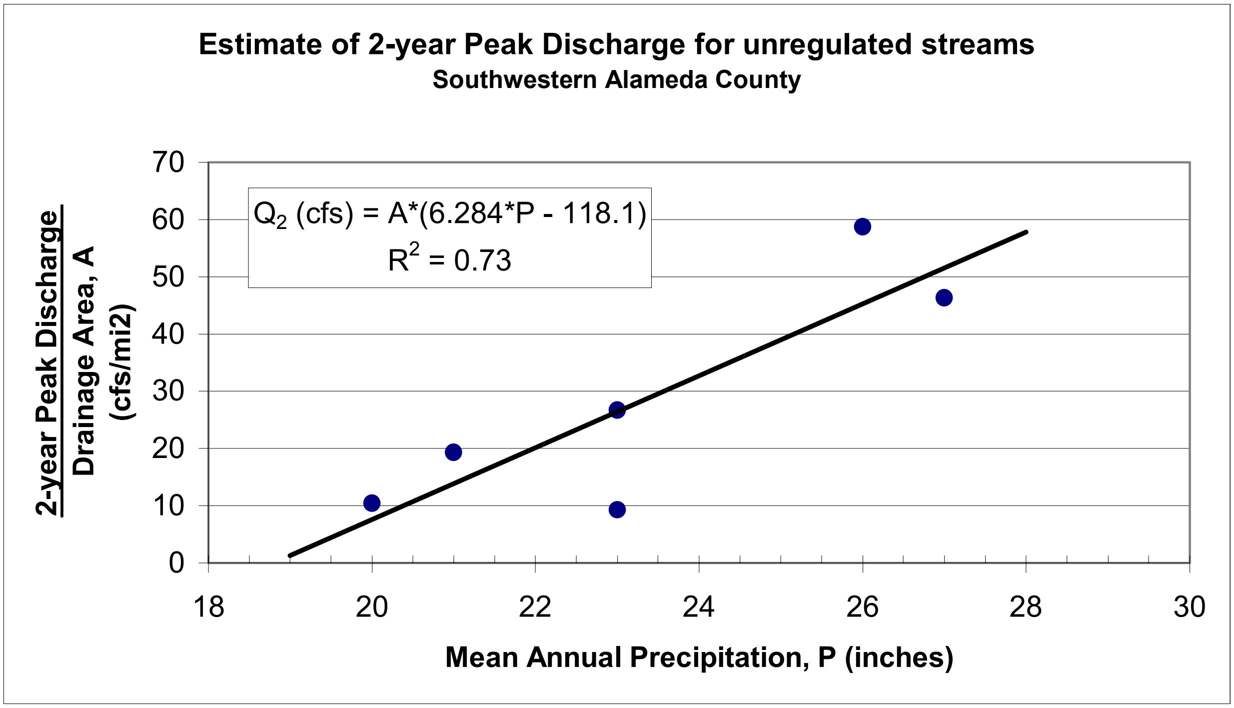


Figure B-1

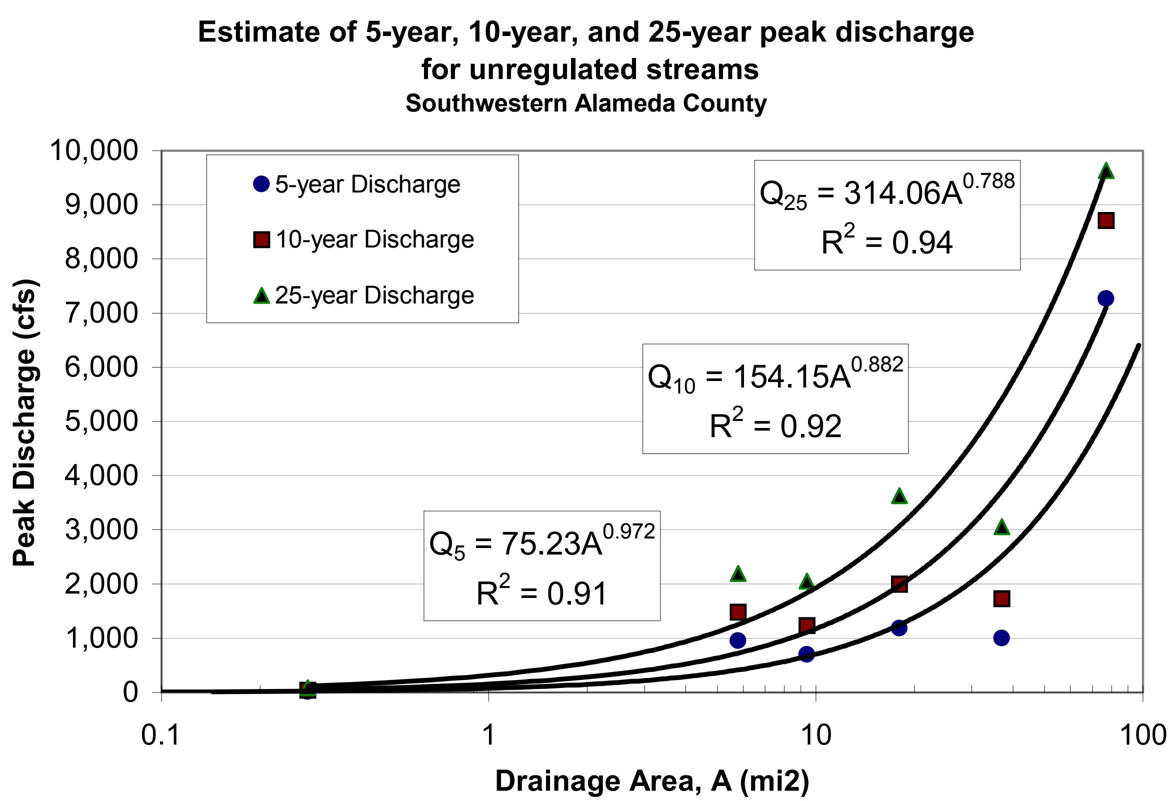


Figure B-2

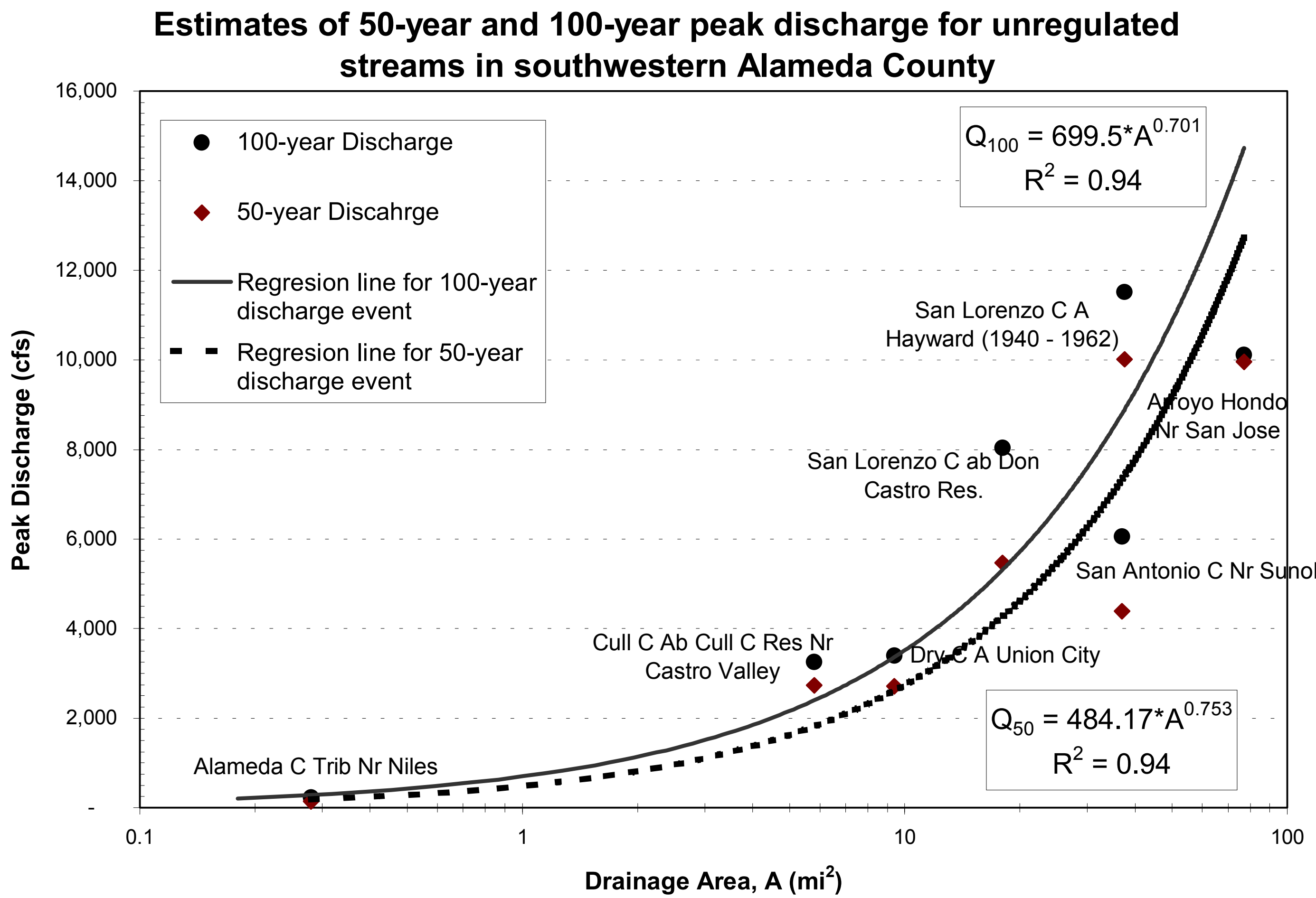


Figure B-3

Figure B-1 through B-3 are plots of predicted peak flows for streams listed in Table B-1. For peak flows associated with the 2-year recurrence interval, a relationship was developed using mean annual precipitation (P) and drainage area (A). For the 5-year, 10-year, 25-year, 50-year, and 100-year recurrence interval, relationships were developed relating drainage area and peak flow.

Table B-2. USGS stream gaging locations within close proximity to Stonybrook Creek, recording daily average flow.

Station Number	Stream Name	Latitude (ddmmss)	Longitude (ddmmss)	Record Length (years)	Coverage (WY)	Drainage Area (sq. miles)	Mean Annual Precipitation (in/yr)
11172945	Alameda C Ab Div Dam Nr Sunol	372951	1214621	5	1995 - 99	33.29	27
11173200	Arroyo Hondo Nr San Jose	372742	1214606	5	1995 - 99	77.10	27
11180500	Dry C A Union City	373622	1220122	44	1917-19 1959 - 99	9.39	21
11180810	Palomares C Nr Hayward	374140	1220126	2	1998 - 99	9.08	24
11180825	San Lorenzo C Ab Don Castro Res	374142	1220238	19	1981-1999	18.00	23
11180900	Crow C Nr Hayward	374218	1220234	2	1998 - 99	10.51	25
11180960	Cull C Ab Cull C Res Nr Castro Valley	374304	1220312	21	1979 - 99	5.79	26
11181004	Castro Valley C A Castro Valley	374242	1220345	2	1979 - 80	0.98	23
11181008	Castro Valley C A Hayward	374048	1220446	22	1978 - 99	5.51	23

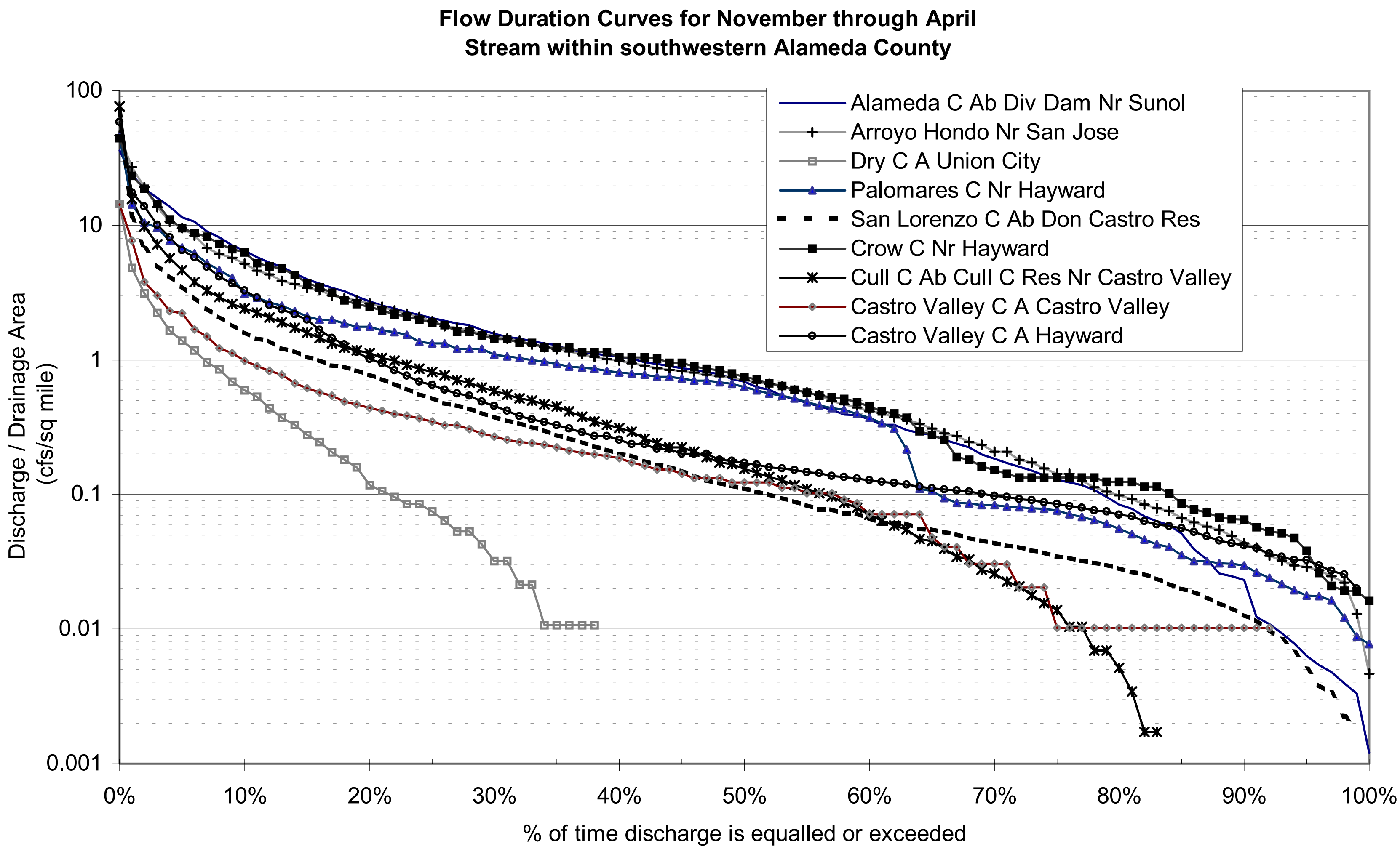


Figure B-4. Flow duration curves constructed using flow data from November through April, the assumed period of steelhead and rainbow trout upstream migration. Note in Table B-2, some of the gage stations have only two years of recorded flows.

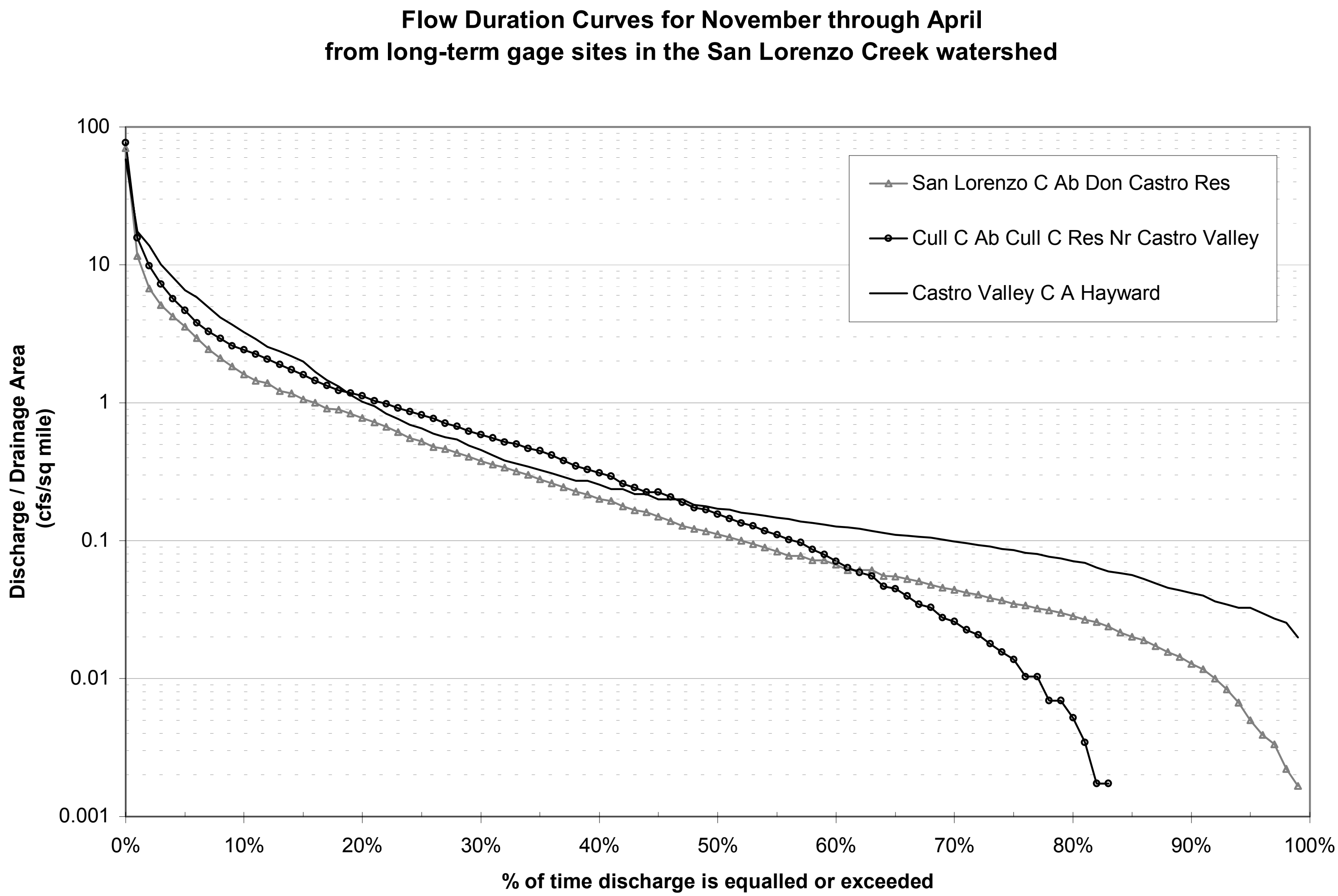


Figure B-5. Flow duration curves constructed using daily average flows from November through April for the three gage sites with the longest record (Dry Creek appears to have regulated flow at times and was excluded).

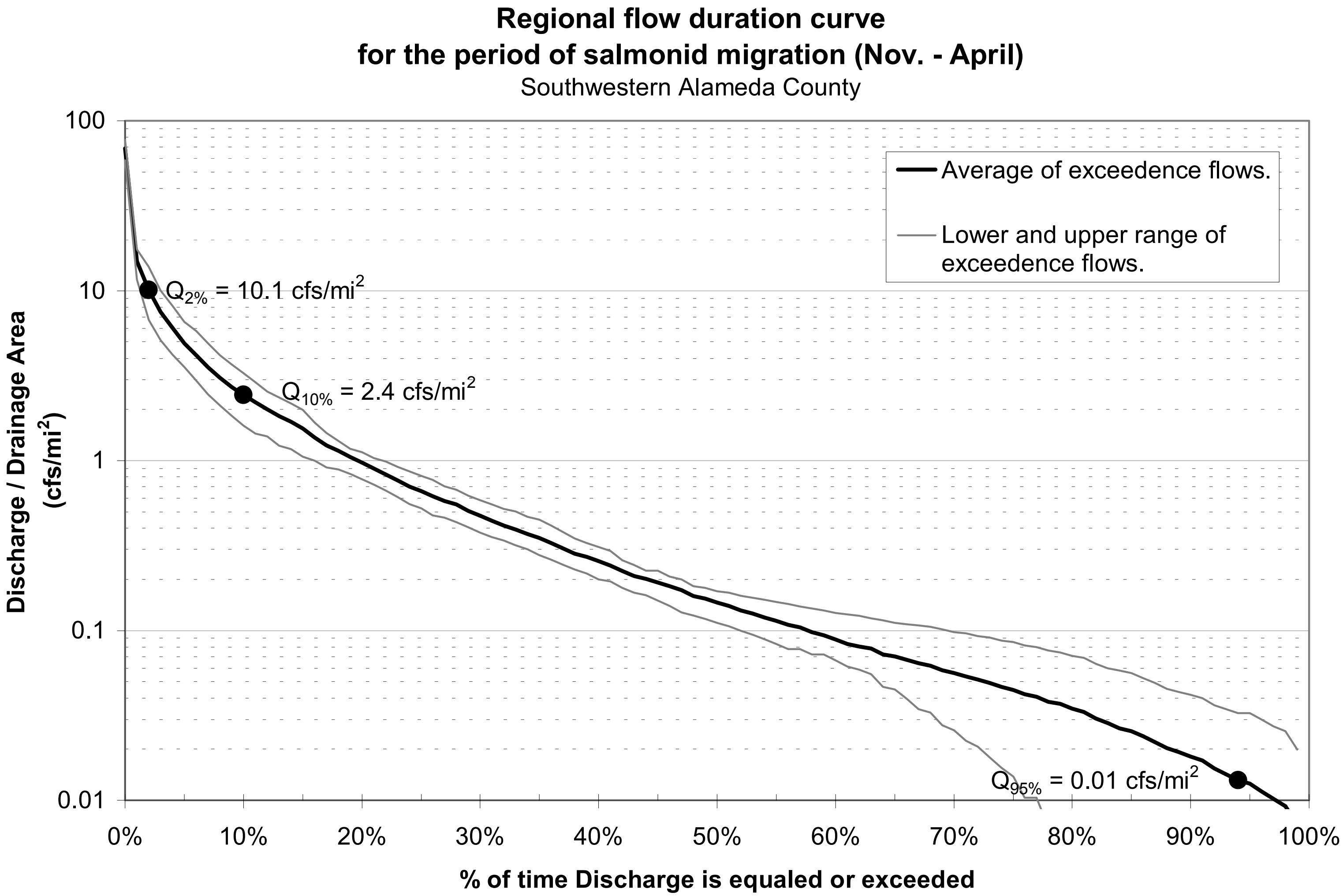


Figure B-6. Regional flow duration curve constructed by averaging the exceedence flows from three stream gaging stations: San Lorenzo Creek above Don Castro Reservoir, Cull Creek above Cull Creek Reservoir, and Castro Valley Creek at Hayward. Error bars represent the minimum and maximum flow associated with the indicated exceedence value.

Appendix C

Site Descriptions and Analysis

Summary of Sites

Stonybrook Creek Raod-Crossing Inventory

Site	Road Name	Posted Mile	Lat/Long (Datum: NAD27)	Drainage Area (mi^2)	Average Active Channel Width (ft)	Crossing End-section Shape	Construction Material	Culvert Inlet Dimensions width (base/top) x height	Culvert Length (including aprons) (ft)
Stobk#1	Hwy 84	12.9	37 35' 53.24" 121 56" 47.47"	6.87	21.1	Box	Concrete	10' x 7'	57.5
Stobk#2	Palomares Road	8.75	37 36' 35.21" 121 56" 37.36"	5.72	20.2	Box	Concrete	8' x 9'	89
Stobk#3	Palomares Road	8.60	37 36' 37.07" 121 56" 29.74"	5.68	21.8	Trapezoid	Stone masonry with rough concrete floor	9'/14.5' x 8'	77
Stobk#4	Palomares Road	8.16	37 36' 53.89" 121 56" 34.85"	4.78	18.0	Trapezoid	Stone with gabion outlet apron	8'/12.5' x 8'	86
Stobk#5	Palomares Road	8.00	37 37' 1.02" 121 56" 38.74"	4.74	14.8	Trapezoid	Stone masonry and bedrock	8.5'/14.5' x 8.5'	101
Stobk#6	Palomares Road	7.57	37 37' 18.02" 121 56" 33.58"	4.14	15.3	Trapezoid	Stone masonry	7'/28' x 10'	56
Stobk#7	Palomares Road	6.28	37 38' 9.40" 121 57' 12.85"	2.33	10.2	Trapezoid	Stone masonry	10.5'/15' x 7'	47
Stobk#8	Palomares Road	6.18	37 38' 10.15" 121 57' 22.31"	2.03	13.3	Trapezoid	Stone masonry walls/open bottom with cobbles	7'/14' x 10.5'	33

Summary of Sites

Stonybrook Creek Raod-Crossing Inventory

Site	Road Name	Posted Mile	Ave. Slope through Culvert (including aprons)	Inlet Type	Inlet Alignment to Channel	Outlet Type	Outlet Perched?	Culvert Condition	Previous Fish Passage Modifications to Culvert
Stobk#1	Hwy 84	12.9	4.02%	Concrete head/ wing wall	45 deg	Concrete head/ wing wall	Yes - 1.2'	Good - minor exposure of rebar on culvert invert	None
Stobk#2	Palomares Road	8.75	6.98% 7.42% (culvert)	Flat concrete apron/ tapered wing wall	30 deg	Flat concrete apron/ tapered wing wall	No	Good - minor exposure of rebar in outlet apron	None
Stobk#3	Palomares Road	8.60	4.46%	Grouted Apron and trapezoidal wing wall	30 deg	Grouted Apron and trapezoidal wing wall	Yes - 4.8'	Good - Newer concrete on floor	None
Stobk#4	Palomares Road	8.16	4.25% 3.5% (culvert) 6.6% (outlet apron)	Grouted stone apron with wing-walls	15 deg	Steep gabion apron (length = 30')	No	Poor - Gabions are beginning to fail after approx. 1 yr.	None
Stobk#5	Palomares Road	8.00	11.2% 7.1% (inlet & crossing) 19.5% (outlet apron)	Grouted stone apron and left wing wall. Right wall is bedrock	30 deg	Stone wing-walls, steep apron of rough concrete (length = 45')	Yes - 1.1'	Poor - Outlet apron is severely undercut.	None
Stobk#6	Palomares Road	7.57	0.49% 0.2% (inlet & crossing) 8.0% (outlet apron)	Stone wing-walls	30 deg	Stone wing-walls, concrete apron	Yes - 2.8'	Moderate - Concrete lined floor, outlet apron undercut by pool.	None
Stobk#7	Palomares Road	6.28	5.79% 0.2%(culvert) 30% (outlet apron)	Stone wing-walls and apron	45 deg	Stone masonry apron and wing-walls	No	Moderate - Toe of apron severely undercut.	None
Stobk#8	Palomares Road	6.18	No Slope	Stone wing-walls	0 deg	Stone wing-walls	No	Moderate - Toe of outlet wing-walls scoured, cracks in wall.	Concrete outlet beam has increased water depths.

Site	Road Name	Posted Mile	Additional Comments	Suggested Treatments
Stobk#1	Hwy 84	12.9	Culvert makes 30-deg right turn 34 ft downstream of inlet. Rebar exposed on invert at corner. Steep channel immediately upstream of inlet due to ponding/deposition. Alameda Creek active channel approximately 100 ft downstream of culvert outlet. Outlet pool is influenced by Alameda Creek during extreme flows.	Baffling culvert will likely create satisfactory conditions. May require downstream weir to minimize leap. Bigger problem is reduced sediment transport (inlet constrictions/alignment) causing drop in channel at culvert inlet. Full replacement may be warranted.
Stobk#2	Palomares Road	8.75	Extreme sediment wedge deposited immediately upstream of inlet, creating a boulder cascade with a drop of 11-feet over 40-feet of channel length (28% slope). Culvert extremely undersized. Outlet backwatered by downstream boulder control.	Full replacement is only feasible option. Best structure for site is bridge (or an equivalent open bottom structure) spanning the active channel (20-feet) to allow unimpeded transport of bedload. Deposited upstream bed material should be reshaped to create even grade through crossing.
Stobk#3	Palomares Road	8.60	Constructed 1938. Newer bridge-deck. Road fill encroaches on upstream channel. Perennial stream with some isolated pools. Bedrock along left side of outlet pool.	Full replacement recommended. Intermediary option: install a fish ladder mounted on left side of outlet apron and attached to bedrock on left bank of pool combined with series of weirs within crossing.
Stobk#4	Palomares Road	8.16	Constructed 1938. Newer bridge-deck. Gabions appear to be 1-2 yr. old. Large portion of water flows subsurface through gabions. Lower 15' of gabion floor has failed exposing sand/silt used for bedding. Slabs from previous granite floor in d/s channel.	Recommend replacement due to limited flood capacity. Alternative option is remove gabion floor/wall and reline floor w/concrete. Install concrete weirs within structure and at tailwater control.
Stobk#5	Palomares Road	8.00	Likely constructed circa 1938. Newer bridge-deck. 4 boulders are grouted at upper edge of apron, creating large water surface drop with no resting area. Left wall and floor constructed grouted stones and some patching with concrete. Right wall is bedrock for first 30'. Outlet apron widens to 18'. Outlet pool to shallow at leap location. Deepest along left bank. Tailwater control constricted by 12' boulder along left bank.	Recommend replacement due to channel constriction caused by existing structure. Other alternatives for adult passage include rebuilding outlet apron with ladder along left side and weirs/baffles within culvert.
Stobk#6	Palomares Road	7.57	Stone walls and floor (no grout) at entrance to crossing. Channel constricts as approaches newer bridge deck. Rough concrete lines floor under bridge and outlet apron. Outlet apron is short but steep.	Raise tailwater 2'-3' with two rock weirs. Reinforce toe of apron w/RSP. Place outlet beam and weirs on apron. Avoid baffles under bridge to maintain flood capacity.
Stobk#7	Palomares Road	6.28	Stream upstream of crossing has recently been chanallized with encroaching retaining wall on right bank. Crossing approach contains stone wing-walls and 45-degree turn. Stone invert and walls in culvert. Steep outlet stone outlet apron. Toe of apron undercut.	Use three rock weirs to raise tailwater 2', completely submerging outlet apron. Downstream channel ~2%-3% slope. Remove lower portion of apron and stabilize toe. Install baffles or outlet beam to create sufficient depth within crossing and possibly retain bedload.
Stobk#8	Palomares Road	6.18	Constructed 1937. Stone masonry wing-walls at inlet and outlet. Stone masonry abutments resting on boulder footings support newer bridge deck. Outlet wing-wall footing scoured, showing exposed boulder footings. Both outlet walls contain cracks. No large sediment deposits present upstream.	Crossing passage fish under most conditions. Recommend treating structural footings.

Stream Name	Road Name	Posted Mile	Drainage Area (mi^2)	Culvert Type	Slope through Culvert (including aprons)	Surveyed Upstream Channel Slope (%)	Surveyed Downstream Channel Slope (%)	Private culverts in upstream reach	Stream distance to next upstream County culvert[1] (ft)	Average Active Channel Width (ft)	Crossing Inlet width[2] (ft)	Channel Constriction at Crossing Entrance	Additional Habitat Comments
Stobk#1	Hwy 84	12.9	6.87	Box	4.02%	6.2%	N/A	3	5,045	21.1	10	53%	First 1,000 feet appear to be depositional, with cobbles and large gravels- potential spawning habitat. Subsurface summer flow at culvert, perennial upstream with good summer pools. 3 private culverts upstream before MP 8.75. First two appear not to be barriers. The third private culvert (MP 9.15) is 2,343 feet upstream and has steep channel drop into inlet.
Stobk#2	Palomares Road	8.75	5.72	Box	6.98% 7.42% (culvert)	6.7%	6.9%	None	557	20.2	8	60%	Water goes subsurface approximately. 200 ft u/s of crossing. Water resurfaces at culvert outlet. Mild gradient downstream of crossing. Approximately. 400' upstream of crossing is natural 5.5-ft falls, possibly creating adult barrier.
Stobk#3	Palomares Road	8.60	5.68	Trapezoid	4.46%	8.8%	9.6%	None	2,419	21.8	9	59%	Road fill encroaches on upstream channel. Perennial stream with some isolated pools. Good canopy over resting pools. Bedrock and boulder controlled.
Stobk#4	Palomares Road	8.16	4.78	Trapezoid	4.25% 3.5% (culvert) 6.6% (outlet apron)	4.9%	-	None	750	18	8	56%	Very steep downstream channel with numerous large perennial pools. Perennial flow through culvert, goes subsurface through gabions.
Stobk#5	Palomares Road	8.00	4.74	Trapezoid	11.2% 7.1% (inlet & crossing) 19.5% (outlet apron)	10.4%	14.0%	None	1,900	14.8	8.5	42%	Upstream channel severely constricted by the encroaching road fill. Flow goes subsurface approx. 80' upstream of crossing and resurfaces 55' downstream of outlet. Good pools upstream and spawning gravel present both above and below crossing.
Stobk#6	Palomares Road	7.57	4.14	Trapezoid	0.49% 0.2% (inlet & crossing) 8.0% (outlet apron)	5.3%	3.9%	At least 1 3,050' upstream	7,080	15.3	7.0	54%	Large perennial outlet pool with numerous salamanders and frogs present. Upstream channel has grade control structure and is low gradient with high flow terraces. Mostly cobbles with some gravel, but lacking deep pools. Good canopy throughout channel. Adjacent landowner intermittently pumping water from outlet pool. One privately owned culvert approx. 3,000' upstream and numerous privately owned bridges.
Stobk#7	Palomares Road	6.28	2.33	Trapezoid	5.79% 0.2%(culvert) 30% (outlet apron)	0.9%	3.1%	None	800	10.2	10.5	-3%	Stream is intermittent. Upstream of crossing is channeled with recently constructed stone walls. Poor habitat, sandy substrate, and little canopy. Downstream channel has good canopy, spawning size gravels, and is low gradient.
Stobk#8	Palomares Road	6.18	2.03	Trapezoid	No Slope	2.8%	3.1%	None - 1 ford crosses 1,100' upstream	None -9,800' of upstream habitat[3]	13.3	7.0	47%	Stream is intermittent. Upstream channel has well defined bankfull terraces, some pools, good canopy, and substrate of cobble and spawning sized gravel. Downstream channel is extremely wide and unpronounced, with grass growing in channel and no canopy. Vineyard encroaches into channel and left bank recently slid into stream Appears aggraded, possibly due to ponding above downstream crossing (Stobk#7).

[1] Channel distances were taken from 7.5-minute USGS topo maps.

[2] For trapezoidal shaped crossings, the base width was used for inlet width.

[3] Estimated length of upstream habitat for steelhead is based on channel distances taken from 7.5-minute USGS topo map. Upper extent of habitat assumed to occur at sustained channel slopes greater than 10%.

Site	Drainage Area (mi^2)	Active Channel Width (ft)	Crossing Inlet width[1] (ft)	Channel Constriction at Inlet	Top of Road Fill HW/D[2]	Entrance Loss Coef.	Roughness (n)	Potential Diversion[3] (y/n)	Capacity to top of Inlet (cfs)	Capacity to top of Road (cfs)	RI to top of Inlet (yr)	RI to top of Road (yr)	Comments
Stobk#1	6.87	21.1	10	53%	1.7	0.50	0.018	n	520	950	4.9	9.2	Depositional reach upstream of culvert, causing 2' drop in channel profile at inlet. Approx. 150' upstream of inlet channel bed elevation is above adjacent road surface, and constrained by hardened levee along left bank.
Stobk#2	5.72	20.2	8	60%	2.7	0.50	0.015	y	590	1500	6.3	29.1	Capacity likely less due to huge sediment wedge and 10' drop in channel at inlet. Evidence of extreme ponding, minimum of 6' above inlet crown, causing deposition of boulders in upstream channel.
Stobk#3	5.68	21.8	9	59%	1.0	0.50	0.018	y	600	600	6.4	6.4	Flow diverts at HW/D>1. Antidotal evidence of overtopping during 1997 storm.
Stobk#4	4.78	18.0	8	56%	1.2	0.50	0.020	y	530	700	6.6	9.1	Flow diverts at HW/D>1.2. Debris line in gabions at bottom of bridge deck on outlet.
Stobk#5	4.74	14.8	8.5	42%	1.2	0.70	0.024	y	590	850	7.4	12.2	Potential diversion.
Stobk#6	4.14	15.3	7.0	54%	1.2	0.50	0.024	y	1,100	1,400	24.5	46.0	Potential diversion.
Stobk#7	2.33	10.2	10.5	-3%	1.3	0.70	0.024	N	530	700	13.9	23.4	Large entrance loss coefficient employed due to sharp turn at inlet.
Stobk#8	2.03	13.3	7.0	47%	1.2	0.50	0.030 0.035 (bed) 0.024 (walls)	N	800	1,100	41.4	114.1	Roughness averaged between substrate and stone walls.

[1] For trapezoid shaped end-sections the base width was used for the inlet width.

[2] Ratio of the water depth when ponded to the road surface at the inlet divided by inlet height.

[3] A crossing has the potential to divert water run down the road or inboard ditch when it ponds above the road bed.

County of Alameda - Fish Passage Assessment of Road-Crossings within the Stonybrook Watershed
Results of Fish Passage Analysis: Passage Flows and Existing Passage Conditions

						Upper Passage Flows		Lower Passage Flow		Juv./Resident Upper Passage Flow		Adult Steelhead Upper Passage Flow	
Crossing Name	Road Name	Posted Mile	Drainage Area (mi^2)	Average Culvert Slope (including aprons)	Lower Passage Flow, $Q_{95\%}$ (cfs)	Juvenile/ Resident trout, $Q_{10\%}$ (cfs)	Adult Steelhead, $Q_{2\%}$ (cfs)	Leap (Pool to Outlet) (ft)	Water Depth[1] (ft)	Water Depth[1] (ft)	Water Velocity[2] (ft/s)	Water Depth[1] (ft)	Water Velocity[2] (ft/s)
Stobk#1	Hwy 84 - Niles Canyon Road	12.90	6.87	4.02%	0.22	16.5	94.8	1.2	0.02	0.3	6.5	0.86	11.0
Stobk#2	Palomares Road	8.75	5.72	6.98% 7.42% (culvert)	0.19	13.7	78.9	0.2	0.02	0.2	7.9	0.45	14.0
Stobk#3	Palomares Road	8.60	5.7	4.46%	0.19	13.6	78.4	4.8	0.02	0.3	6.1	0.79	10.7
Stobk#4	Palomares Road	8.16	4.78	4.25% 3.5% (culvert) 6.6% (outlet apron)	0.16	11.5	66.0	0.0	0.00	0.3	5.4	0.83	9.6
Stobk#5	Palomares Road	8.00	4.74	11.2% 7.1% (inlet & crossing) 19.5% (outlet apron)	0.15	11.4	65.4	1.1	0.00	0.2	5.8	0.69	10.8
Stobk#6	Palomares Road	7.57	4.14	0.49% 0.2% (inlet & crossing) 8.0% (outlet apron)	0.14	9.9	57.1	2.8	0.04	0.57 - barrel 0.21 - outlet apron	2.3 - barrel 5.3 - outlet apron	1.49 - barrel 0.78 - outlet apron	4.4 - barrel 8.0 - outlet apron
Stobk#7	Palomares Road	6.28	2.33	5.79% 0.2%(culvert) 30% (outlet apron)	0.08	5.6	32.2	0.0	0.00	0.42 - barrel 0.08 - outlet apron	1.8 - barrel 6.8 - outlet apron	1.01 - barrel 0.29 - outlet apron	2.9 - barrel 10.5 - outlet apron
Stobk#8	Palomares Road	6.18	2.03	No Slope	0.07	4.9	28.0	0.0	0.80	0.85	1.0	1.03	4.5

[1] Reported depths occur at midpoint in crossing.
[2] Reported water velocities occur at midpoint in crossing.

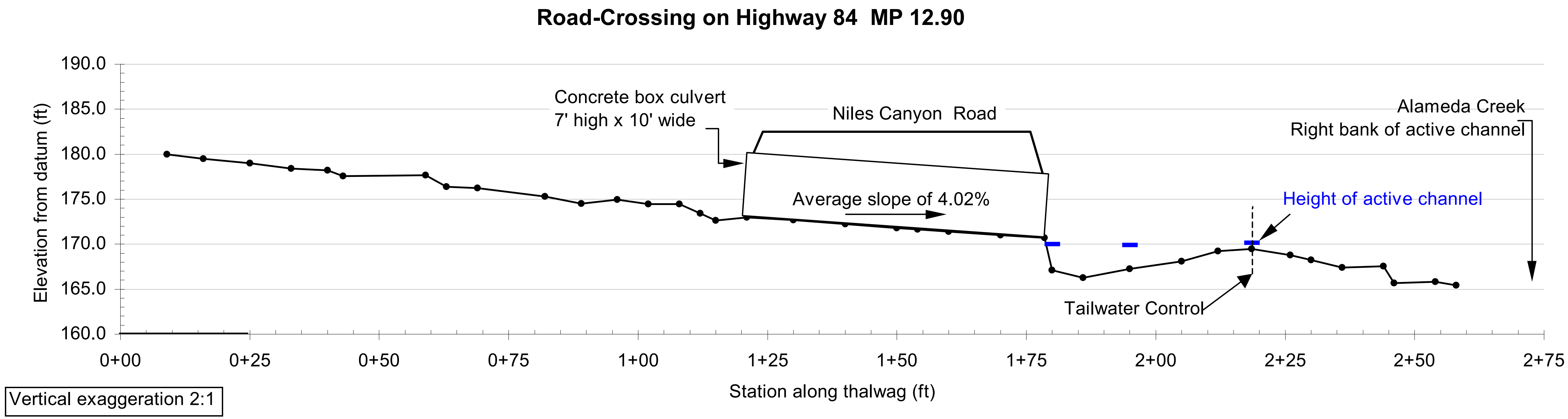
County of Alameda - Fish Passage Assessment of Road-Crossings within the Stonybrook Watershed
Results of Fish Passage Analysis: Passage Flows and Existing Passage Conditions

Crossing Name	Road Name	Posted Mile	Description of Conditions
Stobk#1	Hwy 84 - Niles Canyon Road	12.90	Insufficient water depth and excessive water velocities at most migration flows. Complete barrier to all upstream migrating juvenile and resident salmonids. Individual adult steelhead with strong swimming abilities have a small window for passage.
Stobk#2	Palomares Road	8.75	Insufficient water depth and excessive water velocities at all migration flows makes this crossing a complete barrier to all fish. Additionally, 11-foot drop in channel at culvert inlet prevents upstream fish movement.
Stobk#3	Palomares Road	8.60	Drop at outlet combined with excessive outlet velocities and shallow water depths creates complete upstream migration barrier.
Stobk#4	Palomares Road	8.16	Insufficient water depth and excessive water velocities at most migration flows. Complete barrier to all upstream migrating juvenile and resident salmonids. Individual steelhead with stronger swimming abilities have small window for passage. Lower flow
Stobk#5	Palomares Road	8.00	Insufficient water depth and excessive water velocities at all migration flows makes this crossing a complete barrier to all fish.
Stobk#6	Palomares Road	7.57	Perched outlet and steep outlet apron makes crossing complete barrier to juvenile and resident salmonids. Additionally adult depth criteria for fish passage is insufficient along apron at all migration flows. Some stronger swimming individual steelhead w
Stobk#7	Palomares Road	6.28	Insufficient water depth and excessive water velocities across the outlet apron creates a complete barrier to all fish. Some stronger adult steelhead may be able to negotiate the crossing at moderate flows.
Stobk#8	Palomares Road	6.18	100% passable for all species and lifestages due to concrete weir at outlet.

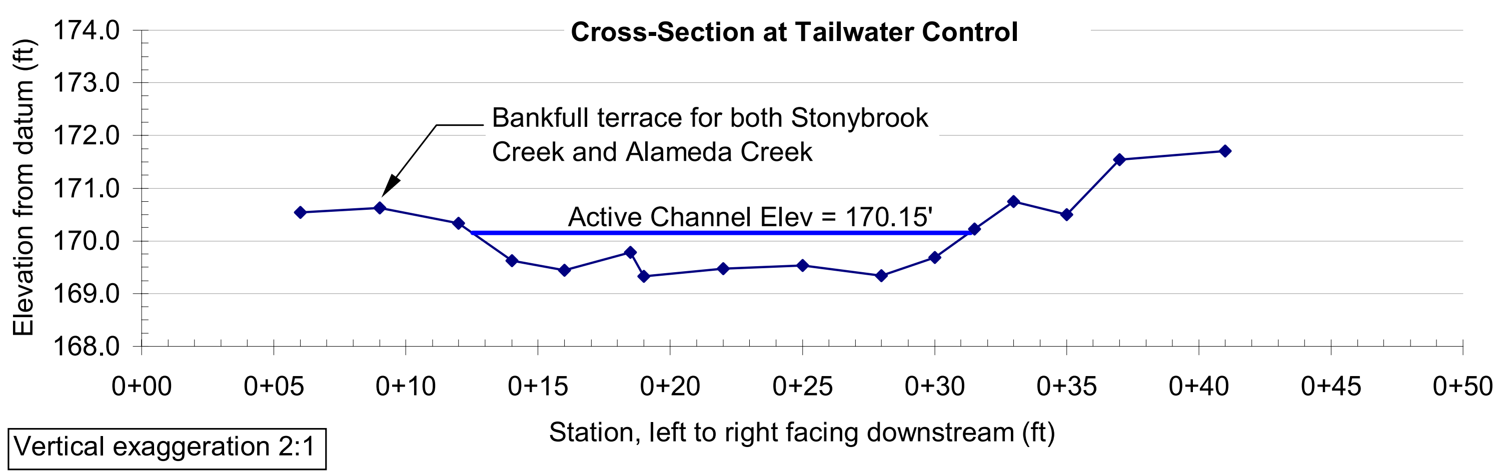
Stobk#1: Highway 84 (Niles Canyon Road), milepost 12.90

Culvert Inlet

Culvert Outlet

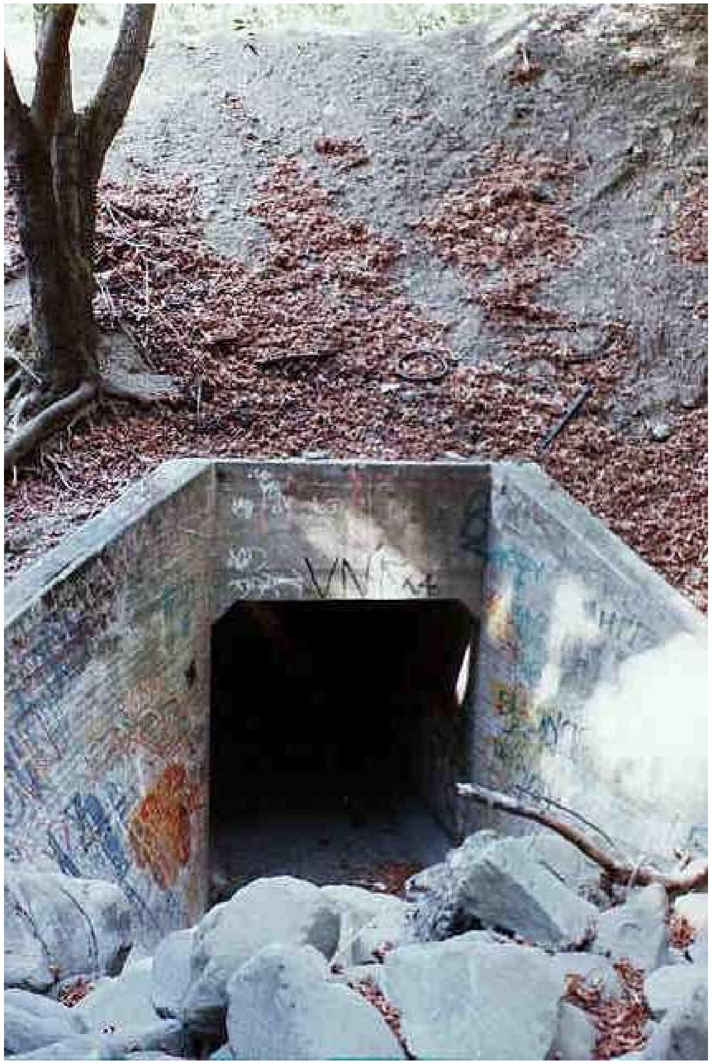


Road-Crossing on Highway 84 MP 12.90
190.0
185.0
180.0
175.0
170.0
165.0
160.0
Elevation from datum (ft)
Concrete box culvert
7' high x 10' wide
Niles Canyon Road
Alameda Creek
Right bank of active channel
Average slope of 4.02%
Height of active channel
Tailwater Control
0+00
0+25
0+50
0+75
1+00
1+25
1+50
1+75
2+00
2+25
2+50
2+75
Station along thalwag (ft)
Vertical exaggeration 2:1



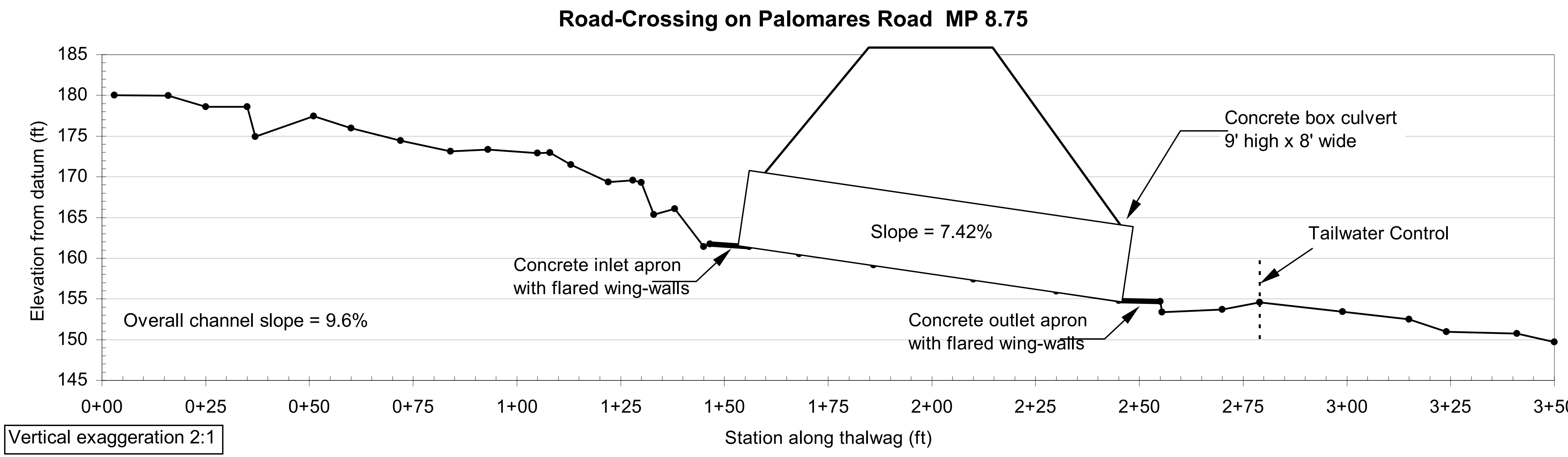
Cross-Section at Tailwater Control
174.0
173.0
172.0
171.0
170.0
169.0
168.0
Elevation from datum (ft)
Bankfull terrace for both Stonybrook
Creek and Alameda Creek
Active Channel Elev = 170.15'
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
0+40
0+45
0+50
Station, left to right facing downstream (ft)
Vertical exaggeration 2:1

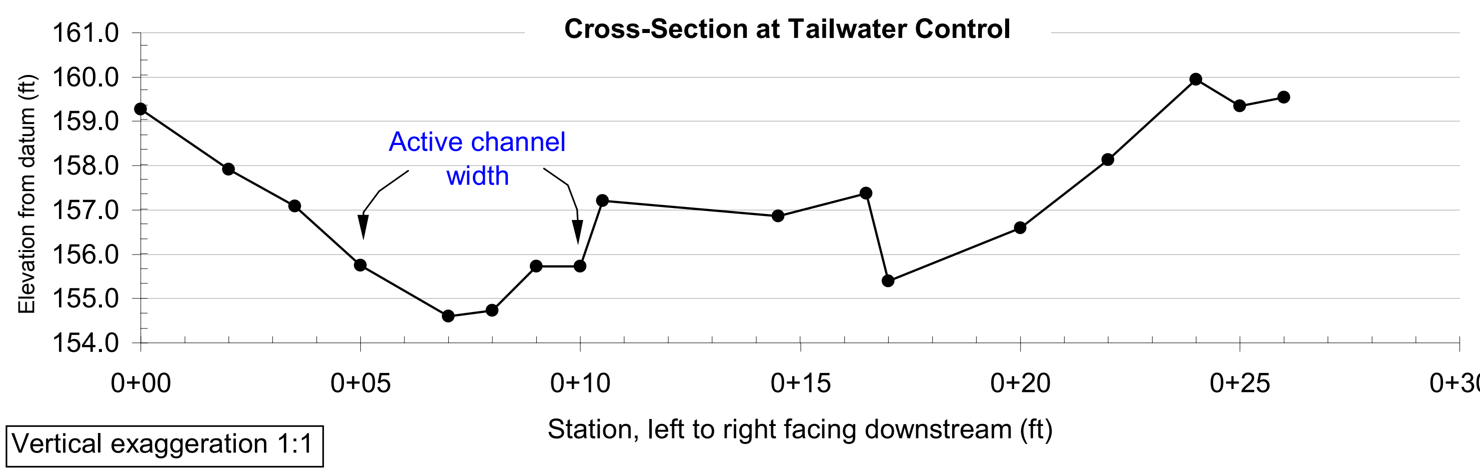
Stobk#2:   Palomares Road, milepost 8.75



Culvert Inlet

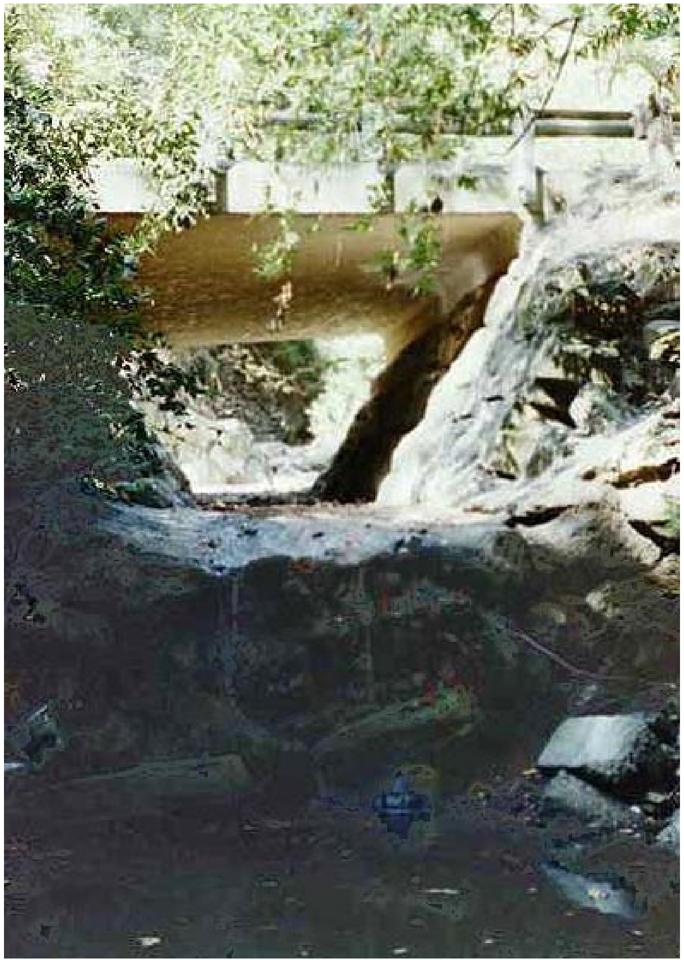
Culvert Outlet


Road-Crossing on Palomares Road MP 8.75
Elevation from datum (ft)
185
180
175
170
165
160
155
150
145
Concrete box culvert
9' high x 8' wide
Slope = 7.42%
Tailwater Control
Concrete inlet apron
with flared wing-walls
Concrete outlet apron
with flared wing-walls
Overall channel slope = 9.6%
0+00
0+25
0+50
0+75
1+00
1+25
1+50
1+75
2+00
2+25
2+50
2+75
3+00
3+25
3+50
Station along thalwag (ft)
Vertical exaggeration 2:1

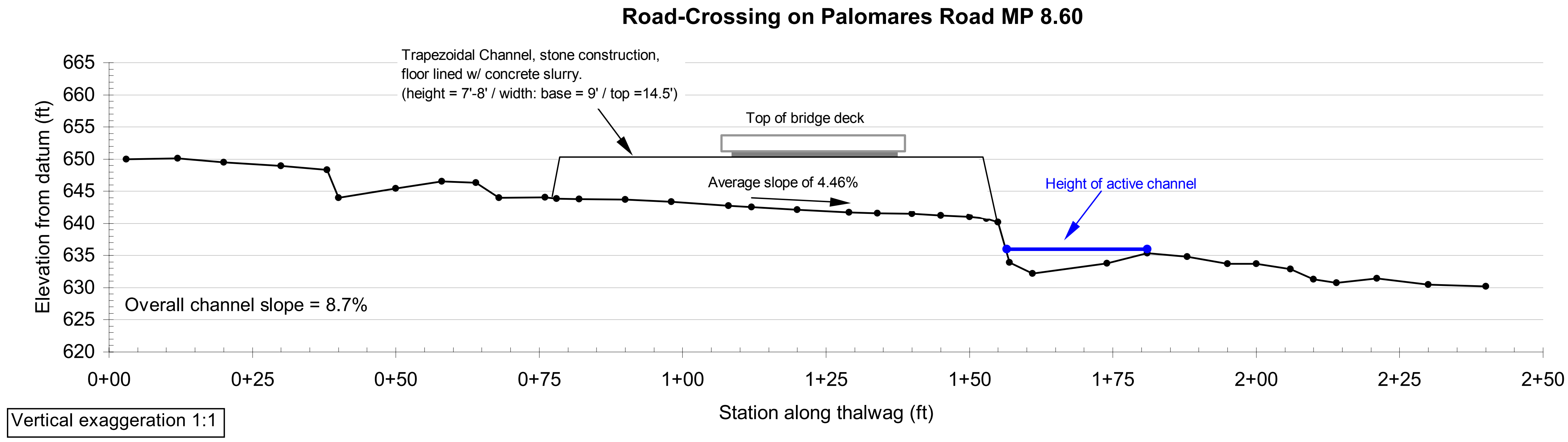

Cross-Section at Tailwater Control
Elevation from datum (ft)
161.0
160.0
159.0
158.0
157.0
156.0
155.0
154.0
Active channel
width
0+00
0+05
0+10
0+15
0+20
0+25
0+30
Station, left to right facing downstream (ft)
Vertical exaggeration 1:1

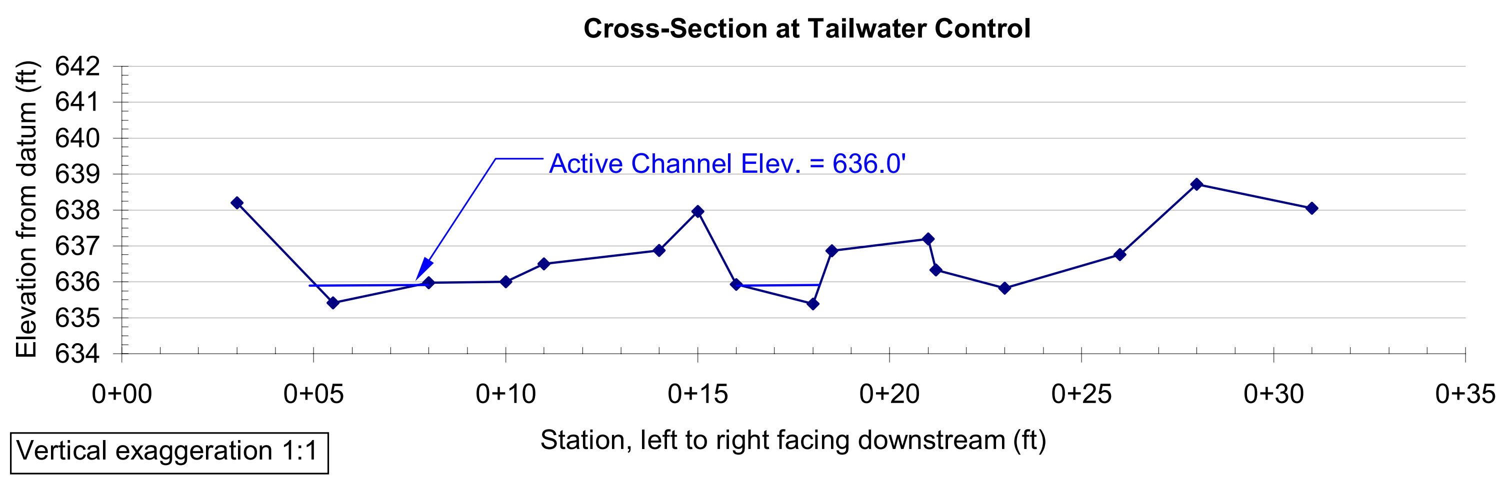
Stobk#3: Palomares Road, milepost 8.60

Inlet of Road-Crossing



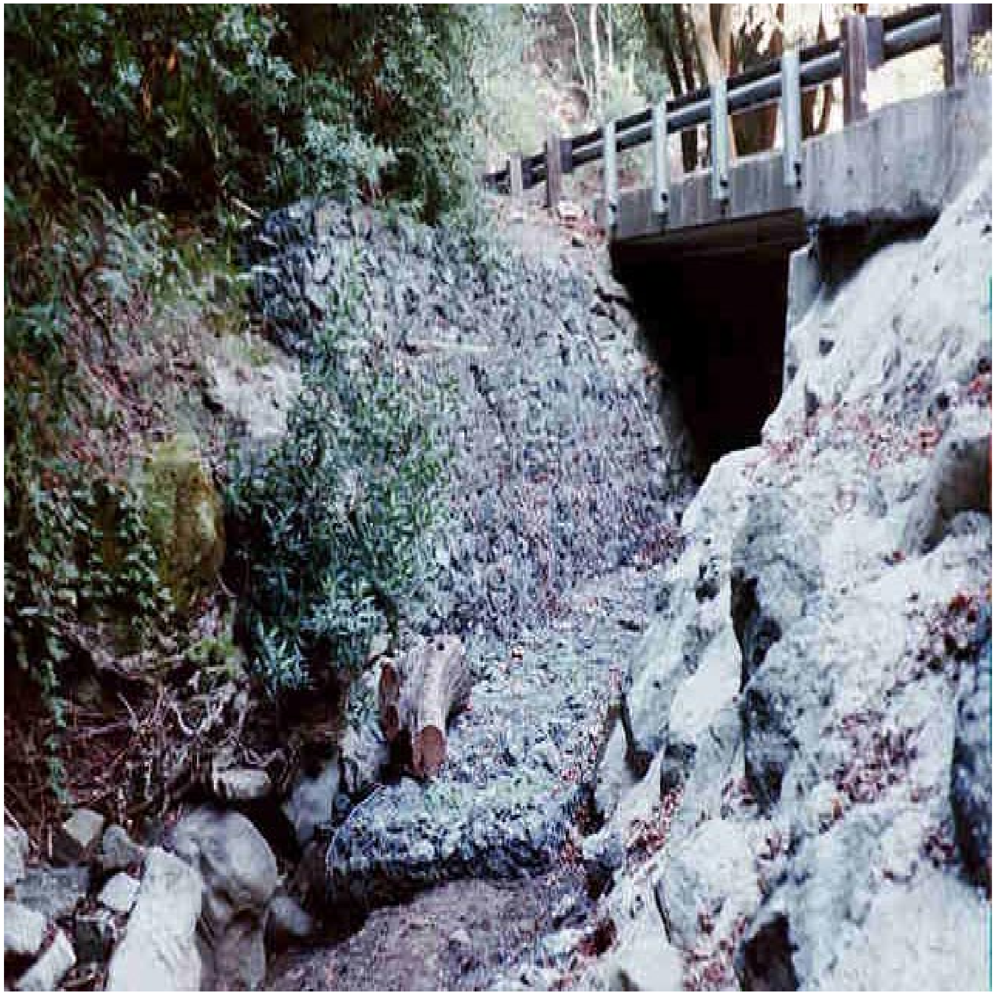
Drop into Pool at Crossing Outlet


Road-Crossing on Palomares Road MP 8.60
Trapezoidal Channel, stone construction,
floor lined w/ concrete slurry.
(height = 7'-8' / width: base = 9' / top =14.5')
Top of bridge deck
Average slope of 4.46%
Height of active channel
Overall channel slope = 8.7%
Elevation from datum (ft)
665
660
655
650
645
640
635
630
625
620
0+00
0+25
0+50
0+75
1+00
1+25
1+50
1+75
2+00
2+25
2+50
Station along thalweg (ft)
Vertical exaggeration 1:1

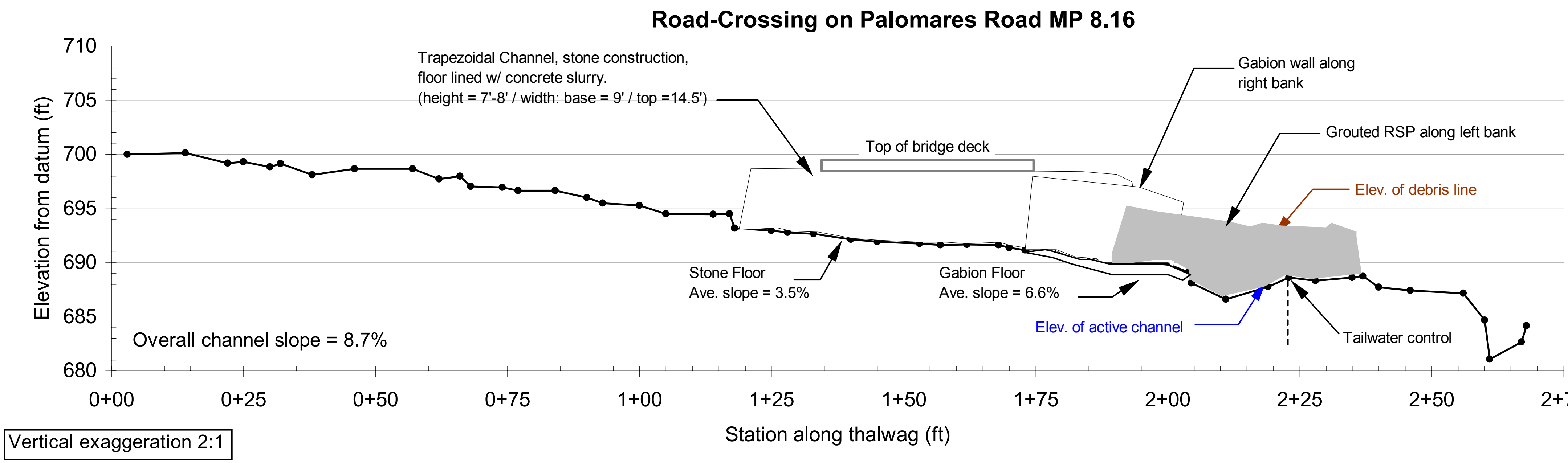

Cross-Section at Tailwater Control
Active Channel Elev. = 636.0'
Elevation from datum (ft)
642
641
640
639
638
637
636
635
634
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
Station, left to right facing downstream (ft)
Vertical exaggeration 1:1

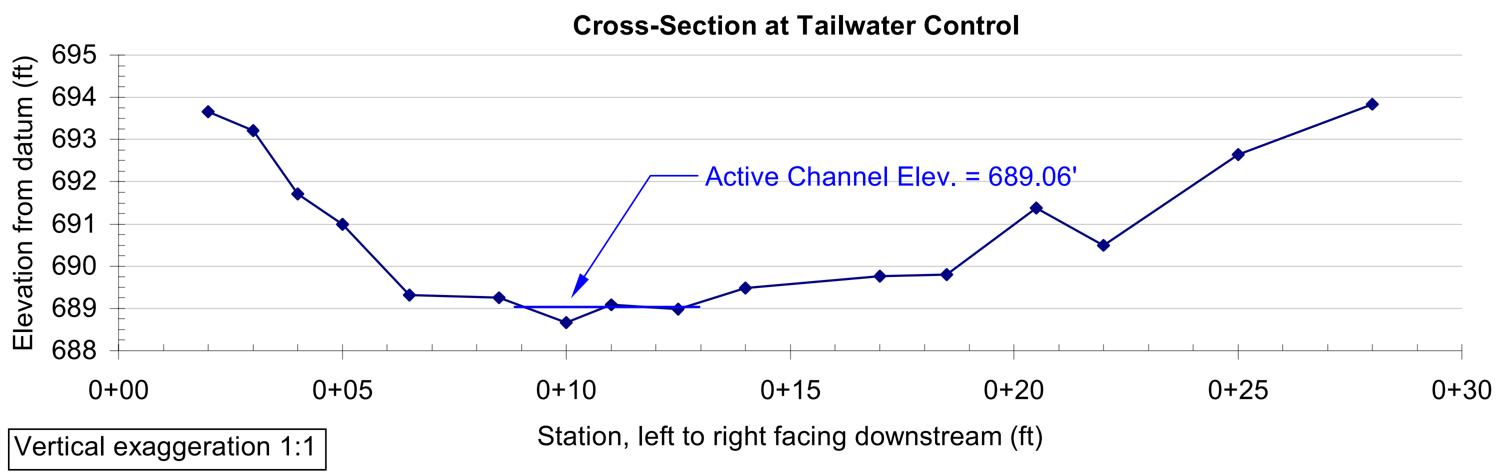
Stobk#4: Palomares Road, milepost 8.16

Crossing Inlet



Outlet of Road-Crossing with Gabions

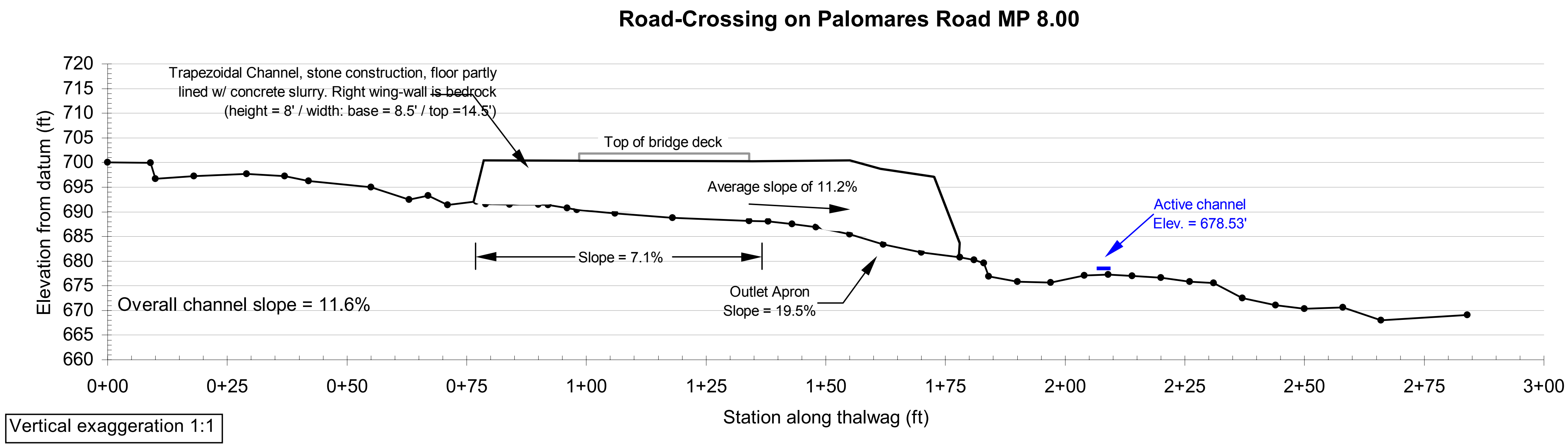

Road-Crossing on Palomares Road MP 8.16
Trapezoidal Channel, stone construction,
floor lined w/ concrete slurry.
(height = 7'-8' / width: base = 9' / top =14.5')
Top of bridge deck
Gabion wall along
right bank
Grouted RSP along left bank
Elev. of debris line
Stone Floor
Ave. slope = 3.5%
Gabion Floor
Ave. slope = 6.6%
Elev. of active channel
Tailwater control
Overall channel slope = 8.7%
Elevation from datum (ft)
710
705
700
695
690
685
680
0+00
0+25
0+50
0+75
1+00
1+25
1+50
1+75
2+00
2+25
2+50
2+75
Station along thalweg (ft)
Vertical exaggeration 2:1


Cross-Section at Tailwater Control
Elevation from datum (ft)
695
694
693
692
691
690
689
688
Active Channel Elev. = 689.06'
0+00
0+05
0+10
0+15
0+20
0+25
0+30
Station, left to right facing downstream (ft)
Vertical exaggeration 1:1

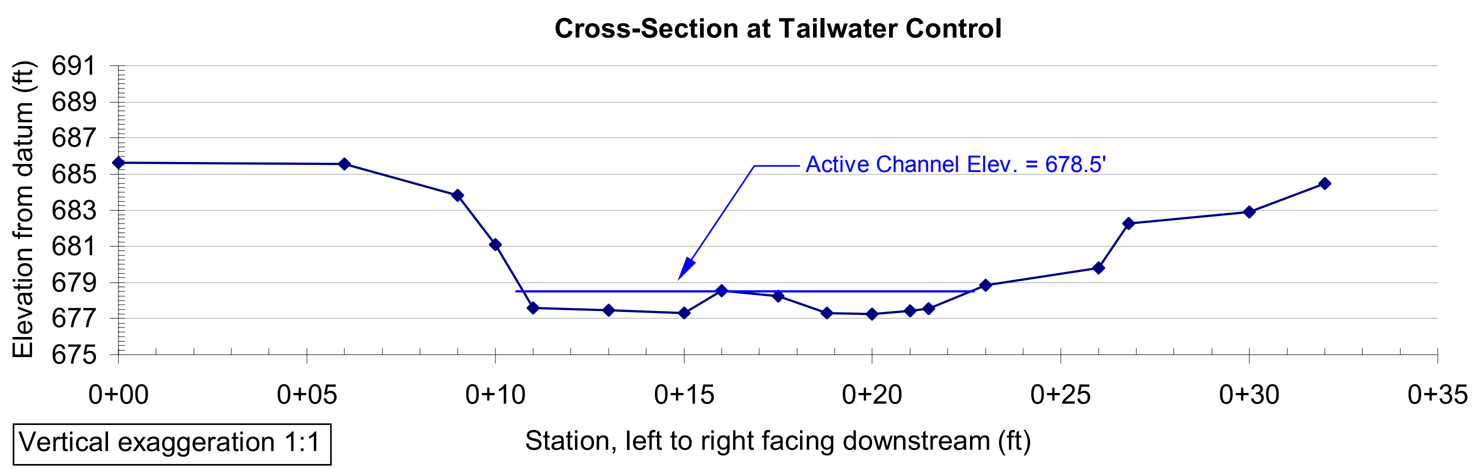
Stobk#5: Palomares Road, milepost 8.00

Road-Crossing Inlet

Outlet Apron

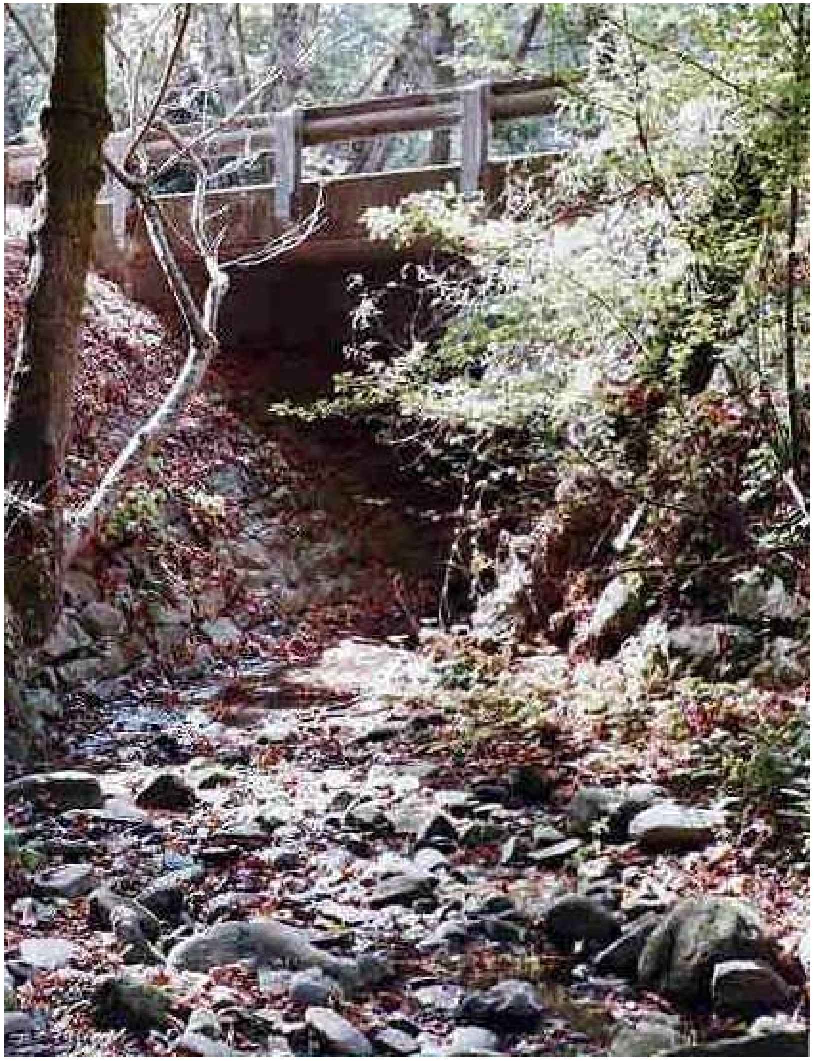


Road-Crossing on Palomares Road MP 8.00
Elevation from datum (ft)
720
715
710
705
700
695
690
685
680
675
670
665
660
Trapezoidal Channel, stone construction, floor partly lined w/ concrete slurry. Right wing-wall is bedrock (height = 8' / width: base = 8.5' / top =14.5')
Top of bridge deck
Average slope of 11.2%
Active channel Elev. = 678.53'
Slope = 7.1%
Outlet Apron Slope = 19.5%
Overall channel slope = 11.6%
0+00
0+25
0+50
0+75
1+00
1+25
1+50
1+75
2+00
2+25
2+50
2+75
3+00
Station along thalwag (ft)
Vertical exaggeration 1:1

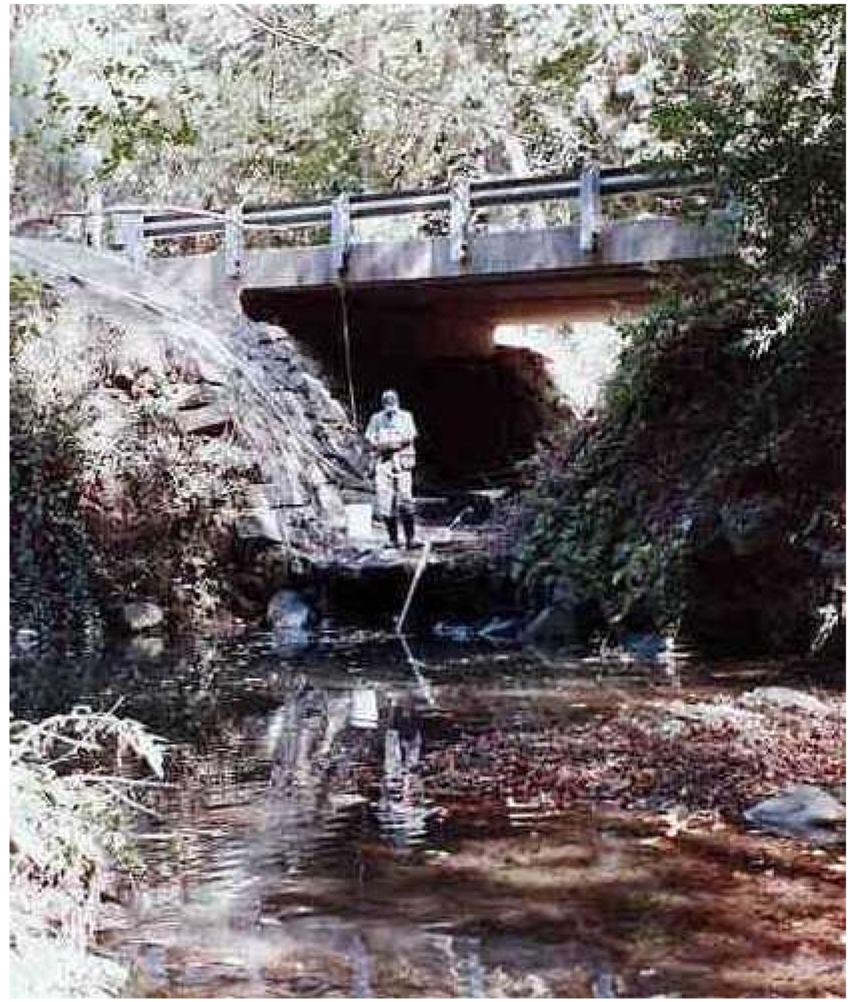


Cross-Section at Tailwater Control
Elevation from datum (ft)
691
689
687
685
683
681
679
677
675
Active Channel Elev. = 678.5'
0+00
0+05
0+10
0+15
0+20
0+25
0+30
0+35
Station, left to right facing downstream (ft)
Vertical exaggeration 1:1

Stobk#6: Palomares Road, milepost 7.57

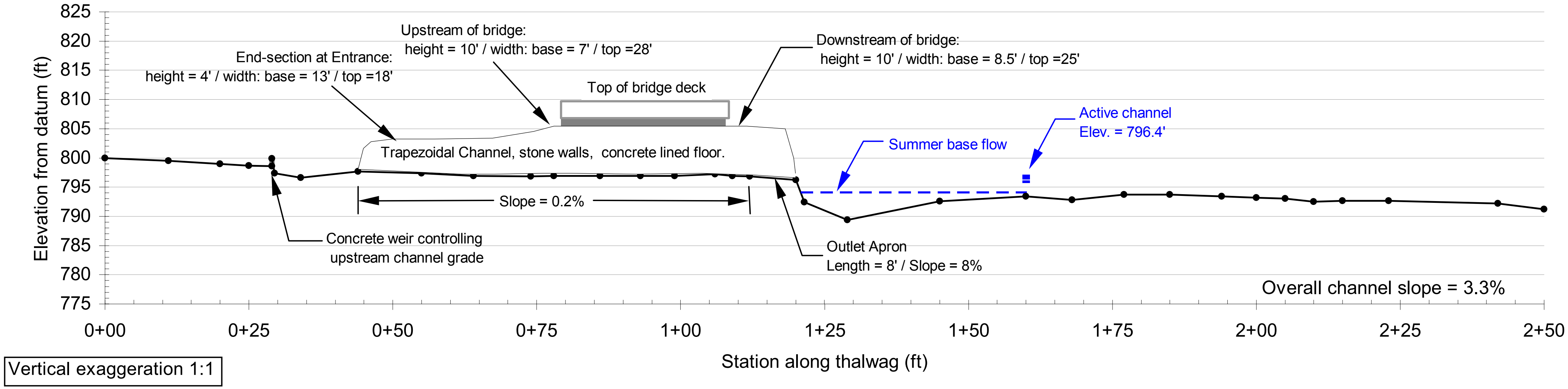


Road-Crossing Inlet

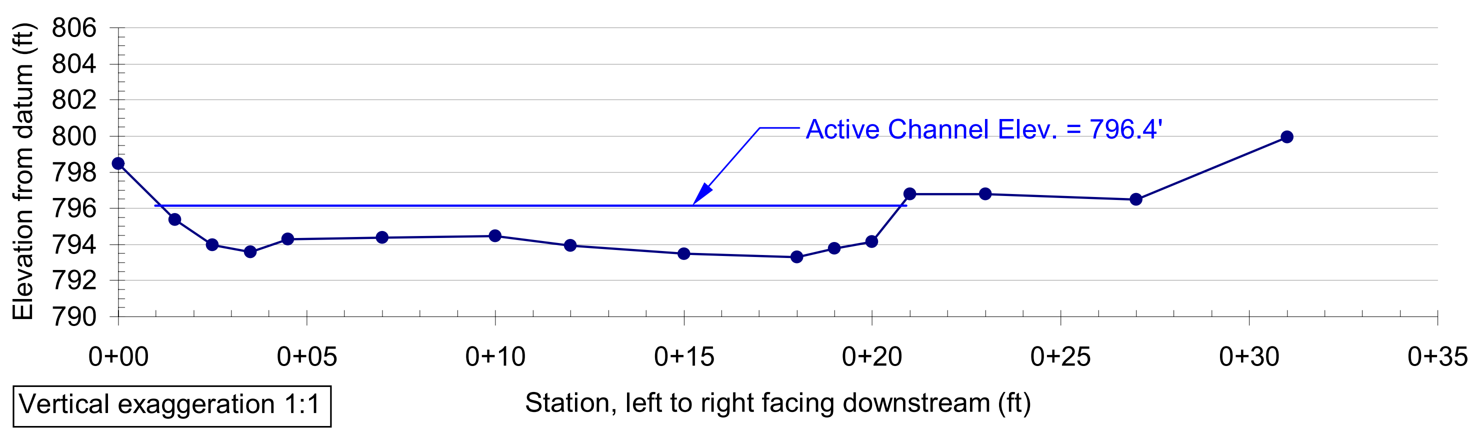


Drop at outlet into pool

Road-Crossing on Palomares Road MP 7.57

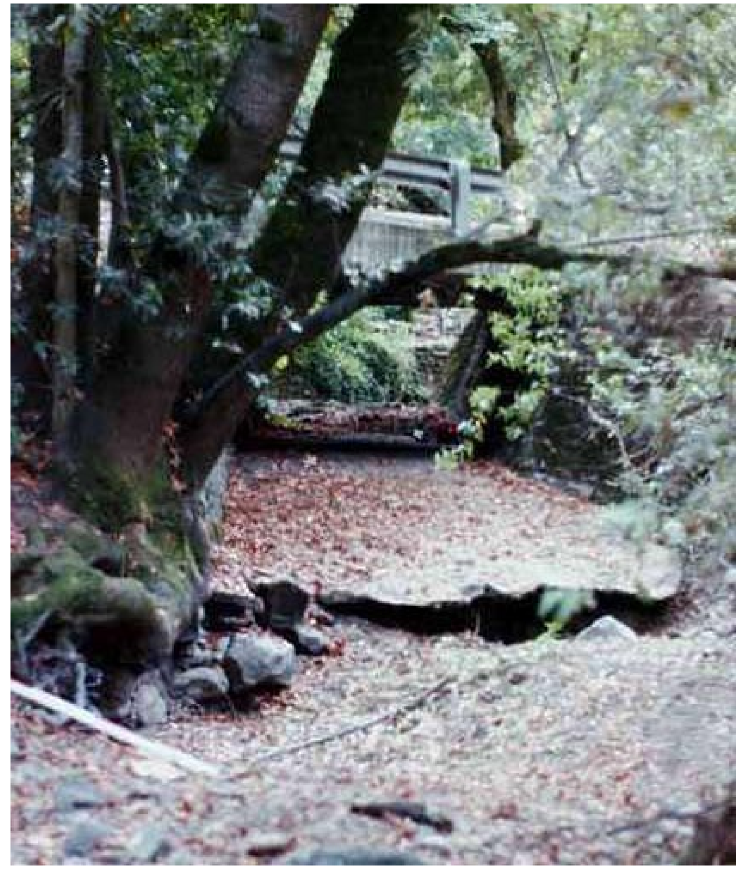


Cross-Section at Tailwater Control

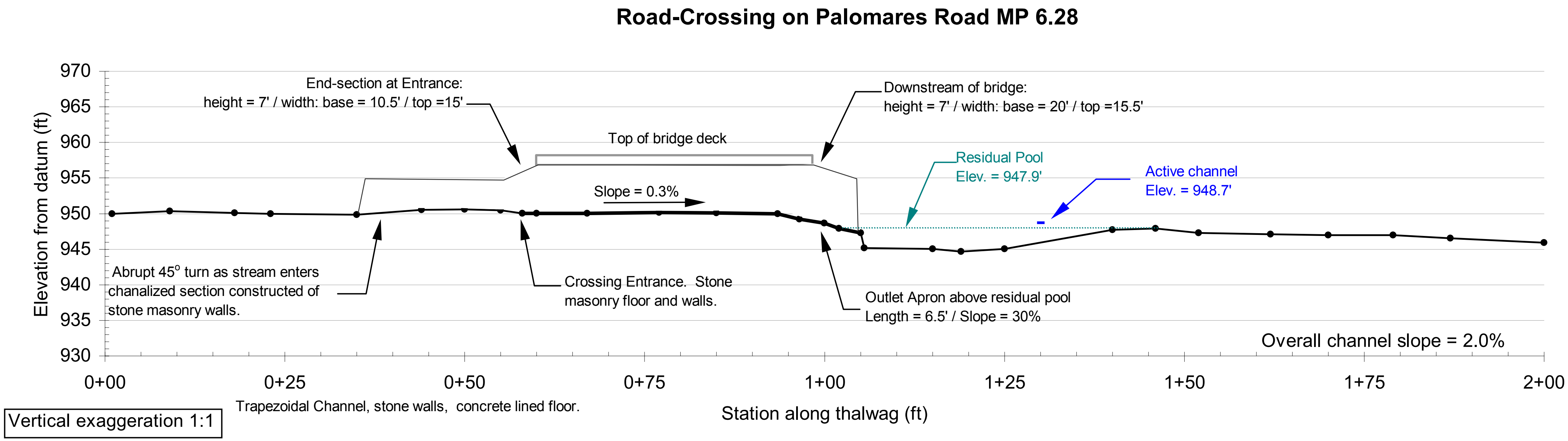


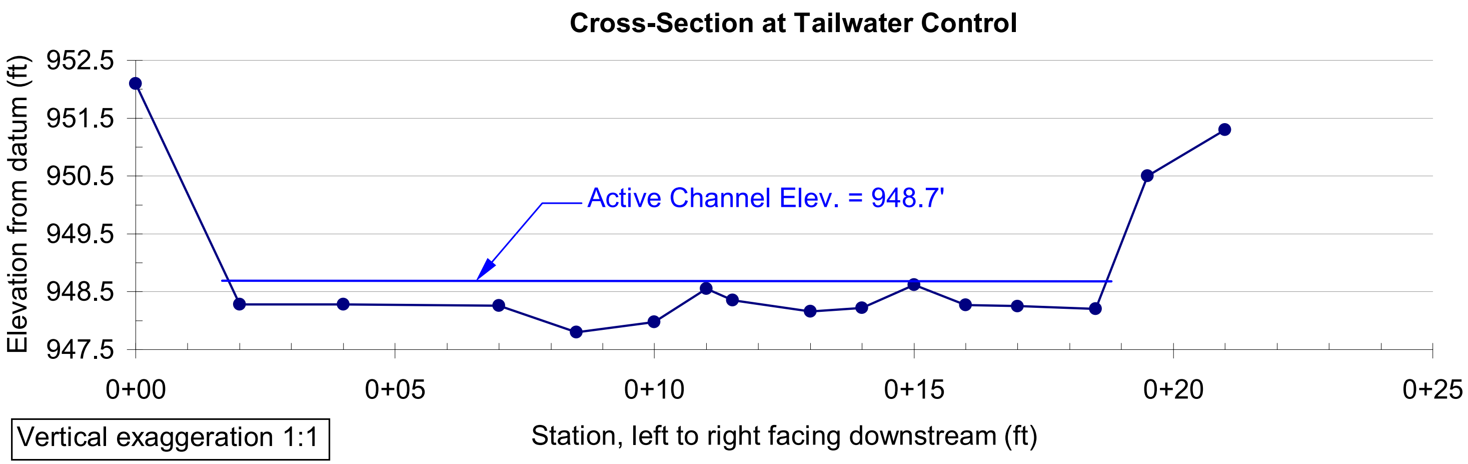
Stobk#7: Palomares Road, milepost 6.28

Road-Crossing Inlet



Outlet Apron


Road-Crossing on Palomares Road MP 6.28
End-section at Entrance:
height = 7' / width: base = 10.5' / top =15'
Downstream of bridge:
height = 7' / width: base = 20' / top =15.5'
Top of bridge deck
Residual Pool
Elev. = 947.9'
Active channel
Elev. = 948.7'
Slope = 0.3%
Abrupt 45° turn as stream enters chanalized section constructed of stone masonry walls.
Crossing Entrance. Stone masonry floor and walls.
Outlet Apron above residual pool
Length = 6.5' / Slope = 30%
Overall channel slope = 2.0%
Elevation from datum (ft)
970
965
960
955
950
945
940
935
930
0+00
0+25
0+50
0+75
1+00
1+25
1+50
1+75
2+00
Trapezoidal Channel, stone walls, concrete lined floor.
Station along thalwag (ft)
Vertical exaggeration 1:1

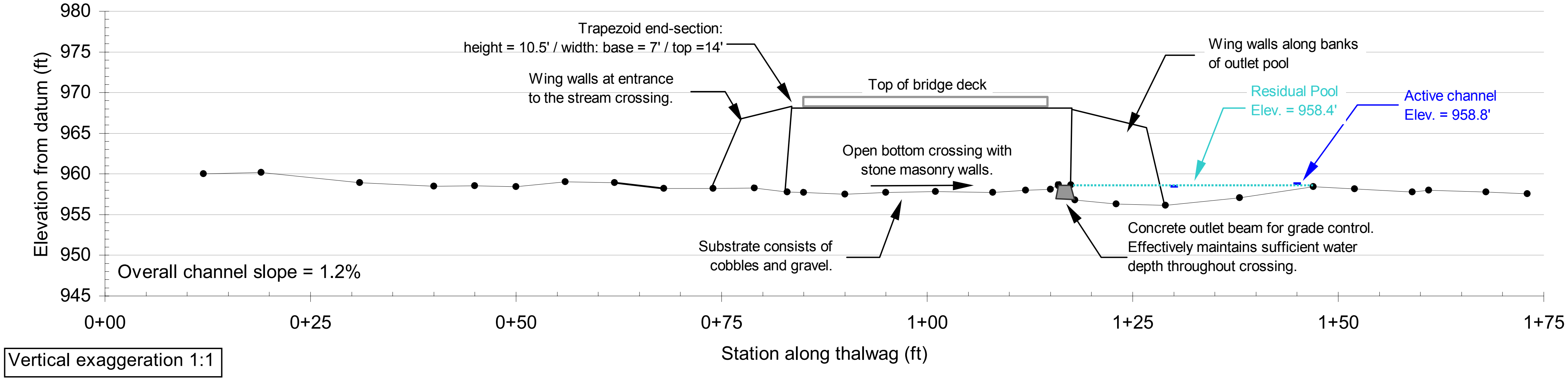

Cross-Section at Tailwater Control
Active Channel Elev. = 948.7'
Elevation from datum (ft)
952.5
951.5
950.5
949.5
948.5
947.5
0+00
0+05
0+10
0+15
0+20
0+25
Station, left to right facing downstream (ft)
Vertical exaggeration 1:1

Stobk#8: Palomares Road, milepost 6.18

Road-Crossing Inlet

Outlet

Road-Crossing on Palomares Road MP 6.18



Cross-Section at Tailwater Control