MEMORANDUM

FC 14 (02-08-19)

TO: Afshin Rouhani, Water Resources Planning and Policy (Unit 245) Manager

FROM Kevin Sibley, Sr. Engineer
James Manitakos, Assoc. Water Resources Specialist

SUBJECT: Stevens Creek Fish Passage Remediation

DATE: August 23, 2021

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1. OVERVIEW

In June 2020 Valley Water's consultant AECOM prepared a report analyzing potential fish passage impediments on Stevens Creek between San Francisco Bay and Stevens Creek Reservoir (Attachment 1). AECOM evaluated 38 potential fish passage impediment sites, consisting of previously identified sites listed in the Passage Analysis Database (PAD) which is maintained by California Department of Fish and Wildlife (CDFW) and additional sites identified during field reconnaissance performed in 2019. Of those 38 sites, 30 were found to warrant analysis using California Department of Fish and Wildlife (CDFW) fish passage protocol. The analyzed sites were scored and then grouped into red, yellow, and green categories. The red group contains sites with severe impediment to fish passage. The yellow group contains sites with moderate impediment. The green group consists of sites with minimal impediment. Application of CDFW fish passage criteria resulted 8 red sites, 8 yellow sites, and 14 green sites.

This memorandum considers additional logistical constraints (i.e., non-fish passage factors) for each of the 8 red and 8 yellow sites to prioritize them for planning, design, and construction. The logistical constraints include property ownership, construction complexity and lifetime maintenance cost, geomorphology and physical creek properties, and environmental impact. The fish-passage scores from the 2020 report are then combined with the logistical constraints to prioritize the 16 red and yellow sites for efficient remediation. This memorandum will be useful to advance future remediation projects to improve fish passage conditions on Stevens Creek.

The draft Fish and Aquatic Habitat Collaborative Effort (FAHCE) settlement agreement contains four sites that are classified as priority barriers owned by Valley Water: Moffett fish ladder, Evelyn fish Ladder, Fremont fish ladder, and Stream Gage 35. The fish passage technical analysis (Attachment 1) ranked Moffett Fish Ladder (Site No. 3) and Vortex Weir at Stream Gage 35 (Site No. 12) in the red category and those sites are analyzed in this memorandum. Evelyn fish ladder was remediated by Valley Water in 2016 and is not included in this study. The Fremont fish ladder was analyzed and found to be a green category site with 70% adult fish passage (see Attachment 1); therefore, it was not carried forward for analysis in this memorandum. The draft FAHCE settlement agreement also lists two priority barriers owned by others: the road crossing and the irrigation diversion, both located at Blackberry Farms. The City of Cupertino and Valley Water have jointly remediated those two barriers; therefore, they are not analyzed in this study.

2. ANALYSIS

2.1 Fish Passage Performance: In April 2021, AECOM identified conceptual approaches to remedy fish passage impediments at the 16 red and yellow sites (Attachment 2). Table 1 lists the 16 fish passage impediment sites included in the red and yellow categories and their fish passage analysis score.

Table 1: Assessment Sites in Red or Yellow Fish Passage Category			
Category	Site No.	Site Name	Fish Passage Score[1]
Red	2	Hwy 101 Crossing, post mile 48.0	2
	6	Drop structure at Hetch Hetchy Crossing	2
	14	Drop structure downstream pedestrian bridge	4
	32	Gaging Weir 44	8
	17.1	Drop structure at storm drain	9
	12	Vortex weir fishway at Gage 35	12
	1	Vernon Avenue grade control	12
	3	Moffett fish ladder	14
Yellow	5	Drop structure upstream of Moffett Boulevard	16
	8	Drop structure downstream of Middlefield Road	16
	9	Drop structure upstream of Middlefield Road	17
	14.1	Drop structure at pedestrian bridge	19
	11	Highway 85 crossing, post mile 23.0	20
	17	El Camino Real crossing	23
	4	Moffett Boulevard crossing	23
	22	Highway 85 crossing, post mile 20.0	24
NOTE: [1] A lower fish passage score indicates greater benefit from remediation.			

2.2 Logistical (Non-Fish Passage) Constraints: The following constraints have the potential to substantially affect the complexity and cost of implementing site remedies:

1. property ownership,
2. construction complexity and lifetime maintenance cost,
3. physical creek properties and geomorphology, and
4. environmental impact.

Based on the preliminary descriptions of remedies for each of the 16 red and yellow sites included in AECOM's conceptual remedy report (Attachment 2), we can estimate the degree to which the logistical constraints affect each site. Definitions and site scores for the four logistical constraints are presented below:

2.2.1 Property Ownership: Acquisition of fee and easement right of way is often a costly and a lengthy process. Therefore, site remedies on existing Valley Water property are preferred. Remedies that require acquisition of privately owned property are least desirable. Scoring definitions are shown in Table 2 with fewer diamonds indicating a lower level of constraint to project implementation.

Table 2: Property Ownership Scoring Definitions	
Diamonds	**Description**
◆	Owned in fee by Valley Water or with an existing Valley Water easement.
◆ ◆	Sites owned by other government agencies lacking Valley Water easement for all or part of site.
◆ ◆ ◆	Privately owned sites lacking a Valley Water easement.

Table 3 presents site scores for property ownership. Detailed information for each site, including assessor's parcel number, California Department of Transportation (Caltrans) parcel number, and Valley Water easement identification numbers are presented in Appendix 1.

Table 3: Property Ownership Scores				
Site No.	**Site Name**	**Landowner (s)***	**Valley Water Easement**	**Score**
1	Vernon Avenue grade control	City of Mountain View, Valley Water	Yes, on city parcel	◆
2	Hwy 101 Crossing, post mile 48.0	Caltrans	No	◆ ◆
3	Moffett fish ladder	City of Mountain View, Valley Water	Yes, on city parcel	◆
4	Moffett Boulevard crossing	Caltrans	Yes	◆
5	Drop structure upstream of Moffett Boulevard	City of Mtn View	Yes	◆
6	Drop structure at Hetch Hetchy Crossing	City and County of San Francisco	No	◆ ◆
8	Drop structure downstream of Middlefield Road	Valley Water	n/a	◆
9	Drop structure upstream of Middlefield Road	City of Mountain View/ Valley Water	Yes, on city parcel	◆
11	Highway 85 crossing, post mile 23.0	Caltrans	Yes (partial)	◆ ◆
12	Vortex weir fishway at Gage 35	Valley Water	n/a	◆
14	Drop structure downstream pedestrian bridge	City of Mountain View	Yes	◆
14.1	Drop structure at pedestrian bridge	City of Mountain View	Yes	◆
17	El Camino Real crossing	Caltrans	No	◆ ◆
17.1	Drop structure at storm drain	City of Mtn View	No	◆ ◆
22	Highway 85 crossing, post mile 20.0	Caltrans	No	◆ ◆
32	Gaging Weir 44 at Stevens creek Park	Santa Clara County	Yes (partial)	◆ ◆

2.2.2 Construction Complexity and Lifetime Costs: Construction complexity includes 6 components: (1) amount of channel disturbance ((2) the area of hardscape to be removed or constructed), (3) presence of utilities that would complicate construction, (4) ease of channel access for construction and maintenance (i.e., presence of access ramp or suitable topography for an access ramp), (5) existing presence or potential for creek bank erosion and channel slope adjustment, and (6) construction and maintenance costs for the lifetime of the project. Because detailed cost estimates are beyond the scope of this Prioritization Study, variable (1), the complexity of construction variable, is used to approximate construction cost, with a lower score indicating lower construction complexity and lifetime cost, therefore less constraints on remedy implementation, as shown in Table 4.

Table 4: Construction Complexity Factor Components

Factor	Score		
	1	2	3
Amount of channel disturbance	≤ 100 linear feet (LF)	>100 LF and ≤300 LF	> 300 LF
Hardscape Removed	≤ 200 Square Feet (SF)	>200 SF and ≤1,000 SF	> 1,000 SF
Utilities	None anticipated	Anticipated	Present
Channel Access	≤ 200 FT from site	> 200 ft and ≤1,000 FT from site	> 1,000 FT
Bank erosion and channel profile adjustment	Stable	Potentially unstable	Eroding banks or presence of hardened profile

Flood risk is not included in Table 4 because each of the remedies has the potential to increase water surface elevations. The relative significance of increased flood risk for each remedy will require a conceptual alternative hydraulic model which is beyond the scope of this report. Because this concern will be addressed during design phase, the sites are not scored on changes to channel capacity in this memorandum.

Lifetime costs include the costs to operate and maintain improvements at the remediated site. Operations and maintenance (O&M) requirements are based on the *Staff-Recommended Alternative Report for the Moffett Fish Passage Project*, prepared by AECOM and Michael Love Associates for Valley Water in December 2018. The report distinguishes between roughened channels and technical fishways (e.g., pool and chute structures, fish transport channels). Both roughened channels and technical fishways would likely require inspections, removal of lodged debris, and reporting of maintenance activities to regulatory agencies on an annual basis. Technical fishways are concrete structures that are resistant to damage from high flows. In contrast, roughened channels contain loose rocks that are expected to be transported downstream by greater than 10-year flows. Roughened channels would require additional maintenance resources to periodically reposition and/or replenish lost rock materials, which may require channel dewatering to accomplish. Annual O&M cost for roughened channels are expected to be twice the O&M cost for technical fishways. Forcing features direct or deflect water flow to create a desirable outcome, such as increased water depth at low flow, that benefit fish passage. Examples include barbs, vanes, rootwads, and many types of weirs. Forcing features generally would not trap debris or loose materials during high flows. As such, they would require the least maintenance resources. Therefore, roughened channels would have the highest O&M cost and receive a score of three; technical fishways would have intermediate O&M cost and receive a score of two; and forcing features would have the least O&M costs and receive a score of one. For hybrid or alternative remedies, the greatest number of diamonds for any component is applied.

Each remediation site is scored in Table 5 for the six construction complexity and lifetime cost components. A higher score indicates greater construction complexity and cost or higher lifetime costs: The total scores for each assessment site scores are then translated into diamonds as shown in Table 4 with fewer diamonds indicating less constraints to implementing the remedy:

Table 5: Construction Complexity and Lifetime Costs Scoring Definitions

Construction Complexity Factor Sub-Score	Diamonds	Description
≤ 11	◆	Low construction complexity and low maintenance needs.
>11 and <14	◆ ◆	Construction complexity and maintenance requirements are medium.
≥ 14	◆ ◆ ◆	High construction complexity OR substantial maintenance required over project life.

Table 6 summarizes the scoring of construction complexity and the number of diamonds awarded to each site.

Table 6: Construction Complexity and Lifetime Cost

Site No.	Factor	Factor Score	Site Name and Notes	Diamonds
1	Amount disturbance	2	<u>Vernon Avenue Grade Control</u>	◆ ◆
	Hardscape removed	3	- Reconstruct 150 to 250 LF channel and create roughened channel	
	Utility lines	3	- Remove ~3,500 SF concrete, sacked concrete and grouted rock	
	Access	1	- Overhead power transmission lines	
	Unstable slopes	1	- Good channel access from low maintenance road connected to Stevens Creek Trail	
	Lifetime costs	3	- No apparent erosion/slope instability issues	
	Total Score	**13**		
2	Amount disturbance	3	<u>Highway 101 Crossing, post mile 48.0</u>	◆ ◆ ◆
	Hardscape removed	3	- Reconstruct 740 LF of channel, including modifying Highway 101 box culvert to build hybrid fish transport l and roughened channel	
	Utility lines	1	- Remove ~ 13,000 SF concrete	
	Access	3	- Overhead power transmission lines should not affect work inside culvert	
	Unstable slopes	1	- Ramp 1,500 ft upstream	
	Lifetime costs	3	- No apparent erosion/slope instability issues	
	Total Score	**14**		
3	Amount disturbance	3	<u>Moffett Fish Ladder</u>	◆ ◆ ◆
	Hardscape removed	3	- Reconstruct 400 LF of channel to build roughened channel	
	Utility lines	3	- Remove ~3,000 SF concrete	
	Access	2	- Overhead power transmission lines and underground gas and water lines	
	Unstable slopes	3		
	Lifetime costs	3		

Table 6: Construction Complexity and Lifetime Cost				
Site No.	**Factor**	**Factor Score**	**Site Name and Notes**	**Diamonds**
	Total Score	**17**	- Ramp 900 ft upstream - Remove bed and bank linings protecting steep slopes	
4	Amount disturbance	1	Moffett Boulevard Crossing - Add elements to create fish transport channel in existing culvert - No removal of concrete - Ramp 200 ft downstream - Anticipate utility lines at road crossing - No apparent erosion/slope instability issues	◆
	Hardscape removed	1		
	Utility lines	2		
	Access	1		
	Unstable slopes	1		
	Lifetime costs	1		
	Total Score	**7**		
5	Amount disturbance	2	Drop Structure upstream of Moffett Boulevard - Reconstruct up to 190 LF of channel to create roughened channel - Remove ~800 SF concrete - Overhead power transmission lines - Ramp 800 ft downstream - Steep potentially unstable lopes	◆◆◆
	Hardscape removed	2		
	Utility lines	3		
	Access	2		
	Unstable slopes	2		
	Lifetime costs	3		
	Total Score	**14**		
6	Amount disturbance	3	Drop Structure at Hetch Hetchy Crossing - Reconstruct up to 310 LF of channel to create roughened channel while protecting Hetch Hetchy aqueduct and cap - Remove ~400 SF concrete weir and sacked concrete - Overhead power transmission lines - Ramp 950 ft upstream - No apparent erosion/slope instability issues	◆◆◆
	Hardscape removed	2		
	Utility lines	3		
	Access	2		
	Unstable slopes	1		
	Lifetime costs	3		
	Total Score	**14**		
8	Amount disturbance	2	Drop Structure downstream Middlefield Road - Reconstruct up to 150 LF of channel to create roughened channel while preserving drop structure - Remove ~150 SF concrete - Overhead power transmission lines - Ramp 300 ft upstream - No apparent erosion/slope instability issues	◆◆
	Hardscape removed	1		
	Utility lines	3		
	Access	2		
	Unstable slopes	1		
	Lifetime costs	3		
	Total Score	**12**		
9	Amount disturbance	2	Drop structure upstream of Middlefield Road - Reconstruct up to 200 LF to create roughened channel, - Remove ~750 SF concrete at drop structure - Overhead power transmission lines - Ramp/channel access 300 ft downstream - Bank instability concerns	◆◆◆
	Hardscape removed	2		
	Utility lines	3		
	Access	2		
	Unstable slopes	3		
	Lifetime costs	3		
	Total Score	**15**		
11	Amount disturbance	2	Highway 85 crossing, post mile 23.0 - Reconstruct up to 300 LF of channel to create roughened channel while protecting Highway 85 culvert - Remove ~120 SF concrete weir	◆◆
	Hardscape removed	1		
	Utility lines	3		
	Access	2		
	Unstable slopes	2		

Table 6: Construction Complexity and Lifetime Cost				
Site No.	**Factor**	**Factor Score**	**Site Name and Notes**	**Diamonds**
	Lifetime costs	3	- Overhead power transmission lines - Channel access from Central Avenue - Bank instability concerns	
	Total Score	**13**		
12	Amount disturbance	1	Vortex Fish Weir fishway at Gage 35 - Reconstruct up to 100 LF of channel to create pool and chute fishway or fish transport channel modify existing fishway - Remove ~80 SF concrete weirs - Overhead power transmission lines - Channel access from Central Avenue - No apparent erosion/slope instability issues	◆
	Hardscape removed	1		
	Utility lines	3		
	Access	2		
	Unstable slopes	1		
	Lifetime costs	2		
	Total Score	**10**		
14	Amount disturbance	2	Drop structure downstream of pedestrian bridge - Reconstruct up to 150 LF of channel to create roughened channel while retaining drop structure - No concrete removal - Overhead power transmission lines - Channel access from Central Avenue, 800 ft downstream - No apparent erosion/slope instability issues	◆ ◆
	Hardscape removed	1		
	Utility lines	3		
	Access	2		
	Unstable slopes	1		
	Lifetime costs	3		
	Total Score	**12**		
14.1	Amount disturbance	2	Drop structure at pedestrian bridge - Reconstruct up to 180 LF of channel to create roughened channel, - Remove ~ 600 SF concrete drop - Overhead power transmission lines - No channel access within 1,000 ft - Bank instability concerns	◆ ◆ ◆
	Hardscape removed	2		
	Utility lines	3		
	Access	3		
	Unstable slopes	2		
	Lifetime costs	3		
	Total Score	**15**		
17	Amount disturbance	2	El Camino Real crossing - Construct 180 LF roughened channel downstream of ECR culvert or fish transport channel in culvert - Remove 3,240 SF concrete in culvert - Overhead power transmission lines - Good channel access, ramp at ECR - No apparent erosion/slope instability issues	◆ ◆
	Hardscape removed	3		
	Utility lines	3		
	Access	1		
	Unstable slopes	1		
	Lifetime costs	3		
	Total Score	**13**		
17.1	Amount disturbance	1	Drop structure at storm drain (upstream of El Camino real crossing - Reconstruct up to 50 LF of channel to create roughened channel - Remove ~3,000 SF concrete drop structure - Overhead power transmission lines - Ramp at ECR 500 ft downstream - Severe bank instability	◆ ◆ ◆
	Hardscape removed	3		
	Utility lines	3		
	Access	2		
	Unstable slopes	3		
	Lifetime costs	3		
	Total Score	**15**		
22	Amount disturbance	1	Highway 85 crossing, post mile 20.0 - Install forcing features in Highway 85 culvert - No concrete removal/structural modification	◆
	Hardscape removed	1		
	Utility lines	1		

Table 6: Construction Complexity and Lifetime Cost				
Site No.	Factor	Factor Score	Site Name and Notes	Diamonds
	Access	3	- Utility lines not a concern - No ramps/channel access within 1,000 ft - No erosion/slope instability issues	
	Unstable slopes	1		
	Lifetime costs	1		
	Total Score	**8**		
32	Amount disturbance	3	Gaging Weir SF44 at Stevens Creek Park - Construct up to 350 ft of roughened channel or pool and chute fishway - Remove 20 SF concrete to enlarge weir notch - No apparent utility lines - Good channel access from County Park Road - No erosion/slope instability issues	◆
	Hardscape removed	1		
	Utility lines	1		
	Access	1		
	Unstable slopes	1		
	Lifetime costs	3		
	Total Score	**10**		

2.2.3 Physical Creek Properties and Geomorphology: Long-term creek functionality and sustainability will depend on maintaining geomorphic characteristics, including sediment transport through the project site. Remedies with substantial change to geomorphic characteristics including physical dimensions (channel cross-section area, hydraulic capacity, hydraulic roughness, width to depth ratio, longitudinal slope), hydraulic conditions (flow frequency), and or sediment continuity transport are expected to increase risk of failure. Table 7 shows geomorphic scoring definitions:

Table 7: Geomorphology Scoring Definitions	
Diamonds	**Description**
◆	Remediation includes minor change to existing physical creek characteristics.
◆ ◆	Remediation includes moderate change to creek geomorphic characteristics.
◆ ◆ ◆	Remediation includes significant change to creek geomorphic characteristics.

Table 8 presents site scores for geomorphology and physical creek properties with lower scores indicating less geomorphic disruption:

Table 8 Site Geomorphology and Physical Creek Properties		
Site No.	**Score**	**Site Name and Notes**
1	◆	Vernon Avenue Grade Control Remedy would replace concrete drop structure with roughened channel (2% profile) and/or pool and chute fishway (8% profile).
2	◆	Highway 101 Crossing, post mile 48.0 Remedy would modify concrete box culvert with minor or no change to local channel slope or geomorphic characteristics.
3	◆	Moffett Fish Ladder Remedy would replace the steel fish ladder and concrete drop structure with a roughened channel (2% profile), improving sediment transport continuity.

Table 8 Site Geomorphology and Physical Creek Properties		
Site No.	**Score**	**Site Name and Notes**
4	◆	Moffett Boulevard Crossing Remedy would modify concrete box culvert for fish passage and improve sediment transport continuity.
5	◆	Drop Structure upstream of Moffett Boulevard Remedy would remove existing concrete drop structure and install roughened channel (2% profile) or pool and chute fishway (5% profile). Either solution would improve geomorphic characteristics.
6	◆	Drop Structure at Hetch Hetchy Crossing Remedy would install a roughened channel (1.5 to 2% profile) or pool and chute fishway (8% profile) over the existing pipeline concrete cap. Either solution would remove the hydraulic drop and improve sediment transport continuity.
8	◆	Drop Structure downstream Middlefield Road Remedy would replace concrete drop structure with a roughened channel (2% profile) or pool and chute fishway (10% profile). Either solution would remove the hydraulic drop and improve sediment transport continuity.
9	◆ ◆	Drop structure upstream of Middlefield Road Remedy would replace concrete drop structure with a roughened channel (2% profile) or pool and chute fishway (10% profile). Either solution would remove the hydraulic drop and improve sediment transport continuity. Bank stability a concern and substantial bank work may be required.
11	◆	Highway 85 crossing, post mile 23.0 Remedy would replace concrete drop structure with a roughened channel (2% profile) or pool and chute fishway (10% profile). Either solution would remove the hydraulic drop and improve sediment transport continuity.
12	◆	Vortex Fish Weir fishway at Gage 35 Remedy would modify concrete vortex weir fishway to reduce hydraulic drop. No change to geomorphic characteristics would result.
14	◆	Drop structure downstream of pedestrian bridge Remedy would replace concrete drop structure with a roughened channel (1 to 2% profile), which would improve geomorphic characteristics.
14.1	◆	Drop structure at pedestrian bridge Remedy would replace grouted rock structure with a roughened channel (0.7% profile) and improve sediment transport continuity.
17	◆	El Camino Real crossing Project would modify concrete box culvert and rock approach to create fish transport channel and/or roughened channel. No change to geomorphic characteristics.
17.1	◆ ◆	Drop structure at storm drain (upstream of El Camino Real crossing) Remedy would replace existing sacked concrete bed and bank lining with roughened channel (2% profile). Bank stability is a concern due to need to modify existing sacked concrete protecting over steepened bank containing large storm drain outfall.

Table 8 Site Geomorphology and Physical Creek Properties		
Site No.	Score	Site Name and Notes
22	◆	Highway 85 crossing, post mile 20.0 Remedy would modify concrete box culvert by installing forcing features with no change to geomorphic characteristics.
32	◆	Gaging Weir SF44 at Stevens Creek Park Remedy would replace concrete weir with roughened channel (2% profile) or chute and pool fish way (10% profile). Remedy would improve geomorphic characteristics and improve sediment transport continuity.

2.2.4 Environmental Impact: The primary environmental impact expected for fish passage remedies described in this report would be riparian corridor disturbance. For construction equipment access and materials delivery, a temporary reduction of riparian habitat value would result because affected vegetation would be replaced or would regrow. For remedies that require permanent maintenance access roads, a permanent reduction of riparian habitat could result.

Other temporary environmental impacts expected during the construction period include noise, air emissions from construction vehicles and equipment and fugitive dust, light emissions, and traffic on local roads generated by construction-related vehicles and equipment, and temporary traffic controls on local traffic roads to ensure construction public safety. Remedy projects described in this report are expected to be small in scale and construction related impacts (other than vegetation removal and channel modification) are expected to be temporary and insubstantial.

Physical modification of the creek would be necessary at most sites; however, physical changes to the creek channel would improve fish passage and aquatic habitat. Thus, the area of riparian habitat disturbance was determined to be commensurate with environmental impact. These areas were determined through aerial imagery analysis for each of the projects. Scoring definitions for environmental impact are shown in Table 9:

Table 9: Environmental Impact Scoring Definitions	
Diamonds	Description
◆	≤ 100 SF riparian vegetation removed.
◆ ◆	>100 SF to ≤500 SF riparian vegetation removed.
◆ ◆ ◆	> 500 SF riparian vegetation removed or construction of grade control structures, concrete/grouted bank protection, channel enlargement, and/or structural modifications of bridges.

Table 10 presents site scores for environmental impact with lower scores indicating less impact:

Table 10: Site Environmental Impact		
Site No.	**Score**	**Notes**
1	◆ ◆ ◆	Vernon Avenue Grade Control Remove approximately 1,000 SF of riparian vegetation growing among rock vanes and concrete grade control structure.
2	◆ ◆	Highway 101 Crossing, post mile 48.0 Remove approximately 450 SF of vegetation growing among rock vanes.
3	◆	Moffett Fish Ladder Little or no vegetation removal required because banks are concrete lined.
4	◆	Moffett Boulevard Crossing No vegetation would be removed because work would be inside of culvert.
5	◆	Drop Structure upstream of Moffett Boulevard No vegetation would be removed because channel is concrete lined. Pool and chute fishway would require partial removal of existing drop structure and construction of concrete weirs.
6	◆ ◆	Drop Structure at Hetch Hetchy Crossing Remove approximately 400 SF of vegetation to access site from top-of-bank trail. Pool and chute fishway would require partial removal of existing drop structure and construction of concrete weirs.
8	◆ ◆ ◆	Drop Structure downstream Middlefield Road Remove approximately 900 SF of vegetation growing on creek banks and among sacked concrete.
9	◆ ◆ ◆	Drop structure upstream of Middlefield Road Remove approximately 2,500 SF of vegetation to access and construct remedy.
11	◆ ◆ ◆	Highway 85 crossing, post mile 23.0 Remove approximately 3,000 SF of riparian vegetation.
12	◆	Vortex Fish Weir fishway at Gage 35 No vegetation would be removed.
14	◆ ◆ ◆	Drop structure downstream of pedestrian bridge Remove approximately 3,500 SF of riparian vegetation.
14.1	◆ ◆ ◆	Drop structure at pedestrian bridge Remove approximately 1,800 SF of riparian vegetation.
17	◆ ◆ ◆	El Camino Real crossing Remove approximately 1,800 SF of riparian vegetation.
17.1	◆ ◆	Drop structure at storm drain (upstream of El Camino Real crossing)Remove approximately 300 SF of riparian vegetation.
22	◆ ◆	Highway 85 crossing, post mile 20.0 Remove approximately 400 SF of riparian vegetation for construction access.
32	◆ ◆ ◆	Gaging Weir SF44 at Stevens Creek Park Remove approximately 1,400 SF of riparian vegetation to access site and construct remedy.

2.2.5 Overall Site Scores for Logistical Constraints

Table 11 presents the number of diamonds for each site summed over all four logistical constraints, with a lower number of diamonds indicating remedy implementation would be less complex and costly.

Table 11: Overall Scores for Logistical Constraints

Site No.	Property Ownership and Access	Construction Complexity and Lifetime Cost	Geomorphology and Physical Creek Properties	Environmental Impact	Total Diamonds
1	◆	◆ ◆	◆	◆ ◆ ◆	7
2	◆ ◆	◆ ◆ ◆	◆	◆ ◆	8
3	◆	◆ ◆ ◆	◆	◆	6
4	◆	◆	◆	◆	4
5	◆	◆ ◆ ◆	◆	◆	6
6	◆ ◆	◆ ◆ ◆	◆	◆ ◆	8
8	◆	◆ ◆	◆	◆ ◆ ◆	7
9	◆	◆ ◆ ◆	◆ ◆	◆ ◆ ◆	9
11	◆ ◆	◆ ◆	◆	◆ ◆ ◆	8
12	◆	◆	◆	◆	4
14	◆	◆ ◆	◆	◆ ◆ ◆	7
14.1	◆	◆ ◆ ◆	◆	◆ ◆ ◆	8
17	◆ ◆	◆ ◆	◆	◆ ◆ ◆	8
17.1	◆ ◆	◆ ◆ ◆	◆ ◆	◆ ◆	9
22	◆ ◆	◆	◆	◆ ◆	6
32	◆ ◆	◆	◆	◆ ◆ ◆	7

3. SITE SCORES CONSIDERING BOTH FISH PASSAGE AND LOGISTICAL CONSTRAINTS

Based on the analysis presented above, Table 12 combines fish passage and logistical constraints site scores. A lower score indicates greater benefit to fish passage and lower constraints to implementation. Table 13 shows the sites in order of prioritization. Two of these sites are listed in draft FAHCE settlement agreement (section 6.5.2.2(A)) and their FAHCE status is provided in Table 12. The draft FAHCE agreement states "SCVWD will be responsible for the costs of such barrier remediation."

Table 12: Combined Site Scores

Site No.	Fish Passage Score	Logistical Constraints Score	Combined Score[1]	Site Name	FAHCE Status
1	12	7	19	Vernon Avenue grade control	not applicable
2	2	8	10	Highway 101 crossing, post mile 48.0	not applicable
3	14	6	20	Moffett fish ladder	Priority barrier owned by SCVWD
4	23	4	27	Moffett Boulevard crossing	not applicable
5	16	6	22	Drop structure upstream of Moffett Boulevard	not applicable
6	2	8	10	Drop structure at Hetch Hetchy crossing	not applicable
8	16	7	23	Drop structure downstream of Middlefield Road	not applicable
9	17	9	26	Drop structure upstream of Middlefield Road	not applicable
11	20	8	28	Highway 85 crossing, post mile 23.0	not applicable
12	12	4	16	Vortex weir fishway at Gage 35	Priority barrier owned by SCVWD
14	4	7	11	Drop structure downstream pedestrian bridge	not applicable
14.1	19	8	27	Drop structure at pedestrian bridge	not applicable
17	23	8	31	El Camino Real crossing	not applicable
17.1	9	9	18	Drop structure at storm drain (upstream of El Camino Real)	not applicable
22	24	6	30	Highway 85 crossing, post mile 20.0	not applicable
32	8	7	15	Gaging weir 44 (Stevens Creek County Park)	not applicable
NOTE: [1] A lower fish passage score indicates greater benefit from remediation.					

Table 13: Site Prioritization for Remedy			
Priority	**Site No.**	**Site Score**	**Site Name**
Highest	2	10	Highway 101 crossing, post mile 48.0
↓	6	10	Drop structure at Hetch Hetchy crossing
	14	11	Drop structure downstream pedestrian bridge
	32	15	Gaging weir 44 (Stevens Creek County Park)
	12*	16	Vortex weir fishway at Gage 35
	17.1	18	Drop structure at storm drain (upstream El Camino Real)
	1	19	Vernon Avenue grade control
	3*	20	Moffett fish ladder
	5	22	Drop structure upstream of Moffett Boulevard
	8	23	Drop structure downstream of Middlefield Road
	9	26	Drop structure upstream of Middlefield Road
	4	27	Moffett Boulevard crossing
	14.1	27	Drop structure at pedestrian bridge
	11	28	Highway 85 crossing, post mile 23.0
	22	30	Highway 85 crossing, post mile 20.0
Lowest	17	31	El Camino Real crossing
*Listed in draft FAHCE settlement agreement			

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APPENDIX 1: REAL PROPERTY OWNERSHIP INFORMATION

Site No.	Site Name	Landowner / APN or Caltrans Parcel No. / SCVWD Easement ID*	Notes
1	Vernon Avenue grade control	City Mtn View / 116-16-062 / 828 SCVWD / 116-16-035 / none SCVWD / 116-16-068 / none SCVWD/ 116-17-005 / none	SCVWD fee IDs 351, 11616035, 11616068
2	Highway 101 crossing, post mile 48.0	Caltrans / 99, 11880 / none	
3	Moffett fish ladder	SCVWD / 153-19-006 / none City of Mountain View / 153-19-005 / 781, 890	SCVWD Fee ID 15319006
4	Moffett Boulevard crossing	Caltrans / 13563, 21040 / 5031	
5	Drop structure upstream of Moffett Boulevard	City of Mtn View / 160-04-001 / 807, 889	
6	Drop structure at Hetch Hetchy crossing	CC of San Francisco/ 160-040-019 / none	Hetch Hetchy
8	Drop structure downstream of Middlefield Road	SCVWD / 160-23-006 / none	SCVWD Fee ID 16023006
9	Drop structure upstream of Middlefield Road	City of Mountain View / 160-37-008 / 804 SCVWD / 160-37-009/ none	SCVWD Fee ID 16037009
11	Highway 85 crossing, post mile 23.0	Caltrans / 13536, 13618 /907, 908, 5020	Highway 85 crossing between Middlefield Rd and Central Expressway, partial SCVWD easement
12	Vortex weir fishway at Gage 35	SCVWD / 158-48-002 / none	SCVWD Fee ID 358
14	Drop structure downstream pedestrian bridge	City of Mtn View / 158-32-001/ 853	
14.1	Drop structure at pedestrian bridge	City of Mtn View / 158-32-001/ 853	
17	El Camino Real crossing	Caltrans / 91 / none	
17.1	Drop structure at storm drain (upstream El Camino Real)	City of Mtn View / 197-43-001 / none	SCVWD easement on west bank (not channel) 783
22	Highway 85 crossing, post mile 20.0	Caltrans / 13515, 20884 / none	
32	Gaging weir 44	Santa Clara County / 351-10-042 / 1002	SCVWD access easement does not include creek channel

ATTACHMENT 1

STEVENS CREEK FISH PASSAGE ANALYSIS

June 2020

STEVENS CREEK
FISH PASSAGE ANALYSIS

Prepared for

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June 2020

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TABLE OF CONTENTS

1 INTRODUCTION 1
- 1.1 STUDY OBJECTIVES 2
- 1.2 TERMINOLOGY 2
- 1.3 STUDY AREA 3

2 METHODS 5
- 2.1 FIELD RECONNAISSANCE 6
- 2.2 ASSESSMENT SITE SURVEYS 7
- 2.3 FISH PASSAGE ASSESSMENT 7
  - 2.3.1 Passage Evaluation Filter 7
  - 2.3.2 Fish Passage Assessment Flows 8
  - 2.3.3 Hydraulic Modeling 9
  - 2.3.4 Fish Routing Modeling 10
- 2.4 SCORING 11

3 RESULTS 15
- 3.1 FIELD RECONNAISSANCE 15
- 3.2 PASSAGE CONDITIONS AT ASSESSMENT SITES 19
- 3.3 SCORING 22
- 3.4 DISCUSSION 22

4 REFERENCES 28

5 LIST OF REPORT PREPARERS 30

Attachments

Attachment A Valley Water Reconnaissance Surveys
Attachment B Example Fish Passage Inventory Data Sheet
Attachment C Spreadsheet Template Used to Standardize Roughness Approach for HEC RAS Models
Attachment D Results of Fishway Spreadsheet Models
Attachment E Assessment Site Summary Sheets
Attachment F Site Ownership

Figures

Figure 1 Study Area and Pre-Identified Sites
Figure 2 Reconnaissance Results
Figure 3 Flows Meeting Passage Assessment Criteria for Adult Steelhead at Each Assessment Site, from Zero to 619 cfs
Figure 4 Assessment Sites with Score Categories

Tables

Table 1 Pre-Identified Sites (prior to the Team's Reconnaissance)
Table 2 Fish Passage Assessment Flows Applied to All Assessment Sites
Table 3 Fish Passage Assessment Criteria
Table 4 Weighting Factors Applied to Each Metric for Scoring of Sites
Table 5 Pre-Identified and Newly Identified Assessment Sites
Table 6 Summary of Fish Passage Assessment Flows Meeting Assessment Criteria for Each Assessment Site
Table 7 Assessment Sites, Scores, and Score Categories
Table 8 List of Study Participants and Report Preparers

List of Acronyms and Abbreviations

CCC	Central California Coast
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
DPS	Distinct Population Segment
ESA	Endangered Species Act
ESA	Environmental Science Associates
fps	feet per second
FR	Federal Register
FRM	fish routing model
ft	feet
HEC-RAS	Hydrologic Engineering Center River Analysis System
min	minutes
MLA	Michael Love & Associates, Inc.
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PAD	Passage Assessment Database
PAD ID	California Fish Passage Assessment Database Identification Number
PM	post mile on referenced road or highway
Pre-Identified Sites	sites identified by Valley Water for the AECOM-Michael Love & Associates, Inc. Team to consider for fish passage assessment
RM	river mile
SCVWD	Santa Clara Valley Water District (Valley Water)
sec	seconds
Study	Stevens Creek Fish Passage Analysis
Team	AECOM-Michael Love & Associates, Inc. Team
USFS	United States Forest Service

1 INTRODUCTION

The Santa Clara Valley Water District (Valley Water) has been working with stakeholders in the Stevens Creek Watershed to recover steelhead since the late 1990s. In 2004, Valley Water's consultant completed a limiting factors analysis for steelhead; this analysis was undertaken to identify and fill information gaps related to physical and biological factors controlling the population dynamics of steelhead in Stevens Creek (Stillwater Sciences 2004). The limiting factors analysis found that anthropogenic fish passage impediments in Stevens Creek downstream of Stevens Creek Dam could limit access to a substantial amount of habitat for the federally threatened Central California Coast (CCC) Distinct Population Segment (DPS) of steelhead (*Oncorhynchus mykiss*). However, the limiting factors analysis did not quantitatively assess passage at the identified passage impediments, and the degree to which the movement of steelhead in Stevens Creek would be impeded was largely unknown.

Reconnaissance surveys conducted by Valley Water and other stakeholders following completion of the limiting factors analysis narrowed the list of potential fish passage impediments downstream of Stevens Creek Dam that required further evaluation (M. Moore, Valley Water, pers. comm., 2019). Many of these potential fish passage impediments are included in the California Fish Passage Assessment Database (PAD) (CalFish 2019). The PAD is an ongoing map-based inventory of known and potential impediments to anadromous fish passage in California, maintained through a cooperative interagency agreement. The PAD compiles currently available fish passage information from many different sources and allows past and future fish passage assessments to be standardized and stored in one place.

The quantitative Stevens Creek Fish Passage Analysis (Study) described in this report began when Valley Water provided the AECOM-Michael Love & Associates, Inc. (MLA) Team (the Team) with a list of 34 pre-identified sites to consider for fish passage[†] assessment (Pre-Identified Sites) on Stevens Creek along the 12.8 miles of the stream that flows from Stevens Creek Dam to South San Francisco Bay. These sites were identified through the previous efforts described above and are current entries in the PAD (CalFish 2019), or they were identified for inclusion in the Study during recent reconnaissance surveys conducted by Valley Water (see Attachment A for details regarding recent reconnaissance conducted by Valley Water). Two of the Pre-Identified Sites (Sites 2 and 3) were included in an earlier quantitative fish passage assessment (MLA 2016) upon which the passage evaluation methods used in this Study were based. Additional information regarding the Pre-Identified Sites, including their PAD identification (PAD ID) numbers, can be found in the methods section of this report (Section 2).

This Study began with 34 Pre-Identified Sites; however, after initiating the Study, the Team conducted additional reconnaissance surveys to confirm the presence of each Pre-Identified Site and to identify any additional sites for inclusion in the Study. Following the Team's reconnaissance, 30 Assessment Sites were evaluated for upstream juvenile and adult steelhead passage in this Study. The number of Assessment Sites differs from the number of Pre-Identified Sites because some of the Pre-Identified Sites were not found during the Team's reconnaissance (and are therefore assumed to no longer be present), and because at other locations new passage impediments were identified for inclusion in the Study. Information describing all Pre-Identified Sites and Assessment Sites can be found in the reconnaissance results section of this report (Section 3.1). As described in that section, recent reconnaissance conducted by Valley Water, combined with the follow-up reconnaissance conducted by the Team, resulted in complete coverage of Stevens Creek between San Francisco Bay and Stevens Creek Dam. Beginning with results Section 3.2, Passage Conditions at Assessment Sites, this report focuses on the Assessment Sites that were found by the Team to potentially hinder steelhead upstream movement and the analysis conducted at those sites.

[†] Although the term "fish passage" is used generally in this report, the passage assessment presented in this report is specific to upstream passage for juvenile and adult steelhead.

This Study fills an important data gap by quantifying the severity of steelhead passage impediments in Stevens Creek between San Francisco Bay and Stevens Creek Dam. Valley Water will use the results of the Study (described in Section 3 of this report) to update the PAD for all Pre-Identified Sites (including instances where a passage impediment in the PAD is no longer present) and Assessment Sites (including creation of new PAD entries for sites not already included in the database). Valley Water will use the information provided in this report, along with other considerations not addressed in this report (e.g., real estate ownership and maintenance requirements) to prioritize the Assessment Sites for passage remediation. This report may also help other stakeholders in the Stevens Creek Watershed prioritize barriers for remediation.

1.1 STUDY OBJECTIVES

The goal of this Study was to quantify passage opportunity at identified steelhead passage impediments along Stevens Creek and to provide information for Valley Water to use when prioritizing barriers for removal or remediation based on the degree to which they limit passage, the position of the barrier in the watershed, and the amount of habitat available upstream before the next substantial barrier. Specific objectives are listed below.

1. Perform a quantitative evaluation of steelhead passage impediments in Stevens Creek between San Francisco Bay and Stevens Creek Dam (12.8 miles) based on the assessment protocol for passage of salmonids contained in Part IX of the California Department of Fish and Wildlife's (CDFW's) *California Salmonid Stream Habitat Restoration Manual* (CDFG 2002).

2. For each steelhead passage barrier identified, quantify the amount of habitat, in river miles (RMs), that will be accessible to steelhead if the barrier is removed or made 100 percent passable (i.e., the distance upstream to the next substantial barrier).

3. Based on Objectives 1 and 2 above, as well as the position of each barrier in the watershed, score the barriers based on the degree to which they limit access to Stevens Creek.

Specific methods used to achieve these objectives are described in Section 2.

1.2 TERMINOLOGY

This report uses several specific and some general terms to refer to assessed sites and their fish passage status. These terms are defined here so that their use is understood in the same way by all readers.

- Assessment Site – A specific term used to refer to fish passage impediments whose presence was confirmed by the Team during the reconnaissance and which were assessed to determine passage conditions for steelhead. Assessment Sites include Pre-Identified Sites and other sites that were identified during the Team's reconnaissance.

- Fish passage impediment – A general term used to refer to features that may hinder fish migration or movement for some life stages, or at some flows, but may not be a complete barrier for all life stages or at all flows. Used generally to refer to features whose passability are unknown but believed to potentially hinder fish movement.

- Partial barrier – A general term for a barrier that is impassible to some fish species, during one or all life stages, at all flows.

- Percent passage – The proportion of passage assessment flows (flow rates, not volumes or durations) meeting assessment criteria, not to be confused with the percentage of the fish population that may successfully pass an Assessment Site (see Section 3.2 for additional discussion regarding interpretation of this term).

- Pre-Identified Site – A specific term used to describe passage impediments that were identified by Valley Water for inclusion in this Study, prior to when the Team conducted site reconnaissance.
- Substantial barrier – A specific term used to describe an Assessment Site with values of percent passage for adult steelhead less than 80 percent.
- Temporal barrier – A general term for a barrier that is impassible to all fish at certain flow conditions.

1.3 STUDY AREA

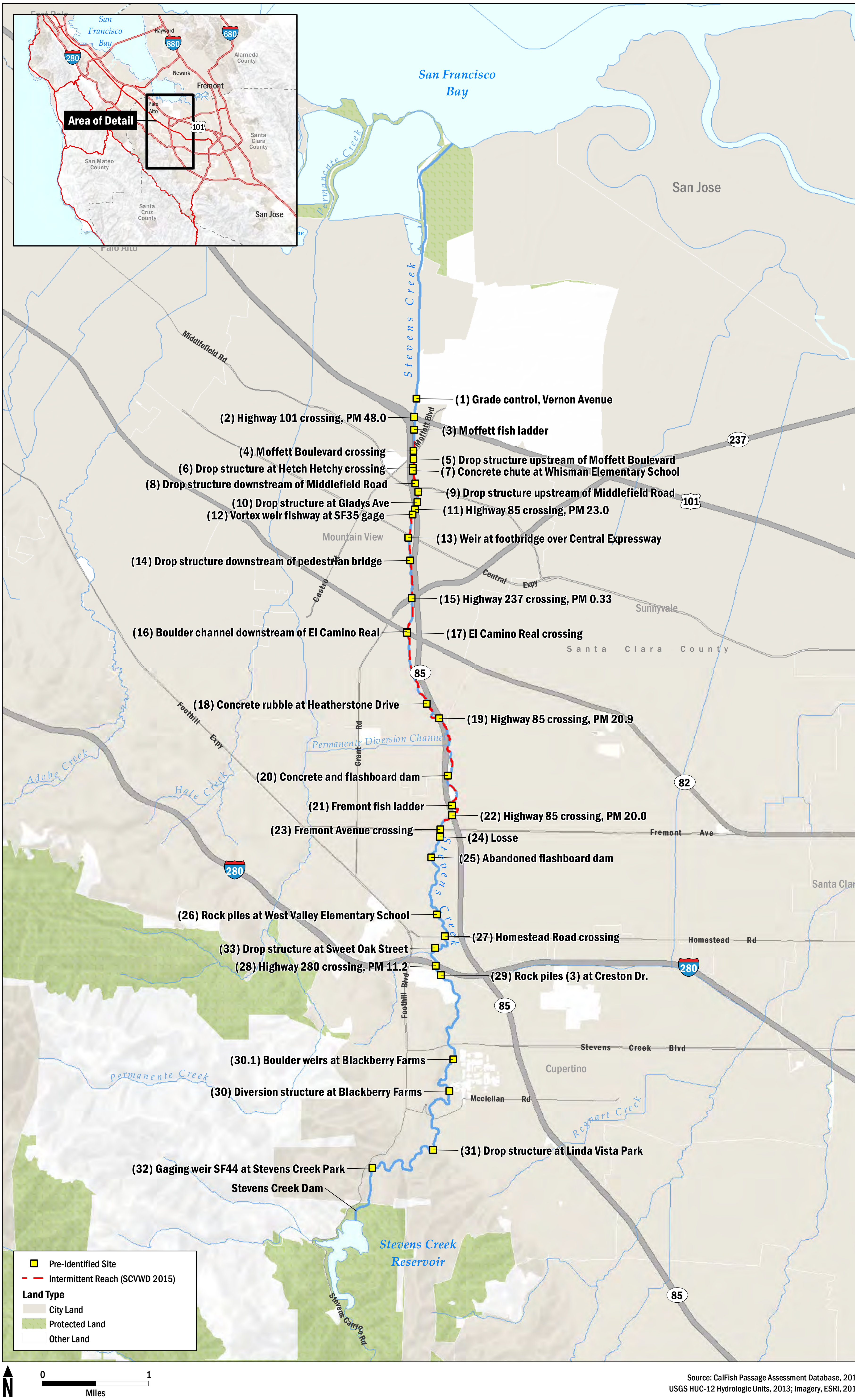
The fish passage assessment Study Area is a stream reach approximately 12.8 miles long, extending from Stevens Creek at South San Francisco Bay upstream to Stevens Creek Dam (Figure 1). This Study identified and evaluated all potential fish passage impediments in the Study Area, except for RMs 3.93 through 4.05. In an effort separate from this Study, Valley Water is currently planning modifications to the Stevens Creek channel between RMs 3.93 and 4.05. The modifications will be designed to mitigate impediments to fish passage. To avoid duplication of effort, that section of Stevens Creek is not analyzed in this Study.

The Stevens Creek watershed is approximately 29 square miles (SCVWD 2015) and lies on the northeastern slopes of the Santa Cruz Mountains in Santa Clara County. Mean annual precipitation varies from a high of approximately 20 to 39 inches on average in the upper slopes of the Santa Cruz Mountains, to a low of approximately 13.5 inches on the valley floor (SCVWD 2015). The majority of precipitation occurs between November and April. All flows from the upper watershed of adjacent Permanente Creek are diverted into Stevens Creek via the Permanente Creek diversion channel, constructed in 1959 for flood protection, bringing the total drainage area of Stevens Creek downstream of the diversion to 46 square miles (SCVWD 2015).

Stevens Creek originates at an elevation of 2,300 feet; it flows easterly as a perennial stream for approximately 8 miles before reaching Stevens Creek Reservoir, which resides at an elevation of 554 feet (SCVWD 2015). The reservoir, constructed in 1935, has a capacity of 3,138 acre-feet and a surface area of 91 acres. The reservoir attenuates flood flows and releases water to control downstream in-stream flows.

The Study Area is entirely downstream of the reservoir, where Stevens Creek runs for 12.8 miles northerly through the Cities of Cupertino, Sunnyvale, and Mountain View before discharging through Whisman Slough into South San Francisco Bay. In most years, Stevens Creek can be characterized as perennial for approximately 5.7 miles downstream of the reservoir, to approximately Fremont Avenue (SCVWD 2015). The stream then dries seasonally and is intermittent from approximately Fremont Avenue to 2 miles downstream of Central Avenue. Eventually, groundwater flow accretes and emerges downstream of Central Avenue, which then keeps the stream perennial again until the South San Francisco Bay. The length of the dry-back area fluctuates year by year, depending on the annual hydrologic cycle, reservoir operations, and local groundwater conditions.

Stevens Creek supports a population of winter steelhead that is part of the CCC DPS. The CCC steelhead DPS is classified as a threatened species under the federal Endangered Species Act (ESA) (62 Federal Register [FR] 43937 August 18, 1997). The freshwater form of *O. mykiss* (i.e., rainbow trout) above impassable barriers is not listed under the federal ESA; however, in Santa Clara Valley, native populations of rainbow trout above barriers are genetically similar to steelhead (Garza and Pearse 2008). Designated critical habitat for the CCC steelhead DPS includes Stevens Creek downstream of Stevens Creek Reservoir (70 FR 52488 September 2, 2005), coincident with the Study Area.



Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 1
Study Area and Pre-Identified Sites

2 METHODS

Valley Water directed the Team to investigate Pre-Identified Sites for fish passage assessment on Stevens Creek along the 12.8 miles of the stream that flows from Stevens Creek Dam to South San Francisco Bay. Through previous efforts by others (see Section 1) and recent reconnaissance conducted by Valley Water (see Attachment A) and the Team (see Section 2.1 and Section 3.1), all anthropogenic structures potentially creating a barrier to steelhead upstream movement were included in the Study.

The overall process for the fish passage assessment involved the following steps:

- **Field Reconnaissance**. The Team visited each of the Pre-Identified Sites to confirm its presence and, if present, to document its condition and outline the approach for future data collection efforts. Pre-Identified Sites confirmed present during the Team's reconnaissance surveys were moved to the list of Assessment Sites. Additionally, unexpected passage impediments encountered while moving between Pre-Identified Sites and during general reconnaissance of the channel were added to the list of Assessment Sites. The Pre-Identified Sites not found, presumably because they are no longer present, were removed from the list of Assessment Sites.

- **Assessment Site Surveys**. Based on information collected during the field reconnaissance, the Team topographically surveyed each Assessment Site. Survey data obtained during this step, along with as-built drawings for some Assessment Sites, were used to build the fish passage analysis Hydrologic Engineering Center River Analysis System (HEC-RAS) models.

- **Fish Passage Assessment.** This step followed methods outlined in the CDFW's *California Salmonid Stream Habitat Restoration Manual, Part IX: Fish Passage Evaluation at Stream Crossings* (CDFG 2004). Upstream passage assessment for juvenile and adult steelhead involved three main steps:

    - **Fish passage evaluation filter.** Passage at each Assessment Site was characterized following CDFW's assessment protocol and the Green-Gray-Red category filter. Characteristics of Green Assessment Sites were documented as detailed in CDFG (2004). All Gray and Red Assessment Sites were further analyzed for fish passage conditions.

    - **HEC-RAS modeling.** Topographic data and field data were used to develop a HEC-RAS hydraulic model of each Assessment Site to evaluate hydraulic conditions.

    - **Fish Passage Analysis.** Hydraulic conditions obtained from the HEC-RAS models were used in a fish routing model (FRM) to determine the passability of each Assessment Site based on the FishXing algorithm.

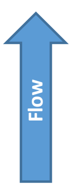
    - **Scoring.** Scores were calculated for the Assessment Sites to allow for relative comparison of their potential to limit access for steelhead to habitat in Stevens Creek.

Each of these steps is explained in detail in the following sections.

2.1 FIELD RECONNAISSANCE

Valley Water provided the Team with a list of 34 Pre-Identified Sites along the Study Area, and their approximate locations (Figure 1, Table 1). As described in Section 1, these sites had been identified and included in the PAD through previous efforts by others (CalFish 2019), or they were identified for inclusion in the Study during recent reconnaissance surveys conducted by Valley Water (see Attachment A). Two of the Pre-Identified Sites (Sites 2 and 3) were included in an earlier quantitative fish passage assessment (MLA 2016) upon which the passage evaluation methods used in this Study were based. As described in Section 1.3, the combined reconnaissance conducted by Valley Water and the Team afforded complete coverage of the Study Area except for the reach between RMs 3.93 and 4.05, where Valley Water is currently planning channel modifications that would mitigate fish passage impediments.

Table 1. Pre-Identified Sites (prior to the Team's Reconnaissance)

	River Mile	Coordinates	Pre-Identified Site No.	PAD Description or other Name (for Sites not in PAD)	PAD ID
	2.64	37.410868, -122.068759	1	Grade control structure at Vernon Avenue	713640
	2.81	37.408345, -122.069111	2	Highway 101 culvert and chute	705646
	2.93	37.406629, -122.069113	3	Moffett fish ladder at grade control structure	707059
	3.13	37.403765, -122.069144	4	Concrete channel at Moffett Avenue bridge	713641
	3.21	37.402642, -122.069119	5	Drop structure at Walker Drive	713642
	3.29	37.401421, -122.069167	6	Drop structure at the Hetch Hetchy pipeline crossing	713643
	3.32	37.401007, -122.069174	7	Concrete chute at Whisman Elementary School	713644
	3.44	37.399298, -122.068750	8	Drop structure, downstream of Middlefield Road	713645
	3.53	37.398158, -122.068170	9	Drop structure, upstream of Middlefield Road	713646
	3.63	37.396752, -122.068327	10	Drop structure at Cypress Point Drive and Easy Street	713647
	3.70	37.395755, -122.068706	11	Drop structure and chute at Highway 85 crossing	713648
	3.76	37.395049, -122.069084	12	Gaging weir (SF35) with drop structure, Central Avenue fish ladder	707058
	3.99	37.391873, -122.069750	13	Weir at footbridge over Central Expressway	713649
	4.20	37.388777, -122.069397	14	Dana Street low flow	713650
	4.56	37.383653, -122.069040	15	Chute at Highway 237 Bridge crossing	713651
	4.89	37.379045, -122.069681	16	Bridge (El Camino Real and Highway 85 bridge)	713652
	4.90	37.378876, -122.069681	17	Chute at El Camino bridge	733959
	5.62	37.369265, -122.066139	18	Concrete rubble at Heatherstone Drive	713653
	5.85	37.367313, -122.063958	19	Chute at Highway 85 Bridge crossing	713654
	6.47	37.359482, -122.062315	20	Concrete and flashboard dam	715100
	6.82	37.355436, -122.061515	21	Fremont fish ladder	707056
	6.96	37.354120, -122.061493	22	Highway 85 bridge (downstream of Fremont Avenue)	733951
	7.15	37.352159, -122.063441	23	Aggraded sediments at Fremont Avenue	713655
	7.24	37.351107, -122.063496	24	Losse	716244
	7.46	37.348288, -122.064913	25	Drop structure at Kircher Court	713656
	7.90	37.340550, -122.063778	26	Rock piles at West Valley Elementary School	713657
	8.37	37.337599, -122.062381	27	Degraded bed armoring downstream of Homestead Road	713658
	8.62	37.335961, -122.063997	33	Drop structure at Sweet Oak Street	NA
	8.82	37.333512, -122.063825	28	Chute at Highway 280 Bridge crossing	713660
	8.92	37.332259, -122.062942	29	Rock piles (3) at Creston Drive	713661
	9.93	37.320811, -122.060600	30.1	Boulder weirs at Blackberry Farm	NA
	10.40	37.316481, -122.061167	30	Diversion structure at Blackberry Farm	713663
	11.26	37.308373, -122.063805	31	Drop structure at Linda Vista Park	713665
	12.28	37.305775, -122.074104	32	Gaging weir (SF44) at Stevens Creek Park	713667

Note:
PAD ID = California Fish Passage Assessment Database Identification Number (CalFish 2019)

Between May 21 and May 23, 2018, with one additional visit on May 9, 2019, the Team visited each of the Pre-Identified Sites and walked much of the channel between the sites. This was done to confirm presence of each Pre-Identified Site, identify additional potential sites that should be evaluated, obtain an overview of each confirmed or additional site, and outline the survey approach for future topographic surveys. The resulting sites, after removing Pre-Identified Sites no longer present, are referred to as the Assessment Sites. An accounting of all Pre-Identified Sites and Assessment Sites, including the Pre-Identified Sites dropped during reconnaissance and new sites found and added during reconnaissance, is provided in the reconnaissance results section (Section 3.1).

During the field reconnaissance, the Team developed a sketch for each Assessment Site. Appropriate locations for surveying channel cross-sections were noted on the field sketches. Channel cross-sections (sections) are the basis of the HEC-RAS models used in the assessments. In general, sections to be surveyed were noted at hydraulic controls (e.g., tailwater crests), in pools immediately below drops, at changes in channel planform (e.g., where the channel widens or constricts), and around infrastructure (e.g., culverts). Assessment Sites were grouped together in reaches to aid in future modeling. There was a desire to group the sites into reaches that could effectively and efficiently be modeled together in HEC-RAS. These reach designations were made in the field, based on proximity of sites to one another, so that single models encompassing multiple sites could be developed (reach designations are provided with other reconnaissance results in Section 3.1).

2.2 ASSESSMENT SITE SURVEYS

Surveys of Assessment Sites were conducted by the Team between June and December 2018, with one additional survey conducted in May 2019, to obtain topography and other physical dimensions sufficient to develop a HEC-RAS model and analyze fish passage conditions for each site. To catalogue data collected at each site in a uniform manner, a Fish Passage Inventory Data Sheet (see Attachment B for example form) was completed for each site.

During the surveys, the reconnaissance site sketch was reviewed, and section locations were finalized and surveyed. Surveying was completed using a Total Station, a device consisting of an electronic theodolite and an electronic distance meter, which is used to measure angles and distances. All data were collected on an assumed datum, although benchmarks were installed to allow the survey to be tied to an established coordinate system in the future, if desired. In addition to surveying sections, a profile of the channel was surveyed to obtain distances between sections as well as channel slopes for model boundary conditions. The Team also qualitatively documented the channel roughness, which provides resistance to flow. For reaches that encompassed more than one Assessment Site, additional sections were surveyed between sites to hydraulically connect them in the HEC-RAS model.

2.3 FISH PASSAGE ASSESSMENT

This section describes the evaluation steps used to assess fish passage at the Assessment Sites, including the passage evaluation filter, fish passage assessment flows, HEC-RAS model, and FRM. Although the term “fish passage” is used generally, the assessment was conducted specifically for juvenile and adult steelhead upstream movement.

2.3.1 PASSAGE EVALUATION FILTER

The first step in the assessment was to apply a fish passage evaluation filter, following the methods and protocols described in CDFW’s *California Salmonid Stream Habitat Restoration Manual, Part IX: Fish Passage Evaluation at Stream Crossings* (CDFG 2004). The Team applied CDFW’s assessment protocol to the passage of adult anadromous and juvenile steelhead, using data collected during the field reconnaissance and Assessment Site surveys. The CDFW Green-Gray-Red categories are described below:

- **Green:** Condition assumed to be adequate for passage of all salmonid species throughout all salmonid life stages.
- **Gray:** Condition may not be adequate for all salmonid species at all their life stages. FishXing (USFS 2006) methodology and hydraulic modeling are used to determine the extent of barriers for each salmonid life stage.
- **Red:** Condition fails to meet CDFW passage assessment criteria at all passage assessment flows for strongest swimming salmonid species and life stages presumed present.

For all Assessment Sites identified as Gray or Red using the fish passage evaluation filter, the Team evaluated passage conditions using the methods outlined below. Assessment Sites identified as Green were documented as detailed in CDFG (2004).

2.3.2 FISH PASSAGE ASSESSMENT FLOWS

High and low fish passage assessment flows were developed following accepted practices and agency guidelines applied to historical Stevens Creek streamflow records. Fish passage assessment flows define the range of stream flows for which fish should be able to move freely past anthropogenic structures. This Study evaluated upstream passage conditions at each Assessment Site between the low and high passage assessment flows for adult anadromous and juvenile steelhead. For example, a site that provides adequate passage conditions at all flows between the low and high passage assessment flows is deemed 100 percent passable; a site that meets assessment criteria for a quarter of the passage assessment flows is considered 25 percent passable.

NMFS (2001) and CDFW (CDFG 2002) define fish passage flows for California based on annual duration of flow, calculated using daily average stream flows. For adult steelhead, the passage range is from the 50 percent exceedance flow to the 1 percent exceedance flow, with an alternative minimum flow of 3 cubic feet per second (cfs) if the 50 percent exceedance flow is less. The 50 percent annual exceedance flow is the daily average flowrate that is equaled or exceeded 50 percent of the time; the 1 percent exceedance flow is equaled or exceeded 1 percent of the time. For juvenile steelhead, the passage range is from the 95 percent exceedance flow to the 10 percent exceedance flow, with an alternative minimum flow of 1 cfs if the 95 percent exceedance flow is less.

The high and low fish passage flows (Table 2) are based on the recorded flows in Stevens Creek and are intended to define the range of flows between which salmonids in Stevens Creek are most likely to migrate upstream. For this Study, the Team used water years 1990 through 2017 to establish the flow record for the analysis because, based on evaluation of historical aerial photographs, this 27-year period represents current, post-urbanization, hydrologic conditions in the lower Stevens Creek watershed. The flow duration curve prepared for Valley Water by AECOM and MLA (2018) for the Moffett Fish Passage Project was used to determine flows for assessing fish passage at Sites 1 through 19, which are downstream of the Permanente Creek Diversion outlet. This flow duration curve was constructed using a Valley Water-provided record of mean daily flows at station SF35 (RM 3.76) on Stevens Creek from water years 1990 through 2017, which represents current (post-urbanization) hydrologic conditions of the lower stream reaches. The low passage assessment flows were defined using the alternative minimum flows described above. The Team prepared a separate flow duration curve using a Valley Water-provided record of mean daily flows at station SF44 on Stevens Creek (RM 12.28) for water years 1990 through 2017. This curve was used to determine flows for assessing fish passage at Sites 20 through 32, which are upstream of the Permanente Creek Diversion confluence. The fish passage assessment flow selection criteria and values are provided in Table 2.

Table 2. Fish Passage Assessment Flows Applied to All Assessment Sites

Assessment Sites	Steelhead Lifestage	Low Passage Assessment Flow		High Passage Assessment Flow	
		Criterion	Study Flow	Criterion	Study Flow
1 through 19	Adult	50% Exceedance Flow or 3 cfs[1]	3 cfs	1% Exceedance Flow	203 cfs
	Juvenile	95% Exceedance Flow or 1 cfs[1]	1 cfs	10% Exceedance Flow	29 cfs
20 through 32	Adult	50% Exceedance Flow or 3 cfs[1]	5 cfs	1% Exceedance Flow	130 cfs
	Juvenile	95% Exceedance Flow or 1 cfs[1]	1 cfs	10% Exceedance Flow	21 cfs

Notes:

[1] The criterion resulting in the greater of the two flows is used.

cfs = cubic feet per second

Once the range of fish passage assessment flows is established for each site , the remainder of the passage analysis aims to identify the flows meeting hydraulic criteria (e.g., depth or velocity) between the low and high passage assessment flows. Passage conditions at each site were also evaluated at stream flows greater than the high passage assessment flow to determine whether there were additional passage opportunities. For sites that had suitable passage conditions at higher flows, the assessment was continued up to the 2-year peak flow of 619 cfs, which is based on return period flows estimated using annual peak flow records from station SF35 developed for the Moffett Fish Passage Project; Feasible Alternatives Report (AECOM and MLA 2018).

2.3.3 HYDRAULIC MODELING

The primary basis for each fish passage assessment was the hydraulic results of a one-dimensional, steady-state HEC-RAS hydraulic model. The Team used individual HEC-RAS models for 16 reaches, 15 of which were developed using the survey data collected during the Assessment Site surveys. The model used for Reach 2 (Sites 2 and 3) was developed previously (MLA 2016). The HEC-RAS model files were provided to Valley Water for their use following completion of the Study. Where practical, multiple sites were analyzed in a single model. For example, Reach 7 is a single HEC-RAS model that includes Sites 16, 17, and 18. Each model was developed using the surveyed sections, thalweg alignment, and other field data. In addition to these data, as-built drawings (if available) were used to confirm or append the field measurements.

Manning's roughness coefficients were determined using methods developed by Phillips and Tadayon (2006). This is the same method used in Valley Water's *Stream Maintenance Guidelines*; *Draft Year 1 Hydraulic Modeling Report* (ESA 2017). The Phillips and Tadayon (2006) methodology requires selecting values from five roughness categories: base material, channel margin irregularity, channel section variation, effect of obstructions, and vegetation. For each category, a predetermined Manning's roughness coefficient value is applied based on the selected material or condition (e.g., base material: gravel = 0.028). The roughness coefficients from the five categories are summed to arrive at a composite Manning's roughness. The final step is to determine whether a multiplier should be applied due to energy loss associated with meanders; in most cases, modeled reaches were relatively straight, so this multiplier was set to "minor," which equates to negligible energy losses from meandering. In a few instances, cross sections were located in notable channel bends; it is likely that turbulent eddies would occur at these locations. To account for the resulting head loss of these eddies, the meander multiplier was set to either "appreciable" or "severe," and a multiplying factor was applied accordingly.

Using this approach, a Manning's roughness coefficient was determined for each section. In general, the channel sections were separated into three subsections: left bank, channel, and right bank. The survey results, photographs, field notes, and other field data for each section were used to select appropriate values for each subsection. For the banks, the only roughness categories applied were base material and vegetation. A spreadsheet template was developed to standardize the approach for each HEC-RAS model. The template is provided in Attachment C.

In the HEC-RAS model, the roughness coefficient values were applied to each section using the *horizontal variation in n values* function. The channel bank markers were placed at the ends of the section so that all the stream flow was between the markers to facilitate the fish passage analysis.

Some sites required additional modeling outside of HEC-RAS. For example, Site 21, which includes a Denil fishway, required development of a spreadsheet model based on accepted fishway equations. The calculation sheets and results from these spreadsheet models are provided in Attachment D. These additional spreadsheet models were used in conjunction with the HEC-RAS model. For Site 16, which contained a rock chute, the Team applied a depth-dependent roughness coefficient based on the Limerinos (1970) roughness equation provided in Appendix XII-B-8 of the CDFW Manual (CDFG 2009). The equation was derived from California stream channel data and presents a Manning's roughness relationship drawing on the hydraulic radius and measured median particle size.

2.3.4 FISH ROUTING MODELING

Once the HEC-RAS analysis of site hydraulics was complete, the results were exported to the FRM. The Team used the FRM to identify the approximate flow range in which the selected passage criteria are satisfied for each steelhead age class. The FRM is a spreadsheet model that follows the U.S. Forest Service FishXing routing algorithm (USFS 2006) and uses the CDFW fish passage assessment criteria (Table 3). Output from the HEC-RAS model, including flows, velocities, water depths, and water surface elevations are entered into the FRM and compared to CDFW fish passage assessment criteria. Results from the fishway spreadsheet models were compared directly to the CDFW fish passage assessment criteria. CDFW fish passage assessment protocol (CDFG 2002) describes minimum required water depths and maximum swimming and leaping speeds for adequate fish passage, as listed in Table 3. Several of these criteria were adjusted, as described below.

Table 3. Fish Passage Assessment Criteria

Species and Life Stage	Minimum Water Depth	Prolonged Swimming Mode		Burst Swimming Mode		Maximum Leap Speed	Maximum Water Surface Drop[1]	Minimum Leap Pool Depth
		Maximum Swimming Speed	Time to Exhaustion	Maximum Swimming Speed	Time to Exhaustion			
Adult Steelhead	0.7 ft (2)	6.0 fps	30 min	10.0 fps	5 sec	15.0 fps	1.5 ft	> leap height
Juvenile Steelhead	0.3 ft	1.5 fps	30 min	3.0 fps	5 sec	4.0 fps	0.5 ft	> leap height

Notes:

1 The Study used water surface drop rather than leap speed to evaluate potential leap barriers.
2 The Study used a 0.7-foot minimum allowable water depth, rather than the 0.8-foot value listed in CDFG (2002)

fps = feet per second
ft = feet
min = minutes
sec = seconds

The Team used the maximum water surface drop in the FRM rather than leap speeds due to HEC-RAS model limitations. Water surface drop is an abrupt change in water surface elevation and is measured as the vertical difference in water surfaces above and below the drop. For juvenile salmonids, the maximum drop criterion was based on CDFW (2002) and NMFS (2001). For adult steelhead, the maximum drop of 1.5 feet was used, based on tests of leap heights using the 15-foot-per-second leap speed in the FishXing software, and based on criteria for maximum water surface drops at fishway entrances for adult anadromous salmonids (NOAA 2011).

Another important criterion is the leap pool depth. The height to which a fish can leap is partially controlled by the depth of the pool from which the leap is initiated. The angle and speed with which the fish can leap is related to the depth of the pool it is leaping from, and a deeper pool is required to execute a higher leap. For this Study, the Team required that the depth of the leap pool be greater than the height of the leap. The requirement that the leap pool depth be greater than the leap height is based on the criteria applied by the FishXing software.

The minimum allowable water depth for adult steelhead was lowered from the value of 0.8 foot given in CDFG (2002) to 0.7 foot for this Study. The change was made to be consistent with Valley Water's minimum depth criteria for critical riffles in Stevens Creek associated with in-stream flow requirements.

To meet fish passage criteria at a specific flow requires that the fish (1) can leap or swim over any vertical feature; (2) have adequate water depth; and (3) can swim through the length of the site without becoming exhausted or swept backward by the water velocities. If the FRM results indicated a fish is unable to navigate a site, the general location and type of the impediment was noted.

The HEC-RAS and FRM analysis was conducted at the fish passage assessment flows. Those sites that provide suitable passage conditions at some assessment flows were considered temporal barriers, requiring additional HEC-RAS and FRM runs to more precisely identify the range of flows at which the site allows passage. In situations where the site was found to be passable at the high passage assessment flow, greater flows were also evaluated to identify the flow threshold for passage up to the 2-year flow event (619 cfs).

2.4 SCORING

The Team scored each Assessment Site to allow for easy comparison of quantitative fish passage assessment results across sites. The scoring system is intended to allow quick identification of the sites that have the biggest potential to affect steelhead access to habitat in Stevens Creek. The scoring system did not account for spatial variability in habitat types, habitat quality or water quality, potential life history strategies of juvenile steelhead, the potential for the Assessment Sites to cause fish injury, or other potential factors not specifically captured in the quantitative evaluation methods described above; consideration of these factors was beyond the scope of this Study but could be incorporated into future efforts. Some of these factors are discussed further in Section 3.4.

The scoring was based on a formula developed to highlight sites in the Study Area that create substantial barriers to fish passage and that, if treated, would provide the most access to upstream habitat. The scoring calculation was set up so that a lesser accumulation of points (lower score) would indicate a greater benefit associated with barrier remediation. The scoring system is based on four metrics:

a. the fish passage assessment results (percent passage) for adult steelhead,
b. the fish passage assessment results (percent passage) for juvenile steelhead,
c. the amount of upstream habitat made accessible to adult steelhead if passage conditions at the site were fully remediated, and
d. the position of the site in the watershed.

For each Assessment Site, metrics a, b, and c were calculated first, and then the score was adjusted based on the site's position in the watershed. Because it was applied last and across the sum of the other scoring metrics, watershed position is the most important metric in this scoring formula, dictating overall Assessment Site scores. These metrics and the scoring formula are described in more detail below.

For metrics a and b, fish passage assessment results were based on the calculated percent passage for adult steelhead and for juvenile steelhead. This is equal to the proportion of flows meeting the Study's passage criteria between the low and high passage assessment flow rates. If all flows between the low and high passage assessment flows met the selected criteria, then the site was considered 100 percent passable. If no flows between the low and high passage assessment flows met the selected criteria, then the site was considered zero percent passable. Those sites that provide suitable passage conditions at some assessment flows were considered temporal barriers and a percent passable value was assigned accordingly. The higher the percentage, the higher score the site would receive. Passage criteria satisfied at flows greater than the high passage assessment flow threshold did not affect the Assessment Site score.

The percent passage metric is based on the percent of fish passage assessment flows meeting the Study's passage criteria rather than percent of time passage criteria are satisfied. Flows at the low end of the passage flow range occur more frequently than higher flows, but this analysis aims to evaluate passage conditions when fish are expected to move. Passage at a site may be available continuously for months at low flows, when steelhead are less likely to be migrating, but passage during less frequent, elevated storm flows that cue steelhead migration is important. The approach used in this Study, and generally accepted by state and federal agencies, is intended to provide equal weight to all flows within the passage flow range, including higher flows that occur less frequently but may be important for fish migration.

The next metric, metric c in the scoring system above, was the amount of upstream habitat made accessible if passage conditions at a site were remediated. This measurement was based on the distance to the next upstream site considered to be a substantial barrier to adult steelhead. The Team defined a substantial barrier as those with values of percent passage for adult steelhead less than 80 percent. The results were then normalized by dividing the distance for each site by the largest value among all the sites, to determine the relative distance to the next upstream barrier.

Metrics a, b, and c were expressed as percentages that could range from 0 to 100 percent. In the scoring calculation the relative distance to the next upstream barrier (metric c in the list above), expressed as a percentage, was subtracted from 100 percent so that, consistent with other scoring metrics, a higher accumulation of points would indicate a lesser benefit associated with barrier remediation. Weighting factors were applied individually to each of these three metrics based on their relative importance. The products of each metric and its weighting factor were summed before applying watershed position across these three metrics.

The position of the site in the watershed was used to adjust the sum product of the other three scoring metrics described above. Watershed position was based on the stream length downstream of the site as a percentage of the entire Study Area's length of 12.8 miles, measured along Stevens Creek from south San Francisco Bay to the Stevens Creek Dam. A site farther downstream would receive a lower percentage, and therefore a lower score, emphasizing the importance of addressing barriers lower in the watershed before addressing upstream barriers.

The scoring formula applied to each site was:

$$\text{SCORE} = ([aW_1 + bW_2 + (1\text{-}c)W_3]d)100$$

where:

a = percent passage for adult steelhead
b = percent passage for juvenile steelhead
c = relative percentage of upstream habitat made accessible if passage conditions at the site are remediated, calculated as [(RM at the next upstream site qualifying as a substantial barrier – RM at the site) / (the maximum distance in RMs between any site and the next upstream site qualifying as a substantial barrier)[‡]]
d = percent of potential habitat downstream of the site, calculated as [RM at site / RM at Stevens Creek Dam] [§]
W_i =weighting factor for each metric

The final weighting factors for each metric are provided in Table 4.

Table 4. Weighting Factors Applied to Each Metric for Scoring of Sites

Weighting Factor		
Variable	**Metric Weight is Applied**	**Weight (%)**
W_1	Adult steelhead percent passage	70
W_2	Juvenile steelhead percent passage	20
W_3	Percent of upstream habitat made accessible if passage conditions at the site are remediated	10

The sensitivity of the scores of Assessment Sites to the weighting factor values was tested by iteratively varying each of the individual weighting factors, as well as the threshold percent passage for adult steelhead used to define a substantial barrier. The weighting factor for adult percent passage was varied between 40 and 100 percent. The weighting factor for juvenile percent passage was varied between 0 and 40 percent. The weighting factor for relative percentage of upstream habitat made accessible if passage conditions at the site are remediated was varied between 0 and 30 percent. The threshold percent passage for adult steelhead used to define a substantial barrier was varied between 60 and 90 percent. The tests suggested that small changes in the distribution of the weights generally had negligible influence on the scores of Assessment Sites and that adult passage was the most significant metric affecting variation in the

[‡] The value used for the maximum distance in RMs between any site and the next upstream site qualifying as a substantial barrier (adult passage less than 80 percent) is 3.61 miles, the distance between sites 33.1 and 32.

[§] The value used for RM at Stevens Creek Dam is 12.81.

cumulative scores among sites. Final weighting values were selected in coordination with Valley Water. The sum of the weighting factors is 100 percent.

Once the scores were calculated for each Assessment Site, the sites were grouped into red, yellow, and green categories by score, as follows:

- Red score category – Sites with scores ranging from 1 to 14
- Yellow score category – Sites with scores ranging from 15 to 24
- Green score category – Sites with scores 25 and higher

The lowest scores generally indicate sites lower in the stream system with poor passage conditions for steelhead and where remediation may open more habitat for more steelhead than other sites; therefore, sites with the lowest scores were placed into the red score category.

3 RESULTS

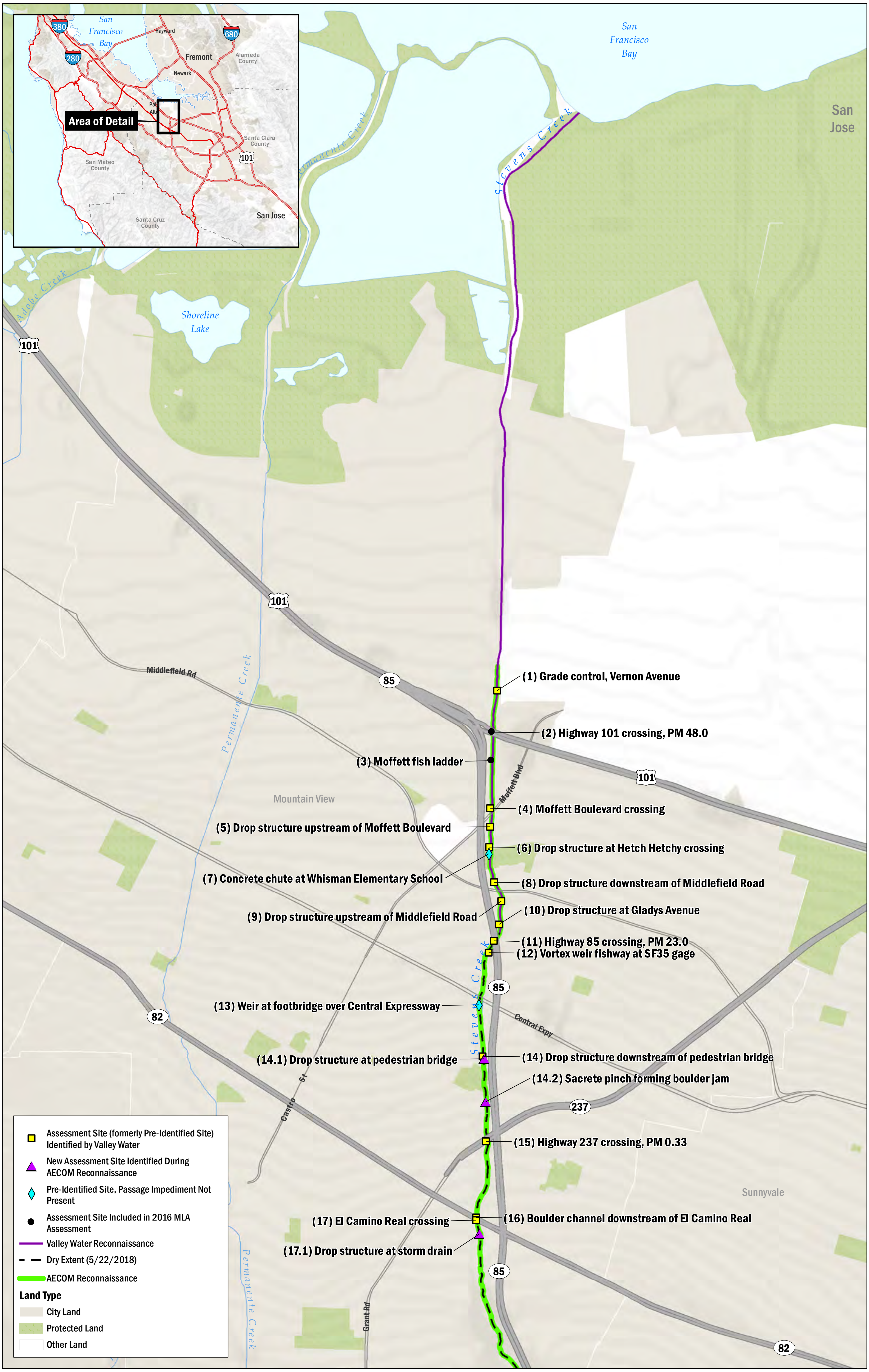
This section presents the results of the Study, including field reconnaissance, passage conditions at the Assessment Sites, and scoring.

3.1 FIELD RECONNAISSANCE

The extent of Stevens Creek walked by the Team during the field reconnaissance is shown on Figure 2. Reconnaissance conducted by Valley Water, described in detail in Attachment A, is also shown on Figure 2. As depicted in the figure, the combined extent of the Team's reconnaissance and Valley Water's reconnaissance completely covered the Study Area, from Stevens Creek Dam to San Francisco Bay, except for a short reach between RMs 3.93 and 4.05, where Valley Water is separately planning channel modifications that would mitigate impediments to fish passage.

During the Team's reconnaissance, the presence of some Pre-Identified Sites was confirmed, others were dropped from the Study, and new sites were added (Figure 2). Of 34 Pre-Identified Sites, the Team confirmed the presence of 25 and failed to locate 9 (presumably because they no longer exist). The Pre-Identified Sites included some passage impediments that had been directly observed by Valley Water in recent years; they also included passage impediments that had been recorded in the PAD from various sources over the years, some of which may have been removed or modified, or may have changed over time. Additionally, the Team found 5 fish passage impediments during field reconnaissance that were not included in the list of Pre-Identified Sites. The net of the field reconnaissance (34 Pre-Identified Sites, minus 9, plus 5) was a list of 30 sites that moved forward as Assessment Sites. These Assessment Sites, as well as Pre-Identified Sites where no passage impediment was present, are all shown in Figure 2. Figure 2 also shows the section of stream in the intermittent reach that was dry in May 2018 during the Team's reconnaissance surveys.

A complete list of sites considered in the Study is shown in Table 5. This table includes a complete accounting of Pre-Identified Sites, both found and not found, as well as sites added to the Study during field reconnaissance. For all sites, Table 5 includes the flow direction, RM, site number, HEC-RAS model reach, Assessment Site name, latitude and longitude coordinates, and whether the potential barrier was found during the Team's reconnaissance. Sites are listed in order by RM, and the PAD ID is shown for sites already included in the PAD. The PAD ID is the unique identification number given to each site in the CDFW-maintained PAD; newly identified Assessment Sites had not been assigned PAD IDs at the time this report was published. In some cases, the Assessment Site names in Table 5 differ from the PAD Descriptions shown in Table 1. Sites were renamed or given a concise name that the Team found accurately described the feature, because some of the PAD Descriptions did not. Sites in the PAD can be definitively tracked using the PAD ID. Tables and figures shown later in this report include only the Assessment Sites, some of which were previously Pre-Identified Sites and some of which were added incidentally to the Study following field reconnaissance. Moving forward, only the Assessment Site names are used. Results of the steelhead passage assessment completed for the Assessment Sites are presented in the following sections.



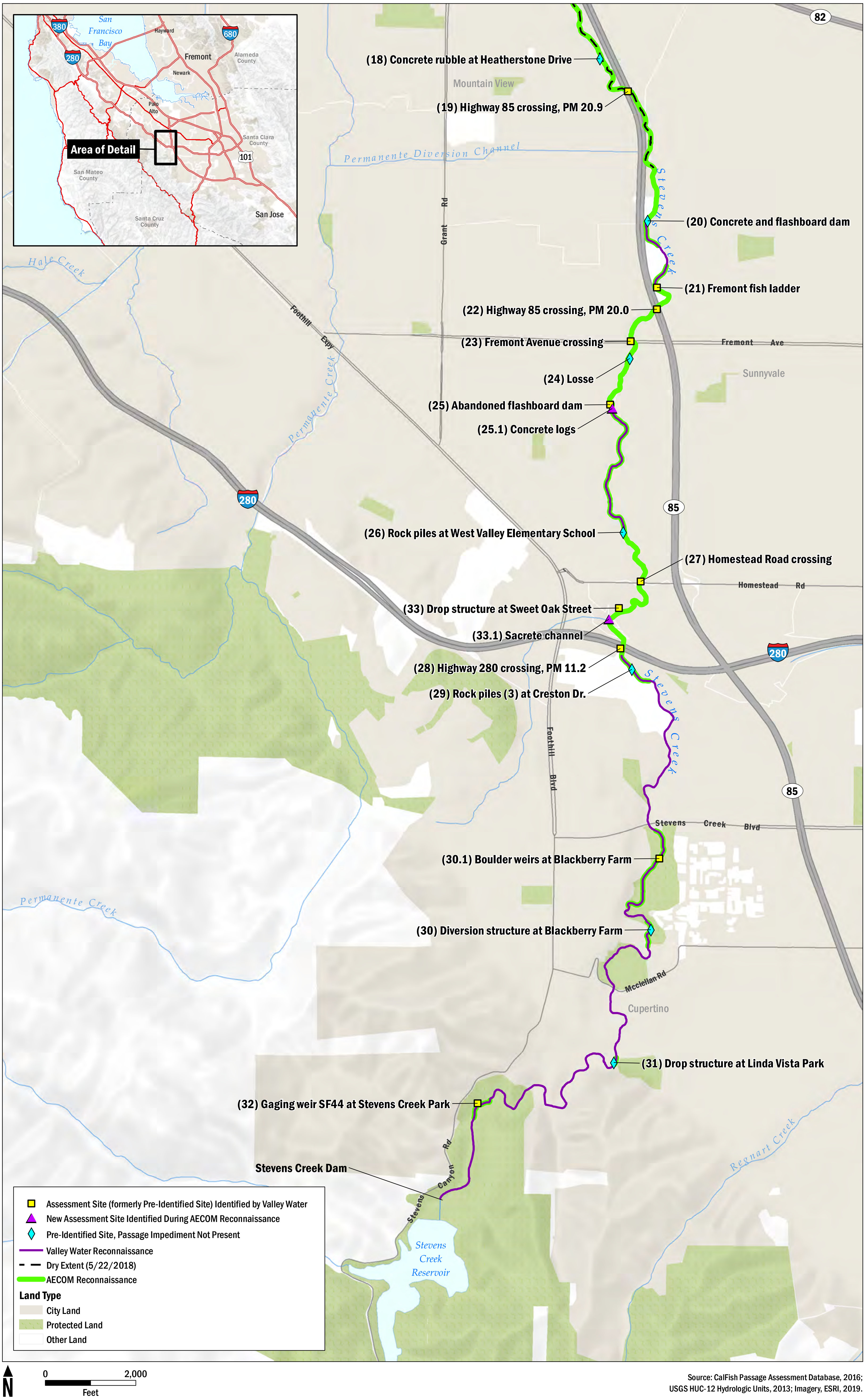
N

0 2,000 Feet

Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 2 (North)
Results of Reconnaissance



Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 2 (South)
Results of Reconnaissance

Table 5. Pre-Identified and Newly Identified Assessment Sites

	River Mile	Pre-Identified Site No.	Assessment Site No.	Reach No.	Assessment Site Name	Coordinates	Site Found?	PAD ID
	2.64	1	1	1	Grade control, Vernon Avenue	37.410868, -122.068759	Yes	713640
	2.81	2	2	2	Highway 101 crossing, PM 48.0	37.408345, -122.069111	Yes	705646
	2.93	3	3		Moffett fish ladder	37.406629, -122.069113	Yes	707059
	3.13	4	4	3	Moffett Boulevard crossing	37.403765, -122.069144	Yes	713641
	3.21	5	5		Drop structure upstream of Moffett Boulevard	37.402642, -122.069119	Yes	713642
	3.29	6	6		Drop structure at Hetch Hetchy crossing	37.401421, -122.069167	Yes	713643
	3.32	7	NA		—	37.401007, -122.069174	No	713644
	3.44	8	8		Drop structure downstream of Middlefield Road	37.399298, -122.068750	Yes	713645
	3.53	9	9		Drop structure upstream of Middlefield Road	37.398158, -122.068170	Yes	713646
	3.63	10	10		Drop structure at Gladys Avenue	37.396752, -122.068327	Yes	713647
	3.7	11	11		Highway 85 crossing, PM 23.0	37.395755, -122.068706	Yes	713648
	3.76	12	12		Vortex weir fishway at SF35 gage	37.395049, -122.069084	Yes	707058
	3.99	13	NA	NA	—	37.391873, -122.069750	No[1]	713649
	4.2	14	14	4	Drop structure downstream of pedestrian bridge	37.388777, -122.069397	Yes	713650
	4.21	NA	14.1		Drop structure at pedestrian bridge	37.388636, -122.069289	Yes	—
	4.39	NA	14.2	5	Sacrete pinch forming boulder jam	37.386036, -122.069117	Yes	—
	4.56	15	15	6	Highway 237 crossing, PM 0.33	37.383653, -122.06904	Yes	713651
	4.89	16	16	7	Boulder channel downstream of El Camino Real	37.379045, -122.069681	Yes	713652
Flow ↑	4.9	17	17		El Camino Real crossing	37.378876, -122.069681	Yes	733959
	4.96	NA	17.1		Drop structure at storm drain	37.378044, -122.069439	Yes	—
	5.62	18	NA	NA	—	37.369265, -122.066139	No	713653
	5.85	19	19	8	Highway 85 crossing, PM 20.9	37.367313, -122.063958	Yes	713654
	6.47	20	NA	NA	—	37.359482, -122.062315	No	715100
	6.82	21	21	9	Fremont fish ladder	37.355436, -122.061515	Yes	707056
	6.96	22	22	10	Highway 85 crossing, PM 20.0	37.354120, -122.061493	Yes	733951
	7.15	23	23	11	Fremont Avenue crossing	37.352159, -122.063441	Yes	713655
	7.24	24	NA	NA	—	37.351107, -122.063496	No	716244
	7.46	25	25	12	Abandoned flashboard dam	37.348288, -122.064913	Yes	713656
	7.48	NA	25.1		Concrete logs	37.348056, -122.064756	Yes	—
	7.9	26	NA	NA	—	37.34055, -122.063778	No	713657
	8.37	27	27	13	Homestead Road crossing	37.337599, -122.062381	Yes	713658
	8.62	33	33	14	Drop structure at Sweet Oak Street	37.335961, -122.063997	Yes	—
	8.67	NA	33.1		Sacrete channel	37.335275, -122.064742	Yes	713659
	8.82	28	28		Highway 280 crossing, PM 11.2	37.333512, -122.063825	Yes	713660
	8.92	29	NA	NA	—	37.332259, -122.062942	No	713661
	9.93	30.1	30.1	16	Boulder weirs at Blackberry Farm	37.320811, -122.060600	Yes	—
	10.4	30	NA	NA	—	37.316481, -122.061167	No	713663
	11.26	31	NA	NA	—	37.308373, -122.063805	No	713665
	12.28	32	32	15	Gaging weir SF44 at Stevens Creek Park	37.305775, -122.074104	Yes	713667

Note:

1 Pre-Identified Site No. 13, PAD ID 713649, refers to a weir that has been removed. Separate from this study, Valley Water is planning modifications to mitigate impediments to fish passage at that location. To avoid duplication of effort, that section of Stevens Creek is not analyzed in this report.

PAD ID = Passage Assessment Database Identification Number
PM = post mile

3.2 PASSAGE CONDITIONS AT ASSESSMENT SITES

Two-page assessment summary sheets for each of the Assessment Sites are provided in Attachment E. The summary sheets describe the features and include photographs of each site. They also list the types and locations of passage limitations identified for the site and the flow range during which they persist.

Using the passage evaluation filter, all the Assessment Sites were confirmed as passage impediments (Gray or Red), except for Site 23 (aggraded sediments at Fremont Avenue). Site 23 was classified as “Green,” or not a barrier, based on CDFW protocol for the “Green-Gray-Red” passage evaluation filter.

Flows meeting passage assessment criteria for juvenile and adult anadromous steelhead, along with the percent passage, are provided for each Assessment Site in Table 6. As defined in Section 1.2, percent passage is the proportion of passage assessment flows that meet assessment criteria and should not be confused with the percentage of the fish population that may successfully pass an Assessment Site. Sites identified as partial barriers or complete barriers fail to meet fish passage criteria throughout some or all (respectively) of the fish passage flow range, but the criteria are intentionally conservative. Fish passage criteria are generally intended to identify conditions that accommodate passage of an average or even below-average fish (i.e., in terms of size and swimming and leaping ability), and it is generally understood that some fish are sometimes able to pass sites that are identified as barriers through this type of analysis . In other words, anadromous fish may be present upstream of a site identified through a fish passage analysis as a barrier.

For Site 23, the “Green” site, the percent passage is listed as 100 percent. Additional considerations for some of the sites are noted in the right-hand or “Comments” column. These notes generally describe factors not well represented in the quantitative assessment that may affect fish passage or result in fish injury. Additional discussion related to these notes is provided in Section 3.4.

In addition to the passage assessment results based on the range of defined fish passage flows, flows meeting passage assessment criteria for adults up to 619 cfs (the 2-year return period flow based on annual peak flow records from station SF35 on Stevens Creek from water years 1990 through 2017) are also listed in Table 6. The intent of the column is to indicate the range of flows meeting passage criteria. The upper end of the passage range is reported in some cases as greater than 619 cfs (>619 cfs), indicating suitable passage conditions provided at flows greater than 619 cfs, but the upper flow range was not identified.

The suitable passage windows for adult steelhead are plotted for each site on Figure 3. This figure demonstrates the locations where adult passage may be completely blocked, as well as temporally blocked, and can be used to illustrate the relationships among passage conditions at the Assessment Sites. The figure shows fish passage assessment flows (representing the range of flows between which fish may be more likely to migrate) bound between the black, dashed lines; the range of flows for which each site is passable is shown in blue and those for which each site is impassable are shown in red; sites are organized from downstream on the left to upstream on the right. The plot may be used to consider the routing of migrating adult steelhead to upstream habitat. Imagine a fish beginning in San Francisco Bay and, at a flow of 125 cfs, trying to migrate upstream. Sites 2 and 6 are clearly major impediments to the fish’s migration and would rank high for remediation in any analysis (this is also applicable to Site 14). Assuming those sites have

Table 6. Summary of Fish Passage Assessment Flows Meeting Assessment Criteria for Each Assessment Site

River Mile	Site No.	Assessment Site Name	Adult Steelhead			Juvenile Steelhead			Comments
			Passage Flows Meeting Assessment Criteria (cfs)	Adult Percent Passage (a)[1]	Total Passage Range[2] (cfs)	Passage Flows Meeting Assessment Criteria (cfs)	Juvenile Percent Passage (b)[1]	Total Passage Range (cfs)	
2.64	1	Grade control, Vernon Avenue	57 to 203	73%	57 to 374	None	0%	None	
2.81	2	Highway 101 crossing, PM 48.0	None	0%	None	None	0%	None	
2.93	3	Moffett fish ladder	59 to 203	72%	59 to 240	None	0%	None	Frequent debris clogging Denil fishway and poor attraction
3.13	4	Moffett Boulevard crossing	15 to 203	94%	15 to >619	3 to 28	89%	3 to 38	
3.21	5	Drop structure upstream of Moffett Boulevard	46 to 203	79%	46 to 213	None	0%	None	
3.29	6	Drop structure at Hetch Hetchy crossing	None	0%	None	None	0%	None	
3.44	8	Drop structure downstream of Middlefield Road	58 to 203	73%	58 to 240	None	0%	None	
3.53	9	Drop structure upstream of Middlefield Road	49 to 203	77%	49 to 329	None	0%	None	
3.63	10	Drop structure at Gladys Avenue	9 to 203	97%	9 to >619	1 to 16	54%	1 to 16	
3.70	11	Highway 85 crossing, PM 23.0	35 to 203	84%	35 to 250	None	0%	None	
3.76	12	Vortex weir fishway at SF35 gage	3 to 90	44%	1 to 90	None	0%	None	
4.20	14	Drop structure downstream of pedestrian bridge	63 to 67	2%	63 to 67	None	0%	None	Roughness of boulders likely provide adult passage at higher flows than estimated
4.21	14.1	Drop structure at pedestrian bridge	64 to 203	70%	64 to 232	None	0%	None	
4.39	14.2	Sacrete pinch forming boulder jam	14 to 203	95%	14 to 262	None	0%	None	
4.56	15	Highway 237 crossing, PM 0.33	25 to 203	89%	25 to >619	None	0%	None	
4.89	16	Boulder channel downstream of El Camino Real	16 to 203	94%	16 to 330	None	0%	None	Boulders likely provide adult and juvenile passage at higher flows than estimated
4.90	17	El Camino Real crossing	63 to 203	70%	63 to 331	None	0%	None	
4.96	17.1	Drop structure at storm drain	34 to 89	28%	34 to 89	None	0%	None	
5.85	19	Highway 85 crossing, PM 20.9	17 to 203	93%	17 to >619	None	0%	None	Coarse streambed likely provides better passage than estimated for juveniles
6.82	21	Fremont fish ladder	42 to 130	70%	42 to 203	None	0%	None	Frequent debris clogging of Denil fishway
6.96	22	Highway 85 crossing, PM 20.0	68 to 130	50%	68 to >619	None	0%	None	
7.15	23	Fremont Avenue crossing	NA	100%	NA	NA	100%	NA	Site determined to be classified as "Green"
7.46	25	Abandoned flashboard dam	38 to 130	74%	38 to 619	9 to 17	29%	9 to 17	
7.48	25.1	Concrete logs	22 to 130	86%	22 to 558	None	0%	None	Hydraulic complexity likely provides better juvenile passage than estimated
8.37	27	Homestead Road crossing	24 to 130	85%	24 to 277	None	0%	None	Jagged debris among concrete rubble may pose risk of harm to adult fish
8.62	33	Drop structure at Sweet Oak Street	49 to 130	65%	49 to 296	None	0%	None	
8.67	33.1	Sacrete channel	37 to 130	74%	37 to >619	None	0%	None	
8.82	28	Highway 280 crossing, PM 11.2	18 to 130	90%	18 to 360	None	0%	None	Juvenile passage likely better than estimated, given shallow and slow water along the channel ed
9.93	30.1	Boulder weirs at Blackberry Farm	5 to 130	100%	5 to 494	None	0%	None	Hydraulic complexity likely provides juvenile passage at all assessment flows
12.28	32	Gaging weir SF44 at Stevens Creek Park	None	0%	260 to >619	None	0%	None	

Notes:

[1] Letters a and b refer to scoring calculation described in Section 2.4. "Percent Passage" refers to the proportion of passage assessment flows meeting assessment criteria, not to be confused with the percentage of the fish population that may successfully pass an Assessment Site.

[2] The assessment evaluated passage at flows up to and including 619 cfs, which is the estimated 2-year flow based on data from the SF35 gage. If the site was found to be passable at 619 cfs, then >619 indicates the site is likely passable at flows greater than 619 cfs, which were not assessed.

cfs = cubic feet per second
PM = post mile

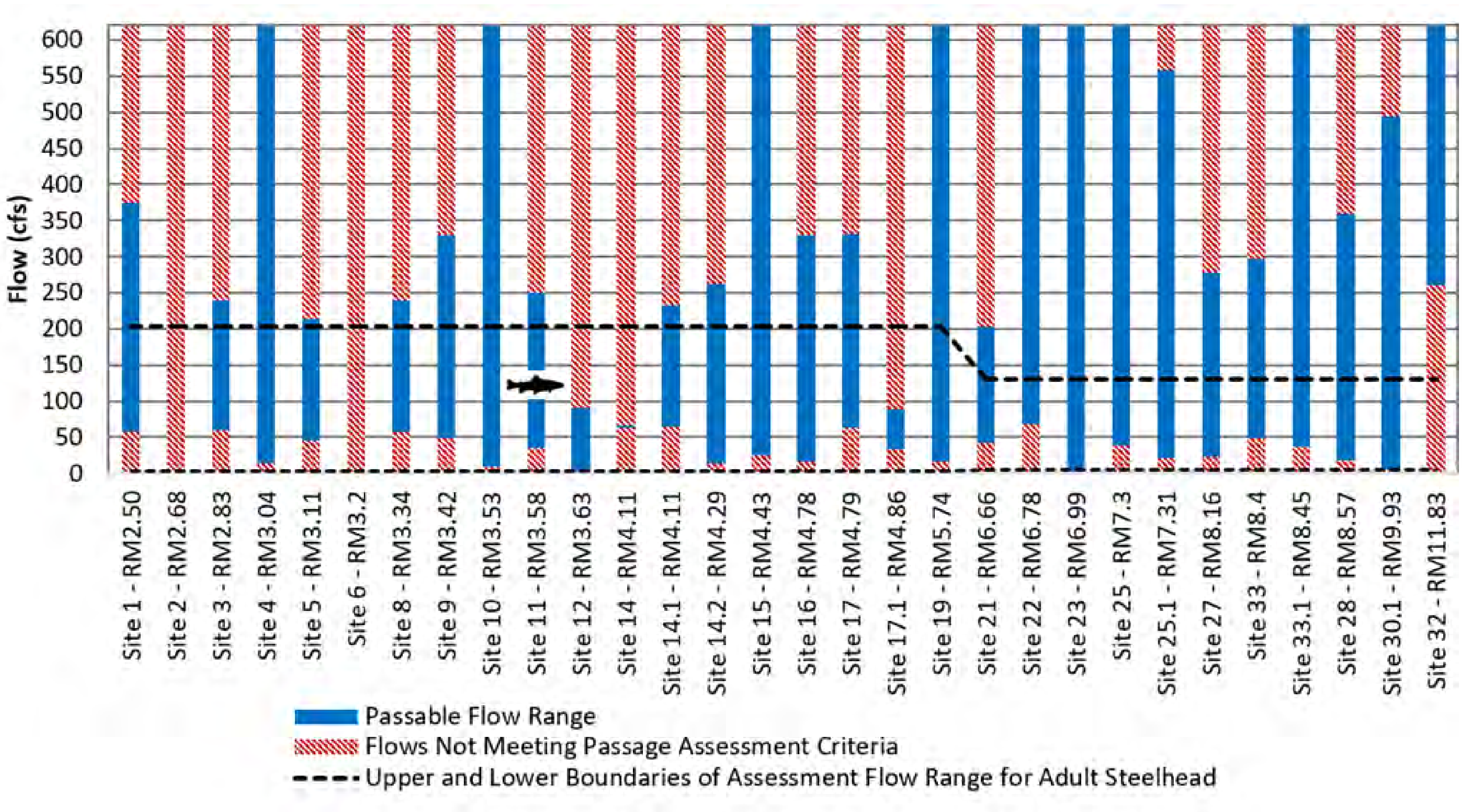


Figure 3. Flows Meeting Passage Assessment Criteria for Adult Steelhead at Each Assessment Site, from Zero to 619 cfs

Note: Sites are arranged from downstream to upstream, with the river mile (RM) indicated. The low and high fish passage assessment flows shown with horizontal dashed lines are 3 cfs and 203 cfs for sites 1 through 19 and 5 cfs and 130 cfs for sites 20 through 32.

been remediated, during its migration the fish could easily swim upstream to Site 12; but because Site 12 is passable only at low flows, the fish would have to hold downstream of Site 12 until flows receded to below 90 cfs, potentially reducing passage opportunities at upstream impediments as flows continue to recede. The same issue may arise at Site 17.1. If an adult steelhead waits at Site 17.1 for flows to recede to a range that allows passage, it may arrive at Site 21 or 22 when flows are too low to provide passage. These scenarios illustrate how the passage flow range at some of the temporal barriers can affect the timing of passage at upstream sites. Although sites such as 12 and 17.1 are passable at lower flows relative to some of the other Assessment Sites, they do not provide passage during the higher end of the fish passage flow range, which may have substantial effect on migration.

3.3 SCORING

All Assessment Sites were scored based on the four metrics described in the methods section. The maximum possible score is 100. Each site was placed into its respective scoring category (red, yellow, or green). Site scores and corresponding score categories are listed in Table 7, and Assessment Sites with their score categories denoted are shown on Figure 4. The scores are the result of a specific, repeatable, quantitative analysis; however, other observations related to fish passage and protection that do not lend themselves to this type of quantitative analysis should also be considered when using these results to prioritize Assessment Sites for passage remediation. These additional considerations are described in Section 3.4.

3.4 DISCUSSION

This section provides a discussion of the results presented in Section 3.3, specifically of factors related to fish passage and protection that should be considered when the Assessment Sites are prioritized for remediation. As described in Section 2.4, the scoring formula used in this Study heavily weighted watershed position, which was the most important metric dictating overall Assessment Site scores. A reader interested in a particular scoring metric, such as adult passage, can review the tabular results (Table 7) and evaluate any single scoring metric on its own.

Although the assessment scores generally reflect their potential to impede steelhead movement, there are important considerations not captured in the quantitative analysis. Some Assessment Sites provide poor conditions for juvenile and adult steelhead upstream movement (Table 7). Many of the sites in the red score category are low in the watershed (Figure 4). For example, Site 2 (Highway 101 crossing, Post Mile 48.0) received the lowest score. Based on agency criteria, it is a complete barrier and it is very low in the watershed (RM 2.81). Sites in the yellow score category provide some passage for adults and in one case also provides juvenile passage opportunities. Sites in the green score category generally provide reasonable passage conditions for adults, and in some cases provide passage opportunities for juveniles. Deviations from these general trends and additional considerations important to fish passage that should be evaluated when prioritizing sites for remediation are described below, ordered by site number from low to high.

- Site 1 (Grade Control, Vernon Avenue) received a score of 12 and is in the red score category. This is the most downstream of the Assessment Sites, at RM 2.64. Although the analysis shows it passable 73 percent of the time by adults, the passage conditions are not suitable until flows rise to nearly 60 cfs. Meanwhile, many of the Assessment Sites upstream are passable at lower flows. Because of its location in the watershed, this site could prevent adult steelhead from moving upstream following early winter storms, thereby limiting passage opportunities at upstream temporal barriers (see Figure 3).

Table 7. Assessment Sites, Scores, and Score Categories

Site No.	River Mile	Assessment Site Name	Adult Percent Passage (a)[1, 2]	Juvenile Percent Passage (b)[1, 2]	Relative Distance to Next Upstream Barrier (c)[1]	Percentage of Assessment Reach Downstream of Site (d)[1]	Score
Red Score Category (Scores 1-14)							
2	2.81	Highway 101 crossing, PM 48.0	0%	0%	3%	22%	2
6	3.29	Drop structure at Hetch Hetchy crossing	0%	0%	4%	26%	2
14	4.20	Drop structure downstream of pedestrian bridge	2%	0%	0%	33%	4
32	12.28	Gaging weir SF44 at Stevens Creek Park	0%	0%	15%	96%	8
17.1	4.96	Drop structure at storm drain	28%	0%	52%	39%	9
12	3.76	Vortex weir fishway at SF35 gage	44%	0%	12%	29%	12
1	2.64	Grade control, Vernon Avenue	73%	0%	5%	21%	12
3	2.93	Moffett fish ladder	72%	0%	8%	23%	14
Yellow Score Category (Scores 15-24)							
5	3.21	Drop structure upstream of Moffett Boulevard	79%	0%	2%	25%	16
8	3.44	Drop structure downstream of Middlefield Road	73%	0%	2%	27%	16
9	3.53	Drop structure upstream of Middlefield Road	77%	0%	6%	28%	17
14.1	4.21	Drop structure at pedestrian bridge	70%	0%	19%	33%	19
11	3.70	Highway 85 crossing, PM 23.0	84%	0%	2%	29%	20
17	4.90	El Camino Real crossing	70%	0%	2%	38%	23
4	3.13	Moffett Boulevard crossing	94%	89%	2%	24%	23
22	6.96	Highway 85 crossing, PM 20.0	50%	0%	14%	54%	24
Green Score Category (Scores 25-100)							
10	3.63	Drop structure at Gladys Avenue	97%	54%	4%	28%	25
15	4.56	Highway 237 crossing, PM 0.33	89%	0%	9%	36%	25
14.2	4.39	Sacrete pinch forming boulder jam	95%	0%	14%	34%	26
16	4.89	Boulder channel downstream of El Camino Real	94%	0%	0%	38%	29
21	6.82	Fremont fish ladder	70%	0%	4%	53%	31
19	5.85	Highway 85 crossing, PM 20.9	93%	0%	27%	46%	33
33.1	8.67	Sacrete channel	74%	0%	100%	68%	35
33	8.62	Drop structure at Sweet Oak Street	65%	0%	1%	67%	37
25	7.46	Abandoned flashboard dam	74%	29%	32%	58%	37
25.1	7.48	Concrete logs	86%	0%	32%	58%	39
28	8.82	Highway 280 crossing, PM 11.2	90%	0%	96%	69%	43
27	8.37	Homestead Road crossing	85%	0%	7%	65%	45
23	7.15	Fremont Avenue crossing	100%	100%	9%	56%	55
30.1	9.93	Boulder weirs at Blackberry Farm	100%	0%	65%	78%	57

Notes:

1 Letters a, b, c, and d refer to the metrics in the scoring calculation defined in Section 2.4.

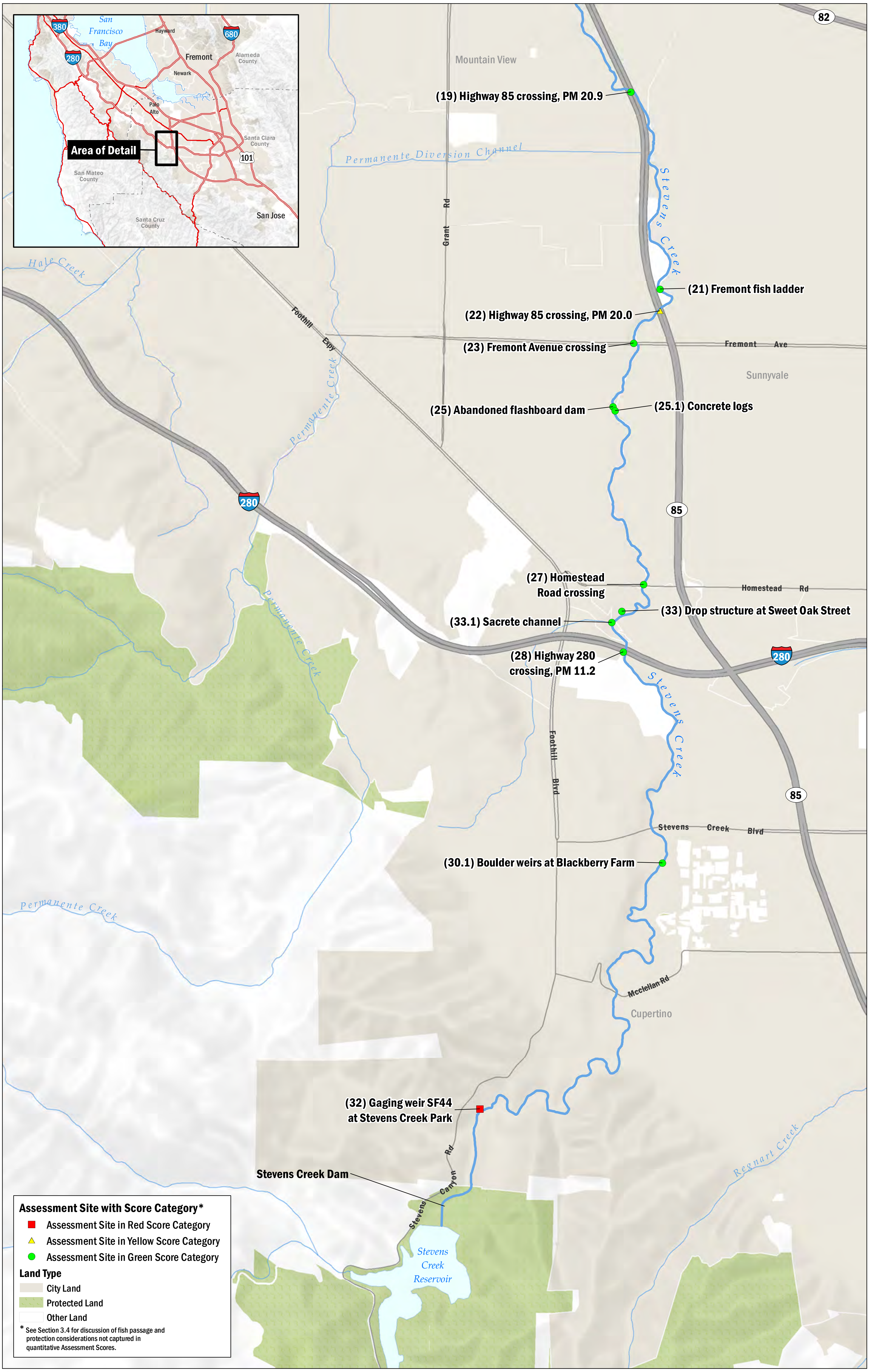
2 “Percent Passage” refers to the proportion of passage assessment flows meeting assessment criteria, not to be confused with the percentage of the fish population that may successfully pass an Assessment Site.

PM = post mile

Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 4 (North)
Assessment Site with Score Categories



Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 4 (South)
Assessment Sites with Score Categories

- Site 3 (Moffett fish ladder) received a score of 14 and is in the red score category. However, observed frequent clogging of the fish ladder with small debris, which makes it impassable much of the migration season, is not captured by the model results. Denil fish ladders (Site 3 and Site 21) have a propensity to clog with sediment and small debris. Maintenance during the migration season is restricted to manual debris removal, which is not always effective or possible during high flows, so these sites may be impassable during substantial portions of the migration season when steelhead are most likely attempting to migrate upstream. Adult passage at this site is likely much lower than the 72 percent suggested by the quantitative analysis.

- Site 4 (Moffett Boulevard crossing) received a score of 23 and is in the yellow score category. The crossing is passable by juveniles and adults at most flows, with insufficient depth at lower flows being the only substantial passage issue. Deposition observed throughout the primary culvert (Attachment E) likely further improves passage conditions. Considering the relatively favorable passage conditions observed at the time of the field survey and evaluated in the Study, the site may not warrant remediation for fish passage; note that its score and placement into the yellow score category were heavily influenced by its position low in the watershed.

- Site 12 (Vortex weir fishway at SF35 gage) received a score of 12 and is in the red score category. The fishway was designed for fish passage and provides reliable passage at lower flows; at flows higher than 90 cfs, however, the water surface drop over the fishway entrance weir (downstream most weir) exceeds the adult passage leap height criterion of 1.5 feet (see Site 12 photographs in Attachment E). In all other ways, the fishway meets passage criteria at all passage assessment flows for adults.

  The shape and roughness of the downstream channel and box culvert controls the water level downstream of the entrance weir and thus influences the overall leap height over the weir. Debris may sometimes naturally accumulate downstream of the structure and reduce the height of the leap required to enter the fishway. An additional weir or half-weir immediately downstream of the structure might decrease the leap height and increase the range of flows meeting passage criteria. This structure has been known to result in fish stranding when the channel reach dries in the spring.

- Site 17 (El Camino Real crossing) received a score of 23 and is in the yellow score category. This site is directly upstream of Site 16 (Boulder channel downstream of El Camino Real), which is a long and steep boulder channel. Site 16 is passable at lower flows than Site 17, raising concern that flow at Site 17 could be too shallow when adult steelhead arrive. There is poor holding habitat between the two sites, which could lead to a steelhead reaching the point of exhaustion and falling back down through Site 16.

- Site 21 (Fremont fish ladder) received a score of 31 and is in the green score category. At this site, poor fishway entrance conditions and the overtopping of the fishway sidewall at higher fish passage flows affect conditions for adult passage. The Fremont fish ladder is also a Denil, and clogging and maintenance issues are the same as those described above for Site 3 (Moffett fish ladder). Because these conditions are not captured in the quantitative results, adult passage is likely much lower than the 70 percent suggested by the quantitative analysis.

- Site 27 (Homestead Road crossing) received a score of 45 and is in the green score category. Although modeled results indicate that adult passage criteria are met between 24 and 277 cfs, or 85 percent of the passage assessment flow range, concrete rubble spans the channel at this site and creates a narrow chute that could result in injury to migrating steelhead. There is also a lot of overhanging concrete in the flow area that is not well reflected in the HEC-RAS model because overhangs could not be modeled. Additional rubble along the banks may fall into the channel in the near-term, further exacerbating fish passage conditions.

- Site 32 (Gaging weir SF44 at Stevens Creek Park) received a score of 8 and is in the red score category. Although this site requires a leap (2.4 feet drop height) that exceeds the height criteria for adult passage at all evaluated flows, the configuration of the site—with a well-concentrated nappe, a relatively deep plunge pool (4.4 feet depth), and a safe landing pool upstream of the weir—likely make passage for an adult steelhead easier than suggested by the quantitative results. This is the most upstream of the Assessment Sites and there is only 0.53 RM between Site 32 and Stevens Creek Dam, a limited amount of habitat with value to steelhead that may be compromised by effects of Stevens Creek Dam and reservoir.

- Site 33 (Drop structure at Sweet Oak Street) received a score of 37. This is the only Assessment Site in the green score category with adult passage less than 70 percent. Adult passage at this site was modeled at 65 percent, but conditions not captured in the model may exacerbate passage conditions or cause fish injury. There is a hole in the concrete apron (visible in the Site 33 photos included in Attachment E) with exposed rebar, which could cause fish injury and fall-back. Additionally, because of its deterioration, the structure tends to catch debris that further affects passage conditions.

The scoring results provided in this Study were developed based largely on the percent of flows passable for adult steelhead at a site and the position of the site in the watershed. The additional considerations listed above for select sites were not used to adjust their scores or score category placements, because category placement was based solely on the quantitative scores calculated for each Assessment Site. However, these additional considerations should inform future efforts to prioritize barriers for remediation. Other biological considerations not accounted for in the scoring could also affect how these sites are prioritized by others for remediation. These considerations may include location of suitable spawning habitat, life history strategies of rearing juvenile steelhead, water quality conditions, and channel drying. If future fisheries studies suggest that additional metrics should be considered, they could be added to the scoring, used to adjust the results, or factored into a future prioritization study, as appropriate. Valley Water will prioritize the Assessment Sites for remediation based on several factors, including the results of this Study, property ownership (Attachment F), and construction cost and logistics.

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5 LIST OF REPORT PREPARERS

The Study was completed for Valley Water by the AECOM-MLA Team, which consists of AECOM as the prime consultant and MLA as the subconsultant. Key staff members contributing to the Study are listed in Table 8 below.

Table 8. List of Study Participants and Report Preparers

Staff Member	Affiliation	Study Role
P. Travis James, P.E.	MLA	Technical Staff
Chris Komlos	Valley Water	Reviewing Water Resources Specialist
Clayton Leal	Valley Water	Reviewing Biologist
Michael Love, P.E.	MLA	Fisheries Engineering Lead
Jessica Lovering	Valley Water	Reviewing Engineer
James Manitakos	Valley Water	Reviewing Water Resources Specialist
Katie McLean	AECOM	Technical Staff
Steve McNeely, P.E.	AECOM	Technical Staff
Melissa Moore	Valley Water	Valley Water Project Manager
Jason Nishijima	Valley Water	Reviewing Water Resources Specialist
Kevin Sibley	Valley Water	Valley Water Project Manager
Jonathan Stead	AECOM	Project Manager and Lead Fish Biologist

Qualifications of the key consultant AECOM-MLA Team members are listed below. Other contributing technical staff members included Oliver Light, Sarah Kassem, and Ryan Haines, AECOM; and Antonio Llanos, MLA.

Jonathan Stead is a fish and wildlife biologist and senior project manager with more than 20 years of experience, with expertise in fish passage, steelhead biology, and aquatic ecology. He earned his master's degree studying fish ecology at UC Davis under Dr. Peter Moyle and currently leads multidisciplinary teams on complex stream restoration, fish passage, dam removal, and water infrastructure projects. Jon has been a major contributor to important fish passage and stream restoration projects for various organizations, including the San Francisco Public Utilities Commission, Monterey Peninsula Water Management District, United States Bureau of Reclamation, Stanford University, and Klamath River Renewal Corporation.

Michael Love, P.E., has been the managing principal of Michael Love & Associates, Inc., since 1999. Michael has extensive interdisciplinary experience in fisheries and fluvial geomorphology, design of stream restoration, and technical and nature-like fishways. He was lead developer of the widely used FishXing software and was a primary author of the fish passage assessment and fish passage design and implementation sections of CDFW's California Salmonid Stream Habitat Restoration Manual (CDFG 2004, CDFG 2009). Michael has been the lead fish passage engineer for more than four dozen passage projects, has led more than two dozen trainings instructing participants on fish passage design and assessment, and regularly collaborates with Humboldt State University to conduct research into fish passage topics.

Steve McNeely, P.E., is a senior water resources engineer, fluvial geomorphologist, and project manager with more than 17 years of experience as an engineering and environmental consultant. Steve has led the planning, design, permitting, and construction supervision of numerous stream restoration projects, as well as the design of fish passage improvement projects ranging from culvert replacements to dam removals.

P. Travis James, P.E., is a licensed civil engineer with extensive experience in water resources engineering, with an emphasis on river systems. His experiences include fluvial geomorphology, fish passage engineering, fish screen systems, watershed hydrology, channel hydraulics, and bank stabilization. Travis has been lead design engineer on many fish passage improvement projects over the past 10 years.

Katie McLean is a fisheries and wildlife biologist with experience surveying special-status species, mapping salmonid habitat, and monitoring habitat conditions in restored streams and wetlands.

Attachment A

Valley Water Reconnaissance Surveys

MEMORANDUM

FC 14 (02-08-19)

TO: Mr. Jon Stead, Project Manager, AECOM

FROM: Santa Clara Valley Water District

SUBJECT: Reconnaissance Surveys for Portions of Stevens Creek to assess the presence of Potential Fish Passage Impediments

DATE: May 9, 2019

Objective: Reconnaissance survey for the presence of potential fish passage impediments for migratory and resident trout within the 12.5 miles of fresh water of Stevens Creek, downstream of Stevens Creek Reservoir. Collection of this data fills in data gaps in the comprehensive fish passage survey of Stevens Creek from the Stevens Creek Reservoir to South San Francisco Bay (Consultant Agreement 4827). The data gaps cover 39,700 linear feet (7.52 miles) of the creek channel, which represents 60.2% of the total study channel length of 66,000 ft (12.5 miles) (Figure 1). The surveys described herein cover all of the data gap areas.

Dates of Surveys: February 12, April 11, and May 2 2019

FEBRUARY 12, 2019 SURVEY

Weather: Overcast, 55° F
Discharge: [1]Gauge 5044 (0.6 miles downstream of Stevens Creek Reservoir-elevation 410 ft.) 108.3 to 109.9 cfs
[1]Gauge 5035 (Station located between Central Avenue and Highway 85-elevation 62 ft.) 89.7 to 105.6 cfs

Staff: Jessica Lovering, Assistant Engineer II
James Manitakos, Associate Water Resources Specialist

Study Area 1: Stevens Creek channel in Cupertino and unincorporated Santa Clara County, CA. Milepost 67,800 (Stevens Creek Dam) to Milepost 57,420 (McClellan Road).

Methodology: The team employed an ocular, walking (adjacent to stream) survey to assess the presence of suspected passage impediments. The team began the survey at the Stevens Creek County Park parking lot and walked the Stevens Creek trail adjacent to the creek upstream to the Stevens Creek Dam. The team then returned to the park parking lot and walked the Stevens Creek trail adjacent to the creek downstream to McClellan Road. Where necessary the team left the trail and walked overland to maintain visual contact with the creek channel throughout the survey area.

Results:

No new potential fish passage impediments were noted. The gauging weir at Stevens Creek Park (44), a previously identified potential impediment, is still present and was confirmed as a potential impediment (see photograph 1).

Photograph 1: Potential fish passage impediment at gauge weir at Stevens Creek Park

APRIL 11, 2019 SURVEY (Study Areas 2, 3, and 4)

Weather: Fair, 66° F
Discharge: [1]Gauge 5044:
40.2 cfs
[1]Gauge 5035:
36.9-29.2 cfs

Staff: Melissa Moore, Senior Water Resources Specialist
Jessica Lovering, Assistant Engineer II
James Manitakos, Associate Water Resources Specialist

Study Area 2: Stevens Creek channel in Cupertino, CA
Milepost 57,420 (McClellan Road) to Milepost 51,500 (Steven Creek Boulevard)

Methodology: The team began the survey at the upstream limits, McClellan Road, and employed an ocular, walking (adjacent to stream) survey to assess the presence of suspected passage impediments. The team walked the entire channel length of the stream from McClellan Road to Stevens Creek Boulevard. The stream was easily surveyed from the stream banks as instream flows (~40 cfs) made walking instream difficult, however, the stream bed and banks could be easily assessed by walking

1. This stream gauge data are Preliminary. Most data relayed by telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions and/or physical changes at the measurement site. Subsequent review of this data by SCVWD hydrographers may result in significant revisions to the data.

adjacent to the channel.   A Trimble Geo7x Global Positioning system hand survey instrument was available to record the location of features of interest.

Results:

One potential fish passage impediment was noted. Water clarity (i.e. turbidity) made viewing the stream bed during the reconnaissance survey challenging therefore, it was difficult to ascertain what type of structure (i.e. concrete weir, bridge footings) was creating the turbulent condition noted in Photograph 2. The potential passage impediment is located directly downstream of a pedestrian bridge crossing on the creek and therefore it was presumed to be infrastructure related to the bridge crossing. The spatial coordinates for this suspected barrier are as follows; latitude 37.32, longitude -122.06.

Photograph 2. Potential fish passage impediment downstream of footbridge.

1. This stream gauge data are <u>*Preliminary.*</u> *Most data relayed by telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions and/or physical changes at the measurement site. Subsequent review of this data by SCVWD hydrographers may result in significant revisions to the data.*

Weather: Fair, 60° F
Discharge: [1]Gauge 44
30.1-25.3 cfs
[1]Gauge 35
19.0-15.3 cfs

Staff: Melissa Moore, Senior Water Resources Specialist
Jessica Lovering, Assistant Engineer II
James Manitakos, Associate Water Resources Specialist

Study Areas: Stevens Creek channel in Cupertino and Los Altos, CA
Study Area 3: Milepost 51,500 (Stevens Creek Boulevard) to Milepost 46,600 (Interstate 280)
Study Area 4: Milepost 42,200 (West Valley Elementary School) to Milepost 39,300 (Kirchner Court)

Methodology: The team began the survey at the upstream limits and employed an ocular, wading (instream) survey to assess the presence of suspected passage impediments. The team waded the entire channel length in areas 3 and 4. A Trimble Geo7x Global Positioning system hand survey instrument was available to record the location of features of interest.

Results: No passage impediments were noted in Areas 3 and 4 of surveyed reaches.

MAY 2, 2019 SURVEY (Areas 5 and 6)

Weather: Fair, 72° F
Discharge: [1]Gauge 44: 16.9 to 16.5 cfs
[1]Gauge 35: 5.5 to 5.7 cfs

Staff:
James Manitakos, Associate Water Resources Specialist
Chris Komlos, Assistant Water Resources Specialist

Study Area 5: Stevens Creek channel in Sunnyvale, CA
Milepost 35,950 (Fremont Fish Ladder) to Milepost 35,100 (850 ft downstream)

Methodology: The team began the survey at the Fremont Fish Ladder and proceeded downstream. The team employed an ocular, walking (adjacent to stream) survey to assess the presence of suspected passage impediments. The team walked the entire study reach. A Trimble Geo7x Global Positioning system hand survey instrument was available to record the location of features of interest.

Results: No potential fish passage impediments were noted in Study Area 5.

Study Area 6: Stevens Creek channel in Mountain View, CA
Milepost 14,750 (Highway 101 culvert) to Milepost 0 (San Francisco Bay)

Methodology: The team began the survey at downstream end of the Highway 101 culvert and proceeded downstream to San Francisco Bay. The team employed an ocular, walking (adjacent to stream) survey to assess the presence of suspected passage impediments. The team walked the entire study reach. A Trimble Geo7x Global Positioning system hand survey instrument was used to record the location of features of interest.

1. This stream gauge data are Preliminary. Most data relayed by telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions and/or physical changes at the measurement site. Subsequent review of this data by SCVWD hydrographers may result in significant revisions to the data.

Results: Two previously recorded potential fish passage impediments were confirmed in Study Area 6: Highway 101 culvert (see Photograph 3) and chute and the grade control structure at Vernon Avenue (see Photograph 4). No other potential fish passage impediments were noted in Study Area 6.

Photograph 3: Highway 101 culvert and chute

1. This stream gauge data are <u>Preliminary.</u> Most data relayed by telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions and/or physical changes at the measurement site. Subsequent review of this data by SCVWD hydrographers may result in significant revisions to the data.

Photograph 4: Grade control structure at Vernon Avenue

1. This stream gauge data are <u>Preliminary.</u> Most data relayed by telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions and/or physical changes at the measurement site. Subsequent review of this data by SCVWD hydrographers may result in significant revisions to the data.

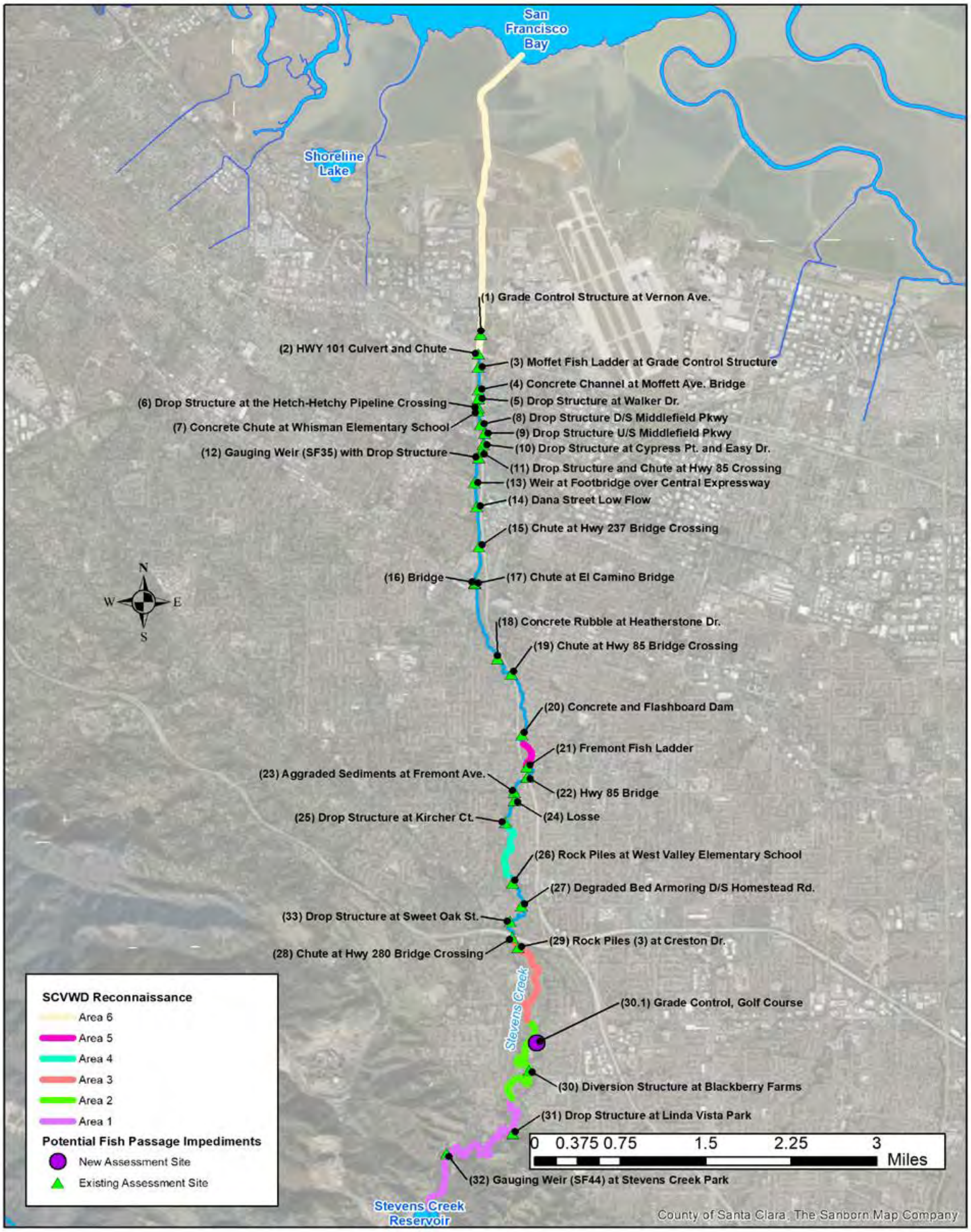


Figure 1. Locations of ocular, pedestrian surveys for potential fish passage impediments, Stevens Creek.

1. This stream gauge data are Preliminary. Most data relayed by telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions and/or physical changes at the measurement site. Subsequent review of this data by SCVWD hydrographers may result in significant revisions to the data.

Attachment B

Example Fish Passage Inventory Data Sheet

FISH PASSAGE INCIDENTAL REPORT (First Pass Data Sheet)

This form is intended to be used for rapid barrier inventorying and barrier data collection. It is not intended for barrier passage assessment and is not meant to replace any existing barrier assessment protocols.

**** Please fill Section I and II even when no barriers found!***

Send to: Anne Elston, CDFW, 830 S Street, Sacramento, CA 95814 or Anne.Elston@wildlife.ca.gov

I. GENERAL

Surveyor(s): | **Date:** / / | **Time:** AM/PM

Agency:

Weather: □ Sunny □ Overcast □ Raining

Water Conditions: □ Clear □ Turbid

Flow Conditions: □ Continuous □ Isolated pools □ Dry

Bank Conditions: □ Channel erosion □ Scour □ Rip/rap

Water Temperature (°C): | **Ambient Temperature (°C):**

II. LOCATION

Latitude: | **Longitude:** | **Quad Name:**

Stream Name: | **Tributary To:**

Barrier(s) Found?: □ Yes □ No | **Stream Segment Surveyed:**

Bank Location (looking downstream): □ Left □ Right □ Both | **Channel Type:** □ **V** □ **U**

Road Name: | **SCVWD Milepost:**

Photos Taken: □ Inlet □ Outlet □ Other

Photo Description/Numbers:

Land Owner: | **Structure Owner:**

III. STRUCTURE

Structure Type: □ Diversion □ Dam □ Arizona crossing (ford) □ Culvert □ Bridge □ Natural □ Other____________

Description:

Passage Status:

IV. FISH

Salmonids Observed Downstream? □ Yes □ No | **Salmonids Observed Upstream?** □ Yes □ No

V. DIVERSION

Diversion Type: □ Slant pump □ Floodgate □ Other_____ □ Vertical pump □ Centrifugal pump □ Siphon □ Submersible pump □ Pump other □ Weir

Pump Running? □ Yes □ No

Pipe Size: □ < 1 ft □ 1 – 2 ft □ > 2 ft

Screened? □ Yes □ No

VI. DAM

Dam Type: □ Earth □ Rock/cement □ Other_________

□ **Seasonal** □ **Permanent**

Dam Height (ft): | **Dam Width (ft):**

Passage Facility? □ Yes □ No

VII. CULVERT

Culvert Type: □ Box □ Circular □ Open-bottom arch □ Pipe arch □ Other____________ □ Abandoned/Unmaintained

Culvert Material: □ Concrete □ Metal □ Plastic □ Log/wood □ Other__________

Number of Barrels/Pipes:

Culvert Diameter: □ ≤ 2 ft □ > 2 ft

Culvert Height (ft): | **Culvert Width (ft):**

Outlet Drop Height: □ < 1 ft □ 1 – 3 ft □ > 3 ft

Weirs/Baffles? □ Yes □ No

Channel Width (ft):

VIII. BRIDGE

Bridge Type: □ Free span □ Instream structure | □ **Active** □ **Abandoned** | **Apron?** □ Yes □ No

IX. NATURAL

Natural Barrier Type: □ Waterfall □ Grade □ Landslide □ Log jam □ Other ____________

Waterfall Drop: □ ≤ 8 ft □ > 8 ft

X. ADDITIONAL NOTES

Does this site needs treatment?

What are specific treatment recommendations?

(Please use other side if needed for additional notes).

INSTRUCTIONS TO FISH PASSAGE INCIDENTAL REPORT

I. GENERAL

Surveyor - Enter the names of people conducting the survey.
Date/Time - Enter the day's date (mm/dd/yy) and the time of the survey.
Agency - Enter the agency name.
Weather - Check the box that best describes weather conditions on the day of the survey.
Water Conditions

- **Clear** - Free from pollution or cloudiness.
- **Turbid** - Muddy or cloudy water.

Flow Conditions

- **Continuous** - Free flowing water.
- **Isolated pools** - Pools are present but they are not connected by free flowing water.
- **Dry** - No water at all.

Bank Conditions

- **Channel erosion** - Channel bank is eroded.
- **Scour** - Severe bank erosion and unstable bank caused by the physical action of flowing water.
- **Rip rap** - Material, mostly rocks, placed on banks to improve the bank stabilization.

Water Temperature/Ambient Temperature – Enter the water and air temperature in the area of the survey.

II. LOCATION

Latitude/Longitude - North American Datum 1983.
Quad Name - U.S.G.S. 7.5 minute quadrangle name if known.
Stream Name - Enter the stream name as it appears on the 7.5 minute quadrangle map. If name not available, enter local name or '*unnamed*'.
Tributary To - Enter the name of the receiving stream, river lake or ocean.
Barrier(s) Found - Mark *No* if barrier(s) not found. If a barrier is found, please fill in the rest of the form.
Stream Segment Surveyed - Record the length of the surveyed stream segment or reach where no barriers found.
Bank Location - Where in the stream the structure is located, looking downstream.
Channel Type

- **V** - For general description purposes, is the channel shaped like a V
- **U** - For general description purposes, is the channel shaped like a U, bank slopes more gradual than V channel

Road Name - Enter road name and/or number.
SCVWD Milepost - Location of barrier based on the Santa Clara Valley Water District Creek Route GIS data. The outlet of Stevens Creek at the San Francisco Estuary is at 0.00 miles, and milepost numbers increase moving upstream.
Photos Taken - Mark when pictures of the inlet, outlet or other parts of a barrier were taken. , please provide the **Photos Description/Numbers -** Describe each picture orientation. Please provide photos with this form. **Land Owner -** May be private, public, tribal, or unknown-if known, put down owners name and contact info.
Structure Owner - May be different from land owner- if known, put down owners name and contact info.

III. STRUCTURE

Structure Type

- **Diversion** - A man-made structure or installation for transferring water from a stream by a pipe, canal, well, or other conduit to another watercourse or to the land. Surface diversions fall into two general categories: pump and gravity.
- **Dam** - A man-made barrier constructed across a stream and designed to control water flow or create a reservoir.
- **Arizona Crossing** - A road crossing that allows the river to run over a road.
- **Culvert** - A pipe that allows streams, rivers, or runoff to pass under a road.
- **Bridge** - A structure conveying a road or pathway over a stream, river, or a depression.
- **Natural** - A barrier that is not man-made, such as: waterfall, beaver dam, insufficient flow, landslide, velocity, etc.
- **Other** - Anything that is not described in the above categories.

Description - Any additional significant details about the structure.

Passage Status - Based on your field observations describe the impact on adult and juvenile salmonid fish passage. (estimate to your best judgment).

IV. FISH

Salmonids Observed Downstream? - Were salmonids observed in the creek below the barrier?
Salmonids Observed Upstream? - Were salmonids observed above the barrier?

V. DIVERSION

Diversion Type

- **Vertical** - The pump is vertically oriented and pulls water straight up.
- **Submersible** - The pump for diverting water is submerged under the water or bank and is not visible.
- **Slant** - Both the pump and intake pipe are angled at a slant up the river bank.
- **Centrifugal** - Old style pump which has a similar visual appearance to a snail shell (spiral or circular).
- **Pump other** - Water diversion where type of pump used is unknown but use of a pump is certain.
- **Floodgate** - Water diversion where water is diverted by gravity flow and controlled via a screwgate.
- **Siphon** - Common in the Delta, not usually seen anywhere else.
- **Weir** - Type of dam structure, usually spanning both banks, where flashboards are used to create head for the pump.
- **Other** - Anything that is not described in the above categories.

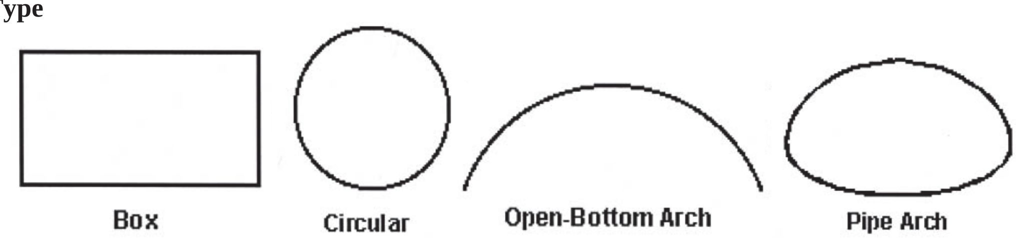
Pipe Size - Inside diameter of the diversion intake or drain.
Screened - Fish screens are supposed to keep fish from being taken out of a stream or river by a water diversion.
Pump Running - Check *Yes* if the diversion was running in the time of the survey.

VI. DAM

Dam Type - Specify the material the dam is made from.
Dam Width/Dam Height - Provide the dam's dimensions in feet if possible.
Seasonal/Permanent - Is the dam operational all year long or seasonally?
Facility - Is there a fish ladder, natural fishway bypass, or some other structure in place to improve fish passage?

VII. CULVERT

Culvert Type



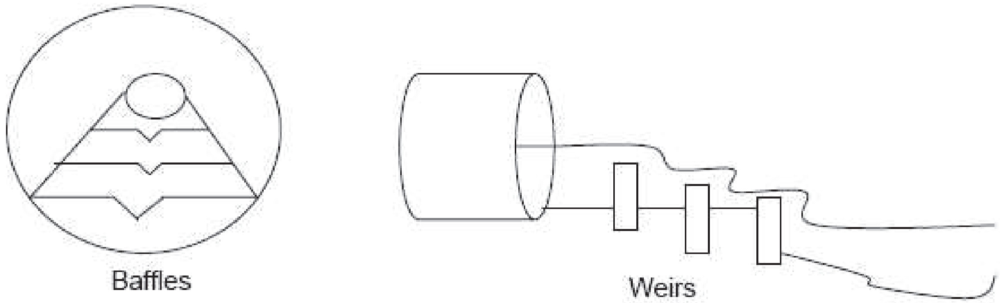
- **Abandoned/Unmaintained -** Check if the culvert appears to be abandoned and/or not maintained.

Culvert Material - Check the box that most accurately describes the culvert's construction material. Check multiple boxes if the culvert is composed of two or more materials.

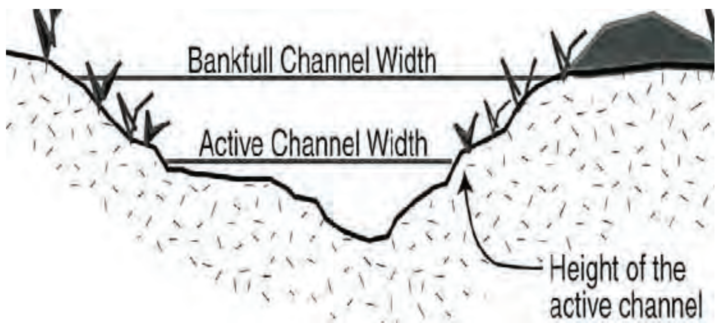
- **Metal** - Includes the Corrugated Metal (Steel) Pipe (CMP) = single sheet pipe of corrugated galvanized steel; Structural Steel Plate (SSP) = multiple plates of corrugated galvanized steel bolted together, and corrugated aluminium. Both the pump and intake pipe are angled at a slant up the river bank.
- **Plastic** - Culvert of various types of high-impact plastics, usually with shallow corrugations.
- **Concrete** - Most county and state roads box culverts. Some circular and arch pipes are made of concrete, generally no corrugations.
- **Log/wood** - Mostly old log stringer bridges and Humboldt crossings, occasionally also box and old circular pipe.
- **Other** - Explain if none of the materials accurately describes the culvert.

Number of Barrels/Pipes - If a culvert consists of numerous barrels or pipe, list the total number.
Culvert Diameter - Check whether inside culvert diameter is bigger or smaller than 2 ft. If multiple culverts, check the diameter of the largest one.
Culvert Height/Width - Provide the culvert dimensions. If multiple culverts, enter the size of the largest one.
Outlet Drop Height - Measure the height at the center of the culvert outlet (e.g. downstream end of the culvert).

Weirs/Baffles - These are generally structures that are added as a retrofit to a culvert (baffles), or placed in the stream (weirs) to reduce velocity or improve fish passage in some way.



Channel Width - The active channel width is identified by locating the height of annual scour along banks developed by annual fluctuations of stream flow.



VIII. BRIDGE

Bridge Type

Free span - No part of the bridge is in the stream.

Instream structure - An abutment, pier, or some other part of the bridge is in the stream.

Active/Abandoned - Is the bridge still utilized for vehicular or pedestrian traffic, or is it abandoned?

Apron - A protective shield, usually made of concrete, to protect against erosion, may be around piers or abutments or span the entire creek.

IX. NATURAL

Natural Barrier Type

Waterfall - A sudden, nearly vertical drop in a stream, as it flows over rock.

Grade - The topography of the streambed is too steep for fish to ascend. Specify details of species and life-stages the grade is to steep for, in the notes section, and/or estimate the slope.

Landslide - Movement of earth down a steep slope into a stream that blocks fish passage.

Log jam - Log debris in a stream such that it blocks fish passage.

Waterfall Drop - Check the appropriate box.

X. ADDITIONAL NOTES

Please provide any additional notes and comments that may help to describe the structure, to determine the need for detail fish passage assessment and needs for barrier remediation. Use other side of the form is needed. Mail or email filled form(s) to:

DFW Passage Assessment Database Project, 830 S Street, Sacramento, CA 95814, Anne.Elston@wildlife.ca.gov

Attachment C

Spreadsheet Template Used to Standardize Roughness Approach for HEC RAS Models

Blue cells to be entered/selected by modeler.

Reach:	
Modeler:	

Based on Phillips and Tadayon (2006), Jarrett (1985) which are modifications of Cowen (1956) and Chow (1959).

Roughness Table	
Roughness Category	n
Base material	
Concrete	0.015
Sakrete	0.020
Bedrock	0.025
Firm Earth	0.022
Coarse Sand (1-2 mm)	0.024
Fine Gravel (2-8 mm)	0.024
Gravel (8-16 mm)	0.026
Coarse Gravel (16-64 mm)	0.028
Cobble (64-256 mm)	0.036
Chnl Margin Irregularity (Channel Only)	
None	0.000
Minor	0.005
Moderate	0.010
Severe	0.020
Channel Section Variation (Channel Only)	
Gradual	0.000
Alternating occasionally	0.005
Alternating frequently	0.015
Effect of Obstructions (Channel Only)	
Negligible	0.000
Minor	0.010
Appreciable	0.025
Severe	0.050
Vegetation	
Negligible	0.000
Low	0.010
Medium	0.020
High	0.035
Very High	0.075
Extremely High	0.150
Degree of Meandering (Multiplier)	
Minor	1.00
Appreciable	1.15
Severe	1.30

Model Reach 1:			Upstream River Station		Downstream River Station	
Roughness Element	Left Bank		Channel		Right Bank	
Base material	Cobble (64-256 mm)	0.036	Coarse Gravel (16-64 mm)	0.028	Firm Earth	0.022
Chnl Margin Irregularity	NA		Moderate	0.010	NA	
Variation in section			Gradual	0.000		
Effect of Obstructions			Negligible	0.000		
Vegetation	High	0.035	Negligible	0.000	Medium	0.020
Subtotals	0.071		0.038		0.042	
Meander Multiplier	NA		Minor	1.00	NA	
Final Mannings	0.071		0.038		0.042	

Model Reach 1: Notes

Modeled Reach 2:			Upstream River Station		Downstream River Station	
Roughness Element	Left Bank		Channel		Right Bank	
Base material	Sakrete	0.020	Gravel (8-16 mm)	0.026	Sakrete	0.020
Chnl Margin Irregularity	NA		None	0.000	NA	
Variation in section			Gradual	0.000		
Effect of Obstructions			Negligible	0.000		
Vegetation	Negligible	0.000	Low	0.010	Negligible	0.000
Subtotals	0.020		0.036		0.020	
Meander Multiplier	NA		Minor	1.00	NA	
Final Mannings	0.020		0.036		0.020	

Modeled Reach 2: Notes

Modeled Reach 3:			Upstream River Station		Downstream River Station	
Roughness Element	Left Bank		Channel		Right Bank	
Base material	Concrete	0.015	Concrete	0.015	Concrete	0.015
Chnl Margin Irregularity	NA		None	0.000	NA	
Variation in section			Gradual	0.000		
Effect of Obstructions			Minor	0.010		
Vegetation	Negligible	0.000	Low	0.010	Negligible	0.000
Subtotals	0.015		0.035		0.015	
Meander Multiplier	NA		Minor	1.00	NA	
Final Mannings	0.015		0.035		0.015	

Modeled Reach 3: Notes

Modeled Reach 4:			Upstream River Station		Downstream River Station	
Roughness Element	Left Bank		Channel		Right Bank	
Base material	Concrete	0.015	Fine Gravel (2-8 mm)	0.024	Concrete	0.015
Chnl Margin Irregularity	NA		None	0.000	NA	
Variation in section			Alternating frequently	0.015		
Effect of Obstructions			Negligible	0.000		
Vegetation	Negligible	0.000	Medium	0.020	Negligible	0.000
Subtotals	0.015		0.059		0.015	
Meander Multiplier	NA		Minor	1.00	NA	
Final Mannings	0.015		0.059		0.015	

Modeled Reach 4: Notes

Attachment D

Results of Fishway Spreadsheet Models

ATTACHMENT D RESULTS OF FISHWAY SPREADSHEET MODELS

TABLE OF CONTENTS

DENIL FISHWAY CALCULATIONS FOR SITES 3 AND 21 .... D-1
- DENIL FISHWAY HYDRAULICS D-2
- SITE 3, MOFFETT FISH LADDER AT GRADE CONTROL STRUCTURE D-3
- SITE 21, FREMONT FISH LADDER D-6

POOL AND CHUTE FISHWAY CALCULATIONS FOR SITE 12 .... D-9
- FISHWAY WEIR HYDRAULICS D-10
- LOOK-UP CHART FOR CALCULATING PLUNGING-STREAMING TRANSITION DEPTH OVER WEIR D-11
- RESULTS D-12
- PLUNGING FLOW HYDRAULIC CALCULATIONS D-12
- STREAMING FLOW HYDRAULIC CALCULATIONS (CHEZY) D-13
- SUMMARY TABLE D-14
- TAILWATER RATING CURVE FOR CALCULATING WATER SURFACE DROP OVER VORTEX POOL AND CHUTE ENTRANCE WEIR D-15
- CHEZY COEFFICIENT VS. DEPTH OVER VORTEX WEIR D-16

ATTACHMENT D REFERENCES D-17

Denil Fishway Calculations for Sites 3 and 21

Denil Fishway Hydraulics

Standard Denil fishway hydraulics have been extensively studied (Rajaratnam and Katopodis 1984, Katopodis et al. 1997, Haro et al. 1999, Kamul and Barthel 2000, Larinier 2002, Odeh 2003,). For this assessment, the following fishway equation by Odeh (2003) was used to estimate the flow in the Denil fishway at varying headwater depths.

$$Q = C_d d^{1.75} b^{0.75} \sqrt{g S_o}$$

Where: Q = Fishway flow (cfs)

C_d = Discharge coefficient (unitless), where $C_d = 1.34 - 1.84 S_o$, where $0.10 \leq S_o \leq 0.25$

d = Headwater depth, measured from the vee invert of the last (upstream) baffle measured in the fishway exit (ft)

b = Weir opening width (ft)

g = Gravitational constant (32.2 ft/s^2)

S_o = Fishway floor slope (ft/ft)

Larinier (2002) presented equations for calculating the upper and lower operating limit of the standard Denil fishway:

$$Lower\ Operating\ Limit = \frac{[d + k_2 \sin(\theta)]}{B} = 0.5$$

$$Upper\ Operating\ Limit = \frac{(d + k_2 \sin(\theta))}{B} = 1.1$$

Where: k_2 = Height of vee (ft)

θ = Baffle angle (degrees)

B = Fishway width (ft)

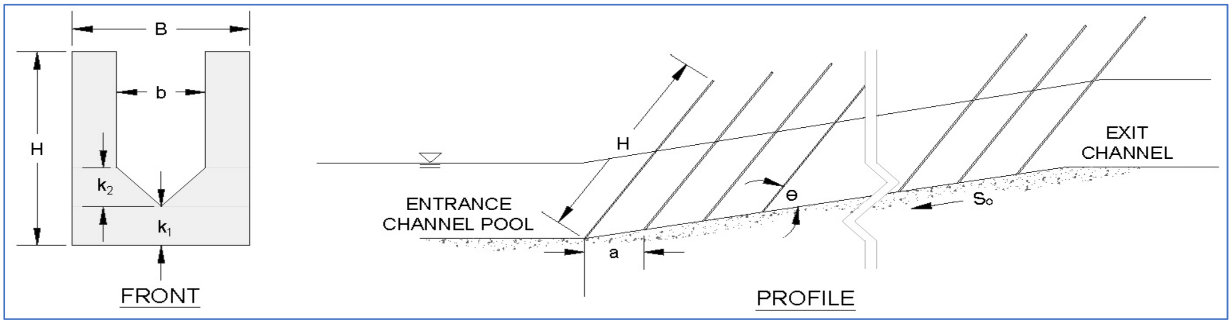
The velocity within a Denil fishway varies with depth. Relatively low velocities exist near the baffle and increase towards the surface. For this assessment the following for the mean velocity in the Denil fishway equation developed by Rajaratnam and Katopodis (1984) was used.

$$V = \frac{Q}{b\left(d - \frac{k_2 \sin(\theta)}{2}\right)}$$

Where: V = Fishway mean velocity (fps)

Site 3 Denil Fishway Input Variables	
Variable	**Value**
Slope, S_o (ft/ft)	0.17
Ladder width, *B* (ft)	4.00
Open width, *b* (ft)	2.33
Notch height, k_1 (ft)	1.00
Notch height, k_1' (ft)	0.71
Baffle Angle, *Theta* (deg)	45.00
Notch Top, k_2 (ft)	1.00
Notch height, k_2' (ft)	0.71
Baffle Height, *T* (ft)	5.00
Baffle Spacing, *a* (ft)	2.67
US Baffle Invert Elev. (ft)	31.10
Number of Baffles, *N* (ft)	17.00
Fishway Length (ft)	48.00
Odeh C_d	1.03
Gravity, *g* (ft/s^2)	32.20

Site 3 Denil Fishway Operating Limits	
Variable	**Value**
Lower Larinier Op. Depth Limit (ft)	1.2
Lower Larinier Op. Flow Limit (cfs)	6.2
Upper Larinier Op. Depth Limit (ft)	3.5
Upper Larinier Op. Flow Limit (cfs)	40.6



Results of Denil Fishway Assessment at Site 3, 1 of 2					
Forebay Elevation (ft)	Depth, *d* (ft)	Ratio *d/b**	Larinier (2002) Operation Range (Unitless)**	Odeh (2003) Flow (cfs)	Rajaratnam and Katopodis (1984) Velocity (fps)
31.2	0.1	0.0	0.23	0.1	
31.3	0.2	0.1	0.25	0.3	
31.4	0.3	0.1	0.28	0.6	
31.5	0.4	0.2	0.30	0.9	
31.6	0.5	0.2	0.33	1.3	9.2
31.7	0.6	0.3	0.35	1.9	7.5
31.8	0.7	0.3	0.38	2.4	7.0
31.9	0.8	0.3	0.40	3.1	6.9
32.0	0.9	0.4	0.43	3.8	6.9
32.1	1.0	0.4	0.45	4.5	7.0
32.2	1.1	0.5	0.48	5.4	7.2
32.3	1.2	0.5	0.50	6.2	7.4
32.4	1.3	0.6	0.53	7.2	7.6
32.5	1.4	0.6	0.55	8.2	7.8
32.6	1.5	0.6	0.58	9.2	8.0
32.7	1.6	0.7	0.60	10.3	8.3
32.8	1.7	0.7	0.63	11.5	8.5
32.9	1.8	0.8	0.65	12.7	8.8
33.0	1.9	0.8	0.68	14.0	9.0
33.1	2.0	0.9	0.70	15.3	9.3
33.2	2.1	0.9	0.73	16.6	9.5
33.3	2.2	0.9	0.75	18.0	9.8
33.4	2.3	1.0	0.78	19.5	10.0
33.5	2.4	1.0	0.80	21.0	10.3
33.6	2.5	1.1	0.83	22.6	10.5
33.7	2.6	1.1	0.85	24.2	10.8
33.8	2.7	1.2	0.88	25.8	11.0
33.9	2.8	1.2	0.90	27.5	11.2
34.0	2.9	1.2	0.93	29.2	11.5
34.1	3.0	1.3	0.95	31.0	11.7
34.2	3.1	1.3	0.98	32.9	12.0
34.3	3.2	1.4	1.00	34.7	12.2
34.4	3.3	1.4	1.03	36.7	12.4
34.5	3.4	1.5	1.05	38.6	12.7
34.6	3.5	1.5	1.08	40.6	12.9
34.7	3.6	1.5	1.10	42.7	13.1
34.8	3.7	1.6	1.13	44.8	13.4
34.9	3.8	1.6	1.15	46.9	13.6
35.0	3.9	1.7	1.18	49.1	13.8
35.1	4.0	1.7	1.20	51.3	14.1
35.2	4.1	1.8	1.23	53.6	14.3
35.3	4.2	1.8	1.25	55.9	14.5

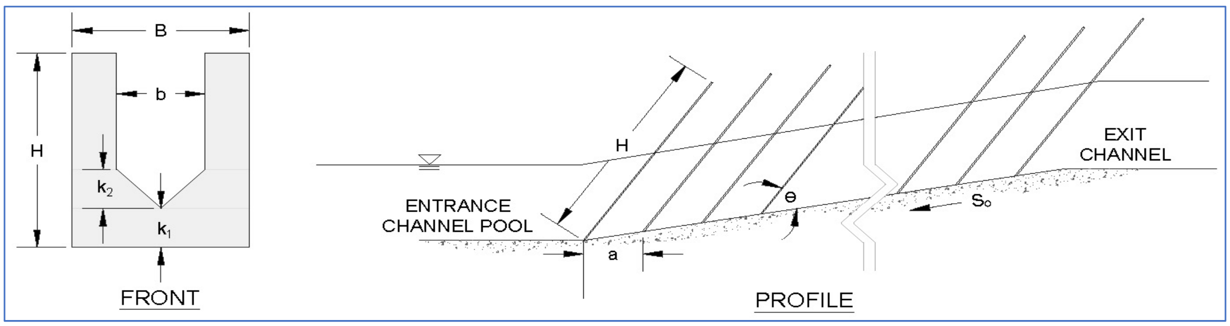
**b* = denil opening width

**Red indicates out of operating range

Results of Denil Fishway Assessment at Site 3, 2 of 2				
Stevens Creek Flow (cfs)	**Forebay Elevation (ft)**	**Denil Flow (cfs)**	**Denil Velocity (fps), Rajaratnam (1984)**	**Fishway Attraction Flow**
1	31.87	1.0		
3	31.87	3.0		
8	31.98	3.6	6.9	45.1%
14	32.06	4.3	7.0	30.4%
16	32.09	4.4	7.0	27.8%
38	32.37	6.2	7.4	16.1%
70	32.55	8.7	7.9	12.4%
139	32.95	13.3	8.9	9.6%
203	33.25	17.3	9.6	8.5%
250	33.45	20.2	10.1	8.1%
300	33.64	23.2	10.6	7.7%
400	34	29.2	11.5	7.3%
450	34.16	32.1	11.9	7.1%
644	34.72	34.0	12.1	5.3%
680	34.81	45.0	13.4	6.6%
700	34.86	46.1	13.5	6.6%

Site 21 Denil Fishway Input Variables	
Variable	**Value**
Slope, S_o (ft/ft)	0.17
Ladder width, *B* (ft)	3.50
Open width, *b* (ft)	2.00
Notch hieght, k_1 (ft)	0.88
Notch height, k_1' (ft)	0.62
Baffel Angle, *Theta* (deg)	45.00
Notch Top, k_2 (ft)	0.88
Notch height, k_2' (ft)	0.62
Baffle Hieght, *H* (ft)	5.00
Baffle Spacing, *a* (ft)	2.33
US Baffel Invert Elev. (ft)	113.48
Number of Baffles, *N* (ft)	32.00
Fishway Length (ft)	72.00
Odeh C_d	1.03
Gravity, *g* (ft/s^2)	32.20

Site 21 Denil Fishway Operating Limits	
Variable	**Value**
Lower Larinier Op. Depth Limit (ft)	1.1
Lower Larinier Op. Flow Limit (cfs)	4.8
Upper Larinier Op. Depth Limit (ft)	3.1
Upper Larinier Op. Flow Limit (cfs)	29.2



Results of Denil Fishway Assessment at Site 21, 1 of 2					
Forebay Elevation (ft)	Depth, *d* (ft)	Ratio *d/b**	Larinier (2002) Operation Range (Unitless)**	Odeh (2003) Flow (cfs)	Rajaratnam and Katopodis (1984) Velocity (fps)
113.6	0.1	0.1	0.23	0.07	
113.7	0.2	0.1	0.26	0.2	
113.8	0.3	0.2	0.29	0.5	
113.9	0.4	0.2	0.32	0.8	4.47
114.0	0.5	0.3	0.34	1.2	3.14
114.1	0.6	0.3	0.37	1.6	2.83
114.2	0.7	0.4	0.40	2.2	2.76
114.3	0.8	0.4	0.43	2.7	2.78
114.4	0.9	0.5	0.46	3.3	2.84
114.5	1.0	0.5	0.49	4.0	2.92
114.6	1.1	0.6	0.52	4.8	3.01
114.7	1.2	0.6	0.54	5.5	3.11
114.8	1.3	0.7	0.57	6.4	3.22
114.9	1.4	0.7	0.60	7.3	3.33
115.0	1.5	0.8	0.63	8.2	3.44
115.1	1.6	0.8	0.66	9.2	3.55
115.2	1.7	0.9	0.69	10.2	3.67
115.3	1.8	0.9	0.72	11.3	3.78
115.4	1.9	1.0	0.74	12.4	3.89
115.5	2.0	1.0	0.77	13.5	4.01
115.6	2.1	1.1	0.80	14.8	4.12
115.7	2.2	1.1	0.83	16.0	4.23
115.8	2.3	1.2	0.86	17.3	4.35
115.9	2.4	1.2	0.89	18.6	4.46
116.0	2.5	1.3	0.92	20.0	4.57
116.1	2.6	1.3	0.94	21.4	4.68
116.2	2.7	1.4	0.97	22.9	4.79
116.3	2.8	1.4	1.00	24.4	4.90
116.4	2.9	1.5	1.03	26.0	5.01
116.5	3.0	1.5	1.06	27.5	5.12
116.6	3.1	1.6	1.09	29.2	5.23
116.7	3.2	1.6	1.12	30.8	5.33
116.8	3.3	1.7	1.14	32.5	5.44
116.9	3.4	1.7	1.17	34.3	5.55
117.0	3.5	1.8	1.20	36.1	5.65
117.1	3.6	1.8	1.23	37.9	5.76
117.2	3.7	1.9	1.26	39.8	5.86
117.3	3.8	1.9	1.29	41.7	5.97
117.4	3.9	2.0	1.32	43.6	6.07
117.5	4.0	2.0	1.34	45.6	6.17
117.6	4.1	2.1	1.37	47.6	6.28
117.7	4.2	2.1	1.40	49.6	6.38

**b* = denil opening width

**Red indicates out of operating range

Results of Denil Fishway Assessment at Site 21, 2 of 2				
Stevens Creek Flow (cfs)	Forebay Elevation (ft)	Denil Flow (cfs)	Denil Velocity (fps), Rajaratnam and Katopodis (1984)	Fishway Attraction Flow
1	114.9	1.0		100%
3	114.9	3.0		100%
5.5	114.9	5.5	3.0	100%
8	114.93	7.5	3.3	94%
14	115.07	8.8	3.5	63%
18	115.14	9.5	3.6	53%
29.0	115.3	11.2	3.8	39%
70	115.72	16.3	4.4	23%
119	116.12	21.7	5.0	18%
130	116.2	22.9	5.1	18%
165	116.44	26.6	5.3	16%
203	116.65	30.0	5.5	15%
212	116.7	30.8	5.5	15%

Pool and Chute Fishway Calculations for Site 12

Fishway Weir Hydrdaulics

Project:	**Stevens Creek Fish Passage Assessment**	Date:	7/9/19
	Site 12 Vortex Weir Fishway at SF35 Gage		
Site:	**Gauging Weir (SF35) with Drop Structure Central Ave. Fish Ladder**	By:	ML

DESIGN INPUTS

Weir Type: Vortex Pool and Chute

Fishway	Fishway Slope	So	**0.037**	ft/ft
	Drop height	dH	**0.89**	ft
	Total Fishway Width (at end of weirs)	T	**35.6**	ft
	Pool Spacing On-Center	L(oc)	**23.95**	ft
	Effective Pool Length (max 8 ft)	L(eff)	**10.00**	ft
	Crest Height from channel bottom	P	**4.00**	ft
	Depth over Weir when Fishway Fully Wetted	Hb	**6.98**	ft
	Fishway Floor Slope (enter 0 if stepped)	Sfloor	0.037	ft/ft
Pool Shape	Pool Bottom Width	Wb	**12.20**	ft
	Side Slope of Side Walls (for trap. Channels)	Ss_walls	**1.00**	h:1V
Chute	Chute bottom width	b	**0.00**	ft
	Chute Depth	hc	**0.00**	ft
	Lateral Slope of Chute	Sc	**0.00**	h:1v
	V-notch angle of chute	Θc	0.0	deg
	Top Width of chute	Tc	0.00	ft
	Area of Wetted Chute	Ac	0.00	
	Wetted Perimeter of Full Chute	Pc	0.00	
	Triangular Weir Coefficient (for sloping sides)	CV_2	0.607	
Shoulder	Slope along Shoulder Crest	Ss	**3.61**	h:1v
	Slope along Shoulder Crest	Θ	149.0	deg
	Projected Shoulder Slope	Ssp	2.6	h:1v
	Projected Shoulder Slope	Θp	137.2	deg
	Triangular Weir Coefficient	CV_3	0.612	
	Shoulder Skew to Flow (mea. from sidewall)	α	**45.00**	deg
	Shoulder Crest Length	W	25.19	ft
	Shoulder Lateral Distance from Chute to Sidewall	y	17.82	ft
	Shoulder Longitudinal Distance from Chute to Sidewall	x	17.82	ft

Head over Weir at Streaming Transition (Ead, 2004)			
Plunging Transition	Qst	**11.86**	cfs/ft
Ratio for X-Axis of Plot	L/P	5.99	ft/ft
Dimensionless Discharge	Qst*	**0.48**	
Head at Transition	**hs**	**1.52**	**ft**
SET EQUAL TO Qst	**Goal**	**11.86**	cfs/ft

Weir Coefficient Equations

Cr = =0.602+0.083(h/P)

Ctri = =0.6071-0.000874*(theta)+6.1039*10^-6*(theta)^2 in deg

Chezy Coefficient (regression of data from Nyberg et al., 2016)

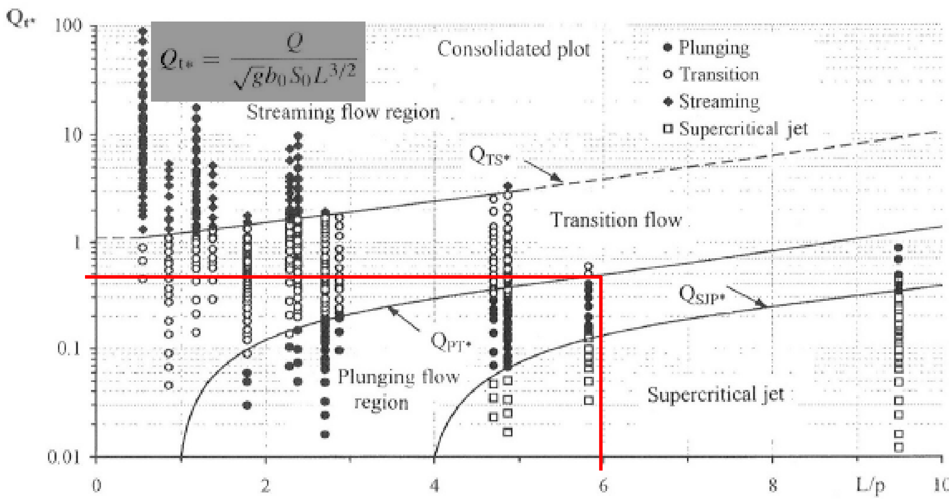
$\mathbf{Ch = 27.04(h1)^{-0.377}}$ ft/s^2

Constants			
Specific Weight of Water	γ	62.4	lb/ft^3
Discharge Exponent	n(tri)	2.5	Triangular
	n(rect)	1.5	Rectangular
	n(trap)	2.0	Trapezoidal
Gravitational Accel	g	32.2	ft/s^2

Design Flows			
Adult Low Pass Flow	Q_{ALP}	**3.0**	cfs
Adult High Pass Flow	Q_{AHP}	**203.0**	cfs (Q1%)
Juv. Low Pass Flow	Q_{JLP}	**1.0**	cfs
Juv High Pass Flow	Q_{JHP}	**29.0**	cfs (Q10%)

Design Elevations			
Fishway Exit Elev.	El(exit)	**54.30**	ft (NAVD88)
Fishway Entrance Weir Elev.	El(entr)	**51.64**	ft (NAVD88)
Fishway Tailwater Control Elev.	El(twc)	**50.85**	ft (NAVD88)
Fishway Overall Drop		**3.44**	ft
Number of Weirs		**4**	

Look-up Chart for Calculating Plunging-Streaming Transition Depth over Weir



From Ead (2004)

INSTRUCTIONS

1. set fishway dimensions
2. Look-up Qpt* on chart for ratio L/p
3. change hs to set goal = Qst

	Fish Passsage Flow	Qlp_juv	Qlp adult	P-S Trans	Qhp_juv	1 ft Entr Drop	Max Entr Drop	Qhp_adult	Max EDF	2-ft Dry Weir	Fully Wetted	
WSEexit	**Water Surface Elevation at Fishway Exit:**	**54.7**	**54.9**	**55.8**	**56.2**	**56.4**	**57.5**	**58.8**	**59.4**	**60.9**	**61.5**	**ft**
TWE	Tailwater Elevation from Rating Curve:	52.1	52.1	52.4	52.5	52.5	53.1	53.7	53.9	53.8	53.7	**ft**
dHentr	**Water Surface Drop across Entrance Weir**	**-0.1**	**0.1**	**0.8**	**0.9**	**1.0**	**1.5**	**2.2**	**2.7**	**4.2**	**4.9**	**ft**
Qfishway	**TOTAL FLOW IN FISHWAY:**	**1.0**	**3.0**	**23.9**	**29.0**	**35.5**	**93.5**	**203.0**	**267.3**	**470.3**	**561.6**	**cfs**
h_1	**HEAD ABOVE CREST:**	**0.40**	**0.63**	**1.52**	**1.73**	**1.90**	**3.00**	**4.32**	**4.92**	**6.42**	**6.98**	**ft**

RESULTS

	Relative Submergence (Pool Depth/Weir Height)	**0.99**	**1.05**	**1.27**	**1.32**	**1.36**	**1.64**	**1.97**	**2.12**	**2.49**	**2.63**	
	Fishway Flow Regime	**Plunge**	**Plunge**	**Plunge**	**Stream**	**Stream**	**Stream**	**Stream**	**Stream**	**Stream**	**Stream**	
Qshoulders	**Plunging flow over Shoulders (for EDF)**	**0.96**	**2.98**	**23.92**	**23.08**	**22.39**	**22.75**	**24.71**	**25.15**	**25.79**	**25.95**	**cfs**
EDF	**Energy Dissipation Factor:**	**0.1**	**0.2**	**1.5**	**1.5**	**1.4**	**1.7**	**2.9**	**4.0**	**11.2**	**19.7**	**lb/ft^2-s**
Ldry	**Dry Shoulder Length per Side:**	**23.8**	**22.9**	**19.7**	**19.0**	**18.3**	**14.4**	**9.6**	**7.4**	**2.0**	**0.0**	**ft**

PLUNGING FLOW HYDRAULIC CALCULATIONS

Section 1 (notch-rectangular section)												
Q1	nonsubmerged Flow:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q1sub	**Flow w/Submergence**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	cfs
Section 2 (Notch-triangular section)												
Q2	nonsubmerged Flow (untruncated V):	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q2untrunc_sub	Flow w/Submergence (untruncated V):	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q2trunc	Truncated Portion of Flow (nonsubmerged):	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q2trunc_sub	Truncated Portion of Flow w/Submergence:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q2sub	**Total Flow w/ Submergence:**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	cfs
Section 3 (Shoulders)												
Q3	nonsubmerged Flow (untruncated one-sided V):	0.96	2.98	26.95	27.04	27.04	27.04	27.04	27.04	27.04	27.04	
Q3untrunc_sub	Flow w/Submergence (untruncated V):	0.96	2.98	23.92	23.08	22.39	22.75	24.71	25.15	25.79	25.95	
Q3trunc	Truncated Portion of Flow (nonsubmerged):	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q3trunc_sub	Truncated Portion of Flow w/Submergence:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Q3sub	**Total Flow on Shoulders w/ Submergence:**	**0.96**	**2.98**	**23.92**	**23.08**	**22.39**	**22.75**	**24.71**	**25.15**	**25.79**	**25.95**	cfs
Qfishway-plung	**Plunging Flow Only (does not include Sec 1 and 2 when streaming)**	**1.0**	**3.0**	**23.9**	**23.1**	**22.4**	**22.8**	**24.7**	**25.1**	**25.8**	**25.9**	**cfs**

h_1 HEAD ABOVE CREST:	0.40	0.63	1.52	1.73	1.90	3.00	4.32	4.92	6.42	6.98	ft
STREAMING FLOW HYDRAULIC CALCULATIONS (CHEZY)											
Within Chute: (h<hc)											
Wetted Area (Trapezoid)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ft^2
Wetted Perimeter (Trapezoid)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ft
Above Chute:											
Wetted Area (rectangle)	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	ft2
On Shoulders (h>hc)											
Wetted Area (shoulders)	0.4	1.0	5.9	7.6	9.2	23.0	47.7	61.8	105.2	124.3	ft^2
Wetted Perimeter (shoulders)	2.2	3.5	8.3	9.5	10.4	16.4	23.7	27.0	35.2	38.3	ft^2
Total Flow Area	0.4	1.0	5.9	7.6	9.2	23.0	47.7	61.8	105.2	124.3	ft^2
Total Wetted Perimeter	2.2	3.5	8.3	9.5	10.4	16.4	23.7	27.0	35.2	38.3	ft
Average water velocity within fishway	**n/a**	**n/a**	**n/a**	**3.8**	**3.8**	**4.1**	**4.3**	**4.3**	**4.5**	**4.5**	**ft/s**
Chezy Coef.	**Plunging**	**Plunging**	**Plunging**	**22.0**	**21.2**	**17.9**	**15.6**	**14.8**	**13.4**	**13.0**	ft^0.5/s
Equivalent manning's n from chezy	**0.040**	**0.043**	**0.056**	**0.065**	**0.069**	**0.088**	**0.108**	**0.115**	**0.133**	**0.140**	
Equivalent manning's n for shoulders only	0.040	0.043	0.056	0.424	0.564	1.876	4.573	6.349	12.584	15.630	
Qfishway-strean Total Fishway when Streaming (excluding orifice)	**Plunge**	**Plunge**	**Plunge**	**29.0**	**35.5**	**93.5**	**203.0**	**267.3**	**470.3**	**561.6**	**cfs**
Effective Pool Volume for Plunging Flow:											
Length along Shoulder in Streaming per side, Lstream	0.00	0.00	0.00	0.74	1.36	5.34	10.11	12.27	17.68	19.70	ft
Streaming Width per side, Wstream	0.0	0.0	0.0	0.5	1.0	3.8	7.1	8.7	12.5	13.9	ft
Effective Pool Bottom Width per side, Bp	6.1	6.1	6.1	5.6	5.1	2.3	0.0	0.0	0.0	0.0	ft
Eff Pool Max Depth, d	3.96	4.19	5.08	5.28	5.46	6.56	6.83	5.90	3.57	2.70	ft
Effective Pool Top Width per side, Wp	10.1	10.3	11.2	10.9	10.6	8.9	6.8	5.9	3.6	2.7	ft
Effective Pool XS Area per side, Apool	31.9	34.3	43.8	43.4	42.9	36.7	23.3	17.4	6.4	3.7	sf
Vol Pool Volume for EDF	639	686	877	868	858	735	466	348	128	73	cf
Upool Velocity in Effective Pool	0.03	0.09	0.55	0.53	0.52	0.62	1.06	1.44	4.04	7.10	ft/s

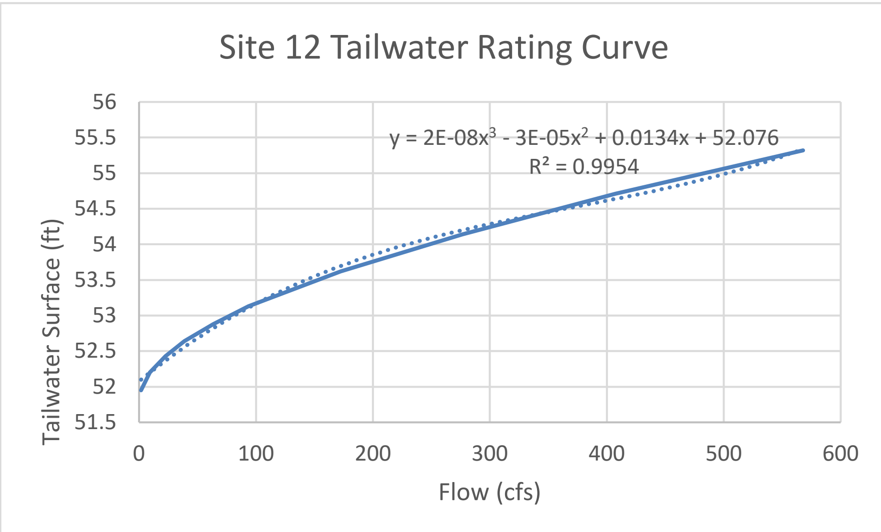
Summary Table

Description	Juvenile Low Passage Flow	Adult Low Passage Flow	Transition to Streaming	Juvenile High Passage	Entrance Drop = 1 ft	Entrance Drop = 1.5 ft	Adult High Passage	Max EDF	2-ft Dry Shoulder per Side	Shoulders Fully Wetted
Fishway Flow	**1 cfs**	**3 cfs**	**24 cfs**	**29 cfs**	35 cfs	94 cfs	203 cfs	**267 cfs**	470 cfs	562 cfs
Fishway Entrance Weir Water Surface Drop	-0.1 ft	0.1 ft	0.8 ft	0.9 ft	**1 ft**	**1.5 ft**	2.2 ft	2.7 ft	4.2 ft	4.9 ft
Depth over Weir	0.4 ft	0.6 ft	1.5 ft	1.7 ft	1.9 ft	3 ft	4.3 ft	4.9 ft	6.4 ft	7 ft
Length of Dry Shoulder per Side	23.8 ft	22.9 ft	19.7 ft	19 ft	18.3 ft	14.4 ft	9.6 ft	7.4 ft	**2 ft**	**0 ft**
Flow Regime in Chute	Plunge	Plunge	Plunge	Stream	Stream	Stream	Stream	Stream	Stream	Stream
EDF in Effective Pool (ft-lb/s/ft3)	0.1	0.2	1.5	1.5	1.4	1.7	**2.9**	4.0	11.2	19.7
Velocity in Effective Pool	0 fps	0.1 fps	0.5 fps	0.5 fps	0.5 fps	0.6 fps	1.1 fps	1.4 fps	4 fps	7.1 fps

Tailwater Rating Curve for Calculating Water Surface Drop over Vortex Pool and Chute Entrance Weir

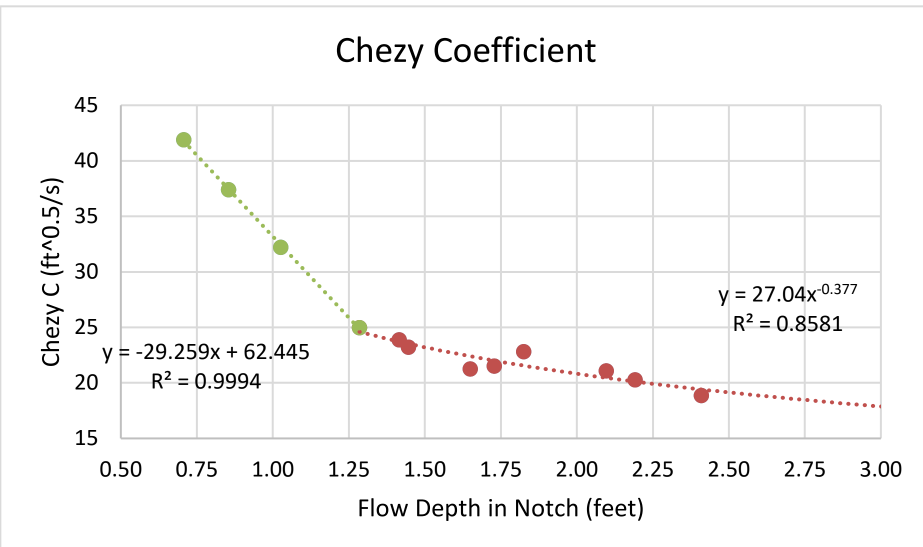
FROM REACH 3 RAS

Flow (cfs)	TWC in RAS	WSE (ft)	TWC Elev	Adjusted WSE (ft)
1.7	120.1	121.2	50.85	51.95
9.3	120.1	121.45	50.85	52.2
22.7	120.1	121.68	50.85	52.43
38.7	120.1	121.89	50.85	52.64
63.5	120.1	122.13	50.85	52.88
93.5	120.1	122.38	50.85	53.13
172.3	120.1	122.87	50.85	53.62
276.7	120.1	123.39	50.85	54.14
407.4	120.1	123.96	50.85	54.71
567.8	120.1	124.57	50.85	55.32



From Nyberg et al. (2016)

Run #	Qmodel (cfs)	Qproto (cfs)	CST (ft1/2/s)	CS/P (ft1/2/s)	HWEIR AVG, Prototype (ft)
Run #1	0.068	58.8	---	41.9	0.71
Run #2	0.085	73.9	---	37.4	0.85
Run #3	0.103	89.8	---	32.2	1.03
Run #4	0.122	106.5	39.2	25.0	1.29
Run #6	0.137	119.8	33.0	23.9	1.42
Run #7	0.165	143.5	26.3	21.3	1.65
Run #9	0.208	181.2	27.2	22.8	1.82
Run #10	0.253	220.2	23.6	21.1	2.10
Run #12	0.325	283.1	22.3	18.9	2.41
Run #5p	0.122	106.5	30.4	23.2	1.45
Run #8p	0.165	143.5	25.6	21.5	1.73
Run #11p	0.253	220.2	22.5	20.3	2.19



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Attachment D References

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Attachment E

Assessment Site Summary Sheets

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	1	**Survey Date:**	9/18/2018	**Analyzed By:**	S.McNeely
River Mile:	2.64	**Surveyors:**	S.McNeely, O.Light, J.Burg, E.Popuch	**Reviewer(s):**	M. Love
Reach:	1				
Site Name:	Grade control, Vernon Avenue				
Latitude:	37.411011	**Longitude:**	-122.068817	**PAD ID:**	713640

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control
Material Forming Drop:	Concrete with Downstream Grouted Rock Veins
Current Drop Condition:	Good.
Drop Structure Width (ft):	25.5 ft (bottom width)
Residual Drop Height (ft):	3.8 ft
Scour Pool Residual Depth (ft):	No pool
Pool Length (ft):	No pool
Active Channel Width (ft):	22.9 ft
Is there a fish ladder?	No

Additional Site Description:

Trapezoidal section with 45 deg. concrete drop structure located downstream of highway 101 crossing. Grouted rock veins located downstream of drop.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<8 cfs	All Flows	All Flows	<27 cfs
Adult	<57 cfs	>373 cfs	>373 cfs	<27 cfs and >374 cfs

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	57 to 203	73%	57 to 374

*Up to the 2-year flow event (619 cfs)

Additional Notes

The grouted rock veins and concrete drop structure provide insufficient depths for juveniles and adults at lower to moderate flows and excessive velocities for juveniles at all flows. The grouted channel bottom below the drop creates insufficient depth for leaping at flows up to 27 cfs. The drop is a leap barrier for juveniles at all flows. A hydraulic jump forms at 375 cfs and higher flows leading to an adult velocity, depth, and leap barrier.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 1
River Mile: 2.64
Reach: 1
Site Name: Grade control, Vernon Avenue
Latitude: 37.411011 **Longitude:** -122.068817 **PAD ID:** 713640

View from downstream looking upstream at grouted rock veins and concrete drop structure

View from upstream looking downstream at drop structure

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	2	**Survey Date:**	2/5/2016	**Analyzed By:**	pTJames
River Mile:	2.81	**Surveyors:**	M. Love, pT. James	**Reviewer(s):**	M. Love
Reach:	2				
Site Name:	Highway 101 crossing, PM 48.0				
Latitude:	37.408317	**Longitude:**	-122.06896	**PAD ID:**	705646

Crossing Description

Culvert 1: West (left)		**Culvert 2: East (right)**	
Shape	Box	**Culvert Shape**	Box
Material	Concrete	**Culvert Material**	Concrete
Bottom Material	Gravel/Concrete	**Culvert Bottom Material**	Gravel/Concrete
Length (ft)	226, 121*	**Length (ft)**	226, 121*
Height/Diameter (ft)	16	**Height/Diameter (ft)**	16
Embedment Depth (ft)	0	**Embedment Depth (ft)**	0
Width (ft)	11, 28**	**Width (ft)**	17
Bottom Slope	0.01%	**Bottom Slope**	0.01%
Inlet Type (e.g. Wingwall)	Straight	**Inlet Type (e.g. Wingwall)**	Straight
Outlet Type (e.g. Wingwall)	Straight	**Outlet Type (e.g. Wingwall)**	Straight
Residual Outlet Drop (ft)	1.5	**Residual Outlet Drop (ft)**	1.5
Outlet Pool Residual Depth (ft)	0.0	**Outlet Pool Residual Depth (ft)**	0.0

Active Channel Width (ft): 26

Additional Site Description:

*Length of culvert bay approximately 226 ft. Length of outlet apron approximately 121 ft.

**Distance between center wall and top of trail bank is 11 ft. Full width, including the trail, is approximately 28 ft.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<19 cfs	All	All	All
Adult	<165 cfs	>49 cfs	None	All

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	None	0%	None

*Up to the 2-year flow event (619 cfs)

Additional Notes

Leap height over edge of apron was calculated using water level downstream of hydraulic jump. Insufficient pool depth downstream of apron requires fish to swim up water surface drop rather than leap. The drop off of the apron with insufficient pool depth and the shallow and fast flow on the apron are the primary barriers for adults.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 2
River Mile: 2.81
Reach: 2
Site Name: Highway 101 crossing, PM 48.0
Latitude: 37.408317 **Longitude:** -122.06896 **PAD ID:** 705646

Looking downstream at Highway 101 inlet (a) west culvert and (b) east culvert, with inlet drop in foreground

a. **b.**

Highway 101 (a) culvert outlet looking upstream and (b) grouted rock veins looking downstream

a. **b.**

Stevens Creek Fish Passage Assessment
Channel Report

Site:	3	**Survey Date:**	2/5/2016	**Analyzed By:**	pTJames
River Mile:	2.93	**Surveyors:**	M. Love, pTJames	**Reviewer(s):**	M. Love
Reach:	2				
Site Name:	Moffett fish ladder				
Latitude:	37.406618	**Longitude:**	-122.069042	**PAD ID:**	707059

Channel Description

Channel Length (ft)	434	
Average Channel Slope (%)	0.10%	
Channel Material (Size etc.)	Concrete with patches of gravel	
Channel Bottom Width (ft)	20	(bottom width)
Bank Material (e.g. Earth, RSP)	Concrete	
Bank Slope (H:V)	1.25	
Drop?	No	
Residual Drop Height (ft)	NA	
Scour Pool Residual Depth (ft):	NA	
Active Channel Width (ft):	26	

Additional Site Description:

Site 3 consists of the concrete channel and upstream drop structure, which is described on an separate summary sheet. The trapezoidal concrete channel extends from the Moffett Drop structure downstream to the Highway 101 crossing structure.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<11 cfs	>2 cfs	NA	NA
Adult	<59 cfs	None	NA	NA

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	59 to 203	72%	59 to 329

*Up to the 2-year flow event (619 cfs)

Additional Notes

Flow is uniform through concrete channel. Depths are too shallow for adult and juvenile fish at low to moderate flows. Velocity are excessive for juveniles, but adults are able to swim the entire length without getting exhausted at the high passage flow (203 cfs). Site overall passage window for adults is 59 cfs to 203 cfs (72% passage), not accounting for low attraction flow and frequent debris clogging of Denil fishway.

Stevens Creek Fish Passage Assessment (Continued)
Channel Site Photos

Site: 3
River Mile: 2.93
Reach: 2
Site Name: Moffett fish ladder
Latitude: 37.406618 **Longitude:** -122.069042 **PAD ID:** 707059

Concrete channel downstream of Moffett Drop Structure, looking downstream to Highway 101 crossing (Site 2)

Concrete channel looking upstream to drop structure

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	3	**Survey Date:**	2/5/2016	**Analyzed By:**	pTJames
River Mile:	2.93	**Surveyors:**	MLove, pTJames	**Reviewer(s):**	M. Love
Reach:	2				
Site Name:	Moffett fish ladder				
Latitude:	37.406618	**Longitude:**	-122.069042	**PAD ID:**	707059

Drop Structure Description

Drop Structure Assumed Purpose:	Grade Control, Infrastructure Protection
Material Forming Drop:	Concrete
Current Drop Condition:	Weathered but fair condition
Drop Structure Width (ft):	34.0
Residual Drop Height (ft):	6.0
Scour Pool Residual Depth (ft):	0.0
Pool Length (ft):	0.0
Active Channel Width (ft):	26
Is there a fish ladder?	Yes, Denil

Additional Site Description:

Site 3 consists of the drop structure and the downstream concrete channel, which is described on an separate summary sheet. The Denil fishway overcomes 6 vertical feet and was installed circa 1984. The dimensions of the fishway fall within the “standard” Denil dimension relationships (Odeh, 2003; Bates, 1992). See images.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<3 cfs	>6 cfs	NA	NA
Adult	<38 cfs	>240 cfs	NA	NA

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	3 to 6	11%	3 to 6
Adult	38 to 203	83%	38 to 240

*Up to the 2-year flow event (619 cfs)

Additional Notes

Fish passage conditions are for passage through the Denil fishway. The drop structure is a complete barrier to all lifestages. The fishway's attraction flow (portion of streamflow in fishway) is <10% (min. recommended value) for all flows >128 cfs. Juvenile passage only occurs at low flows when fishway hydraulics function as pools and weirs. Observations of the Denil fishway has frequently found it plugged with debris and impassible.

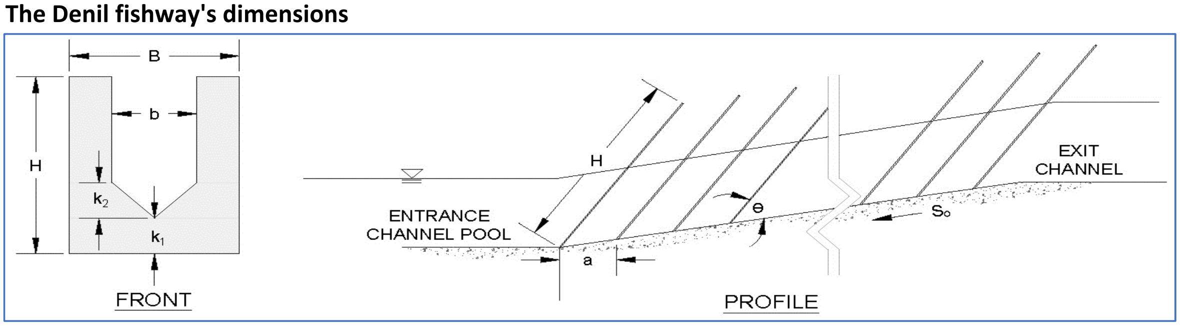
Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 3
River Mile: 2.93
Reach: 2
Site Name: Moffett fish ladder
Latitude: 37.406618 **Longitude:** -122.069042 **PAD ID:** 707059

Moffett drop structure and denil fishway, looking upstream.

(a) (b)

The Denil fishway's dimensions



Variable	Value
Slope, S_o (ft/ft)	0.17
Width, B (ft)	4.0
Open width, b (ft)	2.33
Vee invert, k_1 (ft)	1
Top of vee, k_2 (ft)	1
Spacing, a (ft)	2.67
Baffle angle, θ (deg.)	45
Baffle height, H (ft)	5
Fishway Length, L (ft)	48
Number of baffles	17

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	4	**Survey Date:**	8/7/2018	**Analyzed By:**	O.Light
River Mile:	3.13	**Surveyors:**	S. McNeely, O. Light, S. Kassem	**Reviewer(s):**	M. Love
Reach:	Reach 3				
Site Name:	Moffett Boulevard crossing				
Latitude:	37.403503	**Longitude:**	-122.069337	**PAD ID:**	713641

Crossing Description

Culvert 1 (Right)		**Culvert 2 (Left)**	
Shape	Rectangular	**Culvert Shape**	Rectangular
Material	Concrete	**Culvert Material**	Concrete
Bottom Material	Gravel over Concrete	**Culvert Bottom Material**	Gravel over Concrete
Length (ft)	200	**Length (ft)**	200
Height/Diameter (ft)	15	**Height/Diameter (ft)**	15
Embedment Depth (ft)	<1	**Embedment Depth (ft)**	<1
Width (ft)	15	**Width (ft)**	15
Bottom Slope	0.10%	**Bottom Slope**	0.20%
Inlet Type (e.g. Wingwall)	Wingwall	**Inlet Type (e.g. Wingwall)**	Wingwall
Outlet Type (e.g. Wingwall)	Wingwall	**Outlet Type (e.g. Wingwall)**	Wingwall
Residual Outlet Drop (ft)	None	**Residual Outlet Drop (ft)**	None
Outlet Pool Residual Depth (ft)	NA	**Outlet Pool Residual Depth (ft)**	NA

Active Channel Width (ft): 22

Additional Site Description:

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<3 cfs	>28 cfs	NA	NA
Adult	< 15 cfs	None	NA	NA

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	3 to 28	89%	3 to 28
Adult	15 to 203	94%	15 to >619

*Up to the 2-year flow event (619 cfs)

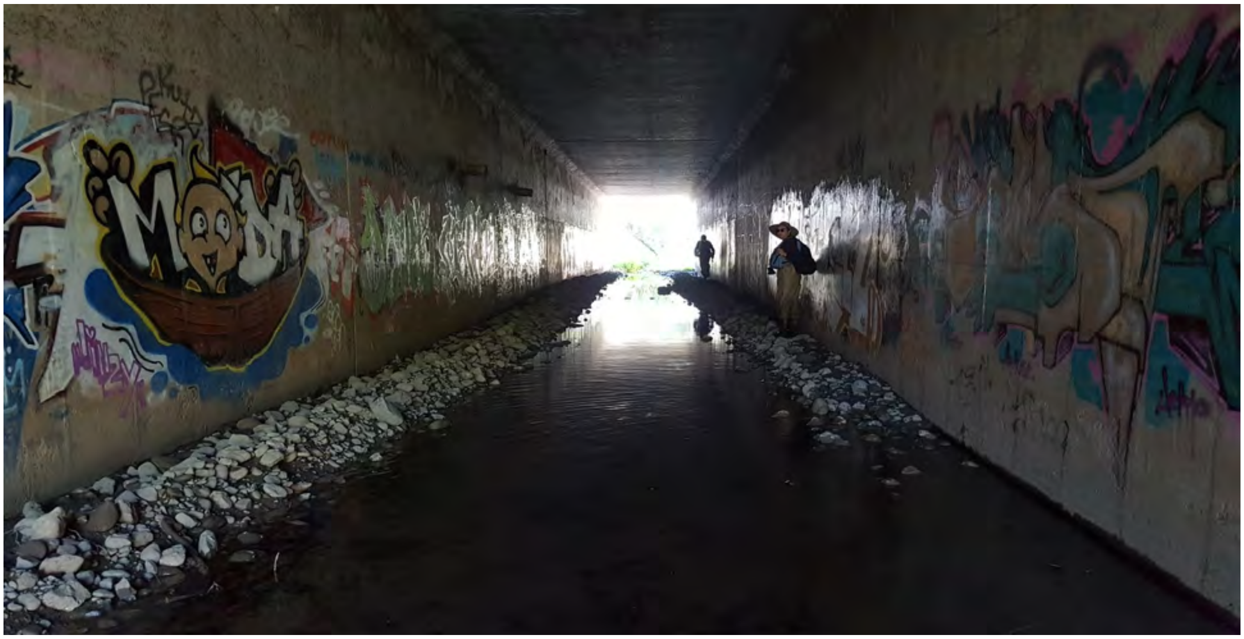
Additional Notes

Deposition in primary culvert that forms gravel/cobble banks and roughness along the wetted edge may be transitory. The crossing is passable by juveniles and adults at most flows, with insufficient depth at lower flows being the only substantial passage issue with this site.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 4
River Mile: 3.13
Reach: Reach 3
Site Name: Moffett Boulevard crossing
Latitude: 37.403503 **Longitude:** -122.069337 **PAD ID:** 713641

Culvert 1: Primary passage culvert, looking downstream. Note low-flow channel shape provides suitable depth.



Culvert outlets looking upstream, primary passage culvert on left

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	5	**Survey Date:**	8/7/2018	**Analyzed By:**	O.Light
River Mile:	3.21	**Surveyors:**	S. McNeely, O. Light, S. Kassem	**Reviewer(s):**	M. Love
Reach:	Reach 3				
Site Name:	Drop structure upstream of Moffett Boulevard				
Latitude:	37.402569	**Longitude:**	-122.069111	**PAD ID:**	713642

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control
Material Forming Drop:	Concrete
Current Drop Condition:	Good
Drop Structure Width (ft):	15.0
Residual Drop Height (ft):	2.5
Scour Pool Residual Depth (ft):	0.4
Pool Length (ft):	125.0
Active Channel Width (ft):	23
Is there a fish ladder?	No

Additional Site Description:

Concrete channel starting at this drop structure and leading to Site 4 at the Moffett Ave. box culverts. Upstream is earthen channel.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<11 cfs	>4 cfs	N/A	N/A
Adult	<46	None	N/A	N/A

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	46 to 203	79%	46 to 213

*Up to the 2-year flow event (619 cfs)

Additional Notes

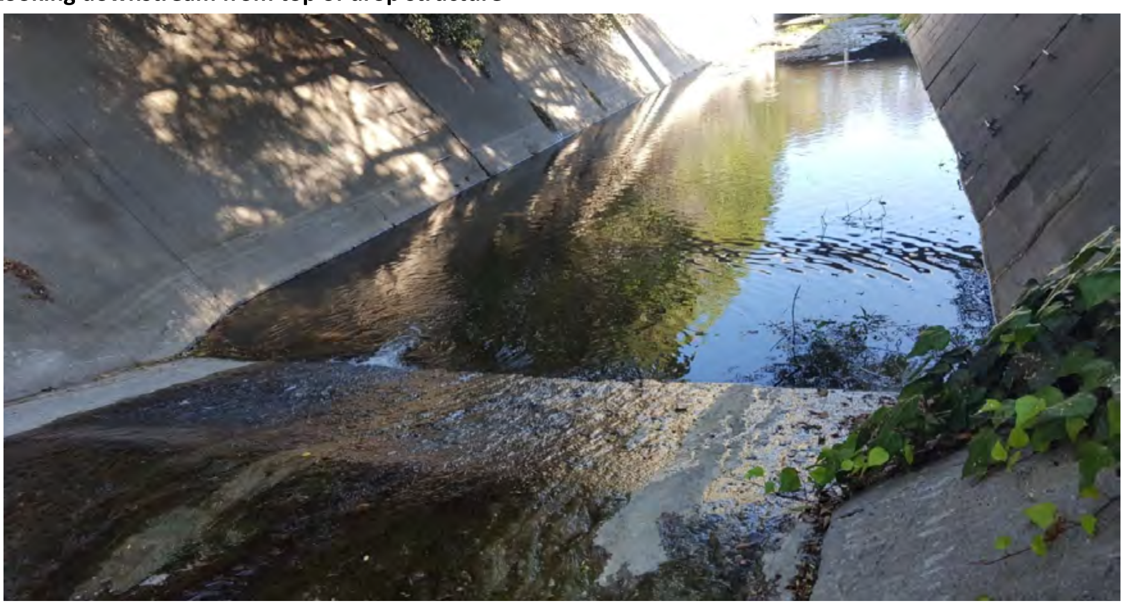
Analysis assumes fish would swim over this sloping drop structure rather than leap. The sloping and flat portions of the drop structure create a depth barrier at low to moderate flows and a velocity barrier for juveniles at most flows.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 5
River Mile: 3.21
Reach: Reach 3
Site Name: Drop structure upstream of Moffett Boulevard
Latitude: 37.402569 **Longitude:** -122.069111 **PAD ID:** 713642

Looking upstream to drop structure

Looking downstream from top of drop structure



Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	6	**Survey Date:**	8/7/2018	**Analyzed By:**	O.Light
River Mile:	3.29	**Surveyors:**	S. McNeely, O. Light, S. Kassem	**Reviewer(s):**	M. Love
Reach:	3				
Site Name:	Drop structure at Hetch Hetchy crossing				
Latitude:	37.401344	**Longitude:**	-122.069073	**PAD ID:**	713643

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control at pipeline crossing
Material Forming Drop:	Concrete
Current Drop Condition:	Moderate to good, slightly scoured
Drop Structure Width (ft):	15.0 (bottom width)
Residual Drop Height (ft):	3.3
Scour Pool Residual Depth (ft):	0.5
Pool Length (ft):	11.0
Active Channel Width (ft):	30.6
Is there a fish ladder?	No

Additional Site Description:

Drop structure with weir downstream to create pool. Upstream of the drop the channel bed and banks alternate between concrete and sacrete for roughly 100 feet.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<11 cfs	All passage flows	All passage flows	<33
Adult	<50 cfs	>110 cfs	All passage flows	<33

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	None	0%	None

*Up to the 2-year flow event (619 cfs)

Additional Notes

The drop height is excessive at all flows for all fish, and the pool depth for leaping is too shallow at flows less than 33 cfs. The concrete/sacrete channel upstream of the drop structure creates a depth barrier at low to moderate flows and a velocity barrier at all flows for juveniles and at high flows for adults.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 6
River Mile: 3.29
Reach: 3
Site Name: Drop structure at Hetch Hetchy crossing
Latitude: 37.401344 **Longitude:** -122.069073 **PAD ID:** 713643

Looking upstream at the drop structure with pool and weir

Looking upstream and concrete and sacrete channel above drop structure

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	8	**Survey Date:**	8/14/2018	**Analyzed By:**	O.Light
River Mile:	3.44	**Surveyors:**	S. McNeely, K. McLean, S. Kassem	**Reviewer(s):**	M. Love
Reach:	3				
Site Name:	Drop structure downstream of Middlefield Road				
Latitude:	37.399328	**Longitude:**	-122.068765	**PAD ID:**	713645

Drop Structure Description

Drop Structure Assumed Purpose: Grade control
Material Forming Drop: Concrete
Current Drop Condition: Good
Drop Structure Width (ft): 15.0 (bottom width)
Residual Drop Height (ft): 0.6
Scour Pool Residual Depth (ft): 1.1
Pool Length (ft): 74.0
Active Channel Width (ft): 29
Is there a fish ladder? No

Additional Site Description:

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<13 cfs	All passage flows	None	None
Adult	<58 cfs	None	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	58 to 203	73%	58 to 240

*Up to the 2-year flow event (619 cfs)

Additional Notes

The concrete forms a depth barrier at low and moderat flows for both juveniles and adults. Backwatering eliminates the water surface drop at 7 cfs, allowing fish to attempt to swim rather than leap onto the drop structure.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 8
River Mile: 3.44
Reach: 3
Site Name: Drop structure downstream of Middlefield Road
Latitude: 37.399328 **Longitude:** -122.068765 **PAD ID:** 713645

Looking upstream to drop structure

Looking downstream from above drop structure and concrete channel bed

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	9	**Survey Date:**	8/15/2018	**Analyzed By:**	O.Light
River Mile:	3.53	**Surveyors:**	S. McNeely, K. McLean, S. Kassem	**Reviewer(s):**	M. Love
Reach:	3				
Site Name:	Drop structure upstream of Middlefield Road				
Latitude:	37.39815	**Longitude:**	-122.068092	**PAD ID:**	713646

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control	
Material Forming Drop:	Concrete	
Current Drop Condition:	Good	
Drop Structure Width (ft):	15.0	(bottom width)
Residual Drop Height (ft):	1.5	
Scour Pool Residual Depth (ft):	0.6	
Pool Length (ft):	53.5	
Active Channel Width (ft):	31.9	
Is there a fish ladder?	No	

Additional Site Description:

Assessed site includes upstream concrete and sacrete channel. Upstream of drop structure the left channel bank experienced severe erosion and retreat, and the channel could potentially flank this grade control if the erosion is left unchecked.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<14 cfs	>1 cfs	All passage flows	<2 cfs
Adult	<49 cfs	None	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	49 to 203	77%	49 to 329

*Up to the 2-year flow event (619 cfs)

Additional Notes

The concrete forming the drop structure creates a depth barrier for juveniles and adults at low to moderate flows, and a velocity barrier for juveniles at nearly all flows.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 9
River Mile: 3.53
Reach: 3
Site Name: Drop structure upstream of Middlefield Road
Latitude: 37.39815 **Longitude:** -122.068092 **PAD ID:** 713646

Looking upstream to drop structure

Looking upstream to above drop structure

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	10	**Survey Date:**	8/21/2018	**Analyzed By:**	O.Light
River Mile:	3.63	**Surveyors:**	S. McNeely, O. Light, E. Popuch	**Reviewer(s):**	M. Love
Reach:	Reach 3				
Site Name:	Drop Structure at Gladys Avenue				
Latitude:	37.396664	**Longitude:**	-122.068217	**PAD ID:**	713647

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control	
Material Forming Drop:	Concrete	
Current Drop Condition:	Good	
Drop Structure Width (ft):	15.0	(bottom width)
Residual Drop Height (ft):	-0.3	(backwatered by downstream gravel tailout)
Scour Pool Residual Depth (ft):	2.4	
Pool Length (ft):	76.0	
Active Channel Width (ft):	23.2	
Is there a fish ladder?	No	

Additional Site Description:

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	None	>16	NA	NA
Adult	<9 cfs	None	NA	NA

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	1 to 16	54%	1 to 16
Adult	9 to 203	97%	9 to >619

*Up to the 2-year flow event (619 cfs)

Additional Notes

When stream is flowing, the downstream gravel tailout completely backwaters the drop structure, allowing fish to swim through it rather than leap. Water depth over the structure is too shallow at low flows for adults and water velocities too high for juveniles at higher flows.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 10
River Mile: 3.63
Reach: Reach 3
Site Name: Drop Structure at Gladys Avenue
Latitude: 37.396664 **Longitude:** -122.068217 **PAD ID:** 713647

Looking upstream to drop structure

Looking downstream from above drop structure

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	11	**Survey Date:**	8/21/2018	**Analyzed By:**	O. Light
River Mile:	3.7	**Surveyors:**	S. McNeely, O. Light, E. Popuch	**Reviewer(s):**	M. Love
Reach:	3				
Site Name:	Highway 85 crossing, PM 23.0				
Latitude:	37.395957	**Longitude:**	-122.068446	**PAD ID:**	713648

Crossing Description

Culvert

Shape	Rectangular bridge crossing
Material	Concrete
Bottom Material	Gravel, sacrete and concrete
Length (ft)	230
Height/Diameter (ft)	20
Width (ft)	20
Bottom Slope	0.95% at steepest
Inlet Type (e.g. Wingwall)	Sacrete sloped abutments
Outlet Type (e.g. Wingwall)	Sacrete sloped abutments and concrete drop structure
Residual Outlet Drop (ft)	1.7
Outlet Pool Residual Depth (ft)	1.1

Additional Site Description:

Site 11 consists of a 230 feet bridge crossing with a mix of sacrete and gravel bed and banks. The outlet consists of a concrete drop structure with a pool tailwater pool formed by a small v-notch weir. Average active channel width measured upstream of the fishway upstream (Site 12) is 19.9 feet.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<5 cfs	>2 cfs	All passage flows	<3 cfs
Adult	<35 cfs	None	None	None

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	35 to 203	84%	35 to 250

*Up to the 2-year flow event (619 cfs)

Additional Notes

Culvert with sacrete invert creates the low-flow depth barrier, the drop structure causes the leap barriers, and at very low flows the plunge pool is too shallow for juveniles to make the leap.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 11
River Mile: 3.7
Reach: 3
Site Name: Highway 85 crossing, PM 23.0
Latitude: 37.395957 **Longitude:** -122.068446 **PAD ID:** 713648

Looking upstream to drop structure and bridge, with v-weir in foreground

Looking downstream to drop structure from within culvert with sacrete invert

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	12	Survey Date:	8/21/2018	Analyzed By:	M. Love
River Mile:	3.76	Surveyors:	S. McNeely, O. Light, E. Popuch	Reviewer(s):	S. McNeely
Reach:	Reach 3				
Site Name:	Vortex weir fishway at SF35 gage				
Latitude:	37.396664	Longitude:	-122.068217	PAD ID:	707058

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control
Material Forming Drop:	Concrete
Current Drop Condition:	Good
Drop Structure Width (ft):	15.0
Overall Drop Height (ft):	3.44
Downstream Pool Residual Depth (ft):	4.2
Downstream Pool Length (ft):	20.3
Active Channel Width (ft):	23.2
Is there a fish ladder?	Yes, Vortex Pool and Chute

Fishway Configuration

Fishway Overall Slope:	3.75%
No. of Weirs:	4
Drop Across Weirs (ft):	0.9
Weir Spacing (ft):	25.2
Slope Along Weir Crest:	3.6H:1V
Residual Pool Depth (ft):	3.1
Skew of Weir to Flow:	45 deg

Additional Site Description:

Fishway built in 2002 to replace original grade control structure. Fishway tailwater controlled by a horizontal concrete and sacrete sill and downstream sedimentation. Immediately downstream is the Highway 85 bridge crossings (Site

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	None	None	All	None
Adult	None	None	>90 cfs	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	3 to 90	44%	1 to 90

*Up to the 2-year flow event (619 cfs)

Additional Notes

Design drop height between weirs is excessive for juveniles. The water surface differential between the entrance weir and tailwater pool becomes greater than 1.0 ft at flows greater than 35 cfs and greater than the 1.5 ft maximum for adults at flows greater than 90 cfs. This is caused by the difference in cross-sectional shape between the v-weir and the horizontal sill controlling the tailwater.

Site: 12
River Mile: 3.76
Reach: Reach 3
Site Name: Vortex weir fishway at SF35 gage
Latitude: 37.396664 Longitude: -122.068217 PAD ID: 713647

Looking upstream at fishway with entrance weir in foreground, and water surface drops increasing from upstream to downstream as a result of the low tailwater

Looking upstream through the fishway from concrete/sacrete tailwater control

Stevens Creek Fish Passage Assessment
Channel Report

Site:	14.0	**Survey Date:**	7/18/2018	**Analyzed By:**	pTJames
River Mile:	4.20	**Surveyors:**	OL, SMc, SK	**Reviewer(s):**	M. Love
Reach:	4				
Site Name:	Drop structure downstream of pedestrian bridge				
Latitude:	37.388716	**Longitude:**	-122.069286	**PAD ID:**	713650

Channel Description

Channel Length (ft)	28.3
Average Channel Slope (%)	6.1%
Channel Material (Size etc.)	Concrete; Boulders, 1 to 3 feet in size
Channel Bottom Width (ft)	19
Bank Material (e.g. Earth, Riprap)	Riprap/Earth
Bank Slope (H:1V)	2.2
Drop?	Yes
Residual Drop Height (ft)	0.9
Scour Pool Residual Depth (ft):	0
Active Channel Width (ft):	22

Additional Site Description:

Concrete grade control sill with short concrete apron and boulder chute downstream.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<16 cfs	>5 cfs	<6 cfs	< 5 cfs
Adult	<63 cfs	>67 cfs	None	<5 cfs

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	63 to 67	2%	63 to 67

*Up to the 2-year flow event (619 cfs)

Additional Notes

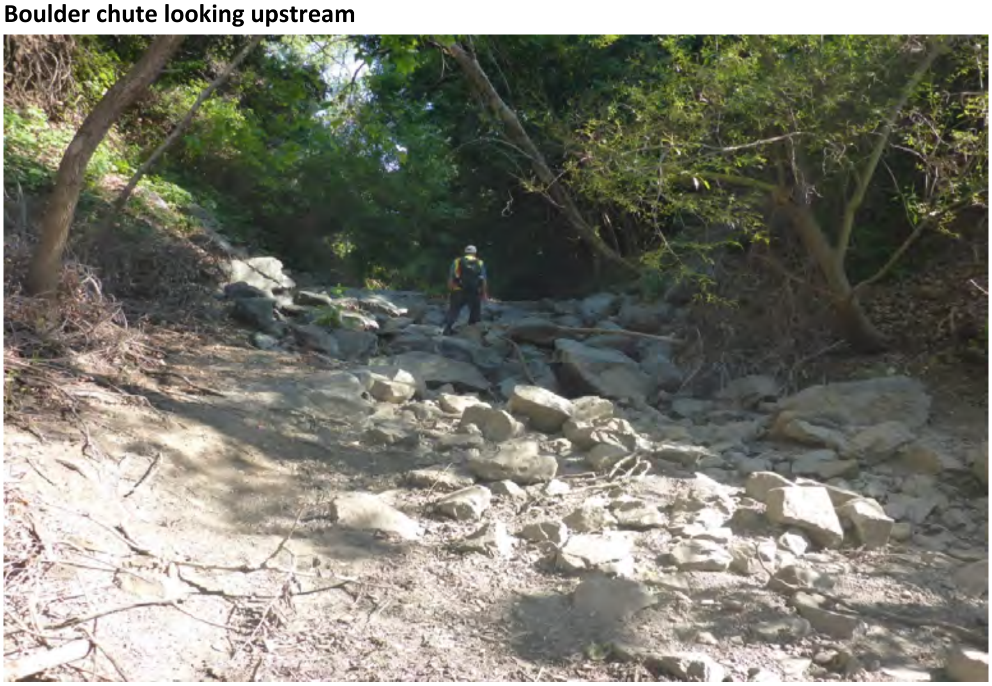
The drop structure becomes backwatered at approximately 30 cfs. At very low flows the concrete apron below the drop provides insufficient pool depth for leaping and swimming. The upstream end of the boulder chute creates excess velocities for adults and juveniles. The analysis likely under estimates passage conditions for adults given flow diversity in the boulder chute at high flows.

Stevens Creek Fish Passage Assessment (Continued)
Channel Site Photos

Site: 14
River Mile: 4.20
Reach: 4
Site Name: Drop structure downstream of pedestrian bridge
Latitude: 37.388716 **Longitude:** -122.069286 **PAD ID:** 713650

Concrete grade control with boulder chute below, looking upstream

Boulder chute looking upstream



Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	14.1	Survey Date:	7/18/2018	Analyzed By: pTJames
River Mile:	4.21	Surveyors:	OL, SMc, SK	Reviewer(s): M.Love
Reach:	4			

Site Name: Drop structure at pedestrian bridge

Latitude: 37.388637 Longitude: -122.069288 PAD ID:

Drop Structure Description

Drop Structure Assumed Purpose:	Grade Control
Material Forming Drop:	Grouted Boulders
Current Drop Condition:	Fair
Drop Structure Width (ft):	30.0
Residual Drop Height (ft):	0.6
Scour Pool Residual Depth (ft):	1.6
Pool Length (ft):	43.0
Active Channel Width (ft):	22
Is there a fish ladder?	No

Additional Site Description:

The drop feature is a channel wide, grouted, boulder structure. River left bank is comprised of native material while river right is a sacrete revetment. The drop feature is not impounding sediment upstream.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<6 cfs	>3 cfs	NA	NA
Adult	<64 cfs	None	NA	NA

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	64 to 203	70%	64 to 232

*Up to the 2-year flow event (619 cfs)

Additional Notes

The downstream face of the grouted rock structure is backwatered and the top of grouted rock has a sloping face, so no leap is required Instead, fish are assumed to attempt to swim over it. The analysis found the depth over the grouted rock is too shallow at low and moderate flows, and became too fast for juveniles at only 4 cfs.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 14.1
River Mile: 4.21
Reach: 4
Site Name: Drop structure at pedestrian bridge
Latitude: 37.388637 Longitude: -122.069288 PAD ID:

Grouted boulder drop structure looking upstream

Right bank sacrete revetment with undermined toe, looking downstream from grouted boulders

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	14.2	Survey Date:	9/4/2018	Analyzed By:	Llanos
River Mile:	4.39	Surveyors:	SK, OL, SM	Reviewer(s):	M. Love
Reach:	5				

Site Name: Sacrete pinch forming boulder jam

Latitude: 37.386035 Longitude: -122.069116 PAD ID:

Drop Structure Description

Drop Structure Assumed Purpose:	None, Self-formed Boulder Jam
Material Forming Drop:	Large Boulders
Current Drop Condition:	Fair
Drop Structure Width (ft):	12.0
Residual Drop Height (ft):	1.7
Scour Pool Residual Depth (ft):	0.3
Pool Length (ft):	50.0
Active Channel Width (ft):	16.1
Is there a fish ladder?	No

Additional Site Description:

Reach constructed by left bank sacrete revetment and imported large boulders. Boulders mobilized to form a channel spanning boulder drop. The left bank is earthen material with vegetation.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	None	>3cfs	All Passage Flows	All Passage Flows
Adult	<6 cfs	>262 cfs	<7 cfs	<14 cfs

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	14 to 203	95%	14 to 262

*Up to the 2-year flow event (619 cfs)

Additional Notes

The drop over the boulders creates a velocity and leap barrier for juveniles at all flows. The shallow pool depth up to 14 cfs creates a barrier for adults attempting to leap.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 14.2
River Mile: 4.39
Reach: 5
Site Name: Sacrete pinch forming boulder jam
Latitude: 37.386035 Longitude: -122.069116 PAD ID:

Looking upstream at boulder jam

Looking downstream from top of boulder jam

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site: 15 **Survey Date:** 8/29/2018 **Analyzed By:** Llanos/pTJames
River Mile: 4.56 **Surveyors:** SK, OL, SM **Reviewer(s):** M. Love
Reach: 6
Site Name: Highway 237 crossing, PM 0.33
Latitude: 37.383605 **Longitude:** -122.068958 **PAD ID:** 713651

Crossing Description

Culvert 1

Shape	Box
Material	Concrete
Bottom Material	Cobble, Gravel, Sand
Length (ft)	200
Height/Diameter (ft)	40
Embedment Depth (ft)	Unknown
Width (ft)	24
Bottom Slope	-0.60%
Inlet Type (e.g. Wingwall)	Straight Wingwall
Outlet Type (e.g. Wingwall)	Straight Wingwall
Residual Outlet Drop (ft)	None
Outlet Pool Residual Depth (ft)	None

Active Channel Width (ft): 15.8

Additional Site Description:

Bridge crossings with continuous concrete walls on both sides and natural channel bed material.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<7 cfs	>3 cfs	NA	NA
Adult	<25 cfs	None	NA	NA

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	25 to 203	89%	25 to 619

*Up to the 2-year flow event (619 cfs)

Additional Notes

The flat over widened channel bed creates a low-flow depth barrier for adults and juveniles. The lack of bed form and low roughness of the bed and concrete walls also creates a velocity barrier for juveniles.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 15
River Mile: 4.56
Reach: 6
Site Name: Highway 237 crossing, PM 0.33
Latitude: 37.383605 **Longitude:** -122.068958 **PAD ID:** 713651

Culvert inlet looking downstream

Mid culvert looking upstream

Stevens Creek Fish Passage Assessment
Channel Report

Site: 16 **Survey Date:** 11/9/2018 **Analyzed By:** S.McNeely
River Mile: 4.89 **Surveyors:** S.McNeely, O.Light, S.Kassem **Reviewer(s):** M. Love
Reach: 7
Site Name: Boulder channel downstream of El Camino Real
Latitude: 37.379266 **Longitude:** -122.069645 **PAD ID:** 733959

Channel Description

Channel Length (ft)	727
Average Channel Slope (%)	1.5% (steeper sections at 4%)
Channel Material (Size etc.)	Boulders (Median Size = 1.6 ft.) with gravel/cobble mix at downstream end
Channel Bottom Width (ft)	Varies. Approximately 20.
Bank Material (e.g. Earth, RSP)	Sandy gravel or soil with medium to thick vegetation.
Bank Slope (H:V)	Varies. Approximately 2:1.
Drop?	No
Residual Drop Height (ft)	NA
Scour Pool Residual Depth (ft):	NA
Active Channel Width (ft):	22.1

Additional Site Description:
Boulder lined reach extending downstream from the end of the concrete apron at the El Camino Real crossing. Boulders appeared to be installed to stabilize incising stream channel downstream of the road crossing.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<4 cfs	All Passage Flows	NA	NA
Adult	<16 cfs	>330 cfs	NA	NA

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	16 to 203	94%	16 to 330

*Up to the 2-year flow event (619 cfs)

Additional Notes

Hydraulic diversity from the boulders likely creates low-velocity pathways that juveniles could use to swim through this reach at most passage flows. This analysis does not account for variability in velocities across the channel width.

Stevens Creek Fish Passage Assessment (Continued)
Channel Site Photos

Site: 16
River Mile: 4.89
Reach: 7
Site Name: Boulder channel downstream of El Camino Real
Latitude: 37.379266 **Longitude:** -122.069645 **PAD ID:** 733959

Looking downstream at boulder lined channel

Looking upstream at downstream end of boulder channel and 2018 bank stabilization project

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	17	**Survey Date:**	11/8/2018	**Analyzed By:**	S.McNeely
River Mile:	4.9	**Surveyors:**	S.McNeely, O.Light, S.Kassem	**Reviewer(s):**	M. Love
Reach:	7				
Site Name:	El Camino Real crossing				
Latitude:	37.378827	**Longitude:**	-122.069665	**PAD ID:**	713652

Crossing Description

Culvert

Shape	Arch
Material	Concrete
Bottom Material	Concrete
Length (ft)	162
Height/Diameter (ft)	20 +/-
Embedment Depth (ft)	0
Width (ft)	30
Bottom Slope	0.34%
Inlet Type (e.g. Wingwall)	~30deg. wingwall on right
Outlet Type (e.g. Wingwall)	~15deg. wingwall both sides
Residual Outlet Drop (ft)	0.44
Outlet Pool Residual Depth (ft)	None

Active Channel Width (ft): 22 ft upstream of culvert, 22.1 ft upstream of Site 17.1

Additional Site Description:

Crossing consists of three concrete arch segments with bridge deck segments as part of extensions on both ends. Minor bend to right in culvert.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<20 cfs	≥1 cfs	None	<2 cfs
Adult	<63 cfs	>331	None	None

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	63 to 203	70%	63 to 331

*Up to the 2-year flow event (619 cfs)

Additional Notes

Shallow depths on concrete floor is a barrier to adults at low to moderate flows. Velocities are excessive on concrete for juveniles at most flows.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 17
River Mile: 4.9
Reach: 7
Site Name: El Camino Real crossing
Latitude: 37.378827 **Longitude:** -122.069665 **PAD ID:** 713652

Looking downstream at culvert inlet

Looking upstream at culvert outlet with boulder channel (site 16) downstream of apron

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	17.1	Survey Date:	11/18/2018	Analyzed By:	S.McNeely
River Mile:	4.96	Surveyors:	S.McNeely, O.Light, S.Kassem	Reviewer(s):	M. Love
Reach:	7				
Site Name:	Drop structure at storm drain				
Latitude:	37.378044	Longitude:	-122.06943	PAD ID:	

Drop Structure Description

Drop Structure Assumed Purpose:	Grade Control, Drainage Outfall Protection
Material Forming Drop:	Sacrete and Concrete
Current Drop Condition:	Eroding Sacrete, Moderate to Poor
Drop Structure Width (ft):	22.3
Residual Drop Height (ft):	None (backwatered from Site 17)
Scour Pool Residual Depth (ft):	3.4
Pool Length (ft):	821.0
Active Channel Width (ft):	22.1
Is there a fish ladder?	No

Additional Site Description:

Trapezoidal section of sacrete set in concrete with approx. 48" diameter culvert outlet located approximately halfway up the right bank. At low flows the drop structure is slightly backwatered by the culvert inlet apron from El Camino Real (site 17), located several hundred feet downstream.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<5 cfs	>1 cfs	None	None
Adult	<34 cfs	>89 cfs	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	34 to 89	28%	34 to 89

*Up to the 2-year flow event (619 cfs)

Additional Notes

Depth is shallow, creating a barrier at low and moderate flows. Velocities accelerate across the sacrete as flow goes supercritical, creating a velocity barrier for juveniles and adults.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 17.1
River Mile: 4.96
Reach: 7
Site Name: Drop structure at storm drain
Latitude: 37.378044 Longitude: -122.06943 PAD ID:

Looking upstream at drop structure/drainage outfall protection

Looking downstream at drop structure/drainage outfall protection

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	19	**Survey Date:**	8/28/2018	**Analyzed By:**	pTJames
River Mile:	5.85	**Surveyors:**	SK, OL, SM	**Reviewer(s):**	M. Love
Reach:	8				
Site Name:	Highway 85 crossing, PM 20.9				
Latitude:	37.366815	**Longitude:**	-122.063793	**PAD ID:**	713654

Crossing Description

Culvert 1

Shape	Rectangle
Material	Concrete
Bottom Material	Gravel and Cobble with Areas of Exposed Concrete
Length (ft)	155
Height/Diameter (ft)	~20
Embedment Depth (ft)	Varies (0 to 2.5)
Width (ft)	25
Bottom Slope	0.10%
Inlet Type (e.g. Wingwall)	Headwall/Wingwall
Outlet Type (e.g. Wingwall)	Headwall
Residual Outlet Drop (ft)	None
Outlet Pool Residual Depth (ft)	None

Active Channel Width (ft): 16

Additional Site Description:

Culvert bends slightly to the left. Upstream of culvert inlet an concrete encased pipeline (assumed), exposed at stream grade, spans the channel.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	29
Adult	3	203

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<4 cfs	All Passage Flows	NA	NA
Adult	<17 cfs	None	NA	NA

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	17 to 203	93%	17 to >619

*Up to the 2-year flow event (619 cfs)

Additional Notes

The concrete pipeline crossing is in a pool and not a barrier. At low flows a riffle in the lower half of the culvert creates a low flow depth barrier and velocity barrier for juveniles. Due to size of the bed material within culvert, juveniles are likely able to find low velocity passageways through this riffle, which is not accounted for in this analysis.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 19
River Mile: 5.85
Reach: 8
Site Name: Highway 85 crossing, PM 20.9
Latitude: 37.366815 **Longitude:** -122.063793 **PAD ID:** 713654

Culvert outlet, looking upstream with some concrete exposure on outside of bend

Looking (a) downstream within culvert and (b) at exposed concrete spanning channel upstream of culvert

(a)

(b)

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	21	**Survey Date:**	9/19/2018	**Analyzed By:**	pTJames
River Mile:	6.82	**Surveyors:**	OL, EP, SM	**Reviewer(s):**	M. Love
Reach:	9				
Site Name:	Fremont fish ladder				
Latitude:	37.355448	**Longitude:**	-122.061686	**PAD ID:**	707056

Drop Structure Description

Drop Structure Assumed Purpose:	Grade Control	**Fish Ladder**	
Material Forming Drop:	Concrete	**Length (ft):**	72
Current Drop Condition:	Good	**Slope:**	16.7%
Drop Structure Width (ft):	27, including ladder	**Width (ft):**	3.5
Residual Drop Height (ft):	13.0	**No. of Baffles:**	32
Scour Pool Residual Depth (ft):	3.3	**Baffle Spacing (ft):**	2.33
Pool Length (ft):	39.0	**Open Width of Baffles (ft):**	2.0
Active Channel Width (ft):	17.2		
Is there a fish ladder?	Yes		

Additional Site Description:

Denil fishway is located on right of drop structure. The dimensions of the fishway fall within "standard" Denil dimension relationships. Grouted rock located at toe of drop and ladder entrance. Ladder has entrance pool. Ladder exit located on inside of bend and there is some sedimentation upstream of the exit.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<21 cfs	All Flows	<6 cfs	<15 cfs
Adult	<42 cfs	203 cfs	None	<18 cfs

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	42 to 130*	70%	42 to 203**

*Up to 619 cfs

Additional Notes

Grouted rock apron and fishway both create juvenile velocity barriers at all flows. Grouted rock apron creates depth barrier and poor entrance conditions at low to moderate flows for adults.

**The Denil fishway length exceeds criteria, and should have two intermediate resting pools. At approximately 165 cfs, flows at top of apron overtop the fishway wall, and spills into the fishway, likely creating a barrier. Debris also likely clogs fishway exit during adult fish migration flows.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 21
River Mile: 6.82
Reach: 9
Site Name: Fremont fish ladder
Latitude: 37.355448 **Longitude:** -122.061686 **PAD ID:** 707056

Looking upstream at Denil fish ladder entrance on left and grouted rock apron

Looking downstream at top of drop structure with Denil fish ladder exit on right

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site: 22 **Survey Date:** 9/5/2018 **Analyzed By:** SK
River Mile: 6.96 **Surveyors:** SK, OL, SM **Reviewer(s):** M. Love
Reach: 10
Site Name: Highway 85 crossing, PM 20.0
Latitude: 37.354203 **Longitude:** -122.06148 **PAD ID:** 733951

Crossing Description

Culvert 1 (Bridge)

Shape	Rectangular
Material	Concrete
Bottom Material	Cobble & gravel
Length (ft)	185
Height/Diameter (ft)	20
Embedment Depth (ft)	NA (natural bottom)
Width (ft)	46
Bottom Slope	0.31%
Inlet Type (e.g. Wingwall)	Sloping earth abutment
Outlet Type (e.g. Wingwall)	Sloping earth abutment
Residual Outlet Drop (ft)	None
Outlet Pool Residual Depth (ft)	None

Active Channel Width (ft): 23.75

Additional Site Description:
Large bridge crossing with three bents. Active channel through center.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<20	>1 cfs	N/A	N/A
Adult	<68	None	N/A	N/A

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	68 to 130	50%	68 to >619

*Up to 619 cfs

Additional Notes

The channel is over-widened under the bridge, resulting in a depth barrier for adults and juveniles up to moderate flows. The analysis found velocity barriers for juveniles within the riffle near the outlet due to lack of roughness.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 22
River Mile: 6.96
Reach: 10
Site Name: Highway 85 crossing, PM 20.0
Latitude: 37.354203 **Longitude:** -122.06148 **PAD ID:** 733951

Bridge outlet looking upstream

Inside bridge, looking downstream.

Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	23	**Survey Date:**	12/7/2018	**Analyzed By:**	SK
River Mile:	7.15	**Surveyors:**	OL, SMc	**Reviewer(s):**	SMc
Reach:	11			**PAD ID:**	713655
Site Name:	Fremont Avenue crossing				
Latitude:	37.352123	**Longitude:**	-122.063271		

Crossing Description

Culvert 1		**Culvert 2 (if applicable)**	
Shape	Open bottom arch	**Culvert Shape**	
Material	Concrete	**Culvert Material**	
Bottom Material	Cobble/gravel	**Culvert Bottom Material**	
Length (ft)	47	**Length (ft)**	
Height/Diameter (ft)	n/a	**Height/Diameter (ft)**	
Embedment Depth (ft)	n/a	**Embedment Depth (ft)**	
Width (ft)	n/a	**Width (ft)**	
Bottom Slope	n/a	**Bottom Slope**	
Inlet Type (e.g. Wingwall)	n/a	**Inlet Type (e.g. Wingwall)**	
Outlet Type (e.g. Wingwall)	n/a	**Outlet Type (e.g. Wingwall)**	
Residual Outlet Drop (ft)	n/a	**Residual Outlet Drop (ft)**	
Outlet Pool Residual Depth (ft)	n/a	**Outlet Pool Residual Depth (ft)**	

Active Channel Width (ft): 17.6

Additional Site Description:

Crossing was deemed not a barrier according to CDFW Green-Gray-Red evaluation. Crossing has well defined thalweg and active channel widths equal to inlet width

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	all passage flows	all passage flows	N/A	N/A
Adult	all passage flows	all passage flows	N/A	N/A

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	all passage flows	100%	all flows
Adult	all passage flows	100%	all flows

*Up to 619 cfs

Additional Notes

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 23
River Mile: 7.15
Reach: 11
Site Name: Fremont Avenue crossing
Latitude: 37.352123 **Longitude:** -122.063271

Culvert outlet facing upstream

Inside culvert, facing upstream

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	25	**Survey Date:**	9/6/2018	**Analyzed By:**	pTJames
River Mile:	7.46	**Surveyors:**	SK, OL, SM	**Reviewer(s):**	MLove
Reach:	12				
Site Name:	Abandoned flashboard dam				
Latitude:	37.348253	**Longitude:**	-122.064682	**PAD ID:**	713656

Drop Structure Description

Drop Structure Assumed Purpose:	Sill of Abandoned Flashboard Dam
Material Forming Drop:	Concrete
Current Drop Condition:	Fair
Drop Structure Width (ft):	21.0
Residual Drop Height (ft):	0.8
Scour Pool Residual Depth (ft):	0.7
Pool Length (ft):	90.0
Active Channel Width (ft):	17
Is there a fish ladder?	No

Additional Site Description:

Concrete retaining walls along both sides of channel extend high up the bank.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<4 cfs	>17 cfs	<9 cfs	None
Adult	<38 cfs	None	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	9 to 17	29%	9 to 17
Adult	38 to 130	74%	38 to >619

*Up to 619 cfs

Additional Notes

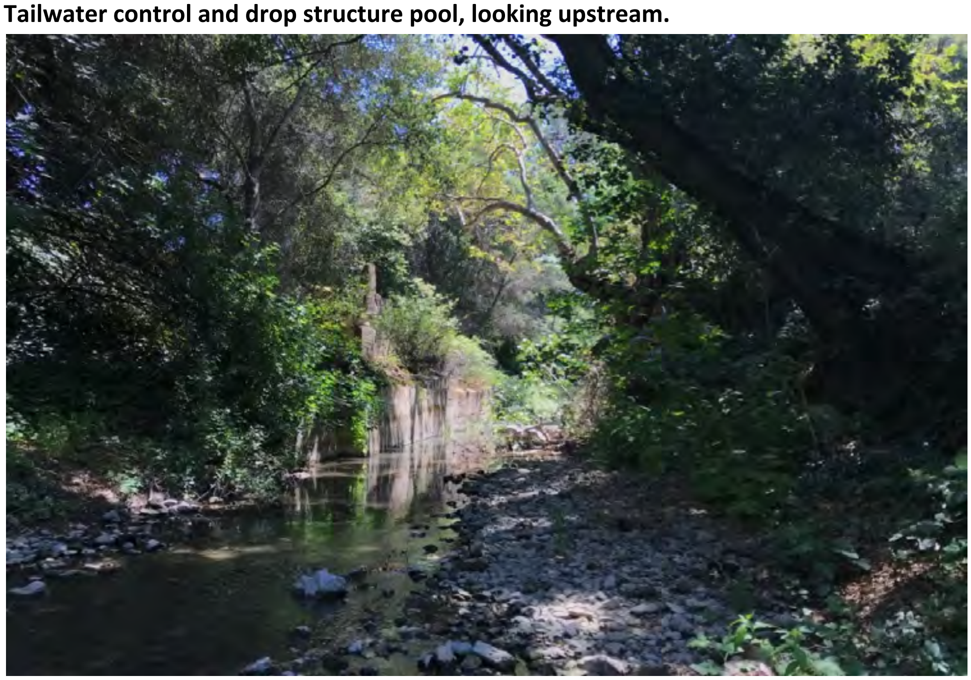
Depth over the concrete sill is insufficient at low flows for adults. At low flows the weir is a leap barrier for juveniles and at higher flows the site presents a velocity barrier for juveniles.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 25
River Mile: 7.46
Reach: 12
Site Name: Abandoned flashboard dam
Latitude: 37.348253 **Longitude:** -122.064682 **PAD ID:** 713656

Drop structure looking upstream.

Tailwater control and drop structure pool, looking upstream.



Stevens Creek Fish Passage Assessment
Drop Structure Report

Site: 25.1 **Survey Date:** 9/6/2019 **Analyzed By:** pTJames
River Mile: 7.48 **Surveyors:** SK, OL, SM **Reviewer(s):** M. Love
Reach: 12
Site Name: Concrete logs
Latitude: 37.348057 **Longitude:** -122.064755 **PAD ID:**

Drop Structure Description

Drop Structure Assumed Purpose:	Grade Control and Possibly Habitat
Material Forming Drop:	Concrete Logs and Wooden Logs
Current Drop Condition:	Original Configuration Unknown, but Logs appear to have shifted
Drop Structure Width (ft):	11.4
Residual Drop Height (ft):	0.6
Scour Pool Residual Depth (ft):	1.0
Pool Length (ft):	8.9
Active Channel Width (ft):	15.1
Is there a fish ladder?	No

Additional Site Description:

A channel spanning concrete log and wooden log structure with a pool downstream controlled by imported boulder. A secondary concrete and wooden log structure runs parallel to flow and appears have shifted (assuming it originally spanned the channel).

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<4 cfs	>2 cfs	<3 cfs	None
Adult	<22 cfs	>558 cfs	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	22 to 130	86%	22 to 558

*Up to 619 cfs

Additional Notes

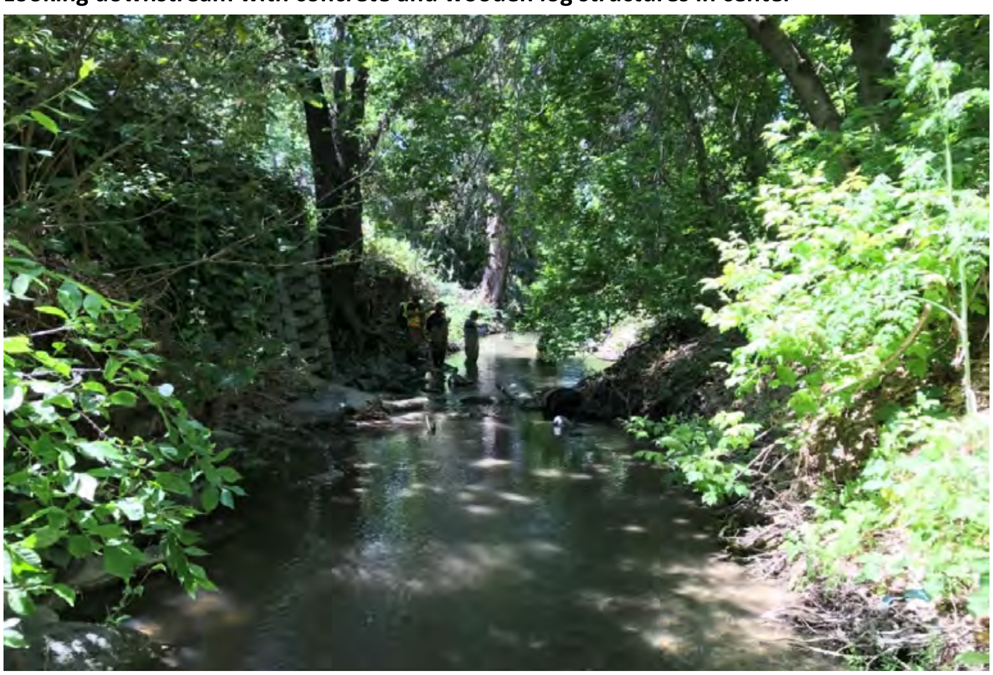
High velocities over the channel spanning concrete log create a juvenile barrier. Shallow depths over the log create a low-flow depth barrier for adults. The hydraulic complexity of the structure likely provides suitable passage routes at most lower flows for juveniles and adults.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site:	25.1				
River Mile:	7.48				
Reach:	12				
Site Name:	Concrete logs				
Latitude:	37.348057	**Longitude:**	-122.064755	**PAD ID:**	

Concrete and wooden log structures, looking upstream.

Looking downstream with concrete and wooden log structures in center



Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site: 27 | **Survey Date:** 9/12/2018 | **Analyzed By:** pTJames
River Mile: 8.37 | **Surveyors:** SK, OL, SM | **Reviewer(s):** M. Love
Reach: 13
Site Name: Homestead Road crossing
Latitude: 37.337629 | **Longitude:** -122.06227 | **PAD ID:** 713658

Crossing Description

Culvert 1

Shape	Box
Material	Concrete
Bottom Material	Natural
Length (ft)	76
Height/Diameter (ft)	~25 ft
Embedment Depth (ft)	NA
Width (ft)	38
Bottom Slope	1.64%
Inlet Type (e.g. Wingwall)	Wingwall
Outlet Type (e.g. Wingwall)	Wingwall
Residual Outlet Drop (ft)	1.1
Outlet Pool Residual Depth (ft)	0.5

Active Channel Width (ft): 13.7

Additional Site Description:

Downstream of the road crossing channel is clogged with large concrete rubble associated with an abandoned concrete structure, assumed to be associated with a previous stream crossing.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<6 cfs	>1 cfs	None	None
Adult	<24 cfs	>277 cfs	None	None

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	24 to 130	85%	24 to 277

*Up to 619 cfs

Additional Notes

At low flows small drops have insufficient pool depth for leaping, although this would likely not inhibit fish passage. High velocities through concrete rubble create juvenile barrier. Jagged debris within rubble posse risk of harm to adult fish.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 27
River Mile: 8.37
Reach: 13
Site Name: Homestead Road crossing
Latitude: 37.337629 **Longitude:** -122.06227 **PAD ID:** 713658

Looking upstream from crossing outlet

Looking upstream at concrete rubble across channel located downstream of the crossing

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	33	Survey Date:	7/16/2018	Analyzed By:	T. James
River Mile:	8.62	Surveyors:	M. Love, T. James, S. McNeely, O. Light, S. Kassem	Reviewer(s):	M. Love
Reach:	14				
Site Name:	Drop structure at Sweet Oak Street				
Latitude:	37.335696	Longitude:	-122.064032	PAD ID:	

Drop Structure Description

Drop Structure Assumed Purpose:	Abandoned Flashboard Dam
Material Forming Drop:	Concrete
Current Drop Condition:	Poor
Drop Structure Width (ft):	17.7
Residual Drop Height (ft):	1.7
Scour Pool Residual Depth (ft):	1.5
Pool Length (ft):	48.0
Is there a fish ladder?	No
Active Channel Width (ft):	16.1 (Measured downstream of site.)

Additional Site Description:
Abandoned flashboard dam. Structure partially failed and sagging in center. Hole in concrete apron with exposed rebar. Debris deposited upstream of hole.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<6 cfs	All Passage Flows	All Passage Flows	None
Adult	<49 cfs	>296 cfs	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	49 to 130	65%	49 to 296

*Up to 619 cfs

Additional Notes

Structure has already partially failed and currently serves no purpose. Hole in concrete apron and exposed rebar further exacerbates passage conditions due to fallback potential and risk of fish injury. Removal of this structure will likely increase drop at downstream end of sacrete channel at next site upstream.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 33
River Mile: 8.62
Reach: 14
Site Name: Drop structure at Sweet Oak Street
Latitude: 37.335696 Longitude: -122.064032 PAD ID:

Drop structure looking upstream from right bank

Drop structure looking upstream from scour pool

Stevens Creek Fish Passage Assessment
Channel Report

Site:	33.1	Survey Date:	7/16/2018	Analyzed By:	T. James
River Mile:	8.67	Surveyors:	M. Love, T. James, S. McNeely, O. Light, S. Kassem	Reviewer(s):	M. Love
Reach:	14				
Site Name:	Sacrete channel				
Latitude:	37.335276	Longitude:	-122.064743	PAD ID:	

Channel Description

Channel Length (ft)	270
Average Channel Slope (%)	0.65%
Channel Material (Size etc.)	Sacrete with gravel and fines
Channel Bottom Width (ft)	6
Bank Material (e.g. Earth, RSP)	Left: Sacrete, Right: Earth
Bank Slope (H:V)	Left 1.7:1, Right 1.7:1
Outlet Drop?	Yes
Residual Outlet Drop Height (ft)	0.4
Scour Pool Residual Depth (ft):	2.9
Active Channel Width (ft):	7.9

Additional Site Description:
Channel bends to right with sacrete bottom along thalweg and left edge of channel. Right side of channel has deposition and vegetation growing on top of the sacrete, constricting the main channel against the left sacrete revetment. Large storm drain entering and small drop into scour pool at downstream end of sacrete.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<11 cfs	All Passage Flows	None	None
Adult	<37 cfs	None	None	None

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	37 to 130	74%	37 to >619

*Up to 619 cfs

Additional Notes

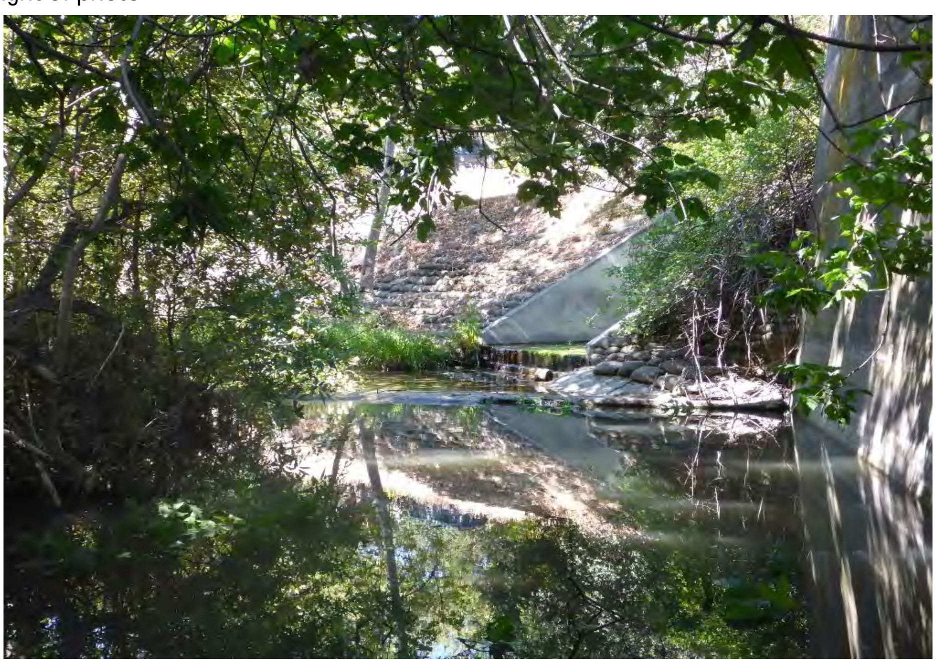
Tailwater control of scour pool influenced by downstream flashboard dam at RM 8.62 (Site 33). Removal of the flashboard dam would increase drop at end of sacrete channel at this site. Extensive depth barrier due to shallow depth on sacrete and concrete apron at downstream end. Velocities are also excessive for juveniles throughout channel at all flows.

Stevens Creek Fish Passage Assessment (Continued)
Channel Site Photos

Site: 33.1
River Mile: 8.67
Reach: 14
Site Name: Sacrete channel
Latitude: 37.335276 Longitude: -122.064743 PAD ID:

Mid-channel reach looking upstream

Looking upstream at downstream end of sacrete channel and storm drain entering on right of photo



Stevens Creek Fish Passage Assessment
Culvert Crossing Report

Site:	28	**Survey Date:**	7/16/2018	**Analyzed By:**	T. James
River Mile:	8.82	**Surveyors:**	M. Love, T. James, S. McNeely, O. Light, S. Kassem	**Reviewer(s):**	M. Love
Reach:	14				
Site Name:	Highway 280 crossing, PM 11.2				
Latitude:	37.333662	**Longitude:**	-122.064036	**PAD ID:**	713660

Crossing Description

Culvert 1		**Culvert 2**	
Shape	Arch	**Culvert Shape**	Circular
Material	Concrete	**Culvert Material**	Concrete
Bottom Material	Gravel on Concrete	**Culvert Bottom Material**	Gravel on Concrete
Length (ft)	400	**Length (ft)**	400
Height/Diameter (ft)	18.5	**Height/Diameter (ft)**	22
Width (ft)	22	**Width (ft)**	NA
Bottom Slope	0.37%	**Bottom Slope**	0.15%
Inlet Type (e.g. Wingwall)	Wingwall	**Inlet Type (e.g. Wingwall)**	Wingwall
Outlet Type (e.g. Wingwall)	Wingwall	**Outlet Type (e.g. Wingwall)**	Wingwall
Residual Outlet Drop (ft)	None	**Residual Outlet Drop (ft)**	None
Outlet Pool Residual Depth (ft)	NA	**Outlet Pool Residual Depth (ft)**	NA

Active Channel Width (ft): 22.1

Additional Site Description:
Standard Caltrans concrete arch culvert with concrete floor embedded below gravel channel bed. Gravel bed has 2-foot deep pool downstream of inlet followed by 200 foot long riffle extending to outlet. Deep outlet scour pool present against right wingwall at bend in channel.

Steelhead Passage Flow Ranges (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flow Ranges by Barrier Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<3 cfs	>2 cfs	None	None
Adult	<18 cfs	>360 cfs	None	None

Passable Flow Ranges

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	18 to 130	90%	18 to 360

*Up to 619 cfs

Additional Notes

Juvenile fish likely able to pass this culvert at nearly all fish passage flows due to velocity diversity. A low flow channel along the right side of the culvert helps concentrate flows to provide adequate depth. This passage analysis fails to account for the areas of low velocity close to the bed of the channel.

Stevens Creek Fish Passage Assessment (Continued)
Culvert Crossing Site Photos

Site: 28
River Mile: 8.82
Reach: 14
Site Name: Highway 280 crossing, PM 11.2
Latitude: 37.333662 **Longitude:** -122.064036 **PAD ID:** 713660

Culvert inlets looking downstream, primary passage culvert on left

Primary passage culvert's outlet, looking downstream. Note low-flow channel shape provides suitable depth.

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	30.1	**Survey Date:**	5/9/2019	**Analyzed By:**	O. Light
River Mile:	9.93	**Surveyors:**	S. McNeely, O. Light, J.Stead	**Reviewer(s):**	M. Love
Reach:	16				
Site Name:	Boulder Weirs at Blackberry Farms				
Latitude:	37.320902	**Longitude:**	-122.060571	**PAD ID:**	

Drop Structure Description

Drop Structure Assumed Purpose:	Grade control/stream restoration
Material Forming Drop:	Boulders
Current Structure Condition:	Good
Drop Structure Width (ft):	18.0
Residual Drop Height (ft):	0.6 (upper weir), 0.4 (lower weir)
Scour Pool Residual Depth (ft):	2.6 (below upper weir), 3.1 (below lower weir)
Pool Length (ft):	52 (upper), 36 (lower)
Active Channel Width (ft):	13
Is there a fish ladder?	No

Additional Site Description:

Two constructed boulder weir drop structures built with 1 to 3 foot diameter rock placed downstream of recently constructed pedestrian bridge. Structures create pool habitat.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	None	>1 cfs	All passage flows	None
Adult	None	None	None	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	5 to 130	100%	5 to 494

*Up to 619 cfs

Additional Notes

The primary barriers are the leap height over the weir for juveniles and the velocity for juveniles. At juvenile low passage flow there is a 0.7 ft of drawdown across the weir that forms the leap barrier. Given the hydraulic complexity and multiple pathways provided by the boulder weirs, it is likely that juveniles fish can swim or leap over these weirs at all juvenile passage flows. This hydraulic complexity is not accounted for in the analysis.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 30.1
River Mile: 9.93
Reach: 16
Site Name: Boulder Weirs at Blackberry Farms
Latitude: 37.320902 **Longitude:** -122.060571 **PAD ID:**

Looking upstream from downstream of lower weir

Looking downstream from upstream of upper weir

Stevens Creek Fish Passage Assessment
Drop Structure Report

Site:	32	**Survey Date:**	9/13/2018	**Analyzed By:**	O. Light
River Mile:	12.28	**Surveyors:**	S. McNeely, O. Light, S. Kassem	**Reviewer(s):**	M. Love
Reach:	15				
Site Name:	Gaging weir SF44 at Stevens Creek Park				
Latitude:	37.305596	**Longitude:**	-122.07425	**PAD ID:**	713667

Drop Structure Description

Drop Structure Assumed Purpose:	Streamflow gage
Material Forming Drop:	Concrete with steel lip
Current Structure Condition:	Moderate. Some Undermining
Drop Structure Width (ft):	38.5
Residual Drop Height (ft):	2.4
Scour Pool Residual Depth (ft):	4.4
Pool Length (ft):	39.0
Active Channel Width (ft):	18.3
Is there a fish ladder?	No

Additional Site Description:

Low angled v-notch gaging weir used by SCVWD to gage in-stream flows below the Stevens Creek Reservoir. Very deep scour pool, but rough concrete protrudes into plunging flow at low flows.

Steelhead Passage Flows (cfs)

Age Class	Low	High
Juvenile	1	21
Adult	5	130

Existing Fish Passage Conditions

Barrier Flows by Type

Age Class	Depth Barrier	Velocity Barrier	Leap Barrier	Insufficient Pool Depth
Juvenile	<3 cfs	>8 cfs	All passage flows	None
Adult	<17 cfs	None	All passage flows	None

Passable Flows

Age Class	Passage Flows Meeting Assessment Criteria (cfs)	Percent of Passage Flows	All Flows Meeting Assessment Criteria* (cfs)
Juvenile	None	0%	None
Adult	None	0%	260 to >619

*Up to 619 cfs

Additional Notes

The primary barrier is the leap height over the weir. At adult high passage flow there is a 2 ft drawdown across the weir that forms the leap barrier. At very high flows tailwater becomes high enough for adults to swim across the weir rather than leap.

Stevens Creek Fish Passage Assessment (Continued)
Drop Structure Site Photos

Site: 32
River Mile: 12.28
Reach: 15
Site Name: Gaging weir SF44 at Stevens Creek Park
Latitude: 37.305596 **Longitude:** -122.07425 **PAD ID:** 713667

Looking upstream to gaging weir

Looking upstream at riffle control of pool below gaging weir

Attachment F

Site Ownership

Attachment F

Site Ownership as Provided by Valley Water

Assessment Site No.	Description	Landowner / APN or Caltrans Parcel No. / SCVWD Easement ID*	NOTES
1	Grade control, Vernon Avenue	City Mtn View / 116-16-062 / 828	SCVWD fee IDs 351, 11616035, 11616068
		SCVWD / 116-16-035 / none	
		SCVWD / 116-16-068 / none	
		SCVWD/ 116-17-005 / none	
2	Highway 101 crossing, PM 48.0	Caltrans / 99, 11880 / none	
3	Moffett fish ladder	SCVWD / 153-19-006 / none	SCVWD Fee ID 15319006
		City of Mountain View / 153-19-005 / 781, 890	
4	Moffett Boulevard crossing	Caltrans / 13563, 21040 / 5031	
5	Drop structure upstream of Moffett Boulevard	City of Mtn View / 160-04-001 / 807, 889	
6	Drop structure at Hetch Hetchy crossing	CC of San Francisco/ 160-040-019 / none	Hetch-Hetchy Crossing
8	Drop Structure downstream of Middlefield Road	SCVWD / 160-23-006 / none	SCVWD Fee ID 16023006
9	Drop Structure upstream of Middlefield Road	City of Mountain View / 160-37-008 / 804	SCVWD Fee ID 16037009
		SCVWD / 160-37-009/ none	
10	Drop Structure at Gladys Avenue	SCVWD / 160-37-006 / none	SCVWD Fee ID 16037006
		City of Mountain View / 160-37-002 / 893	
11	Highway 85 crossing, PM 23.0	Caltrans / 13536, 13618 /907, 908, 5020	Highway 85 crossing between MiddlefieldRd and Central Exwy, partial SCVWD easement
12	Vortex Fish Weir at SF35 Gage	SCVWD / 158-48-002 / none	SCVWD Fee ID 358
14	Drop Structure Downstream of Pedestrian Bridge	City of Mtn View / 158-32-001/ 853	
14.1	Drop Structure at Pedestrian Bridge	City of Mtn View / 158-32-001/ 853	
14.2	Sacrete pinch forming boulder jam	Ralston Capital Multi-family V LLC / 158-32-005 / 805	
15	Highway 237 Crossing, PM 0.33	Caltrans / 13633 / none	
16	Boulder channel downstream of El Camino Real	PG&E / 161-02-011 / none	SCVWD Fee on east and west banks (not channel) 16102003, 16102004
17	El Camino Real crossing	Caltrans / 91 / none	
17.1	Drop structure at storm drain	City of Mtn View / 197-43-001 / none	SCVWD easement on west bank (not channel) 783
19	Highway 85 crossing, PM 20.9	Caltrans / 20901 / none	
21	Fremont fish ladder	City of Sunnyvale / 202-38-042 / 846	
22	Highway 85 crossing, PM 20.0	Caltrans / 13515, 20884 / none	
23	Fremont Avenue crossing	SCVWD / 318-21-042 / none	SCVWD ID no. 31821042
		City of Sunnyvale / 320-07-005 / 842	
		Stauffer Chemical Co. / No APN / 831	
25	Abandoned flashboard dam	City of Sunnyvale / 320-07-005 / 842	

Attachment F

Site Ownership as Provided by Valley Water

Assessment Site No.	Description	Landowner / APN or Caltrans Parcel No. / SCVWD Easement ID*	NOTES
25.1	Concrete logs	Albert S. Penilla / 318-22-040 / 784	
27	Homestead Road crossing	Bridge: No info / APN Missing / none	Homestead Road crossing, likely City of Sunnyvale fee; SCVWD Fee IDs 32001001, 32601002
		Downstream: SCVWD/ 320-01-011/ none	
		Upstream: SCVWD / 326-01-002 / none	
33	Drop structure at Sweet Oak Street	SCVWD / 326-35-040 / none	SCVWD Fee ID 32635040
33.1	Sacrete channel	SCVWD / 326-35-064 / none	SCVWD Fee ID 32635064
28	Highway 280 crossing, PM 11.2	Caltrans / 13806, 13807, 13808, 29630, / none	
30.1	Boulder weirs at Blackberry Farms	City of Cupertino 357-10-007/ none	
		City of Cupertino 357-09-053/ none	
32	Gaging weir SF44 at Stevens Creek Park	Santa Clara County / 351-10-042 / 1002	SCVWD access easement does not include creek channel

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DATA SOURCE: SCVWD GIS Server and Caltrans District 4 Right of Way Maps (https://caltrans.maps.arcgis.com/apps/webappviewer/index.html?id=04efb9a9f14c4da2aabd9ce36b7dda48)

ATTACHMENT 2

CONCEPTUAL APPROACHES TO REMEDY FISH PASSAGE IMPEDIMENTS IN STEVENS CREEK

April 2021

CONCEPTUAL APPROACHES TO REMEDY FISH PASSAGE IMPEDIMENTS IN STEVENS CREEK

Prepared for

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April 2021

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TABLE OF CONTENTS

1 INTRODUCTION 1

2 GENERAL PASSAGE APPROACHES 7
- 2.1 ROUGHENED CHANNEL 7
- 2.2 TECHNICAL FISHWAY 11
- 2.3 FISH TRANSPORT CHANNEL 13
- 2.4 FORCING FEATURES 15
- 2.5 APPLICABLE FISHWAY TYPES FOR STEVENS CREEK 17

3 SPECIFIC PASSAGE REMEDIES 19
- 3.1 REACH 1 19
  - 3.1.1 Site 1: Grade Control, Vernon Avenue 19
- 3.2 REACH 2 21
  - 3.2.1 Site 2: Highway 101 Crossing, PM 48.0 21
  - 3.2.2 Site 3: Moffett Fish Ladder 23
- 3.3 REACH 3 23
  - 3.3.1 Site 4: Moffett Boulevard Crossing 23
  - 3.3.2 Site 5: Drop Structure Upstream of Moffett Boulevard 24
  - 3.3.3 Site 6: Drop Structure at Hetch Hetchy Crossing 25
  - 3.3.4 Site 8: Drop structure Downstream of Middlefield Road 26
  - 3.3.5 Site 9: Drop Structure Upstream of Middlefield Road 27
  - 3.3.6 Site 11: Highway 85 Crossing, PM 23.0 28
  - 3.3.7 Site 12: Vortex Weir Fishway at SF35 Gage 29
- 3.4 REACH 4 30
  - 3.4.1 Site 14: Drop Structure Downstream of Pedestrian Bridge 30
  - 3.4.2 Site 14.1: Drop Structure at Pedestrian Bridge 30
  - 3.4.3 Combined Sites 14 and 14.1: Two Drop Structures Near Pedestrian Bridge 31
- 3.5 REACH 7 31
  - 3.5.1 Site 17: El Camino Real Crossing 31
  - 3.5.2 Site 17.1: Drop Structure at Storm Drain 33
- 3.6 REACH 10 33
  - 3.6.1 Site 22: Highway 85 Crossing, PM 20.0 34
- 3.7 REACH 15 34
  - 3.7.1 Site 32: Gaging Weir SF44 at Stevens Creek Park 34

4 REFERENCES 36

5 LIST OF REPORT PREPARERS 38

Figures

Figure 1-1 Assessment Sites in Red and Yellow Score Categories 5
Figure 2-1 Generalized Configurations for (a) Full-Width, (b) Partial-Width, and (c and d) Bypass Fishways 8
Figure 2-2 Roughened Riffle with a Naturally Formed Pool Downstream 9
Figure 2-3 Chutes-and-Pools Roughened Channel on an Incised Reach of Penitencia Creek in Alum Rock Park, San Jose, California 10
Figure 2-4 Plan and Section of Typical Pool-and-Chute Fishway (Looking Upstream), with Flow States and Definitions 12
Figure 2-5 Vortex Pool-and-Chute Fishway on Stevens Creek at Gage SF35 (left image) and in Del Norte County, California (right image) 14
Figure 2-6 Fish Transport Channels (Looking Downstream), with Notches and Fish Baffles to Control Depths and Velocities under Interstate 80 on Pinole Creek in Pinole, CA (left image) and on Strongs Creek in Fortuna, CA (right image) 14
Figure 2-7 Rock Forcing Features Including (a) a J-Hook Weir, (b) a V Weir, (c) a W Weir, and (d) a Barb Structure 16
Figure 2-8 Wood Forcing Features, Including (a) an Apex Jam on the North Fork Salmon River and (b) a Root Wad in the Salt River Channel that Causes Flow to Backwater and Spill through an Opening in the Berm 17
Figure 3-1 Longitudinal Profile of the Exiting Channel from Downstream of Highway 101 (Site 2) Upstream through the Moffett Boulevard Crossing (Site 4) 22
Figure 3-2 Site 9 – Looking (a) Downstream, Where the Stream Flows Directly into a Failing Bank before Turning Right and Going Over the Site 9 Drop Structure, and (b) Looking Upstream at Site 9, with Failing Banks in Background 27

Tables

Table 1-1 Stevens Creek Fish Passage Assessment Sites 2
Table 1-2 Stevens Creek Fish Passage Assessment Scores 3
Table 2-1 Typical Similarities and Differences between Riffles and Pools Roughened Channel Type and Chutes and Pools Roughened Channel Type 10
Table 2-2 Summary of Technical Fishway Considerations for Stevens Creek 12
Table 2-3 Summary of Considerations for Four Fishway Types Applicable to Stevens Creek 18
Table 3-1 Summary of Identified Passage Remedies 20
Table 5-1 List of Study Participants and Report Preparers 38

List of Acronyms and Abbreviations

Analysis report	Stevens Creek Fish Passage Analysis report
Caltrans	California Department of Transportation
CCR	Conejos Canyon Ranch
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
ESM	engineered streambed material
	feet per second
MLA	Michael Love & Associates, Inc.
NRCS	Natural Resources Conservation Service
PM	Post Mile on referenced road or highway
RM	river mile
Remedies report	Conceptual Approaches to Remedy Fish Passage Impediments in Stevens Creek report
Team	AECOM-Michael Love & Associates, Inc. Team
Valley Water	Santa Clara Valley Water District

1 INTRODUCTION

The Santa Clara Valley Water District (Valley Water) has been working with stakeholders in the Stevens Creek Watershed to recover steelhead since the late 1990s. In 2004, Valley Water's consultant completed a limiting factors analysis for steelhead and found that anthropogenic fish passage impediments in Stevens Creek downstream of Stevens Creek Dam could limit access to a substantial amount of habitat for the federally threatened Central California Coast Distinct Population Segment of steelhead (*Oncorhynchus mykiss*) (Stillwater Sciences 2004). Beginning in 2018, Valley Water's consultant quantitatively assessed fish passage at all impediments in Stevens Creek between San Francisco Bay and Stevens Creek Dam (Table 1-1). The consultant scored the passage impediments based on their position in the watershed, effects on adult and juvenile passage, and amount of upstream habitat (Table 1-2) (AECOM and MLA 2020).

Valley Water has begun prioritizing the Stevens Creek fish passage Assessment Sites identified in the Stevens Creek Fish Passage Analysis report (Analysis report) (AECOM and MLA 2020) for passage remediation. Valley Water will use the results of the Analysis report, along with other considerations not evaluated in that report (e.g., property ownership and construction cost and logistics), to develop their prioritization. To facilitate the prioritization, AECOM and Michael Love & Associates, Inc.(MLA) (the Team) have prepared this report, titled "Conceptual Approaches to Remedy Fish Passage Impediments in Stevens Creek," (Remedies report), identifying potentially suitable approaches for remediating fish passage at a subset of the impediments identified in the Analysis report. Valley Water will consider the potential fish passage remedies identified in this report during an evaluation of general and site-specific parameters (e.g., relative construction and operation and maintenance costs) that will inform their prioritization.

The goal of this Remedies report is to identify one or more potentially suitable fish passage remedy for each of the 16 Assessment Sites that scored in the red and yellow categories in the Analysis report (AECOM and MLA 2020). The name, number, river mile (RM), and fish passage assessment score for each Assessment Site evaluated in the Analysis report is shown in Table 1-2. Sites that scored in the red and yellow categories are shown in Figure 1-1 (at the end of this section) and are addressed further in this Remedies report. Additional information regarding all Assessment Sites, including location maps for all sites; detailed descriptions of the methods used for passage assessment and to determine the assessment scores; and the results of that scoring can be found in the Analysis report.

Based on the potential project length, the grade that must be recovered through each reach, and known or suspected physical constraints, the Team identified one or more conceptual fish passage remedy that may be suitable for remediating adult and juvenile fish passage at each site. The Team used topographic survey data and site-specific information collected for the previous Analysis report (AECOM and MLA 2020) to generate stream profiles and evaluate fish passage remedies for Assessment Sites in the red and yellow score categories. The Team briefly reviewed Valley Water's hydraulic model to generally identify reaches where channel capacity and flooding may limit the feasibility of some passage remedies, but no flood modeling or analysis was completed as part of this Remedies report. The Team also reviewed available as-built drawings previously provided by Valley Water to identify known infrastructure, such as pipeline crossings. Where known infrastructure was identified, its location was considered during the evaluation of site-specific passage remedies. However, a comprehensive utility check will be required prior to confirming suitability of any site-specific passage remedy.

Table 1-1 Stevens Creek Fish Passage Assessment Sites

River Mile	Site No.	Reach	Assessment Site Name	Adult Percent Passage[1]	Juvenile Percent Passage[1]	Comments
2.64	1	Reach 1	Grade control, Vernon Avenue	73%	0%	
2.81	2	Reach 2	Highway 101 crossing, PM 48.0	0%	0%	
2.93	3		Moffett fish ladder	72%	0%	Denil fish ladder suffers from debris clogging and poor attraction flow
3.13	4	Reach 3	Moffett Boulevard crossing	94%	89%	
3.21	5		Drop structure upstream of Moffett Boulevard	79%	0%	
3.29	6		Drop structure at Hetch Hetchy crossing	0%	0%	
3.44	8		Drop structure downstream of Middlefield Road	73%	0%	
3.53	9		Drop structure upstream of Middlefield Road	77%	0%	
3.63	10		Drop structure at Gladys Avenue	97%	54%	
3.70	11		Highway 85 crossing, PM 23.0	84%	0%	
3.76	12		Vortex weir fishway at SF35 gage	44%	0%	
4.20	14	Reach 4	Drop structure downstream of pedestrian bridge	2%	0%	Roughness of boulders likely provide adult passage at higher flows than estimated
4.21	14.1		Drop structure at pedestrian bridge	70%	0%	
4.39	14.2	Reach 5	Sacrete pinch forming boulder jam	95%	0%	
4.56	15	Reach 6	Highway 237 crossing, PM 0.33	89%	0%	
4.89	16	Reach 7	Boulder channel downstream of El Camino Real	94%	0%	Roughness of boulders likely provide adult and juvenile passage at higher flows than estimated
4.90	17		El Camino Real crossing	70%	0%	
4.96	17.1		Drop structure at storm drain	28%	0%	
5.85	19	Reach 8	Highway 85 crossing, PM 20.9	93%	0%	Coarse streambed likely provides better passage than estimated for juveniles
6.82	21	Reach 9	Fremont fish ladder	70%	0%	Denil fish ladder suffers from debris clogging and poor attraction flow
6.96	22	Reach 10	Highway 85 crossing, PM 20.0	50%	0%	
7.15	23	Reach 11	Fremont Avenue crossing	100%	100%	
7.46	25	Reach 12	Abandoned flashboard dam	74%	29%	
7.48	25.1		Concrete logs	86%	0%	Hydraulic complexity likely provides better juvenile passage than estimated
8.37	27	Reach 13	Homestead Road crossing	85%	0%	Jagged debris among concrete rubble may pose risk of harm to adult fish
8.62	33	Reach 14	Drop structure at Sweet Oak Street	65%	0%	
8.67	33.1		Sacrete channel	74%	0%	
8.82	28		Highway 280 crossing, PM 11.2	90%	0%	Juvenile passage likely better than estimated, given shallow and slow water along the channel edge
9.93	30.1	Reach 16	Boulder weirs at Blackberry Farm	100%	0%	Hydraulic complexity likely provides juvenile passage at all assessment flows
12.28	32	Reach 15	Gaging weir SF44 at Stevens Creek Park	0%	0%	Site conditions may favor adult passage at flows lower than suggested by model results

Note:

[1] Zero percent passage means that no flows between the low and high passage assessment flows met the selected criteria, although it is generally understood that some fish are sometimes able to pass sites that do not meet passage criteria.

Table 1-2 Stevens Creek Fish Passage Assessment Scores

Site No.	River Mile	Assessment Site Name	Score[1]
Red Score Category (Scores 1-14)			
2	2.81	Highway 101 crossing, PM 48.0	2
6	3.29	Drop structure at Hetch Hetchy crossing	2
14	4.20	Drop structure downstream of pedestrian bridge	4
32	12.28	Gaging weir SF44 at Stevens Creek Park	8
17.1	4.96	Drop structure at storm drain	9
12	3.76	Vortex weir fishway at SF35 gage	12
1	2.64	Grade control, Vernon Avenue	12
3	2.93	Moffett fish ladder	14
Yellow Score Category (Scores 15-24)			
5	3.21	Drop structure upstream of Moffett Boulevard	16
8	3.44	Drop structure downstream of Middlefield Road	16
9	3.53	Drop structure upstream of Middlefield Road	17
14.1	4.21	Drop structure at pedestrian bridge	19
11	3.70	Highway 85 crossing, PM 23.0	20
17	4.90	El Camino Real crossing	23
4	3.13	Moffett Boulevard crossing	23
22	6.96	Highway 85 crossing, PM 20.0	24
Green Score Category (Scores 25-100)			
10	3.63	Drop structure at Gladys Avenue	25
15	4.56	Highway 237 crossing, PM 0.33	25
14.2	4.39	Sacrete pinch forming boulder jam	26
16	4.89	Boulder channel downstream of El Camino Real	29
21	6.82	Fremont fish ladder	31
19	5.85	Highway 85 crossing, PM 20.9	33
33.1	8.67	Sacrete channel	35
33	8.62	Drop structure at Sweet Oak Street	37
25	7.46	Abandoned flashboard dam	37
25.1	7.48	Concrete logs	39
28	8.82	Highway 280 crossing, PM 11.2	43
27	8.37	Homestead Road crossing	45
23	7.15	Fremont Avenue crossing	55
30.1	9.93	Boulder weirs at Blackberry Farm	57

Notes:

From Stevens Creek Fish Passage Analysis (AECOM and MLA 2020).

[1] Possible scores range from 1 to 100, where a lesser accumulation of points (lower score) indicates a greater benefit associated with barrier remediation. Scores are based on watershed position, adult and juvenile passage, and available upstream habitat. See the Analysis report (AECOM and MLA 2020) for additional information. Fish passage remedies were developed for Assessment Sites in red and yellow score categories only.

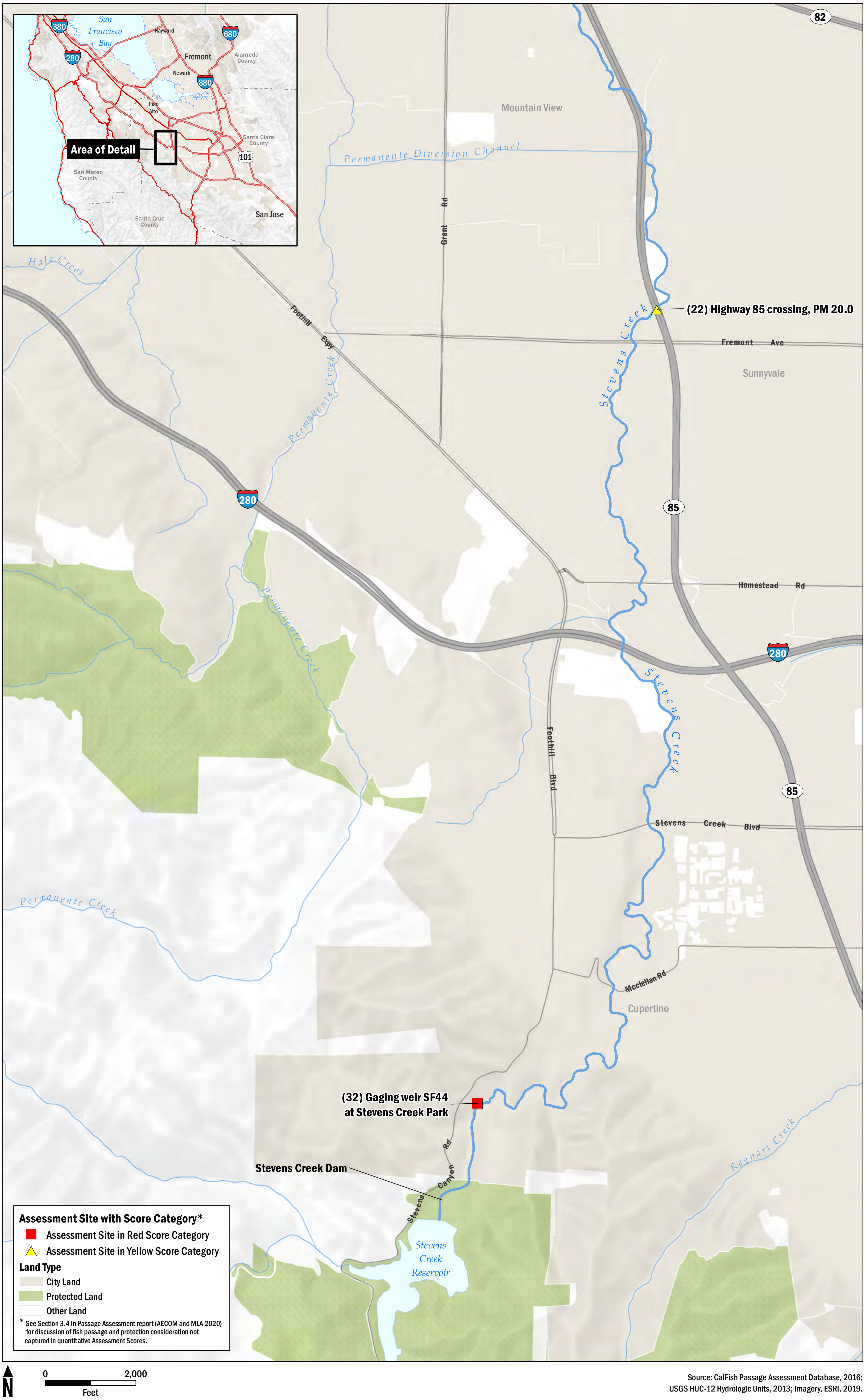
Where feasible based on this limited analysis, a single conceptual passage remedy was identified as being most suitable. More than one potentially suitable fish passage remedy was identified in cases where additional analysis would be required to select a single passage remedy. Site-specific results—including the conceptual passage remedies identified as potentially suitable for the site, a range of possible lengths of a project reach, a range of possible gradients through a project reach, and brief notes—are provided in Section 3. The various fish passage approaches applicable to Stevens Creek Assessment Sites are described in general in Section 2, along with their typical operations and maintenance requirements, and general advantages and disadvantages. Each passage remedy identified in Section 3 as a possible solution for a specific Assessment Site uses one of the general approaches introduced in Section 2.

Identification of potential fish passage remedies and other site-specific considerations such as potential project length will allow Valley Water to apply their own site-specific knowledge and develop an analysis of relative project cost and complexity to inform Valley Water's prioritization effort. The analysis in this Remedies report does not consider property ownership, unknown underground utilities, or site-specific project layouts or maintenance considerations. A more detailed analysis to confirm the preferred approach for a given site will require additional analysis, such as development of conceptual project layouts, flood modeling, and hydraulic analyses of possible project configurations. This type of analysis may require a level of effort that would be more appropriate after Valley Water's prioritization is complete and the highest priority sites have been selected.

Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 1-1 (North)
Assessment Sites in Red and Yellow Score Cateogries



Source: CalFish Passage Assessment Database, 2016; USGS HUC-12 Hydrologic Units, 2013; Imagery, ESRI, 2019.

AECOM

Figure 1-1 (South)
Assessment Sites in Red and Yellow Score Categories

2 General Passage Approaches

This section describes the various fish passage approaches that were applied to specific Assessment Sites in Section 3 as options for remediating adult and juvenile fish passage. The approaches are described generally in this section to provide context for the passage remedies identified in Section 3. Each general description in this section provides a brief introduction to a passage approach and includes considerations typical of its application. Summary information, including identification of the four fishway types that best suit site conditions and passage objectives for Stevens Creek, is presented in Section 2.5.

One consideration common across fish passage approaches is the width of the fishway relative to the existing channel. There are generally three different fishway configurations relative to the channel: full-width, partial-width, and bypass (Figure 2-1). A full-width fishway is channel-wide and conveys all streamflow. A key advantage to this configuration is that fish moving up or downstream will find the fishway because there are no alternative routes; a primary disadvantage is that it must provide passage and remain stable while conveying the total streamflow.

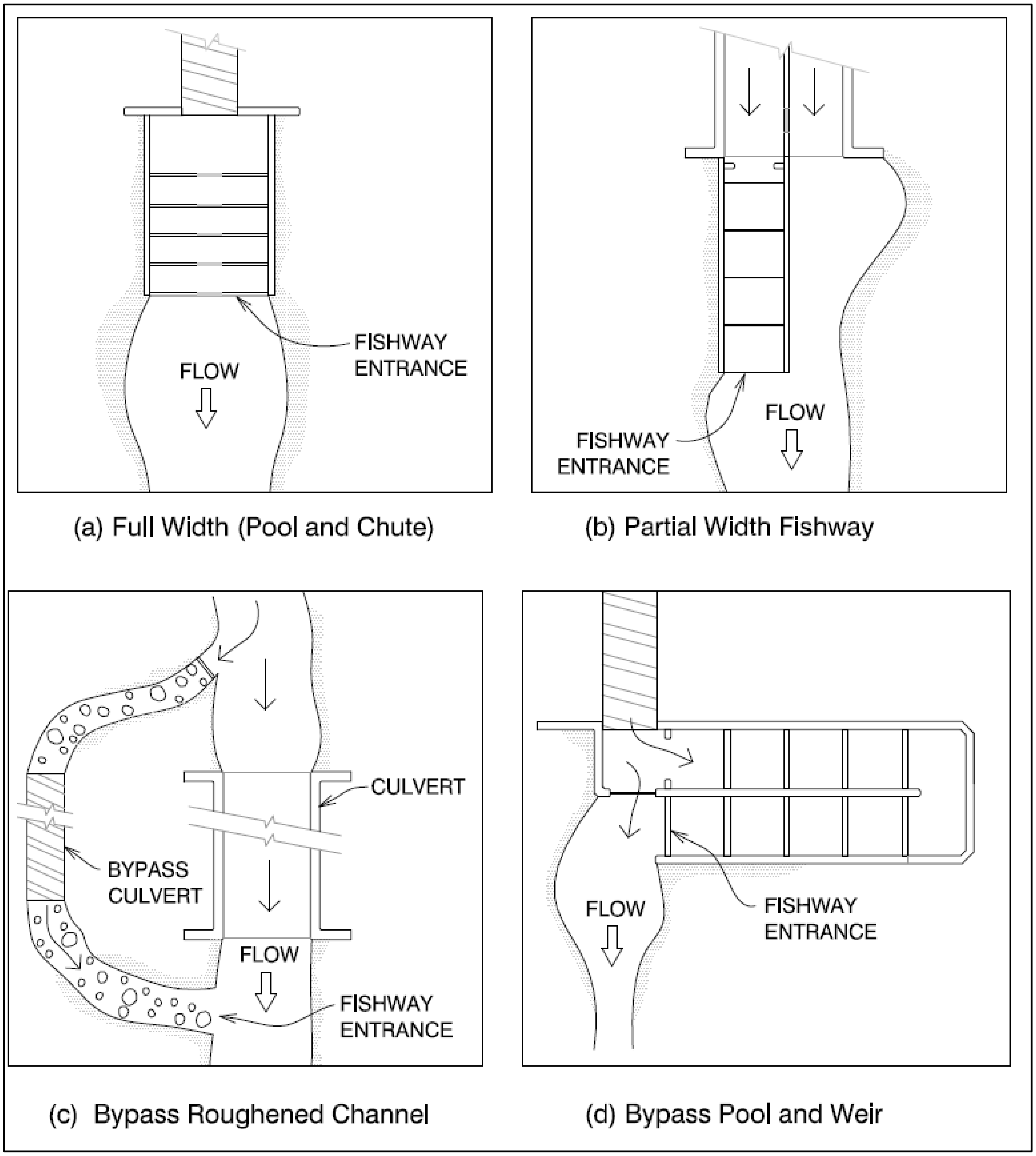
A partial-width fishway is one that spans part of the channel and conveys only a portion of the total streamflow. The primary advantage of this configuration is that the range of flows over which the fishway needs to function is less than a full-width fishway because a portion of the streamflow is conveyed outside of the fishway. However, because the partial-width fishway is within the channel, it is still subject to high flows and debris. The fish attraction in a partial-width fishway is less than that in a full-width fishway because only a portion of the streamflow discharges from the fishway entrance. Also, due to site constraints, the entrances to partial-spanning fishways are often farther downstream of the barrier (Figure 2-1b) than in the case of full-width fishways (Figure 2-1a), allowing some fish to swim past the entrance and further reducing fish attraction.

A bypass fishway is outside of the channel. It bypasses both flow and fish around the barrier. A bypass fishway's primary advantage is that it is not exposed to high flows and debris. Another advantage is that the flow into the fishway is controlled, thus allowing it to provide passage over a wide range of streamflows. The primary disadvantage is that only a portion of the streamflow discharges from the fishway, which can reduce the ability of fish to locate the fishway entrance and result in reduced fish attraction. Another primary limitation is the availability of land outside of the channel suitable for a bypass fishway.

In general, the Team focused on full-width fishways for this analysis. At most of the Assessment Sites, Stevens Creek is highly constrained between urban and suburban development, private property, and existing infrastructure. At many locations, a bypass fishway would be infeasible, and partial-width fishways were considered less desirable than full-width fishways due to concerns about fish attraction. Therefore, the general fish passage approaches described below, as they apply to the Assessment Sites and remedies presented in Section 3, are focused on full-width, channel-spanning layouts.

2.1 ROUGHENED CHANNEL

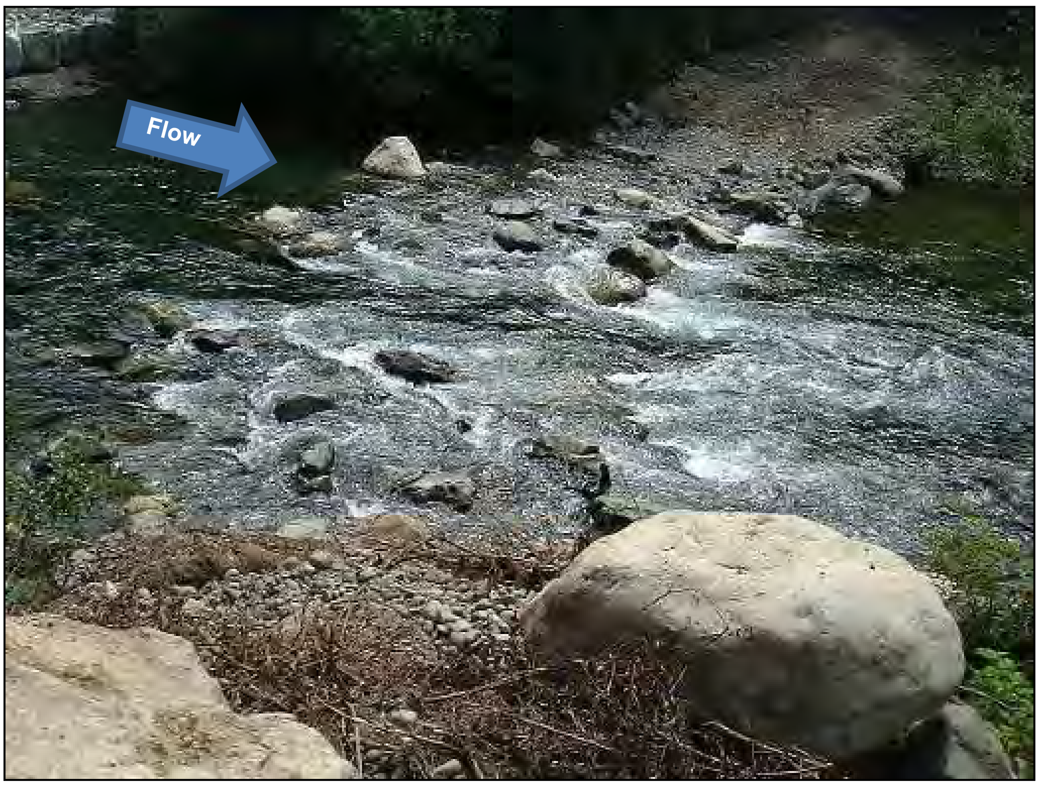
Roughened channels, sometimes referred to as nature-like fishways, are constructed using rock and aggregate, with a wide range in size. Boulders provide hydraulic roughness, flow diversity, and high-flow stability. The finer material, from cobbles to sands and silts, fills voids between the boulders and controls porosity and subsurface flow. The placement of the material is intended to



Source: CDFG 2009

Figure 2-1 Generalized Configurations for (a) Full-Width, (b) Partial-Width, and (c and d) Bypass Fishways

create a channel bed that mimics the form and hydraulic conditions found in natural steep streams. The bed material placed in the roughened channel is referred to as engineered streambed material (ESM). CDFG (2009) describes a variety of roughened channel bedforms. Two common types of roughened channel with applicability in Stevens Creek are "riffles and pools" (Figure 2-2) and "chutes and pools" (Figure 2-3). In both cases, the pools provide resting places for migrating fish, and the riffles and chutes (aka rapids) are used to make up grade through a steeper channel section. The primary differences are that (1) the riffles are lower sloped than the chutes; and (2) the pools and glides between riffles are longer and primarily composed of native streambed material, and the pools and glides between chutes are shorter and composed of ESM to control scour. Similarities between these two types of roughened channel are summarized in Table 2-1.



Source: CDFG 2009

Figure 2-2 Roughened Riffle with a Naturally Formed Pool Downstream

Figure 2-3 Chutes-and-Pools Roughened Channel on an Incised Reach of Penitencia Creek in Alum Rock Park, San Jose, California

Table 2-1 Typical Similarities and Differences between Riffles and Pools Roughened Channel Type and Chutes and Pools Roughened Channel Type

	Riffles and Pools	Chutes and Pools
Similarities	Boulders provide hydraulic roughness, flow diversity, and high-flow stability	
	Finer material fills voids and controls porosity and subsurface flow	
	Intended to mimic form and hydraulic conditions found in natural steep streams	
	Riffles and chutes make up grade through steeper sections between pools	
	Pools provide fish with resting places	
Differences	Riffles have lower slope than chutes	Chutes have higher slope than riffles
	Pools and glides between riffles are typically longer	Pools and glides between chutes typically shorter
	Pools and glides primarily composed of native material that self-scours	Pools and glides typically composed of ESM to control scour

Note:

ESM = engineered streambed material

Roughened riffles and chutes create hydraulic diversity over a wide range of flows suitable for upstream passage of both large and small fish, do not require the fish to leap, and can continue functioning even when rocks shift. They are more stable than other types of rock-composed fish passage approaches, such as boulder weirs, due to the interlocking of the large rock across the entire channel; and because they dissipate energy through both hydraulic roughness in the chutes or riffles, and turbulence in the pools. A primary disadvantage of roughened channels is associated with low-flow performance. In areas with low base flow, the amount of flow required to meet depth criteria for fish passage is often greater than the low-passage design flow. Another disadvantage of roughened channel fishways is that they have a relatively lower slope, and therefore longer footprint, than technical fishways. Generally, the California Department of Fish and Wildlife (CDFW, previously CDFG) and the National Marine Fisheries Service limit overall slope of roughened channels to 4 percent for fish passage, especially in low-sloped streams such as Stevens Creek. Additionally, the sizes of rock required to maintain stability depends on the roughened channel slope; often the design slope becomes limited to less than 4 percent to achieve a stable and reasonable rock size.

The Team developed a preliminary design for a chutes-and-pools roughened channel for the Moffett Fish Ladder (Site 3) in Reach 2, as described in the Staff-Recommended Alternative Report for the Moffett Fish Passage Project (AECOM and MLA 2018). The analysis conducted for the site found that the maximum feasible overall slope for a roughed channel in this section of flood control channel was 2 percent. Higher slopes would require ESM that includes rock greater than 4.6 to 5.5 feet in diameter (with each rock weighing 4 to 7 tons), thus making it impractical to construct and difficult to seal the chutes to maintain lower flows on the surface. Therefore, for Assessment Sites in the flood control channel of Reaches 1, 2, and 3 that include a roughened channel remedy in Section 3, a 2 percent maximum slope was assumed.

2.2 TECHNICAL FISHWAY

Technical fishways are hydraulic structures, typically constructed of concrete or steel, and designed to produce controlled hydraulic conditions suitable for fish passage. The layout is somewhat standardized to provide predictable hydraulics. Types of technical fishways, as described in CDFG (2009), include (1) vertical slot and orifice controlled fishways; (2) roughened-chute fishways (such as a Denil fish ladder); (3) pool-and-weir fishways; and (4) pool-and-chute fishways. The first two types are not channel-spanning fishways, are highly susceptible to plugging with debris, and are generally not suitable for upstream passage of juvenile steelhead. Therefore, they are not proposed as remedies for fish passage at the Assessment Sites in Section 3. Pool-and-weir fishways rely on plunging flow over weirs and dissipation of the flow's energy in the receiving pool. Their primary disadvantage is that they operate over a narrow range of flows and are therefore typically used as bypass fishways. Depending on the size of the size of the structure, a pool-and-weir fishway can be designed for high or low flows, but the range of flows that an individual pool-and-weir fishway can accommodate is generally narrower than other types of fishways. As flow in the fishway increases, the hydraulics over the weirs and in the pools transition from the plunging regime to the streaming (a.k.a. skimming) regime. This results in high water velocities and turbulence throughout the pools, which are adverse for fish passage. Given that fish passage should be provided over a wide range of flows in Stevens Creek, the pool-and-weir fishway is not proposed as a remedy for fish passage at Assessment Sites in Section 3. A summary of the considerations for technical fishways at Steven Creek is presented in Table 2-2.

The fourth type of technical fishway is a pool-and-chute fishway. Referred to as a hybrid, it resembles a pool-and-weir fishway but is designed to function simultaneously with plunging and streaming flow regimes over the weirs and in the pools. Conventional pool-and-chute fishways are described by Bates (1991, 2000, and 2001) and CDFG (2009). They are widely used for upstream passage of both adult and juvenile salmon and steelhead, and in most cases also provide downstream passage. The conventional pool-and-chute fishway weir shape has a notch, or chute, in the center and sloping shoulders along the sides. The weir shape promotes streaming flow down the chute while flow plunges over the shoulders (Figure 2-4). As flows increase, the width of streaming flow increases, and the plunging flow moves toward the edges of the shoulder. At higher flows, the majority of the fishway flow streams down the center of the fishway; the flow over the shoulders and along the pool margins is slow and less turbulent, allowing fish to migrate upstream in this "passage corridor." Another advantage of pool-and-chute fishways is their ability to maintain sediment transport through the fishway. Turbulence generated in the pools during high flows, when sediment is derived from upstream, generally keeps them clear of sediment (except for deposition on the upstream side of the weirs), thereby maintaining adequate pool volume to control turbulence during fish passage flows.

Table 2-2 Summary of Technical Fishway Considerations for Stevens Creek

Fishway Type:	Vertical Slot and Orifice Controlled	Roughened Chute (e.g., Denil)	Pool-and-Weir	Pool-and-Chute
Width	Typically partial channel spanning	Typically partial channel spanning	Full or partial channel spanning	Full or partial channel spanning
Debris Management	Susceptible to debris capture and clogging	Susceptible to debris capture and clogging	May capture large debris	May capture large debris
Juvenile Passage	Less suitable	Least suitable	Most suitable	More suitable
Flow Range	Less suitable for low-flow, narrow operating range	Least suitable for low-flow, narrow operating range	Suitable for low-flow, narrow operating range	Suitable for low-flow, wide oparating range
Flow Regime	Jet (slot) and wake (pool)	Streaming	Plunging	Plunging at low-flow, Streaming and plunging flow (hybrid) at higher flows
Energy Dissipation	Flow expansion in pool	Turbulance in streaming flow	Turbulance in pool	Turbulance in pool and in streaming flow
Sediment Management	Less likely to capture sediment*	Least likely to capture sediment*	More likely to capture sediment	May capture limited sediment
Fish Stranding	Less likely	Less likely	More likely	More likely
Use in this Report	Rejected because not channel-spanning, suseptable to debris, and low operating flow range	Rejected because not channel-spanning, suseptable to debris, and low operating flow range	Rejected because less suitable at higher flow	Retained as most suitable technical fishway

Note:
* Efficient at accumulating sediment once debris jams form.

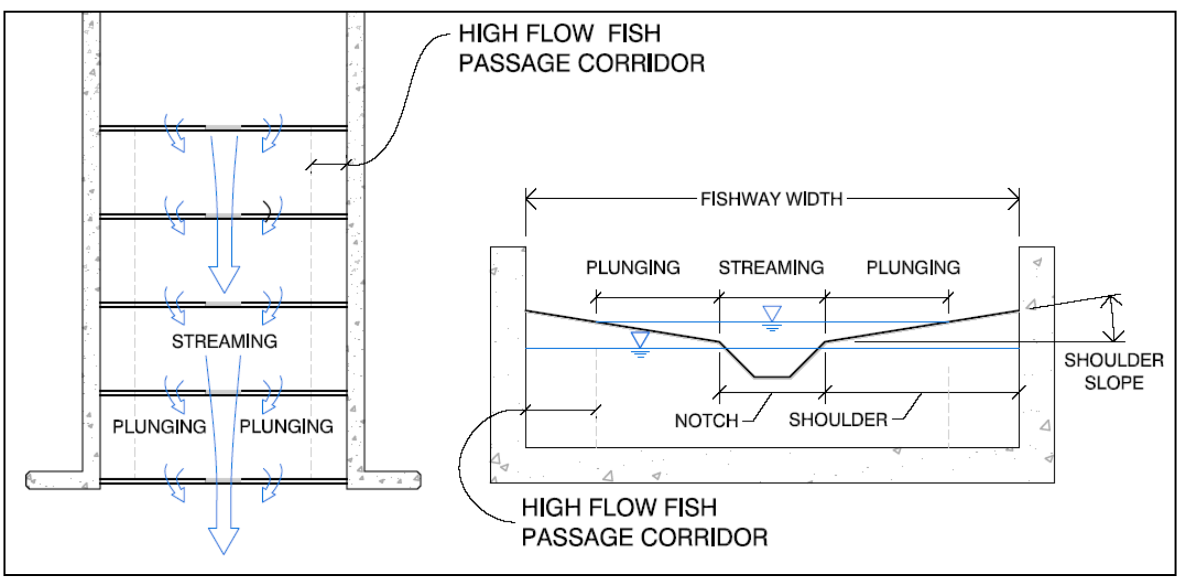


Figure 2-4 Plan and Section of Typical Pool-and-Chute Fishway (Looking Upstream), with Flow States and Definitions

In streams that have intermittent flows, a key disadvantage of pool-and-chute fishways is that they may strand fish in their pools as flows recede annually and the pools become isolated from one another via lack of surface flow. In Stevens Creek, some reaches flow perennially and others flow intermittently (AECOM and MLA 2020). In intermittent reaches, or if groundwater levels adjust downward in the future in reaches that are now perennial, stranding could be a concern with this type of fishway in Stevens Creek. Stranding typically requires labor-intensive fish rescues to return the fish to more suitable instream habitat. Another disadvantage is the potential for large debris to become lodged on the weirs, requiring timely in-channel maintenance to remove the debris and restore fish passage during high-flow events when fish may be likely to migrate upstream.

The maximum slope appropriate for a pool-and-chute fishway depends on the overall drop in elevation (from exit to entrance) that the fishway spans, where steeper slopes can be used with shorter fishways. Pool-and-chute fishways have frequently been constructed at slopes of 10 to 12 percent and steeper, with the overall drop limited to between 6 and 8 feet. However, at sites with this slope range and larger overall drops, flume studies (Bates 1991) and field observations (Lang and Cashman 2008) found that the hydraulics near the downstream end of the fishway can become unstable. Meanwhile, fishways of this type constructed at lower slopes have not experienced issues with unstable hydraulics in drops greater than 6 to 8 feet. This was confirmed in a recent flume study at Humboldt State University for a pool-and-chute fishway at 8 percent slope (Nyberg et al. 2016). Therefore, pool-and-chute fishway remedies included in this report for Stevens Creek were limited to a maximum 8 percent slope for drops of 6 feet or greater and a maximum 10 percent slope for drops of less than 6 feet.

A vortex pool-and-chute fishway is a variation of the standard pool-and-chute fishway. Vortex pool-and-chute fishways have the shoulders aligned in a V-shape (in plan view), with the point of the V directed upstream. This layout helps concentrate flow and velocities toward the centerline of the fishway while reducing turbulence along the edges of the fishway pools, producing noticeably less turbulent flow in the “fish passage corridor.” The V-shape of the weirs also provides for a longer weir crest length, thus increasing the range of flows over which the fishway provides passage. One of the first vortex pool-and-chute fishways was constructed circa 2002 by Valley Water on Stevens Creek at Gage SF35 (Assessment Site 12, Figure 2-5). Since then, several others have been constructed in California, and scaled physical models have been used to develop hydraulic coefficients that support the design process for vortex pool-and-chute fishways (Lang and Cashman 2008, Nyberg et al. 2016).

2.3 FISH TRANSPORT CHANNEL

A fish transport channel is an extended, low-gradient (typically ≤ 0.5 percent), fish passage corridor designed to provide adequate depth and flow velocities through a modified or artificial channel. Fish transport channels may be used in Stevens Creek to improve passage conditions through concrete channels and culverts that have insufficient depth and/or excessive velocities. These channels may be retrofitted with concrete roughness elements, such as fish baffles (Figure 2-6), concrete blocks, or grouted or loose rock-filled bottoms, to provide hydraulic roughness. The use of fish baffles to slow water velocities is generally limited to slopes less than 3 percent, and often less than 2 percent. At higher slopes the hydraulics become unstable, resulting in hydraulic jumps and excessive turbulence. Baffles can be constructed of concrete, wood, or steel.

Figure 2-5 Vortex Pool-and-Chute Fishway on Stevens Creek at Gage SF35 (left image) and in Del Norte County, California (right image)

Figure 2-6 Fish Transport Channels (Looking Downstream), with Notches and Fish Baffles to Control Depths and Velocities under Interstate 80 on Pinole Creek in Pinole, CA (left image) and on Strongs Creek in Fortuna, CA (right image)

Fish transport channels may alternatively include bed retention sills. These are intended to capture and retain some of the streambed sediment moving downstream that would otherwise not deposit in a smooth concrete channel. Constructed of steel, concrete, or wood, they are designed to be buried by streambed material and only function during high flows, when the bed material is mobile. They can also be designed to function as baffles, so that if they fail to retain streambed sediment they still improve passage conditions by increasing water depths or reducing flow velocities.

The primary advantage of fish transport channels with roughness elements is that they are a low-cost solution appropriate for certain sites. Fish baffles and sediment retention sills can be constructed with minimal effort. In many cases, prefabricated steel and wood baffles have been installed in a single day. However, the effectiveness of juvenile salmonid passage through channels with standard fish baffles has not been well studied. If passage of juvenile salmonids is a primary objective, standard fish baffles may not be preferred. Grouted or loose-filled rock creates additional hydraulic complexity when compared to baffles. This type of complexity can offer multiple low-velocity pathways for a small fish swimming upstream and may be more appropriate for juvenile passage.

Other potential disadvantages of fish baffles include high maintenance requirements and effects on flood capacity. Although the shape and configuration of fish baffles have been refined to minimize racking of debris, baffles are still prone to catching debris, which can create passage impediments. Projects that use fish baffles are typically required to implement an ongoing monitoring, maintenance, and reporting program. This involves checking and clearing any identified debris blockages after each high-flow event and providing annual reports to fisheries resource agencies. Fish baffles and other hydraulic roughness elements also often reduce the overall flood capacity of the channel or culvert. In some situations, the transport channel has been recessed into the floor of the concrete channel to offset this decrease in capacity (Figure 2-6).

For considering passage remedies for Stevens Creek, it is recommended that the slope of transport channels—whether baffles, bed retention sills, or other roughness elements—be limited to a maximum of 0.5 percent to maintain suitable hydraulic conditions over the range of fish passage flows. It may be determined through additional hydraulic analysis that this slope range can be increased without compromising passage.

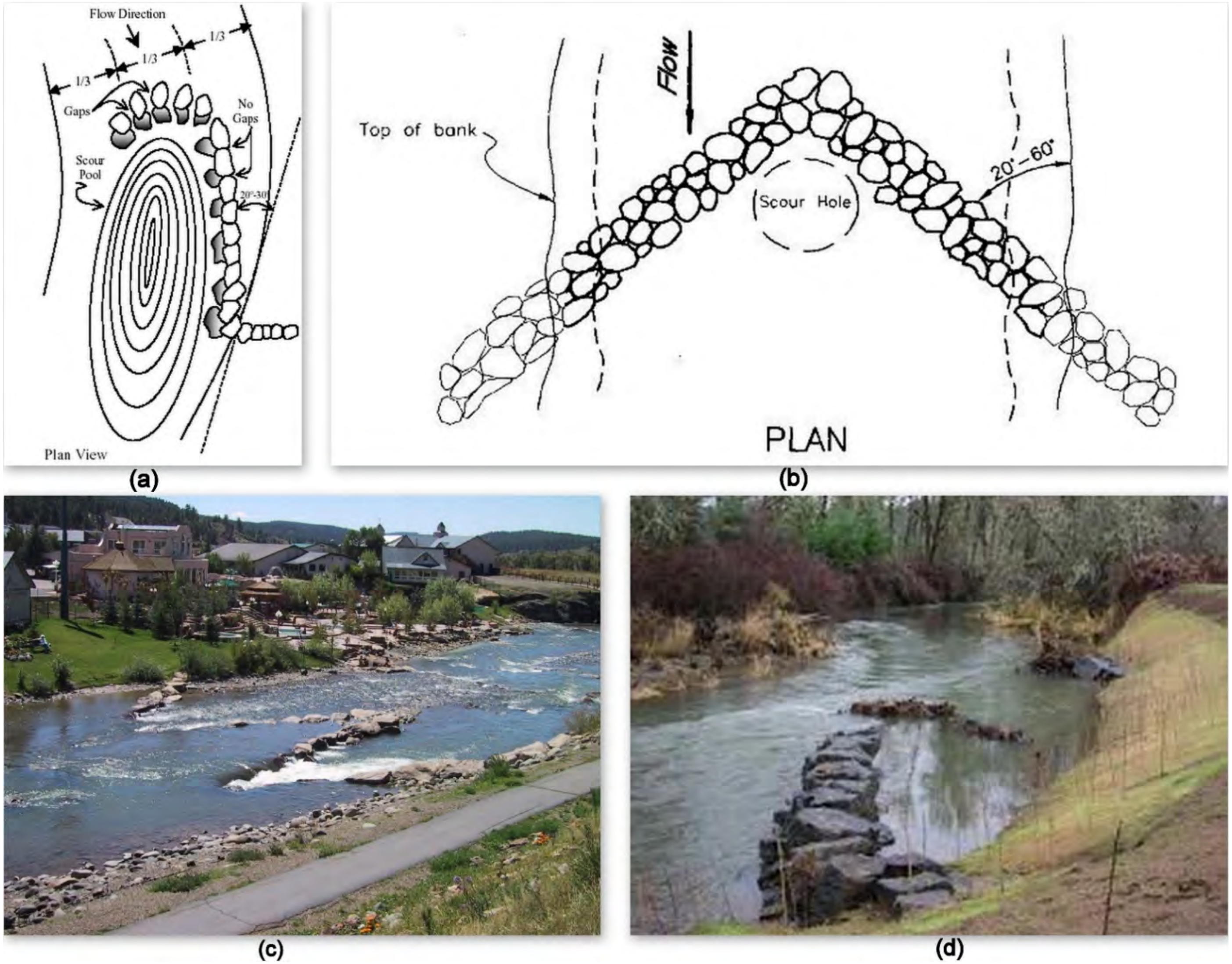
2.4 FORCING FEATURES

A forcing feature causes a flow disruption that directs or deflects water for a particular purpose and can also be used to maintain channel grade. There are several types of constructed forcing features, but nearly all perform a similar function: to create desirable hydraulics by obstructing (in whole or in part) the flowing water. Commonly, constructed forcing features are implemented to protect banks from erosion, but can be used to create low-flow channels; to help the creation of pools; or to split the flow. Natural forcing features (e.g., bedrock outcrops or large wood) are a common feature in natural channels. As applied to fish passage, forcing features are sometimes used to concentrate flows to increase depth in a low-flow channel, or to constrict flow at a pool's tailwater crest and increase pool depth.

Constructed forcing features include barbs, vanes, bendway weirs, j-hook weirs, V and W weirs, and wood structures such as root wads embedded into the bank or apex jams. Barbs, vanes, bendway weirs, j-hook weirs, and V and W weirs are generally constructed of rock (Figure 2-7). Generally, these structures begin at the bank, are gently sloped toward the center of the channel (with the higher end at the bank), and are oriented to direct flow away from the bank. These structures attempt to decrease velocities on the channel margin(s) and concentrate flow away from the margin(s). They can also be used to control the channel's grade, and to recruit sediment and raise the stream bed's elevation.

Wood forcing features are also designed to interrupt stream flow paths to produce specific hydraulic effects (Figure 2-8). Structures such as root wads installed into stream banks (with roots oriented into the flow and slightly upstream) disrupt flow, causing decreased velocity along the bank. This protects the bank or forces the flow to split. An apex jam is not generally intended to protect the margin(s) of a channel but instead to disrupt and spilt flow into two or more paths to create hydraulic complexity.

Advantages of forcing features include the relatively low capital costs required to construct them and their pleasing aesthetic. Projects using forcing features will typically require less imported material to construct than would be required to rebuild the entire channel, and less infrastructure (e.g. formwork) than would be required to build a concrete structure. Rock and wood forcing features can also provide a more appealing look when compared to traditional forcing features such as rock slope protection or concrete structures, which may be important in relatively natural settings or in high-use or high-visibility areas.



Sources: (a) Carleton 2020; (b) NRCS 2013; (c) CCR 2020; (d) NRCS 2005

Figure 2-7 Rock Forcing Features Including (a) a J-Hook Weir, (b) a V Weir, (c) a W Weir, and (d) a Barb Structure

Figure 2-8 Wood Forcing Features, Including (a) an Apex Jam on the North Fork Salmon River and (b) a Root Wad in the Salt River Channel that Causes Flow to Backwater and Spill through an Opening in the Berm

An important disadvantage of rock and wood forcing features is the uncertainty of the hydraulic outcome compared to traditionally engineered structures. Because the structure uses natural materials, the hydraulic outcome is less predictable, and improper design or construction could result in failure of the structure. Failure generally implies that the intended objective was not achieved or was initially achieved but then something changed. Even a well-designed and well-constructed project could fail. An example of failure would be when the rock(s) used in the structure shift or move completely, changing the shape of the structure. Another disadvantage of forcing features is the possibility of unintended consequences, such as flow causing erosion where it did not occur previously and is not desired.

2.5 APPLICABLE FISHWAY TYPES FOR STEVENS CREEK

Review of various fishway categories and types, as described in CDFG (2009), led to selection of four fishway remedies that best suit site conditions and passage objectives for Stevens Creek. These four fishways are listed in Table 2-3, along with a comparison of performance. In general, one or more of these fishway types are recommended for consideration as a specific passage remedy for each assessment site in the red and yellow score categories.

Table 2-3 Summary of Considerations for Four Fishway Types Applicable to Stevens Creek

Fishway Type	Chutes-and-Pools Roughened Channel	Pool-and-Chute Technical Fishway	Fish Transport Channel	Forcing Features
Purpose	Overcome vertical differences along channel length	Overcome vertical differences along channel length	Passaege through shallow/swift flow	Scour low-flow channel, raise water levels
Typical Width	Full channel width	Partial or full channel width	Partial or full channel width	Full channel width
Typical Slopes	Moderate slope (generally ≤ 2%)	Steepest slope (generally ≤ 10%)	Low slope (generally ≤ 0.5%)	Low slope (at existing channel slope)
Operating Fish Passage Flows	Wide flow range	Wide flow range	Moderate flow range	Wide flow range
Low-Flow Passage Performance	Low to moderate	High	Moderate to high	Moderate to high
Passage Suitability for Juveniles	Moderate to high	Moderate	Low to moderate	High
Passage of Sediment and Debris	High	Moderate	Moderate	High
Flood Flow Structural Stability	High stability	Highest stability	Moderate stability	Lower stability

3 SPECIFIC PASSAGE REMEDIES

This section presents the results of the site-specific evaluation of potentially suitable passage remedies for all Assessment Sites in the red and yellow score categories (Figure 1-1). The results are organized by analysis reach, from downstream to upstream. The analysis reaches were established in the Analysis report because it was effective to group and model contiguous Assessment Sites in a single hydraulic model. The reach designations are not intended to differentiate reaches based on habitat quality or other defining characteristics. For each analysis reach, results are organized by site, also from downstream to upstream. The identified passage remedies are summarized in Table 3-1. These remedies have been identified based on limited analysis and are intended for Valley Water's use in developing their barrier prioritization only. Additional alternatives analysis will be required for most sites to confirm feasibility and select a preferred alternative for design.

Valley Water understands that the downstream portion of Stevens Creek lacks 100-year flood capacity due to channel overflow between Evelyn Avenue and Moffett Boulevard, but the upstream reaches may not be flow-capacity limited. The Team's limited review of Valley Water's hydraulic model suggested that channel capacity may limit the suitability of some fish passage remediation approaches, from San Francisco Bay to upstream near Highway 237 (inclusive of Sites 14 and 14.1). Channel capacity appeared to be adequate upstream from near Highway 237 to Homestead Road (inclusive of Site 22), but upstream of Homestead Road (including Site 32) our review was inconclusive. Channel capacity was considered during development of the specific passage remedies presented in this section, but this was not the primary consideration. Any concept for remediating fish passage that moves forward following prioritization should be carefully evaluated for its potential to affect flooding.

3.1 REACH 1

This section presents fish passage remedies for Assessment Site 1, which falls in the red score category and is the only Assessment Site in Reach 1.

3.1.1 SITE 1: GRADE CONTROL, VERNON AVENUE

Assessment Site 1 is a grade-control structure at Vernon Avenue (RM 2.64), downstream of the Highway 101 crossing. This grade-control structure is trapezoidal in section, with a 45-degree slope concrete drop structure and grouted rock vanes downstream of the drop. The trapezoidal channel upstream of the concrete drop is lined with sacrete for a length of approximately 30 feet, although the majority of the sacrete lining the channel bed has eroded. The grouted rock vanes and concrete drop structure provide insufficient depths for juveniles and adults at low to moderate flows and excessive velocities for juveniles at all flows. The grouted channel bottom below the drop creates insufficient depth for leaping at flows up to 27 cubic feet per second (cfs) and the drop is a leap barrier for juveniles at all flows. Several passage remedies were considered for this site, including variations on a roughened channel and a pool-and-chute fishway.

Table 3-1 Summary of Identified Passage Remedies

Flow Direction	River Mile[1]	Site No.	Reach No.	Assessment Site Name	Identified Passage Options	Potential Project Length(s) (feet)	Potential Project Gradient(s) (percent)	Notes
↑	2.64	1	1	Grade control, Vernon Avenue	Roughened channel	250	2	
					Pool-and-chute fishway/roughened channel combination	130	8, 2	8 percent fishway, 2 percent roughened channel
	2.81	2	2	Highway 101 crossing, PM 48.0	Fish transport channel/roughened channel combination	>740	0.5, 2	650-foot transport channel at 0.5 percent, >90-foot roughened channel at 2 percent
	2.93	3		Moffett fish ladder	Roughened channel	400	2	See Staff-Recommended Alternative Report, AECOM and MLA 2018
	3.13	4	3	Moffett Boulevard crossing	Fish transport channel	385	0.1	Sills may be less expensive, roughness may provide more reliable juvenile passage
	3.21	5		Drop structure upstream of Moffett Boulevard	Roughened channel	190	2	
					Pool-and-chute fishway	70	5	
	3.29	6		Drop structure at Hetch Hetchy crossing	Roughened channel	210 - 310	1.5 - 2	Shorter, steeper channel allows for resting pool
					Pool-and-chute fishway	60	8	
	3.44	8		Drop structure downstream of Middlefield Road	Roughened channel	150	2	
					Pool-and-chute fishway	10	10	
	3.53	9		Drop structure upstream of Middlefield Road	Roughened channel	200	2	
					Pool-and-chute fishway	10	10	
	3.7	11		Highway 85 crossing, PM 23.0	Roughened channel	200	2	
					Roughened channel	300	2	Could also remediate passage at Site 12, feasibility uncertain
					Pool-and-chute fishway	50	10	Could also remediate passage at Site 12
	3.76	12		Vortex weir fishway at SF35 gage	Pool-and-chute fishway	71	7.5	Modify existing fishway weirs
					Fish transport channel	100	0.5	Roughness elements downstream of fishway
					Backwatered by Site 11 modifications	50	10	Same as the Site 11 options
	4.2	14	4	Drop structure downstream of pedestrian bridge	Roughened channel	225 - 350	1 - 2	See combined Site 14/Site 14.1 passage option below
	4.21	14.1		Drop structure at pedestrian bridge	Roughened channel	180	0.7	See combined Site 14/Site 14.1 passage option below
	4.2	14 and 14.1		-	Roughened channel	300 - 500	0.5 - 2	Addresses sites 14 and 14.1, split grade (0.5 and 2 percent) would be 420 feet long
	4.9	17	7	El Camino Real crossing	Roughened channel	180	3	Avoids construction in Caltrans' right-of-way
					Fish transport channel	162	0.3	All construction within Caltrans' right-of-way
	4.96	17.1		Drop structure at storm drain	Roughened channel	30	2	Implementation of either passage option at Site 17 could also remediate passage at Site 17.1
	6.96	22	10	Highway 85 crossing, PM 20.0	Forcing features	200	0.07	
	12.28	32	15	Gaging weir SF44 at Stevens Creek Park	Roughened channel	350	2	
					Pool-and-chute fishway	30	10	
					Forcing features	25	3	

Note:

1 River mile, when converted to feet, is equal to creek station in Valley Water's GIS database.

Roughened Channel

A roughened channel at Site 1 could begin approximately 80 feet upstream of the concrete drop structure, at the elevation of the drop structure, and extend downstream for approximately 250 feet at a slope of approximately 2 percent. The existing sacrete, concrete drop structure, and grouted rock vanes would all be removed and replaced with the roughened channel. This would eliminate the need for a fish to leap and would reduce the lower end of the range of flows at which this site accommodates passage. The likely advantages that a 250-foot roughened channel would have over longer roughened channel remedies constructed at lower slopes would include (a) lower cost and (b) maintenance of flood event water surface profiles that are roughly the same as existing conditions.

Pool-and-Chute Fishway with Roughened Channel

A pool-and-chute fishway may also be appropriate for fish passage at Site 1 and would require a section of roughened channel. The 50-foot-long fishway could begin at the upstream end of the sacrete-lined channel, approximately 30 feet upstream of the existing drop structure, and could be built at a slope of approximately 8 percent. A roughened channel approximately 80 feet in length at a slope of approximately 2 percent would extend from the downstream end of the fishway, tying into the existing channel downstream of the grouted rock vanes. The existing sacrete, concrete drop structure, and grouted rock vanes would all be removed and replaced with the fishway and roughened channel. The roughened channel section would eliminate the need for a fish to leap over the drop structure; this would eliminate the depth issue at flows less than 27 cfs and extend the lower end of the range of flows at which this site accommodates passage. Possible advantages of the fishway and roughened channel combination may include increased predictability of hydraulics in the fishway and a reduction in the length of the project by approximately 50 feet. Disadvantages of the fishway may include the required reinforced concrete construction, which may be more complicated than the construction of a roughened channel alone.

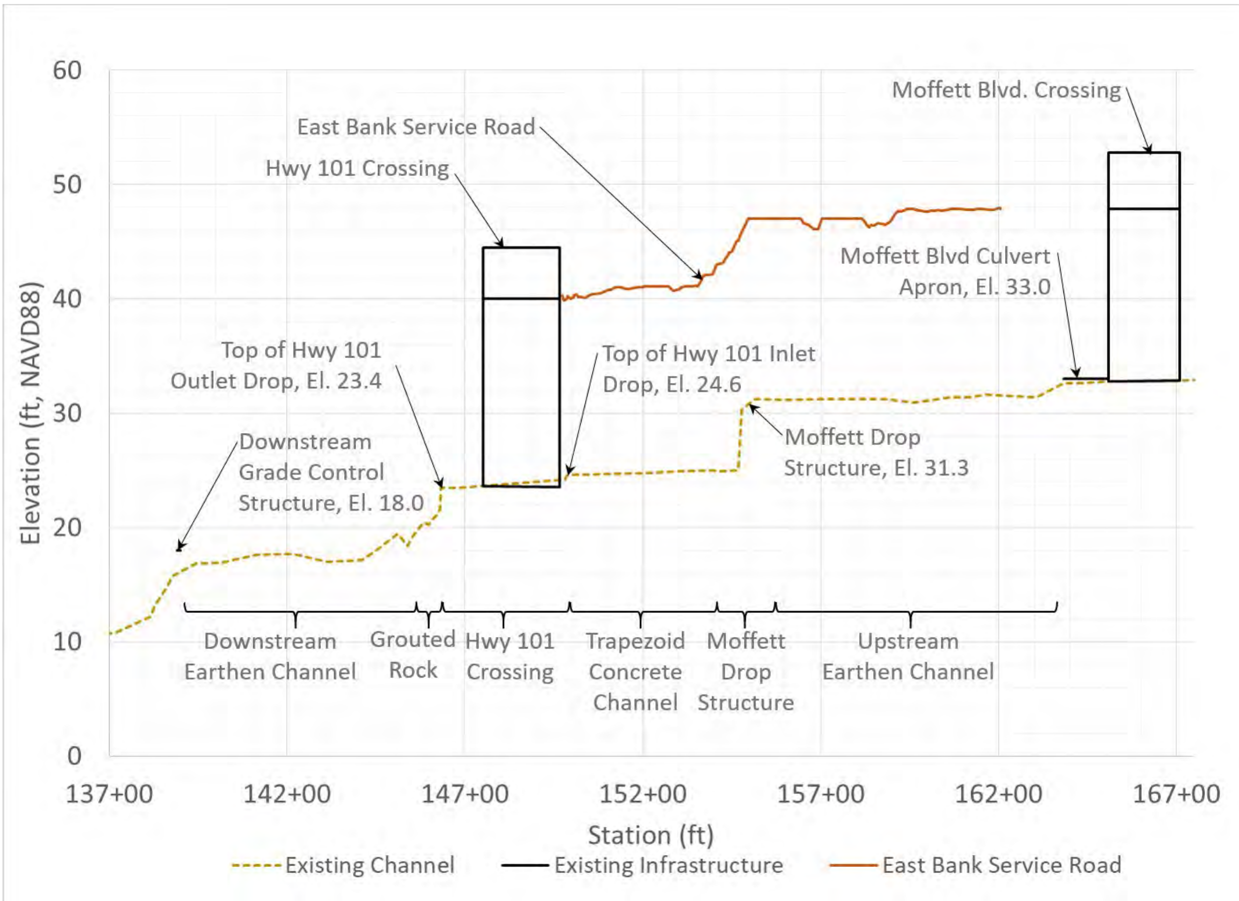
3.2 REACH 2

This section presents fish passage remedies for Assessment Sites in Reach 2 that fall in the red and yellow score categories; these consist of Assessment Sites 2 and 3. Both of these sites are addressed at differing levels of detail in the Staff-Recommended Alternative Report for the Moffett Fish Passage Project (AECOM and MLA 2018). Especially for Site 3, where preliminary engineering designs have been developed, this Remedies report relies on the information presented in the Staff-Recommended Alternative Report.

3.2.1 SITE 2: HIGHWAY 101 CROSSING, PM 48.0

Assessment Site 2, the Highway 101 crossing at Post Mile (PM) 48.0, is at RM 2.81. This site was considered during development and selection of a design alternative for Site 3 (AECOM and MLA 2018). It is shown on Figure 3-1, as presented in prior reports focused on that location. The channel bottom cross slope is nearly flat through the upstream concrete trapezoidal channel and the double box culvert, with a longitudinal slope of approximately 0.1 percent. There is a vertical drop of approximately 1 foot off the apron onto the grouted rock below. The primary area that limits passage is the concrete outlet apron, which produces shallow depths and high velocities. Downstream of the apron, grouted rock vanes provide additional grade control but prevent the formation of a scour pool below the apron, which prevents fish from leaping.

Figure 3-1 Longitudinal Profile of the Exiting Channel from Downstream of Highway 101 (Site 2) Upstream through the Moffett Boulevard Crossing (Site 4)



Given that the existing channel is undersized and that flood flows are predicted to inundate adjacent properties, any solution for Site 2 should avoid reduction in channel and Highway 101 crossing hydraulic capacity. AECOM and MLA (2018) developed a preliminary design for the next site upstream (Site 3). This preliminary design would lower the channel elevation at the upstream end of Site 2, thereby avoiding an increase in out-of-bank flooding. The design assumes that a fish transport channel would be constructed through Site 2 and is the basis for the remedy described below.

Fish Transport Channel with Roughened Channel

An upstream fish transport channel could be combined with a downstream roughened channel to provide passage at Site 2. The fish transport channel could be formed as a compound channel recessed into the bottom of the existing concrete floor in the upstream concrete channel, box culvert, and outlet apron. A recessed channel may be preferred over transport channel approaches that would raise the elevation of the existing streambed through the culvert due to conveyance capacity and flooding issues in this reach. However, the potential effects of a recessed transport channel on the structural and seismic stability of the streambed would need to be evaluated. This transport channel would be approximately 650 feet in length and have a slope of 0.5 percent. It would likely range in depth below the existing concrete invert, from approximately 1.5 feet at the upstream end to more than 3 feet deep at the downstream end of the outlet apron. To control velocities and depths in the transport channel, roughness elements would be added such as baffles or other types of low-profile flow obstructions.

Downstream of the transport channel, the grouted rock vanes (and grout spanning the channel) could be removed and replaced with a short, roughened rock riffle that ties into the bottom of the existing downstream scour pool. Replacement of the vertical drop from the concrete apron onto the grouted rock vanes with roughened channel would create hydraulic complexity, thereby increasing depths and decreasing velocities; this would eliminate the need for passing fish to leap, thus reducing the depth needed for passage. This roughened channel section would need to be a minimum of 90 feet in length at an overall slope of 2 percent. Combined with the transport channel described above, this would give the entire project reach a length of at least 740 feet.

Alternatively, the grouted rock vanes, which were found to provide relatively good passage conditions, could be left in place in lieu of constructing the short, roughened channel. However, leaving grouted rock in the channel may not be preferred by permitting agencies.

3.2.2 SITE 3: MOFFETT FISH LADDER

Assessment Site 3, the concrete drop structure and Denil fish ladder approximately 500 feet upstream of the Highway 101 crossing, is at RM 2.93. Valley Water has already completed an alternatives evaluation and selected a design for improving fish passage at the Moffett Fish Ladder (AECOM and MLA 2018). The Moffett Fish Ladder is at the Moffett Drop Structure shown on Figure 3-1. The selected alternative is a 400-foot roughened channel at a 2 percent grade, consisting of five chutes and five pools designed to provide fish passage and channel grade control. The project involves removing the existing concrete drop structure, abandoned sewer line crossing, and Denil fishway. Analysis of the selected alternative indicates that, with the modifications, passage criteria would be met for adults throughout the entire fish passage assessment flow range and for juveniles throughout 89 percent of the fish passage assessment flow range. This alternative is described in detail in the Staff-Recommended Alternative Report, which includes design drawings and a preliminary construction cost estimate (AECOM and MLA 2018). That information provides a robust basis for Valley Water's incorporation of design-related considerations for Site 3 into their prioritization, so additional information is not provided here.

3.3 REACH 3

This section presents fish passage remedies for Assessment Sites in Reach 3 that fall in the red and yellow score categories; these consist of Assessment Sites 4, 5, 6, 8, 9, 11, and 12.

3.3.1 SITE 4: MOFFETT BOULEVARD CROSSING

Assessment Site 4, the Moffett Boulevard Crossing, is at RM 3.13. It is shown on Figure 3-1. This is a double bay concrete box culvert with extended concrete inlet and outlet aprons. Sediment has deposited throughout the length of the crossing, providing good passage conditions (94 percent passable for adults and 89 percent passable for juveniles). However, changes in downstream channel bed elevations or a decrease in sediment supply could result in the channel bed degrading and exposing the concrete invert, thus deteriorating fish passage conditions. Two approaches were considered for this site that attempt to mitigate this risk, both of which are variations of a fish transport channel (Section 2.3). Specifically, the remedies considered include a fish transport channel with sediment retention sills and a fish transport channel with grouted rock or other roughness elements.

Fish Transport Channel – Sediment Retention Sills

Sediment retention sills (steel or concrete) could be installed, spanning the width of the concrete floor at widely spaced intervals under the Moffett Boulevard crossing and on the aprons, to retain the existing natural gravel substrate observed in August 2018, which concentrates low flows but may otherwise wash out during high flows. Sediment retention sills may be designed to be cross-sloped or have a higher elevation along the sides. Such sills would be installed throughout the length of the existing crossing and extend upstream to the drop structure at Site 5, a length of approximately 385 feet. The design thalweg profile slope would be the same as the exiting profile through the crossing of approximately 0.1 percent. Because the sills could become exposed if the downstream channel degrades, they should also be designed to provide fish passage if the gravel washes out of the culvert. Given the low channel slope, it is likely that sills would only be needed at a spacing of every 100 feet or less. If flood elevations in this culvert are controlled by hydraulic roughness, then any change to roughness in the culvert could affect flood elevations. Alternatively, flood elevations may be inlet controlled or controlled by the downstream tailwater; therefore, additional analysis would be required to confirm potential effects of this remedy on water surface elevations during flood events.

Fish Transport Channel – Roughness Elements

Another means of maintaining or improving passage conditions under Moffett Boulevard would be to install grouted rock or concrete roughness elements (e.g., concrete boulders or concrete cylinders) along the same channel length and slope described above for sediment retention sills. This would increase hydraulic roughness and slow water velocities in the crossing, thereby promoting sediment retention. The roughness elements could be designed to provide suitable passage hydraulics for both the observed sediment condition and, in case the sediment in the culvert washes out, a potential future condition where sediment is absent. Achieving the desired roughness would require installing many more features than the sediment retention sill remedy. However, the hydraulic diversity created by the roughness elements may provide better passage conditions, especially for juvenile salmonids. As described above for sediment retention sills, the potential for additional roughness through the culvert to affect water surface elevations during flood events would require additional analysis.

3.3.2 SITE 5: DROP STRUCTURE UPSTREAM OF MOFFETT BOULEVARD

Assessment Site 5 is a concrete drop structure at RM 3.21. The site is at the upstream end of the inlet apron and trapezoidal concrete channel of the Moffett Boulevard crossing. The sloping and flat portions of the drop structure create a depth barrier at low to moderate flows, and a velocity barrier for juveniles at most flows. Several remedies were considered for this site, including variations on a roughened channel and a pool-and-chute fishway.

Roughened Channel

A roughened channel at Site 5 could extend upstream, from the downstream end of the existing drop structure, for approximately 190 feet at a slope of approximately 2 percent. The existing concrete drop structure would be removed and replaced with the roughened channel. This 190-foot-long roughened channel would complement potential fish passage remedies identified at Site 6, and could extend from the upstream end of the sediment retention sills identified for Site 4 (described above) to the downstream end of the roughened channel remedy identified for Site 6 (described below). A pool would need to be constructed in the concrete trapezoidal channel downstream of the existing Site 5 drop structure as a transition to the sediment retention sills identified for Site 4. Passage remedies, including this roughened channel, that are proposed for further consideration in this Remedies report are expected to increase the range of flows within which water depths, velocities, and hydraulic criteria meet passage guidelines; however, quantification of the anticipated magnitude of the improvements would require additional analysis.

Pool-and-Chute Fishway

A pool-and-chute fishway may also improve fish passage at Site 5. Construction of a fishway would likely involve removing the floor of the drop structure and building a series of concrete weirs into the existing trapezoidal concrete channel. Such a fishway could begin at an elevation approximately 0.5 foot higher than the existing drop structure and extend downstream for approximately 70 feet at a slope of approximately 5 percent. Based on these assumptions, the primary advantage of a pool-and-chute fishway over a roughened channel at this location is a lesser project extent (70 feet long, compared to 190 feet long for a roughened channel). Use of a fishway may increase potential fish stranding, given that this portion of the channel is intermittent and typically dries in the summer. A fishway may also require annual maintenance to keep the weirs clear of debris.

3.3.3 SITE 6: DROP STRUCTURE AT HETCH HETCHY CROSSING

Assessment Site 6, the concrete drop structure at the Hetch Hetchy water supply pipeline crossing, is at RM 3.29. The pipeline crosses beneath the drop structure and it was assumed that the pipeline would remain in its current location when fish passage remedies were considered. The drop height is excessive at all flows for all fish, and the pool depth for leaping is too shallow at flows less than 33 cfs. The concrete and sacrete channel upstream of the drop structure creates a depth barrier at low to moderate flows and creates a velocity barrier at all flows for juveniles and at high flows for adults. Like the drop structure upstream of Moffett Boulevard, a roughened channel or a pool-and-chute fishway could be used to improve fish passage at the Hetch Hetchy crossing.

Roughened Channel

A roughened channel extending downstream from the existing drop structure could be used to improve fish passage at Site 6. It is assumed that the roughened channel would begin immediately downstream at an elevation approximately 0.5 foot above the existing drop structure to provide sufficient water depth over the top of the drop structure and upstream sacrete. The roughened channel might extend downstream between approximately 210 and 310 feet at a slope of between 1.5 and 2 percent. Either the short or the long roughened channel remedy would eliminate the drop that creates the passage impediment at this site, thereby eliminating the need for a pool of adequate depth for a fish to stage a leap over the structure. A longer, 310-foot roughened channel at a 1.5 percent slope could tie directly into a roughened channel described above as a remedy for Site 5. Alternatively, a shorter, 210-foot roughened channel with a slope closer to 2 percent, extending downstream from Site 6, would leave space for a large resting pool to be incorporated into the design as potential fish habitat upstream of the potential roughened channel described above for Site 5. Either remedy has the potential to reduce the flood capacity of the channel, which should be thoroughly analyzed prior to selection as a preferred remedy.

Pool-and-Chute Fishway

A pool-and-chute fishway may also be a remedy for fish passage at Site 6. Construction of a fishway would likely include building a series of concrete weirs, starting at the crest of the drop structure and progressing downstream. The fishway exit weir would be constructed on the downstream edge of the drop structure, at a weir crest elevation approximately 0.5 foot higher than the existing drop structure, and extend downstream for approximately 60 feet at a slope of approximately 8 percent. Use of a fishway may increase potential fish stranding in this intermittent reach, which typically dries in the summer. A fishway may also require annual maintenance to keep the weirs clear of debris. The fishway has the potential to reduce the flood capacity of the channel, which should be thoroughly analyzed prior to selection as a preferred remedy.

3.3.4 SITE 8: DROP STRUCTURE DOWNSTREAM OF MIDDLEFIELD ROAD

Assessment Site 8, the drop structure downstream of Middlefield Road, is at RM 3.44. The concrete forms a depth barrier at low and moderate flows for both juveniles and adults. The structure has a 1.5-foot drop, but backwatering in the hydraulic model eliminated the water surface drop at 7 cfs, allowing fish to attempt to swim rather than leap onto the drop structure. However, the channel immediately downstream of the drop did not appear vertically stable during field work in 2018 and 2019. Any passage remedy should consider that the tailwater control downstream of the drop structure may degrade or wash out, making the next downstream riffle crest the controlling elevation and increasing the water surface drop to approximately 1.8 feet. Two different passage remedies were identified for the site: a roughened channel and a pool-and-chute fishway.

Roughened Channel

Like other sites in Reach 3, one passage remedy would be to construct a roughened channel immediately downstream of the drop structure, with a maximum overall slope of 2 percent. Placing the upstream end of the roughened channel 0.5 foot above the existing drop structure would allow it to be backwatered, assuming it would remain in place. The downstream end of the roughened channel could be approximately 0.75 foot below the existing, downstream riffle crest to accommodate some vertical adjustments to the downstream channel bed. This layout results in a roughened channel that is 150 feet in length. Given known site conditions, it is anticipated that this would provide good fish passage conditions, would be relatively stable, and would require minimal maintenance.

Pool-and-Chute Fishway

Another passage remedy at Site 8 would be a concrete pool-and-chute fishway. It would likely involve cutting the existing 15-foot-wide by 10-foot-long floor of the drop structure and reforming a 12-foot-wide concrete fish ladder in this space. Hydraulic control could be created using two concrete weirs, spaced approximately 10 feet apart, with a 1-foot drop between the two weirs. This could accommodate future downstream channel bed degradation of approximately 1 foot while maintaining a water surface drop of no more than 1 foot at the fishway entrance. The fishway would be within the footprint of the existing sloping drop structure and would not likely change channel capacity at this location. Use of a fishway may increase potential fish stranding in this intermittent reach, which may dry in the summer. A fishway may also require annual maintenance to keep the weirs clear of debris.

3.3.5 SITE 9: DROP STRUCTURE UPSTREAM OF MIDDLEFIELD ROAD

Assessment Site 9, the drop structure upstream of Middlefield Road, is at RM 3.53. The invert of the drop structure is backwatered by the downstream riffle crest, providing sufficient depth for adult fish to swim over it at flows above 49 cfs. As a result, the site is 77 percent passable for adult steelhead but zero percent passable for juveniles, due primarily to excessive water velocities. Immediately upstream of the structure, the channel has dramatically shifted laterally to the left (looking downstream) and is now flowing into a vertical earthen streambank at nearly a perpendicular angle, causing the bank to actively fail (Figure 3-2a). If allowed to continue, the channel may erode behind the existing concrete revetment at Site 9 (Figure 3-2b). Any action taken at Site 9 will require a larger stream repair project to stabilize this reach. For this reason, fish passage improvements at this site should be in alignment with upstream channel repair. Two passage remedies were considered for the site, including a roughened channel and pool-and-chute fishway.


(a)

(b)

Figure 3-2 Site 9 – Looking (a) Downstream, Where the Stream Flows Directly into a Failing Bank before Turning Right and Going Over the Site 9 Drop Structure, and (b) Looking Upstream at Site 9, with Failing Banks in Background

Roughened Channel

One approach would be to remove the existing drop structure and construct a roughened channel that would start at Site 9 and extend upstream. The downstream thalweg elevation of the roughened channel would be equal to the crest elevation of the Site 8 drop structure. The roughened channel would extend upstream approximately 200 feet, at an overall slope of 2 percent, to tie into the existing thalweg at its upstream end. Construction of the roughened channel would also involve reconstruction and stabilization of the channel banks along this entire reach. This approach would combine channel adjustment and bank repair with fish passage and would provide opportunities to include habitat features for fish in the roughened channel. Constructing the roughened channel downstream of Site 9 was also considered, but that alignment would extend the roughened channel to the inlet of an existing culvert, thus creating undesirable hydraulic conditions for both conveyance of flood flows and for stability of the rock in the roughened channel.

Pool-and-Chute Fishway

An alternative to the roughened channel would be to construct a concrete pool-and-chute fishway like the one described for Site 8. It would replace the existing drop structure with two concrete weirs spaced approximately 10 feet apart, with a 1-foot drop between the two weirs. The downstream weir crest would likely be placed based on the crest elevation associated with the fish passage improvements at Site 8. Like the roughened channel described above, this remedy would need to be coordinated with upstream channel maintenance, which may require grade control, such as a short, roughened channel, upstream of the new fishway to maintain existing channel grade. The fishway would be within the footprint of the existing drop structure and would likely have no impact on existing channel capacity. A fishway could cause fish stranding in this intermittent reach, which dries in the summer and may require annual maintenance to keep the weirs clear of debris.

3.3.6 SITE 11: HIGHWAY 85 CROSSING, PM 23.0

Assessment Site 11, the Highway 85 crossing at PM 23.0, is at RM 3.7. It is one of several similar concrete drop structures in Reach 3, with a structural drop of 1.7 feet, as measured from the top of the drop structure to the downstream tailwater control. The drop creates a leap barrier for juvenile fish; shallow flow across the top of the concrete structure makes a low-flow depth barrier for adult fish and a depth and velocity barrier for juvenile fish. Fish passage remedies for this site must consider structural impacts to the existing crossing and potential reductions in channel capacity. Downstream, Assessment Site 10, another of these drop structures, is currently at grade and not a fish passage barrier; however, Assessment Site 10 is a hardpoint in the channel that can be relied on when identifying downstream elevations of fish passage remedies at Assessment Site 11.

Roughened Channel

One approach for fish passage is a roughened channel that would extend downstream from Site 11. The thalweg at the upstream end of the roughened channel would be approximately 6 inches above the existing sacrete floor of the crossing, to backwater it. The roughened channel would extend downstream for approximately 200 feet at a 2 percent slope. The downstream end of the roughened channel would be at an elevation slightly below the crest elevation of the Site 10 drop structure.

Another roughened channel configuration was considered, extending downstream of the Highway 85 crossing, but with an upstream crest elevation high enough to backwater the fishway entrance weir at Assessment Site 12, thus addressing two sites with one project. This would require a roughened channel that has an upstream crest elevation 2 feet higher than the previously described roughened channel and extends downstream to Site 10, for a length of approximately 300 feet at a 2 percent slope. The potential reduction in channel capacity associated with filling the channel with roughened channel material, along with the substantial length of the roughened channel, may make this remedy less desirable, and potentially infeasible.

Pool-and-Chute Fishway

Another passage remedy for Site 11 that would also improve passage at Assessment Site 12 would be a concrete, pool-and-chute fishway downstream of the Site 11 drop structure and Highway 85 crossing. The elevation of the downstream entrance weir of the Site 11 fishway would need to be slightly below the Site 10 drop structure elevation to ensure that the entrance water surface drop is not excessive at higher passage flows. The upstream fishway exit weir would be at an elevation slightly below the exiting Site 12 entrance weir, to reduce the leap required of a fish to enter the existing Site 12 fishway. Overall, the drop across the Site 11 fishway would be approximately 5 feet. Assuming an overall slope of 10 percent and weirs spaced 10 feet apart with 1-foot drops, the fishway would have six weirs and be 50 feet in length. The upstream weir could be built on top of the existing Site 11 drop structure, with the entrance weir 50 feet downstream.

This pool-and-chute fishway remedy has a small footprint and could improve passage conditions at two Assessment Sites. Its smaller footprint and steeper slope would likely have less of an impact on channel capacity downstream of the drop structure compared to the roughened channel remedy. Like the existing fishway at Site 12, fish could be stranded in a fishway in this intermittent reach, and annual maintenance may be needed to keep the weirs clear of debris.

3.3.7 SITE 12: VORTEX WEIR FISHWAY AT SF35 GAGE

Assessment Site 12, the existing vortex weir fishway at the SF35 stream flow gage, is at RM 3.76. At flows greater than 90 cfs, the entrance (downstream) weir currently creates a water surface drop that exceeds 1.5 feet. Due to the V-shape of the weir and the rectangular channel shape controlling downstream water levels, as flows increase, so does the resulting water surface drop across the weir. Several passage remedies were considered to address this issue.

Pool-and-Chute Fishway – Modifying Existing Fishway Weirs

One approach would be to modify the existing concrete weirs in the 71-foot-long, 7.6 percent grade fishway to reduce the cross-slope along the weir crest. This may involve cutting the concrete weir crests to make them level at a height approximately 2.5 feet above the center of the weir. This would continue to concentrate flows and create the desired “vortex” hydraulics of the fishway, while reducing the depth over the weirs at high fish passage flows, thus reducing the water surface drop across the fishway entrance weir. This remedy would require minimal effort to implement. Some additional analysis of the fishway hydraulics would be needed to determine the exact modification of the weirs and any potential impacts regarding sedimentation in the pools between the weirs.

Transport Channel – Roughness Elements

Another remedy would be to add roughness elements downstream of Site 12 to increase the water surface elevation below the fishway entrance weir. Roughness elements may include grouted boulders, cast concrete cylinders, or fish baffles that would likely extend approximately 100 feet downstream of the culvert inlet. One potential disadvantage of this approach that should be evaluated is an incidental reduction in the hydraulic capacity of the Highway 85 crossing. A review of the District’s HEC-RAS model of the reach shows that this highway crossing is capacity limited. The potential for reducing existing capacity with this remedy should be evaluated before selecting it as a preferred remedy. See the description of this remedy above, under Site 11.

Pool-and-Chute Fishway – Backwatering from Site 11

As described for Assessment Site 11, another remedy for Site 12 is to use fish passage improvements at Site 11 to backwater the Highway 85 crossing and raise the water level downstream of the existing vortex fishway entrance weir at Site 12. This involves placing the Site 11 exit (upstream-most) weir higher in elevation to backwater the fishway entrance weir at Site 12. The influence on channel capacity at the Highway 84 crossing should be evaluated before selecting this as a preferred remedy. See the description of this remedy above, under Site 11.

3.4 REACH 4

This section presents fish passage remedies for Assessment Sites in Reach 4 that fall in the red and yellow score categories; these consist of Assessment Sites 14 and 14.1. Reach 4's average slope is 0.35 percent and Sites 14 and 14.1 are only 180 feet apart. Because of the proximity of these two sites, the best fish passage remedy is likely one solution that addresses both sites. However, to facilitate Valley Water's site-specific prioritization study, this section includes individual passage remedies for each site, followed by a single remedy that would address passage at both sites.

3.4.1 SITE 14: DROP STRUCTURE DOWNSTREAM OF PEDESTRIAN BRIDGE

Assessment Site 14 is at RM 4.20 and includes a channel-spanning concrete structure, with large boulders placed in the channel downstream. The boulders appear to have been placed (presumably to reduce scour) sometime after the concrete structure's construction. There is insufficient depth for passage at lower flows across the boulders and over the concrete apron. Also, the upstream end of the placed boulders creates a velocity barrier for adult and juvenile fish.

Grade control is the primary design driver for this site, followed by minimizing impacts to the adjacent banks. Approximately 475 feet downstream of Site 14 is the upstream limit of the recently constructed Evelyn fish passage project. A sheetpile weir serves as grade control at this location and prevents further incision in Reach 4.

Roughened Channel

A roughened channel could be constructed, beginning at the existing concrete structure and extending downstream with a slope between 1 and 2 percent, to improve fish passage at Site 14. At 1 percent, the channel would be approximately 300 feet long; at 2 percent, it would be approximately 150 feet long. Both remedies extend downstream to end at an elevation equal to the upstream control for the recently completed Evelyn Project. Both then tie into the existing channel bed, which is lower, at a 25 percent slope. However, because Site 14 is only 180 feet downstream of Site 14.1, fish passage at the two sites may best be addressed with a single fish passage remedy, as described in Section 3.4.3.

3.4.2 SITE 14.1: DROP STRUCTURE AT PEDESTRIAN BRIDGE

Assessment Site 14.1 is at RM 4.21, 180 feet upstream of Site 14. Site 14.1 is a channel-spanning, grouted rock structure that was presumably installed to reduce channel incision. The grouted rock provides insufficient depths for fish passage at low flows and a velocity barrier for juvenile fish at nearly all flows. Like Site 14, the primary design driver at Site 14.1 is vertical control, followed by minimizing impacts to the adjacent banks.

Roughened Channel

One remedy for fish passage at Site 14.1 would be to remove the existing grouted rock structure and replace it with a roughened channel that would extend downstream from the current location of the existing grouted rock structure to the concrete structure at Site 14. A resting pool could be included immediately upstream of Site 14 so that fish overcoming Site 14 would have a chance to recover before navigating the new roughened channel. The distance between the two sites is approximately 180 feet, and the resulting average slope of the roughened channel would be approximately 0.7 percent. However, due to proximity, a more practical solution may address Sites 14 and 14.1 together (Section 3.4.3).

3.4.3 COMBINED SITES 14 AND 14.1: TWO DROP STRUCTURES NEAR PEDESTRIAN BRIDGE

As stated above, the most practical fish passage remedy at Sites 14 and 14.1 would be to address both sites at the same time because they are only 180 feet apart.

Roughened Channel

To address fish passage at both Sites 14 and 14.1, a roughened channel could replace the existing structures at Sites 14 and 14.1, providing both grade control and fish passage (by increasing hydraulic complexity and providing areas of greater depth and lower velocity) through this reach. The roughened channel would extend downstream from Site 14.1 through Site 14. Several channel slopes, ranging between 0.5 and 2 percent, were evaluated. At a 2 percent slope, the roughened channel would be approximately 215 feet long. At a 1 percent slope, the roughened channel would be approximately 430 feet long. A single-sloped 0.5 percent remedy is not feasible, but a split grade or “broken back” remedy, in which the channel changes slope along its length, would be feasible. For example, a slope of 0.5 percent from Site 14.1 to Site 14 and then a slope of 2 percent downstream would result in a roughened channel with total length of approximately 350 feet; would end downstream at an elevation equal to the upstream control of the recently completed Evelyn Project; and would then tie to the existing channel bed, which is at a lower elevation, at a slope of 25 percent. The broken back design approach could better protect the banks than a single-slope remedy, while providing good fish passage conditions. Overall, it may be more cost effective to design and construct this combined passage improvement for Sites 14 and 14.1 than it would be to design and construct individual solutions for each site.

3.5 REACH 7

This section presents fish passage remedies for Assessment Sites in Reach 7 that fall in the red and yellow score categories; these consist of Assessment Sites 17 and 17.1.

3.5.1 SITE 17: EL CAMINO REAL CROSSING

Assessment Site 17, the stream crossing at El Camino Real, is at RM 4.90. The crossing consists of three concrete arch segments, with bridge deck segments extending over the stream at both the upstream and downstream ends. Due to the wide, flat concrete floor throughout the length of the crossing, shallow depths are a barrier to adults at low to moderate flows, and velocities are excessive for juveniles at most flows. Roughened channel and fish transport channel remedies were considered for Site 17. The roughened channel remedy would avoid construction in the

California Department of Transportation (Caltrans) right-of-way, but would involve modifying the existing Site 16, which falls in the green score category.

Roughened Channel

Site 17 is immediately upstream of Site 16, the boulder-lined reach that extends downstream of the concrete apron at the El Camino Real crossing. Boulders associated with Site 16 were presumably installed to stabilize channel incision downstream of the road crossing. Site 16 has an average slope of approximately 1.5 percent and includes some sections with slopes of approximately 4 percent. Site 16 provides passage for adult steelhead over a wider range of flows than does the crossing at Site 17 (Table 1-1). Analysis in the Assessment Report did not account for variability in velocities across the channel width (AECOM and MLA 2020), but hydraulic diversity in this boulder-lined reach likely creates low-velocity pathways and opportunities for juvenile passage.

Passage through the El Camino Real crossing at Site 17 could be improved by supplementing the material at the upstream end of Site 16 to create a roughened channel that would backwater the crossing at Site 17 to increase depths and decrease velocities at low flows, thereby extending the range of flows at which the crossing is passable for both adult and juvenile steelhead. If the elevation of the upstream end of the roughened channel was 0.5 foot above the elevation of the concrete floor through the culvert, then the roughened channel would extend downstream at 3 percent for approximately 180 feet (roughly 30 percent of the existing, approximately 600-foot-long boulder chute at Assessment Site 16; see the Analysis report for a description of Site 16). One advantage of this roughened channel remedy is that construction could be entirely outside of the Caltrans right-of-way.

Potential disadvantages include steepening a quarter of an existing roughened channel that is already extremely long and contains limited resting areas for fish. It may be necessary to reconstruct other areas of the existing boulder chute to incorporate resting areas. Also, stability analysis of a 3 percent chute at this site should be conducted prior to selecting this as a preferred remedy.

Fish Transport Channel – Sediment Retention Sills

A fish transport channel that aims to retain streambed material along its invert may be a feasible remedy for Site 17. This would likely involve cutting the floor of the culvert and aprons and reforming a recessed concrete channel that contains sediment retention sills, similar to the remedy described for Site 2. The invert of the transport channel should be set low enough to be partially backwatered by the downstream roughened channel, thus providing swim-in conditions for fish moving upstream from Site 16. Sediment retention sills (steel or concrete) would span the width of the recessed transport channel to capture and retain natural gravel substrate. Sediment retention sills may be designed to be cross-sloped or have a higher elevation along the sides. The design thalweg profile slope would be the same as the existing profile through the crossing, approximately 0.3 percent. Sills could be designed to provide fish passage with or without sediment, so that they would continue to function during periods when they may not retain sediment. Sills would only be needed at a spacing of every 50 feet or more due to the relatively flat grade through the 162-foot-long crossing. The transport channel width would be governed by the resulting velocities and shear stress, as determined through hydraulic and sediment transport analysis. This remedy would allow all of the passage improvements to be done in the Caltrans right-of-way. However, it would lower the hydraulic grade line upstream of the crossing, thus further exacerbating passage conditions at Site 17.1, only 240 feet upstream. The remedy could also potentially accommodate removal of upstream Site 17.1, while maintaining the upstream channel grade. Alternatively, given the flat slope and short length of the crossing, a similar sediment retention effect might be induced via the downstream roughened channel remedy, thus avoiding Caltrans' involvement in the design approval process.

Fish Transport Channel – Roughness Elements

An alternative to the sediment retention sills described above, the recessed transport channel could be lined with ESM, grouted rock, or concrete roughness elements installed along the same transport channel length and slope described above. Roughness elements could also be designed to provide suitable passage hydraulics with or without accumulated sediment. Achievement of the desired roughness would require installing many more features than using the bed retention sill approach, but the hydraulic diversity created by the roughness elements may provide better passage conditions, especially for juvenile salmonids. However, the use of roughness elements rather than retention sills would likely require a deeper recessed transport channel. The remedy could also potentially accommodate removal of upstream Site 17.1, while maintaining upstream channel grade. As noted above, given the flat slope and short length of the crossing, a similar sediment retention effect might be induced via the downstream roughened channel remedy, thus avoiding construction in the Caltrans right-of-way.

3.5.2 SITE 17.1: DROP STRUCTURE AT STORM DRAIN

Assessment Site 17.1 is a drop structure associated with a storm drain at RM 4.96. The drop structure is a trapezoidal section of sacrete set in concrete, with an approximately 48-inch-diameter culvert outlet roughly halfway up the right bank. At very low flows, the drop structure is slightly backwatered by the concrete inlet apron at the El Camino Real crossing (Site 17), several hundred feet downstream. However, due to the wide, flat bottom of the drop structure, depth remains shallow as flows increase and become supercritical across the sacrete, creating a velocity barrier for juveniles and adults at low and moderate flows.

Roughened Channel

Given its proximity to Site 17 (approximately 240 feet downstream), passage at Site 17.1 could likely be marginally improved by the construction of a roughened channel downstream of El Camino Real or construction of a transport channel with adequate roughness elements to backwater the drop structure. However, removing the existing grade control structure at Site 17.1 and replacing it with a boulder grade control structure and roughened channel may improve passage at Site 17.1 more than modifications at Site 17 alone. This would involve removing the existing concrete and sacrete and installing boulder grade control. The downstream end of the boulder grade control structure could be set 0.5 foot below the elevation of the El Camino Real crossing so that it is backwatered at low flows, and the roughened channel would extend upstream from the grade control structure for approximately 30 feet at a 2 percent slope. This grade control would also continue to provide scour protection for the water discharging from the storm drain.

3.6 REACH 10

This section presents fish passage remedies for Assessment Site 22, which falls in the yellow score category and is the only Assessment Site in Reach 10.

3.6.1 SITE 22: HIGHWAY 85 CROSSING, PM 20.0

Assessment Site 22, the stream crossing at PM 20.0 on Highway 85, is at RM 6.96. There are cobbles and gravels throughout the width and length of the crossing structure, and the average slope through the site is 0.07 percent. The natural substrate channel in the crossing is broad and featureless, resulting in insufficient depth at lower passage flows and excessive velocities for juveniles at all flows. The primary design driver is to create a low-flow channel, which could be done with forcing features.

Forcing Features

The channel through the crossing has a slight right bend (looking downstream), and low flows are currently somewhat concentrated on the left side of the channel. The objective of adding forcing features is to amplify existing conditions by concentrating low flows to this left side of the channel and inducing local scour along the thalweg, thus increasing depth. A barb is a type of forcing feature (Section 0) that would be suitable for this site. A series of rock barbs could be constructed on the right side of the channel. Horizontally, the barb structures would begin at the existing wall and extend away from the wall and slightly upstream toward the existing low flow channel on left side of the channel. Vertically, the crest of the barb would be highest at the existing wall, higher than the channel is currently, and slope down to the preferred elevation of the low flow channel's bankline. If barbs are constructed every 30 feet, there would seven barb structures under the approximately 200-foot-long Highway 85 crossing. In addition to the barbs, a constructed rock bankline along the river left wall would reduce velocities along the wall and improve passage conditions.

3.7 REACH 15

This section presents fish passage remedies for Assessment Site 32, which falls in the red score category and is the only Assessment Site in Reach 15.

3.7.1 SITE 32: GAGING WEIR SF44 AT STEVENS CREEK PARK

Assessment Site 32, the stream flow gaging weir SF44 at Stevens Creek Park, is at RM 12.28. The flow gaging weir is a channel-spanning concrete structure. The primary design driver for the site is to reduce the jump height at the structure, and it is assumed that modifications must retain the ability to measure flow at the site. Two remedies to improve fish passage conditions at Site 32 are described in this section: a roughened channel and a technical fishway. Both remedies would likely require updating the stage-discharge rating curve for the gaging weir.

Roughened Channel

Available survey data do not extend far enough to capture the most downstream tailwater control, but it is assumed that a 300-foot-long roughened channel constructed downstream of the weir at an overall slope of 2 percent would be adequate to improve passage at Site 32. Additional survey would be required to determine the most appropriate slope. Construction of the roughened channel would require removal of existing mature riparian vegetation and may affect the reliability of the gaging weir, given that the boulders at the upstream end of the roughened channel would likely control the stage-discharge relationship and be subject to shifting during high flows.

Pool-and-Chute Fishway

Another remedy would be a technical fishway. The objective would be to create steps for fish to more easily overcome the vertical barrier. Because there is a pool upstream of the existing gaging weir, the existing gaging weir could be notched with either a “V” or rectangle shape to lower the existing invert elevation between 0.5 to 1 foot. Then a 30-foot-long pool-and-chute fishway, at a 10 percent grade with two or three additional steps, could break up the remaining drop. This remedy would allow the gaging site to continue functioning with minimal impacts to the existing riparian vegetation. The upstream-most weir would control the stage-discharge relationship. Given that the weir would be constructed of concrete, the relationship should remain stable once established.

Forcing Features

Forcing features are a third remedy that could be used to improve passage at the gaging weir by constricting the channel at the existing tailwater control and increasing the water surface elevation of the pool downstream of the weir. Forcing features for this application could include one or more rootwads installed into the streambank(s), or boulders placed on the margins of the channel. Because there is a floodplain on river left (looking downstream), the bankline in the pool between the weir and the tailwater control may need to be raised to keep the water from simply flowing around the forcing feature. This type of project may affect a length of stream estimated to be roughly 25 feet long but would not modify the approximately 3 percent grade through the reach. Advantages of this remedy would be a reduced project footprint and cost relative to a roughened channel or technical fishway, and potentially less maintenance (e.g., fish rescue, debris management) than a pool-and-chute fishway. However, channel adjustments and backwater effects at higher flows may make the gage’s rating curve less reliable than under current conditions or with a technical fishway, and adjustments could also affect fish passage conditions. Potential effects of this remedy on connectivity between the channel and the floodplain should also be evaluated if it is pursued.

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5 List of Report Preparers

This Remedies report was completed for Valley Water by the Team, which consists of AECOM as the prime consultant and MLA as the subconsultant. Key staff members contributing to this Remedies report are listed in Table 5-1 below.

Table 5-1 List of Study Participants and Report Preparers

Staff Member	Affiliation	Study Role
P. Travis James, P.E.	MLA	Technical Staff
Michael Love, P.E.	MLA	Fisheries Engineering Lead
Jessica Lovering	Valley Water	Reviewing Engineer
James Manitakos	Valley Water	Reviewing Water Resources Specialist
Steve McNeely, P.E.	AECOM	Technical Staff
Kevin Sibley	Valley Water	Valley Water Project Manager
Jonathan Stead	AECOM	Project Manager and Lead Fish Biologist

Qualifications of the key consultant Team members are listed below.

Jonathan Stead is a fish and wildlife biologist and senior project manager with more than 20 years of experience, with expertise in fish passage, steelhead biology, and aquatic ecology. He earned his master's degree studying fish ecology at UC Davis under Dr. Peter Moyle and currently leads multidisciplinary teams on complex stream restoration, fish passage, dam removal, and water infrastructure projects. Jon has been a major contributor to important fish passage and stream restoration projects for various organizations, including the San Francisco Public Utilities Commission, Monterey Peninsula Water Management District, United States Bureau of Reclamation, Stanford University, and Klamath River Renewal Corporation.

Michael Love, P.E., has been the managing principal of Michael Love & Associates, Inc., since 1999. Michael has extensive interdisciplinary experience in fisheries and fluvial geomorphology, design of stream restoration, and technical and nature-like fishways. He was lead developer of the widely used FishXing software and was a primary author of the fish passage assessment and fish passage design and implementation sections of CDFW's California Salmonid Stream Habitat Restoration Manual (CDFG 2004, CDFG 2009). Michael has been the lead fish passage engineer for more than four dozen passage projects, has led more than two dozen trainings instructing participants on fish passage design and assessment, and regularly collaborates with Humboldt State University to conduct research into fish passage topics.

Steve McNeely, P.E., is a senior water resources engineer, fluvial geomorphologist, and project manager with more than 17 years of experience as an engineering and environmental consultant. Steve has led the planning, design, permitting, and construction supervision of numerous stream restoration projects, as well as the design of fish passage improvement projects ranging from culvert replacements to dam removals.

P. Travis James, P.E., is a licensed civil engineer with extensive experience in water resources engineering, with an emphasis on river systems. His experience includes fluvial geomorphology, fish passage engineering, fish screen systems, watershed hydrology, channel hydraulics, and bank stabilization. Travis has been lead design engineer on many fish passage improvement projects over the past 13 years.