Preliminary Assessment of Salmonid Passage Downstream of AR1 Diversion Facility

Steelhead and Chinook Salmon Passage in the Chaparral Lane Cataract

August 2020 | NID-14

Prepared for:

Nevada Irrigation District
1036 W. Main Street
Grass Valley, CA 95945

Prepared by:

HELIX Environmental Planning, Inc.
11 Natoma Street, Suite 155
Folsom, CA 95630

Preliminary Assessment of Salmonid Passage Downstream of AR1 Diversion Facility

Steelhead and Chinook Salmon Passage in the Chaparral Lane Cataract

Prepared for:

Nevada Irrigation District
1036 W. Main Street
Grass Valley, CA 95945

Prepared by:

HELIX Environmental Planning, Inc.
11 Natoma Street, Suite 155
Folsom, CA 95630

August 2020 | NID-14

This page intentionally left blank

TABLE OF CONTENTS

Section **Page**

LIST OF APPENDICES

This page intentionally left blank

1.0 INTRODUCTION

HELIX Environmental Planning, Inc. (HELIX) was contracted by the Nevada Irrigation District (NID) to provide an initial and preliminary assessment of fish habitat and fish passage conditions downstream from the Auburn Ravine 1 (AR-1) Diversion Facility and Canal Project, located immediately upstream of a high stream gradient area known locally as the Chaparral Lane Cataract (Cataract). Often referred to as the Gold Hill Diversion, AR-1 is the largest diversion facility on Auburn Ravine.

The Scope of Work for this project initially included an investigation of three tasks: 1) a review for other passage documents in upper Auburn Ravine, fish passage requirements for adult Central Valley (CV) fall and late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) and CV steelhead (*O. mykiss*), and DWR and CDFW files pertaining to fish sampling in Auburn Ravine (both of which were not forthcoming); 2) a longitudinal gradient profile of Auburn Ravine starting from below the Cataract and extending to the diversion facility, a total of approximately 1.0 mile; and 3) preparation of a document of findings including an assessment of the probability of successful fish passage and potential fish migration blockage downstream from AR-1.

Species Summary and Passage Success

Central Valley (CV) fall-/late fall–run Chinook salmon. Adult fall run Chinook salmon enter the Sacramento and American river systems from mid-September through January, peaking in Auburn Ravine from mid-October through December, and sometimes extending through February, from spawning data collected by CDFW in 2012 and 2014 (Hoobler 2015). Spawning occurs from mid-October through early February, with peak spawning occurring from mid-October through December. During spawning, the female digs a redd (gravel nest) in which she deposits her eggs, which are then fertilized by the male. The duration of egg incubation and time of fry emergence depends largely on water temperature. In general, eggs hatch after a 3 to 5-month incubation period, and alevins (yolk-sac fry) remain in the gravel until their yolk sacs are absorbed (2 to 3 weeks). Newly emerged fry remain in shallow, lower-velocity edgewater habitat, particularly where debris congregates and provides cover from predators.

Juveniles typically rear in freshwater in their natal streams, the Sacramento River system, and the Sacramento–San Joaquin River Delta (Delta) for 3 to 6 months (fall-run) or up to 12 months (late fall-run) before entering the ocean. Juveniles migrate downstream from January through June. Important winter habitat for juvenile Chinook salmon includes flooded bars, side channels, and overbank areas with relatively low water velocities. Cover structures, space, and food are necessary components of Chinook salmon rearing habitat. Suitable habitat includes areas with instream and overhead cover in the form of undercut banks, downed trees, and large, overhanging tree branches. The organic materials forming fish cover also help provide sources of food, in the form of both aquatic and terrestrial insects.

CV Steelhead. Historically, CV steelhead spawned and reared in most of the accessible upstream reaches of Central Valley rivers, including the Sacramento and American Rivers and many of their tributaries. Steelhead generally migrated far into tributaries and headwater streams where cool, well-oxygenated water is available year-round. Central Valley steelhead is classified as a winter-run species, with peak adult migration through the Delta occurring from September through February (Busby et al. 1996). The upstream migration and spawning of adult steelhead in Auburn Ravine occurs primarily from December through March.

CV steelhead fry usually emerge between February and May, sometimes extending into June (Barnhart 1986; Reynolds et al. 1993). Initially, juvenile steelhead are found in or near their natal spawning streams. As they grow and mature, juvenile steelhead may move downstream into larger stream segments, including the mainstem American and Sacramento rivers. Juvenile steelhead rear throughout the year and may spend 1 to 3 years in freshwater before emigrating to the ocean. Steelhead generally emigrate from March to June (Barnhart 1986; Reynolds et al. 1993). Steelhead typically spend 2 years in the ocean before returning to spawn in freshwater. A portion of steelhead, in contrast to anadromous salmon, spawn more than once, with adults returning to the ocean and reentering the Delta to spawn in Central Valley tributaries. Recent research indicates steelhead can successfully pass greater stream gradient than Chinook salmon.

2.0 METHODS

This section provides a summary of the major tasks performed by HELIX on this project.

Literature Review

HELIX conducted a search of available documents that would describe fisheries and hydrologic conditions in Auburn Ravine in the vicinity of the cataracts downstream of the AR-1 Diversion Facility. We reviewed documentation pertaining to requirements of adult salmonids for upstream passage as well as conditions (e.g., stream gradient) that would preclude upstream passage (Powers and Orsborn (1985), R2 Resource Consultants (2007), Burnett et al. (2007), NOAA (2007), USFS (2006), Stuart (1962), and Bain and Stevenson (1999)). We also reviewed biological data for Auburn Ravine from several sources including Baily and Buell (2005), Flosi et al. (2010), and HELIX (2019).

Longitudinal Profile

It is currently believed that the limit of adult anadromous salmonid upstream passage is in the vicinity of the Chaparral Lane Cataract, per the limit of CV Steelhead Critical Habitat. However, this has not been documented and there is some disagreement regarding whether fish could successfully navigate the Cataract given suitable (and yet to be determined) streamflow. Stream gradients have been evaluated to understand maximum values that would either allow or preclude upstream passage by adult steelhead and Chinook salmon in Northern California (SWRCB Instream Flow Policy: GIS-Analysis Criteria for Upstream Distribution Limit of Steelhead). One such investigation conducted by R2 Resource Consultants (2007) provided an initial evaluation, based on their general experience that steelhead passage would likely be precluded by reaches 150-meters (m) or longer over a longitudinal slope continuously greater than or equal to 8 percent. After conducting a literature review and contacting various researchers from the U.S. Forest Service and National Marine Fisheries Service (NMFS), R2 refined these criteria to a slope of approximately 12 percent, as discernable over 100-m using digital elevation models (DEMs), as a limit to upstream passage of steelhead, and by default, Chinook salmon which generally are found lower in the watershed. In summary, a stream gradient of about 12 percent or greater would likely limit upstream passage. Burnett et al. (2007) found that upstream passage suitability was negligible at gradients in excess of 7 percent for steelhead and 5 percent for Coho salmon. Agrawal et al. (2005) found that maximum stream gradients below which their passage model considered differences in habitat availability to be negligible were 5 percent (Coho salmon), 12 percent (steelhead), and 3.5 percent (Chinook salmon).

The CDFW has also conducted a literature review of sustained slope gradient as it pertains to fish passage and selected a sustained slope of >8 percent as measured off a topographic map to define the upper limit of anadromy for the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2010)

Powers and Orsborn (1985) have also developed a methodology for determining successful upstream passage of anadromous salmonids. We reviewed those methods for suitability of their use on Auburn Ravine. HELIX biologists collected gradient data along the high gradient stretch of Auburn Ravine (cataract) using an inclinometer to calculate the steam gradients in 25-m sections along the longitudinal profile of Auburn Ravine. We also calculated stream reach gradients digitally from Google Earth. Finally, we compared calculated and measured percent gradients with known maximum gradient for steelhead and salmon passage (10 to 12 percent over a length equal to the stream width or up to 25-m).

During the stream gradient survey, HELIX fish biologists visually assessed the stream for the presence and abundance of fish, especially salmonids, within each 25-m section.

Habitat Mapping, Report Finalization, Management, Quality Assurance

At the time of the first site visit (August 21, 2019), it was discovered that streamflow was too high to allow upstream access through the Cataract. Overgrown vegetation (primarily blackberry) blocked access along the channel edges due to the presence of steep banks on both sides of the ravine. For safety reasons, we were forced to cancel the survey attempt until later in the year when flows would be diminished to around 10 cfs. During subsequent surveys we were able to survey the lower of the two high-gradient reaches; the first being in the vicinity of Chaparral Lane and the upper reach located immediately below the AR-1 facility. The two high-gradient reaches are separated by a lower gradient reach. We were able to conduct surveys through the lower gradient reach that ended at the beginning of the second high-gradient reach.

The second survey was conducted on October 31, 2019 and focused on collecting data on specific habitat units within the high gradient Cataract reach. A third survey was conducted on November 12, 2019 where additional detailed information was collected, such as jump heights and jump pool depths at cascade units. For safety reasons (flows still too high, overgrown vegetation), the crew could not access the upper cataract. However, a Friends of Auburn Ravine associate was able to wade through this area in May of this year (2020), when flow conditions were at their lowest. We provide a summary of the findings from that survey as a Personal Communication.

A crew of two HELIX biologists conducted the habitat mapping surveys that included identifying each habitat unit encountered and collecting the following data: habitat unit length, average width, and depth. We also collected stream channel gradient and in the case of potential barriers to upstream passage, we collected the height of the barrier (see Table 1 in Appendix A). Using a benchtop analysis of lidar data, we also determined the elevation of each habitat unit, where possible.

Low waterfalls (less than six feet), cascades, and chutes in natural watercourses can affect fish migration in several ways. When water drops vertically into a pool of depth at least 1.25 times height of the drop, fish generally have little difficulty jumping over a low obstruction. The upwelling water, or a standing wave created by flow plunging into the pool may assist fish by imparting an upward force as a fish leaps from the pool. However, an incline or chute can form a hydraulic jump further downstream; encouraging fish to jump too far from the crest of the drop. NOAA guidelines (2001) indicate that the depth of a jump pool at least 1.5 times the jump height, or at least 2 feet depth, is necessary for passage. We therefore calculated the potential jump height for both 1.25 and 1.5 times the depth of the jump pool immediately below the potential barrier and compared that value with the barrier height (see Table 1 in Appendix A) to assess the probability of successful passage.

HELIX provides a discussion of findings from Tasks 1 and 2, along with longitudinal profile data calculated from Auburn Ravine compared against stream gradients from other streams known to either contain or preclude upstream passage of steelhead and Chinook salmon. HELIX provides a discussion of findings from Tasks 1 and 2, along with longitudinal profile data calculated from Auburn Ravine and compared against stream gradients from other streams known to either contain or preclude upstream passage of steelhead and Chinook salmon. Representative site photos of stream habitats in the Chaparral Lane Cataract are provided in Appendix B.

3.0 RESULTS

Channel Conditions

Elevations of the reach surveyed on October 31, 2019 ranged from 355 feet (Habitat Number 1, about 50 m downstream of the Cataract) to 414 feet (Habitat Number 26, about 40 m upstream from the Cataract), an increase of 59 feet (18 m) over a length of about 1,890 feet (576 m). Within the Cataract, elevation ranged from 360 feet (Habitat Number 4) to 389 feet (Habitat Number 14), an increase of 29 feet (8.8 m) over a length of 364 feet (110.9 m) (approximate overall gradient of 8 percent within the Cataract).

Downstream from the Chaparral Lane Cataract, the average stream gradient is about 2 percent. Habitat units below the cataract are dominated by pool, low gradient riffle, and run habitat. In the lower portion of the Cataract, higher gradient cascades, step pool and step run habitat are present. In the upper portion of the Cataract, average gradient is roughly 7 percent, with spikes in gradient up to 24 percent at two cascade/bedrock chutes and falls. Habitat types at the top end of the Cataract are dominated by cascade/bedrock chutes, high gradient riffle, and step run/step pool habitat.

The overall observed gradient (approximately 8 percent) through the roughly (364 feet (110.9 m) length of the lower Cataract appears to be within the range of potentially unsuitable gradient percentage (8 to 12 percent over 100 m reach of stream channel) for upstream passage of steelhead, and is most likely too great for Chinook salmon passage as well. In recent years, Chinook salmon have been observed by local residents in the large pool below the Cataract (Habitat Unit Number 4). No fish have been observed upstream from this pool, which indicates that the upper limit for CV steelhead Critical Habitat in Auburn Ravine at the beginning of the Cataract is likely appropriate.

Several barriers are certainly full passage barriers at lower flows. Often as flows increase, water surface level also increases which may assist fish in being able to pass over a barrier. However, as flows increase, velocities also increase that may be too great to allow for passage. Within the lower Cataract, there is a bedrock chute and falls complex that increases in surface elevation from 367 feet at the low plunge pool of the bedrock chute to 381 feet at the crest (upper pool) of the cascade, an increase of 14 feet (4.3 m) over a distance of 128 feet (39 m) (11 percent gradient). At the bedrock chute unit, a gradient of 24 percent was measured.

Jumping pools and landing pools must also be of appropriate depths. Stuart (1962) gives the range of 1.25 to 1.5 times the jumping pool depth and comparing that value against the jump height (barrier height). The value must be greater than the jump height to allow for successful passage. This range of values is currently used by both CDFW and NMFS when assessing potential passage suitability.

Powers and Orsborn discuss the difference of steelhead condition (bright or good condition) as being a factor in successfully navigating potential barriers. For example, a fish in good condition and that has not been overly challenged by repeated passage impediments downstream would have a better chance of passing over a questionable barrier as opposed to a fish that has repeatedly had to negotiate high gradient sections of stream or questionable barriers. These fish would more likely seek out spawning areas lower in the watershed than bright fish.

In addition to jumping distances, successful passage over a natural feature is also dependent upon depth of the jump pool and velocity at the barrier crest (for jumping barriers), or chute velocity for swimming barriers. Optimal jump pool depth has been described as being at least 1.25 times the total barrier height (Stuart 1962); whereas minimal pool depths are characterized as being at least equal to fish length (e.g., 2 to 3 feet for steelhead) and deep enough such that plunge pool turbulence does not extend to the pool bottom.

The barrier crest where a fish is expected to re-enter the water must be at least as deep as the fishes body depth (~0.4 to 0.6 feet) and the crest water velocity cannot exceed a steelhead's maximum burst swimming speed, which has been cited as ranging from 13 to 27 fps, depending on fish size and physical condition (USFS 2006). The higher burst rates may be more appropriate for large, "bright" fish encountering barriers reasonably close to the ocean, whereas the lower burst speed might represent small adults or fish at barriers far from the ocean. Additional barrier characteristics that effect passage success and should be considered in estimating the probability of passage, include the amount of turbulence within the jumping pool; turbulence and (especially) whitewater will degrade jumping ability.

The ability for a steelhead or Chinook salmon to successfully pass to any point in the watershed is dependent on the cumulative probability of passing all barriers downstream of the study location. This is determined by multiplying the estimated passage probability of a particular barrier by the cumulative probability up to that location. Thus, if all downstream barriers are judged as fully passable, then passage will likely be successful, whereas if any single barrier is judged as non-passable, successful passage is marginalized for all reaches above that barrier. Finally, as described for the riffle depth variable, a barrier assessment at a single flow may not provide an accurate estimation of passability. Ideally a barrier would be reassessed at a variety of flows that are typical of conditions during upstream migration in order to determine the range of passable conditions, and then combine that information with hydrology to estimate the probability of achieving those flows during the migration period.

Adult anadromous salmonids also require adult holding pools. Pools containing dense cover reach maximum suitability at 3 feet depth, whereas pools devoid of dense cover achieve maximum suitability at 8 feet in depth. Such pool habitat is relatively limited downstream of the Cataract.

On May 8, 2020, James Haufler, Friends of Auburn Ravine, (personal communication) conducted a wading survey in the 1/2-mile section of the creek from the bridge at the eastern end of Chaparral Lane upstream to Gold Hill Dam (AR-1), focusing mainly on the upper Cataract. Mr. Haufler concluded that no obvious major natural barriers to upstream migration of salmon or steelhead were observed, other than one area he descried as a cascade made up of a huge jumble of large boulders. It was his opinion that *this major jumble of large angular boulders will prove difficult for Chinook Salmon at all flow levels. It is likely that it could be passable for Steelhead when the water is much higher than shown in this photo.* However, he did not consider the effect of higher velocities at higher flows, which would likely be too great to allow for passage. He further explained that the jumble of boulders extends from bank to bank and for about 20 yds upstream, further increasing the likelihood of unsuitable passage conditions.

He further opined that the stream channel offers few (or no) good areas for spawning of salmonids, alternating between deep pools with mud or sand on the bottom, bedrock slicks, jumbles of boulders, numerous cascades, and riffles composed of loose and fixed angular rocks measuring 6 inches across or larger.

4.0 CONCLUSIONS

Based on recent research discussed above regarding suitability of gradient for steelhead and Chinook salmon, together with the data collected for this project and anecdotal evidence provided by local landowners, this report concludes that Chinook salmon upstream passage is most likely blocked by the Chaparral Cataract over all flows. This assessment is based upon:

- Sustained high gradient of 8 percent over 364 feet (110.9 m) of cataract.
- Two individual bedrock chutes/cascades with short distance gradient of 22 and 24 percent.
- Cascade feature (habitat unit number 9) has a jumping pool of 4.0 feet depth and height of 7.0 feet; passage calculation value of 1.5 X 4.0 = 6.0 is less than cascade height of 7.0, indicating migration would be blocked at this unit, at least during the current flow level.

It is more difficult to assess whether steelhead can pass the Cataract, given their ability to pass over a higher sustained gradient than Chinook salmon. Conditions in the Cataract appear to be on the edge for potentially successful passage. This report concludes that under low to moderate flow conditions (e.g., less than 150 cfs) upstream passage of steelhead would likely not be possible. At higher flows, some of the bedrock chutes/cascades may become ‘drowned out’ which could level out surface flows somewhat, however stream velocities would likely be too great to allow passage. With a lack of data for higher flow conditions, likelihood of potential passage ability over the Cataract by steelhead is necessarily inconclusive. A complete and more detailed field survey using total station survey equipment would be necessary to further describe and analyze the potential of steelhead passage over the Cataract.

Potential Next Step

Various assessment methodologies have been developed for predicting passage over natural barriers, such as steep cascades, chutes, and falls. Most such analyses, including a qualitative assessment in Bain and Stevenson (1999), rely heavily on fish performance data described in Powers and Orsborn (1985). Repeated measurements at multiple flows are required to predict what range of flows, if any, would allow passage over a given barrier. Typically, a formal barrier assessment should be conducted by the agencies that will estimate what flows, if any, would provide passage over the barrier. For example, Fish Xing software (USFS 2006) can be used to estimate the range of passage flows for culvert barriers. In addition, a flow duration curve could be derived to estimate the probability that passage flows will occur in a given year (during the migration season). These techniques require labor intensive field effort and benchtop modeling which are outside the scope of the current study.

A qualitative and field-friendly protocol based on Powers and Orsborn (1985) leaping curves for steelhead utilized a modified jump chart for evaluating natural barriers in the Ventura Basin. The jump chart represents a composite of vertical and horizontal jump distances for adult steelhead in “bright” and “good” condition, where barriers falling within the “passable” area should be manageable by fish in either condition, and barriers within the “possible” area are most likely to be ascended by “bright” fish fresh from the ocean. This type of assessment would also require repeated observations over several flow levels.

More detailed data would need to be collected through the use of total station survey gear. Prior to introduction of a survey crew, major vegetation removal (non-native species) would be necessary to assist in allowing the crew to pass upstream, even during low streamflow.

5.0 REFERENCES

Agrawal, A., R.S. Schick, E.P. Bjorkstedt, R.G. Szerlong, M.N. Goslin, B.C. Spence, T.H. Williams, and K.M. Burnett. 2005. Predicting the potential for historical coho, Chinook, and steelhead habitat in northern California. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-379. Southwest Fisheries Science Center, Santa Cruz CA.

Baily, R, and J. Buell. 2005. ANADROMOUS FISH SCREENING AND PASSAGE OPPORTUNITIES IN WESTERN PLACER COUNTY AND SOUTHERN SUTTER COUNTY

Bain, M. and N. Stevenson. 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society. Maryland.

Barnhart, R. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) – steelhead, USFWS Bio Report 82 (11.60), USACOE, TR EL - 82.4.21 pp.

Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17(1): 66-80.

Busby, P. Wainwright, T., Bryant, G., Lierheimer, L., Waples, R., Waknitz,F., and I. Lagomarino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California, National Marine Fisheries Service.

Flosi, G., DOWNIE, S., HOPELAIN, J., BIRD, M., COEY, R., and B. COLLINS. 2010. CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL, 4th Edition. State of California, The Resources Agency.

Haufler, J. May 2020. Personal communication. Friends of Auburn Ravine.

HELIX Environmental Planning, Inc. (HELIX). 2019. Salmon Spawning and Water Quality Surveys in Auburn Ravine, Results of Two Seasons (2017 and 2018) of Surveys on Auburn Ravine near Hemphill Diversion Facility, Nevada Irrigation District.

Hoobler, Sean. 2015. Completion of the Auburn Ravine Chinook Salmon Redd Survey Report. State of California, Department of Fish and Wildlife, Memorandum to Ms. MaryLisa Lynch, dated September 14, 2015.

National Oceanic and Atmospheric Administration (NOAA). 2007. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service, Southwest Region.

Powers, P. and J. Orsborn, 1985. "New Concepts in Fish Ladder Design: Analysis of Barriers to Upstream Fish Migration, Volume IV of IV; Investigation of the Physical and Biological Conditions Affecting Fish Passage Success at Culverts and Waterfalls", 1982-1984 Final Report, Project No. 198201400, 134 electronic pages, (BPA Report DOE/BP-36523-1).

R2 Resource Consultants. 2007. SWRCB Instream Flow Policy: GIS-Analysis Criteria for Upstream Distribution Limit of Steelhead. Memorandum to James Reilly, Stetson.

Reynolds, F.L., Mills, T.J., Benthin, R., and Low, A. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game, Inland Fisheries Division. Sacramento, California.

Stuart, TA. 1962. The leaping behavior of salmon and trout at falls and obstructions. Department of Agriculture and Fisheries for Scotland, Freshwater and Salmon Fisheries Research, His Majesty's Stationary Office 28, Edinburgh, Scotland.

U.S. Forest Service (USFS). 2006. FishXing Software.

This page intentionally left blank

Appendix A

Table 1, Habitat Units Surveyed in Auburn Ravine in the Vicinity of and including the Chaparral Lane Cataract, October 31, 2019

This page intentionally left blank

Table 1
Habitat Units Surveyed in Auburn Ravine in the Vicinity of and including the Chaparral Lane Cataract, October 31, 2019

Habitat No.	Habitat Unit Type	Gradient %	Length (m)	Width (m)	Depth (cm)	Depth (ft)	Height (ft)	Pass. Calc. 1.5	Pass. Calc. 1.25	Coordinates	Elevation Estimate Using Lidar Data
1	MCP/glide	2	17.4	11.0	61	2.00					355'
2	STP		51.1	7.3	90	2.95					356'
3a	LGR -right	3.5	19.2	4.6	35	1.15					357'
3b	LGR - left		19.2	1.4	25	0.82					
4	MCP		12.8	6.4	60	1.97					360'
5a	SRN - left	2	14.6	6.4	57	1.87		2.805	2.34		361'
5b	STP - right		8.2	6.4	90	2.95	1.5	PASSABLE	3.69	38°53'59.73" N, 121°10'14.75" W	364'
6	PLP		8.2	5.5	95	3.12		4.68	3.90	38°53'59.79" N, 121°10'14.67" W	367'
7	BDRK chute	24	6.4	0.7	36	1.18	3.5	PASSABLE	1.48	38°54'00.33" N, 121°10'14.61" W	371'
8	PLP		14.6	2.3	123	4.04		6.045	5.04	38°54'00.64" N, 121°10'14.25" W	373'
9	CAS	22	1.8	0.9	20	0.66	7	BLOCKED	0.82	38°54'0.88" N, 121°10'14.7" W	380'
10	MCP		11.0	7.3	63	2.07			2.58	38°54'01.08" N, 121°10'13.81" W	381'
11a	LGR - left		11.9	1.8	22	0.72			0.90	38°54'01.30" N, 121°10'14.28" W	381'
11b	MCP - right		9.1	4.6	100	3.28		4.92	4.10	38°54'01.43" N, 121°10'13.51" W	382'
12	CAS/HGR	9	2.7	7.3	65	2.13	3	PASSABLE	2.67	38°54'01.53" N, 121°10'13.55" W	385'
13	STP	7	33.8	6.4	105	3.44		5.16	4.31	38°54'02.46" N, 121°10'13.18" W	386'
14	CAS	7	3.2	2.7	20	0.66	2.5	PASSABLE	0.82	38°54'03.72" N, 121°10'10.71" W	389'
15	MCP		11	7.3	135	4.43					
16	RUN		15.5	7.3	30	0.98					
17	MCP	1	43	9.1	135	4.43					399'
18	HGR	20	10.1	2.7	50	1.64					405'
19	SRN	11	16.5	1.8	55	1.80					410'
20	LGR		10.1	1.8	35	1.15					
21	MCP		11	2.3	50	1.64					
22	LGR	3.5	43.9	4.6	45	1.48					412'
23	STP		101.5	6.4	150	4.92					412'
24	SRN	1.5	35.7	5.5	50	1.64					413'
25	LGR		29.3	8.2	30	0.98					414'
26	MCP	0.5	48.5	15.5	120+	3.94+				38°54'01.48" N, 121°10'01.876" W	414'

Appendix B

Representative Site Photos

This page intentionally left blank

Photo 1: Beginning of Cataract, looking upstream.

Photo 2. Bottom half of chute, looking upstream.

Photo 3. Upper half of chute.

Photo 4. Cascade.

Photo 5: Top of Cascade.

Photo 6. Second Cascade, looking upstream.

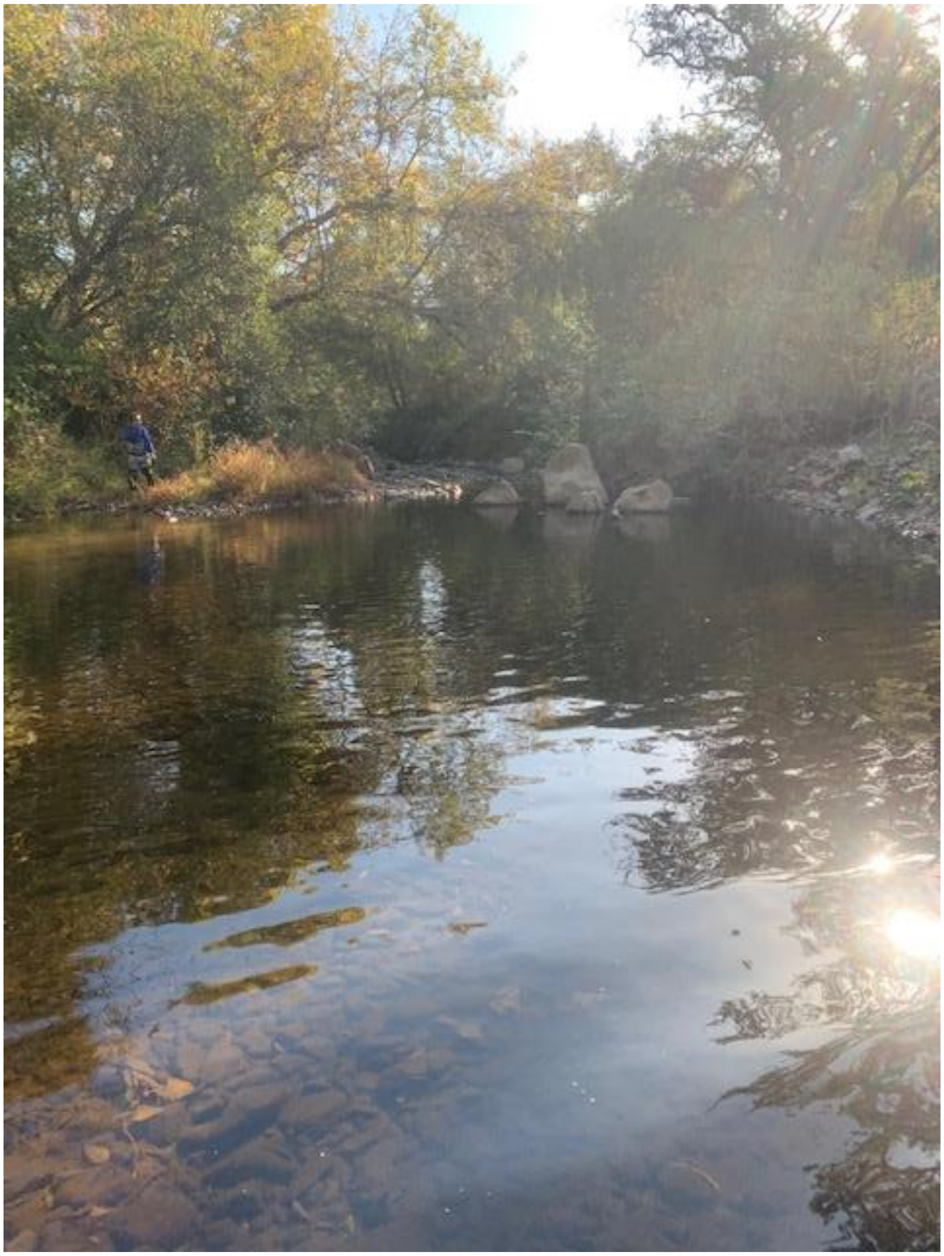

Photo 7. Low gradient reach between Cataracts, looking upstream.