# Eagle Canyon Fish Passage Improvements in Battle Creek
## Lower and Upper Barrier Sites

## Basis of Design Memorandum



**February 2017**

Prepared for:

**California Department of Fish and Wildlife**
(Agreement Number D1499019)

Prepared by:

Michael Love & Associates
*Hydrologic Solutions*
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**(Page intentionally left blank)**

# Eagle Canyon Fish Passage Improvements in Battle Creek, Lower and Upper Barrier Sites

## Basis of Design Memorandum

Prepared for:

**California Department of Fish and Wildlife**
Agreement Number D1499019

Prepared by:

**Michael Love P.E.**
Principal Engineer
License No. C71681
Michael Love & Associates, Inc.
mlove@h2odesigns.com • (707) 826-2411 x1

**Travis James P.E.**
Senior Project Engineer
License No. C76663
Michael Love & Associates, Inc.
ptjames@h2odesigns.com • (707) 826-2411 x5

**February 2017**

# Table of Contents


**1 Purpose and Introduction ..... 1**
**2 Background and Setting ..... 1**
2.1 Project Location ..... 2
2.2 Previous Work and Relevant Studies by Others ..... 2
2.2.1 In-Stream Flow Agreements ..... 2
2.2.2 Hydrology Studies and Streamflow Gaging ..... 2
2.2.3 Fish Passage and Fish Monitoring Studies ..... 5
2.3 Summary of Previous Work Completed by MLA Design Team ..... 6
2.3.1 Survey and Mapping ..... 7
2.3.2 Engineering Geologic Studies ..... 7
2.3.3 Characterization of Existing Hydraulic and Fish Passage Conditions Methods ..... 7
2.3.4 Alternative Analysis ..... 7
2.3.5 Construction Alternative Analysis ..... 7
2.3.6 Class 4 Cost Analysis ..... 8
2.3.7 Construction Schedule ..... 8
2.4 Lower Barrier Site Summary of Existing Conditions ..... 8
2.4.1 LBS Layout ..... 8
2.4.2 LBS Geologic Conditions and Hazards ..... 8
2.4.3 LBS Site Hydrology ..... 10
2.4.4 LBS Fish Passage Conditions ..... 12
2.5 Upper Barrier Site Summary of Existing Conditions ..... 12
2.5.1 UBS Layout ..... 12
2.5.2 UBS Geologic Conditions and Hazards ..... 13
2.5.3 UBS Site Hydrology ..... 14
2.5.4 UBS Fish Passage Conditions ..... 14
**3 Project Goals, Objectives, and Fish passage Design Criteria ..... 16**
3.1 Project Goal ..... 16
3.2 Project Objectives ..... 16
3.3 Fish Passage Design Criteria and Design Flows ..... 16
3.4 General Fish Passage Performance Evaluation Method ..... 17
**4 Lower Barrier Site Project ..... 18**
4.1 LBS Project Description ..... 18
4.2 Construction ..... 20
4.3 Anticipated Fish Passage Performance ..... 21
4.3.1 Methods ..... 21
4.3.2 Results ..... 21
4.4 Expected Design Life ..... 29
4.5 Anticipated Maintenance Requirements ..... 29
4.6 Recommended Post-Construction Monitoring ..... 29
4.6.1 As-Built Survey ..... 29
4.6.2 Startup Monitoring ..... 30
4.6.3 Biological Monitoring ..... 30
4.6.4 Inspection and Maintenance ..... 30
4.7 Design Limitations and Uncertainties ..... 30

**5 Upper Barrier Site Project ..... 31**
5.1 UBS Project Description ..... 31
5.2 Construction ..... 35
5.3 Stability Analysis of Placed Boulders ..... 37
5.4 Anticipated Fish Passage Performance ..... 37
5.4.1 Methods ..... 37
5.4.2 Results ..... 38
5.5 Expected Design Life ..... 39
5.6 Anticipated Maintenance Requirements ..... 46
5.7 Recommended Post-Construction Monitoring ..... 46
5.7.1 As-Built Survey ..... 46
5.7.2 Startup Monitoring ..... 46
5.7.3 Biological Monitoring ..... 47
5.7.4 Inspection and Maintenance ..... 47
5.8 Design Limitations and Uncertainties ..... 47
**6 References ..... 48**

## Attachments

**Attachment 1 – 90% Design Drawings**

**Attachment 2 – Annotated Bibliography of Previous Battle Creek Studies and Reports**

**Attachment 3 –** *Eagle Canyon Fish Passage Improvements; Alternative Analysis Constructability Review Memorandum* **(SRD, 2016a)**

**Attachment 4 –** *Eagle Canyon Fish Passage Improvements; Alternative Class 4 Estimate Narrative* **(SRD, 2016b)**

**Attachment 5 –** *Construction Schedule*

# 1 PURPOSE AND INTRODUCTION

This Basis of Design Memorandum (BODM) is intended to provide a summary of the proposed fish passage improvements at the Lower Barrier Site and Upper Barrier Site in Eagle Canyon on North Fork Battle Creek near Manton, California. This memorandum provides the project goals and objectives, design criteria and decisions, description of the proposed project, anticipated fish passage conditions resulting from the project, anticipated monitoring and maintenance required, and limitations and uncertainties associated with implementation and project performance.

The information presented in this memorandum relies on previously completed work. Repeating information from other documents was minimized but some information is repeated or summarized for convenience. A discussion of previously completed documents is included in Sections 2.2 and 2.3. Descriptions and analysis presented in this BODM are based on the 90% design drawings, which are included as Attachment 1.

The organization of this BODM is as follows:

**Section 2 - Background and Setting:** Presents the project location, a summary of the work completed previously by others and the Design Team for this project, and a summary of the existing LBS and UBS conditions.

**Section 3 - Project Goals, Objectives, and Fish Passage Design Criteria:** Describes design considerations and criteria used for this project.

**Section 4 - Lower Barrier Site Design:** Presents the Lower Barrier Site design, including a description of the design, anticipated fish passage performance, anticipated maintenance requirements, expected design life, recommended post-construction monitoring, and design limitations and uncertainties.

**Section 5 - Upper Barrier Site Design:** Presents the Upper Barrier Site design, including a description of the design, anticipated fish passage performance, anticipated maintenance requirements, expected design life, recommended post-construction monitoring, and design limitations and uncertainties.

**Section 6 - References:** Lists reports and publications cited in this document.

# 2 BACKGROUND AND SETTING

Battle Creek has historically been regarded as a uniquely important watershed because of the abundance and broad diversity of Chinook salmon and steelhead that used the creek. The year-round influence of cold water springs allowed for such diversity to develop, including winter-run Chinook salmon, which are now extirpated from the watershed and in danger of extinction. Hydroelectric facilities, operations, and other human factors likely caused the extirpation of winter-run Chinook from the Battle Creek watershed in the early 1900s (Reynolds et al. 1993).

After many years of planning, there is currently a major fisheries restoration project being completed by many organizations and led by the U.S. Bureau of Reclamation (USBR) on Battle Creek, referred to as *The Battle Creek Salmon and Steelhead Restoration Project* (USBR Restoration Project). Upon its

completion, the goal of the USBR Restoration Project is to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, plus an additional six miles on its tributaries.

The California Department of Fish and Wildlife (CDFW) has retained the services of Michael Love & Associates, Inc. (MLA) to design and develop construction ready documents to improve upstream fish passage conditions at two natural fish barriers on North Fork Battle Creek (NFBC): Lower Barrier Site (LBS) and Upper Barrier Site (UBS). This Eagle Canyon Fish Passage Improvement Project (Project) is being completed for CDFW under Agreement Number D1499019.

The following sections present background and setting information pertinent to this memorandum. This includes the project location, summary of previously completed work, and summaries of the existing conditions at both sites.

## 2.1 Project Location

This project is located within Eagle Canyon, along the border of northern Tehama and southern Shasta counties on North Fork Battle Creek (Figure 2-1). The separation between the Lower Barrier Site (LBS) and Upper Barrier Site (UBS) is approximately 1,200 feet. Eagle Canyon Dam, operated by Pacific Gas & Electric (PG&E), is located at approximately the mid-point between the two project sites. See Attachment 1, Sheet 3, for an additional site location map.

## 2.2 Previous Work and Relevant Studies by Others

The Battle Creek watershed has been the subject of many previous studies. An annotated bibliography of the previously completed work obtained as part of this project is included in Attachment 2. The following sections further highlight some of the studies.

### 2.2.1 In-Stream Flow Agreements

In February 1999, the National Marine Fisheries Service (NMFS), U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (USFWS), California of Department of Fish and Game (CDFG), and Pacific Gas and Electric Company (PG&E) entered into a memorandum of understanding (MOU). The MOU outlined the roles and responsibilities regarding actions to be undertaken as part of the Battle Creek Chinook Salmon and Steelhead Restoration Project. Among other details, the MOU outlined minimum instream flow releases below various diversion dams within the anadromous reaches of North and South Fork of Battle Creek. Table 2-1 presents minimum instream flow releases at North Battle Creek Feeder Dam (Feeder Dam) and Eagle Canyon Dam by month. Figure 2-2 shows the location of these dams relative to the project sites. Currently, PG&E is operating under interim instream flow requirements.

### 2.2.2 Hydrology Studies and Streamflow Gaging

Figure 2-2 presents an overview of the USBR Restoration Project components with the location of the LBS and UBS indicated. The figure also indicates the location of key dams and flow gaging stations within the watershed that may be discussed in this memorandum. MLA's *Existing Site and Hydraulic Characterization Technical Memorandum* (MLA, 2016b), presents a detailed discussion of project hydrology.

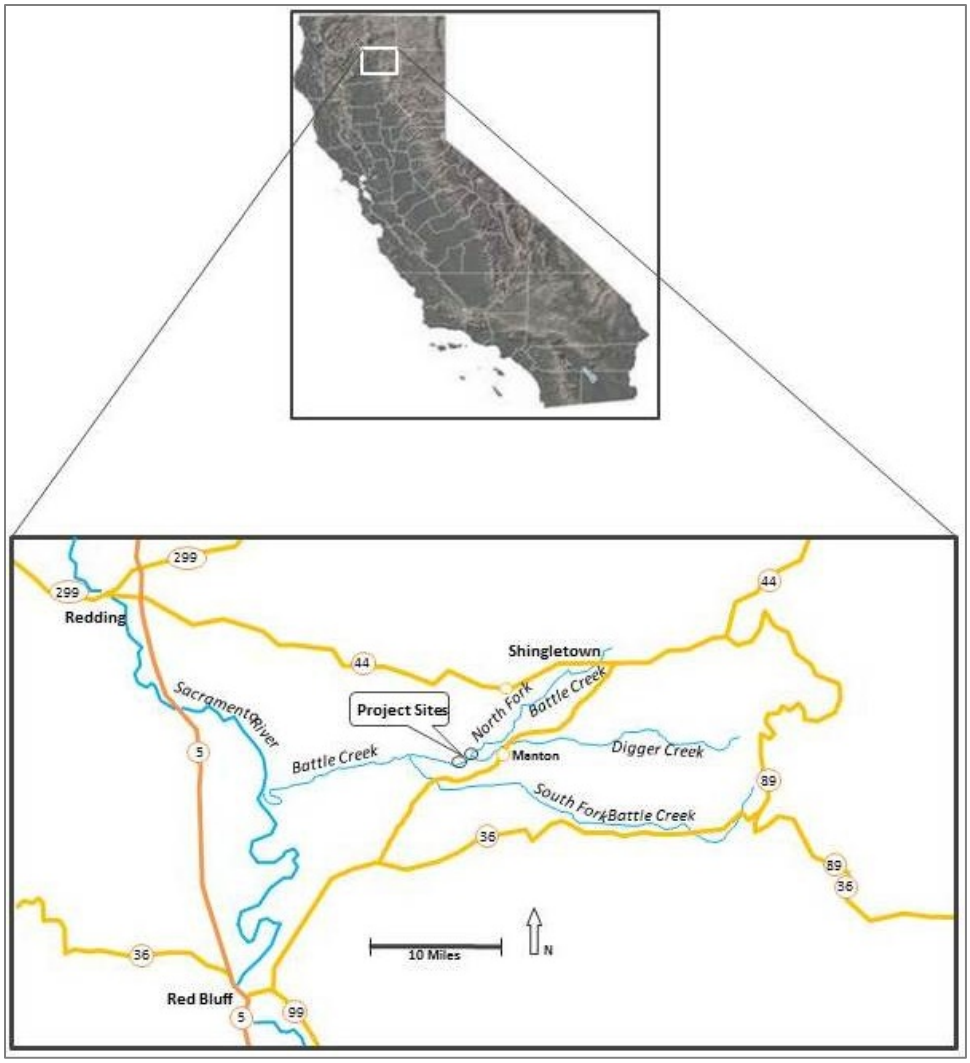
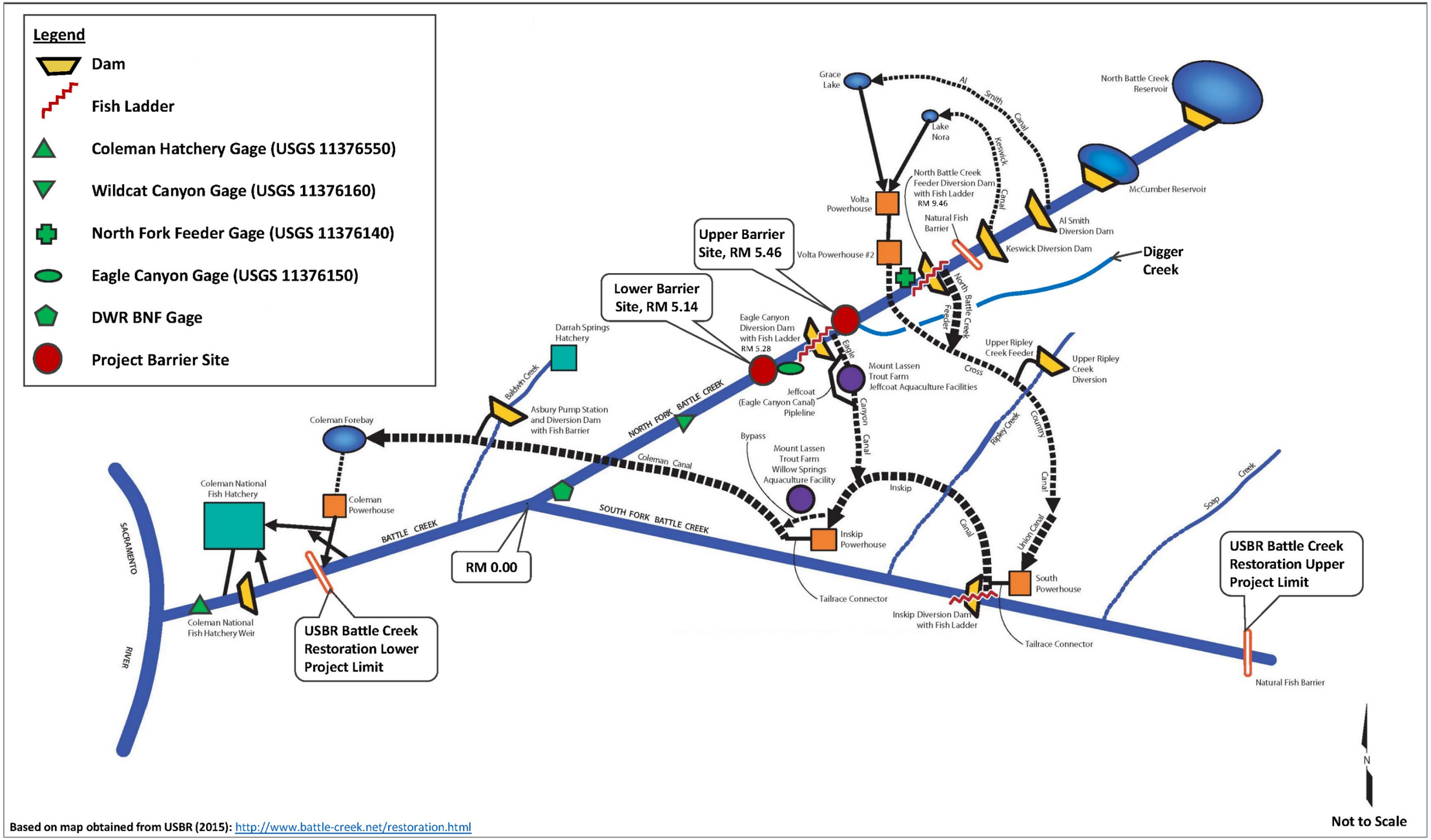



**Figure 2-1. Project location map.**

**Table 2-1. Minimum instream flow releases by month for the Feeder Dam upstream of the UBS and Eagle Canyon Dam upstream of the LBS (from the 1999 MOU).**

| | Minimum Instream Bypass Flow (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Diversion Dam** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Feeder Dam[1] | 88 | 88 | 67 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 88 |
| Eagle Canyon[2] | 46 | 46 | 46 | 46 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 46 |
| 1. On occasion the release is not attainable due to the quantity of inflow reaching the dam. Additional inflows to the North Battle Creek Feeder reach are occasionally received from the junction box of the Volta 2 Powerhouse Tailrace and Cross-Country Canal a short distance downstream. | | | | | | | | | | | | |
| 2. Eagle Canyon Dam releases reported on this table include releases from Eagle Canyon Springs (the springs located downstream of Eagle Canyon Dam). | | | | | | | | | | | | |




**Based on map obtained from USBR (2015):** http://www.battle-creek.net/restoration.html

**Figure 2-2. Battle Creek Schematic for USBR Restoration Project with this project's site locations and the location of various flow gages indicated.**

### 2.2.3 Fish Passage and Fish Monitoring Studies

There have been several fish passage and fish monitoring studies completed for Battle Creek. The following paragraphs highlight some of these studies. Refer to MLA (2016b) for additional details.

Figure 2-3 presents a map of partial and complete natural barriers identified by Thomas R. Payne and Associates (TRPA, 1998), with the current two project barriers indicated by the red dots. Located between LBS and UBS is Eagle Canyon Dam. TRPA (1998) identified several barriers downstream and upstream of these two barrier sites. In general, they concluded that the barriers downstream of the LBS were all passable at flows greater than 35 cfs. USFWS continues to monitor some of these barriers to determine at what flows passage is feasible. USFWS is also monitoring locations between Eagle Canyon Dam and the UBS.

The UBS is located approximately 600 feet upstream of Eagle Canyon Dam. For reasons unknown, the 1998 TRPA fish passage assessment makes no mention of the UBS. Earley (2014) identified the UBS, referred to as Barrier B. Earley concluded that the UBS was a complete barrier at low and moderate flows, with the potential for an alternative passage route around the barrier at high flows. MLA (2016b), discussed in the following section, concluded that the primary drop is a complete barrier at all flows.

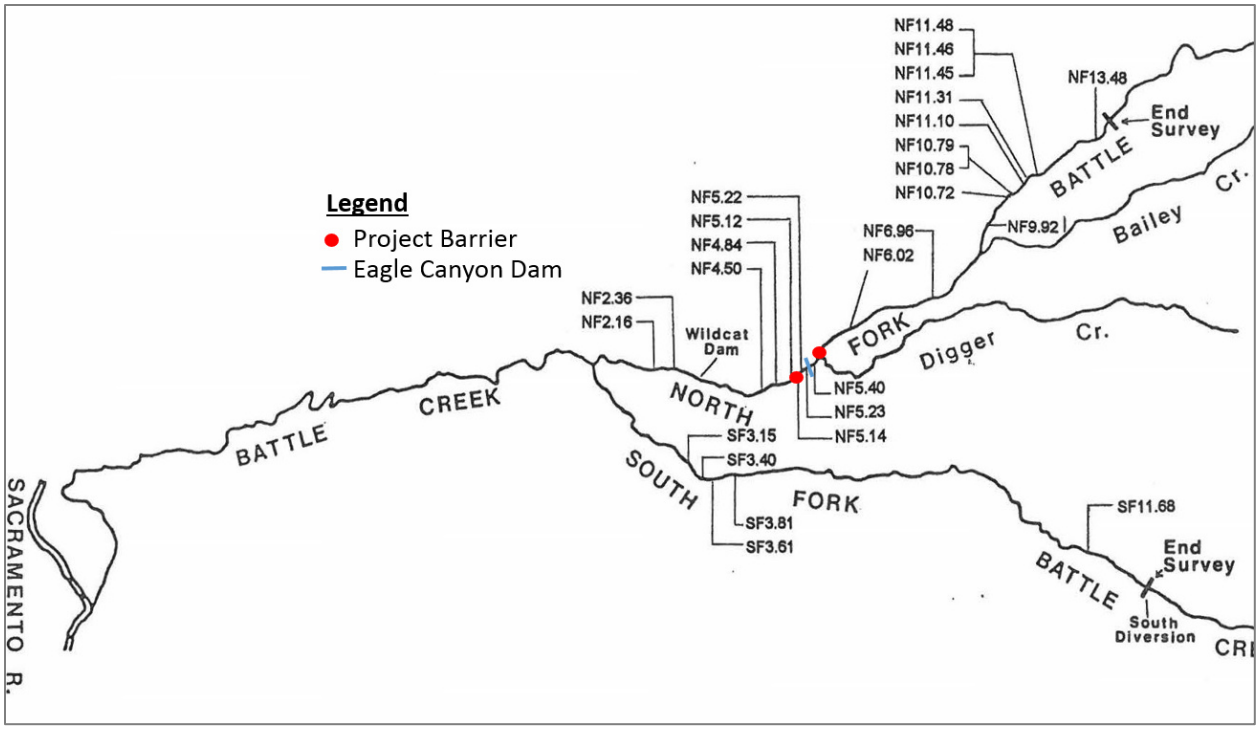



**Figure 2-3. Locations of identified barriers (TRPA, 1998) with the current Project's barriers labeled by red dots.**

## 2.3 Summary of Previous Work Completed by MLA Design Team

Work presented in this memorandum relies on work completed and documented in early documents. Many of these previous documents were included within the appendices of the *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Alternative Analysis Report* (MLA, 2017). Table 2-2 presents the studies completed for this project by the MLA design team.

**Table 2-2. A list of previously completed documents completed for this Project by the MLA Design Team.**

| Associated Task | Document Title | Primary Author | Status | Where Available |
|---|---|---|---|---|
| Task 2 | *Final Eagle Canyon Fish Passage Improvement Project Task 2: Topographic Surveying and Boulder Mapping Results* | Michael Love & Associates, Inc. | Final, May 2016 | MLA, 2017, App. E[1] |
| Task 2 | *North Fork Battle Cr Eagle Canyon Survey Report* | GMA Hydrology, Inc. | Final, January 2016 | |
| Task 3 | *Engineering Geologic Investigation Technical Memorandum Eagle Canyon Fish Passage Improvement in Battle Creek* | Cotton, Shires and Associates, Inc. | Final, August 2016 | MLA, 2017, App. F[1] |
| Task 4 | *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Existing Site and Hydraulic Characterization Technical Memorandum* | Michael Love & Associates, Inc. | Final, October 2016 | MLA, 2017, App. G[1] |
| Task 5 | *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Alternative Analysis Report* | Michael Love & Associates, Inc. | Final, January 2017 | MLA, 2017 |
| Task 5 | *Eagle Canyon Fish Passage Improvements; Alternative Analysis Constructability Review Memorandum* | SR Diversified | Revision 3, October 2016 | Attachment 3 |
| Task 5 | *Eagle Canyon Fish Passage Improvements; Alternative Class 4 Estimate Narrative* | SR Diversified | November 2016 | Attachment 4 |

1. Indicates the Appendix the document can be found within the *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites (MLA, 2017)*

### 2.3.1 Survey and Mapping

GMA Hydrology's (GMA's) *North Fork Battle Cr Eagle Canyon Survey Report* (GMA, 2016) presents the work completed to develop the base topographic data for the project. This included brining control to the project sites, obtaining LiDAR data, conducting ground base scans, conducting traditional total station surveys, conducting sonar-based bathometric surveys, and obtaining low-elevation aerial photographs of the sites. Survey products included detailed point clouds, surfaces, and meshes for both sites.

MLA's *Final Eagle Canyon Fish Passage Improvement Project Task 2: Topographic Surveying and Boulder Mapping Results Technical Memorandum* (MLA, 2016a) provided the results of the work completed under Task 2 by MLA. This included the labeling of boulders for both sites, mapping hydraulic control for both sites, mapping high and low flow alignments, and delivering all of the electronic information developed by both MLA and GMA.

### 2.3.2 Engineering Geologic Studies

Cotton, Shires and Associates' (CSA's) *Engineering Geologic Investigation Technical Memorandum Eagle Canyon Fish Passage Improvement in Battle Creek* (CSA, 2016) provided the findings of their engineering geologic investigation. This included a rigorous investigation of the UBS and a qualitative investigation of the LBS.

### 2.3.3 Characterization of Existing Hydraulic and Fish Passage Conditions Methods

The *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Existing Site and Hydraulic Characterization Technical Memorandum* (MLA, 2016b) summarized the work and findings for characterizing existing conditions. This included field measurements (water level logger, several surveys, and time-lapse cameras) and desktop exercises (rating curves, hydraulic models, and maps) based on the field data and research. A summary of existing fish passage conditions and recommendations for the two sites are presented in Sections 2.4.4 and 2.5.4.

### 2.3.4 Alternative Analysis

Based on work completed earlier, MLA scoped potential concepts to improve fish passage at the LBS and UBS. From the scoped concepts, two concepts for the LBS and three concepts for the UBS were selected for full alternative development. The concepts and alternatives were presented in *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Alternative Analysis Report* (MLA, 2017). The Report culminated by selecting preferred alternatives for both sites. This BODM presents additional information related to these two preferred alternatives based on the 90% Design Drawings.

### 2.3.5 Construction Alternative Analysis

Based on the Draft *Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Alternative Analysis Report* (Draft Alternative Analysis Report), SR Diversified developed the *Eagle Canyon Fish Passage Improvements Alternative Analysis Constructability Review Memorandum* (SRD, 2016a, Attachment 3). Within this memorandum, SR Diversified conceptually analyzed large equipment access options (helicopter, crane, skyline yarder), foot and small equipment access, water control and water quality control, and rock demolition from a contractor's point of view regarding feasibility and potential issues to overcome. MLA used this information during the development of 65% design documents.

### 2.3.6 Class 4 Cost Analysis

Based on the Draft Alternative Analysis Report for the Project, SR Diversified developed the *Eagle Canyon Fish Passage Improvements Alternative Class 4 Estimate Narrative* (SRD, 2016b, Attachment 4). SR Diversified was directed to review three large equipment options (helicopter, crane, and skyline yarder) and develop an AACE Class 4 construction cost estimate for the two project sites. Based on the conceptual designs, the three options were found to produce similar construction costs.

### 2.3.7 Construction Schedule

Based on the 65% drawings and technical specifications, SR Diversified developed a construction schedule. The first schedule developed was for a single construction season. The single construction season provided no float time, requiring everything to proceed on schedule with no unforeseen conditions arising during construction. The single season schedule also required that streamflows be low enough in June to allow installation of a stream diversion. The schedule was viewed as too optimistic, and a two-season construction schedule was developed. The LBS will be constructed the first season and the UBS the second season.

## 2.4 Lower Barrier Site Summary of Existing Conditions

This section summarizes the LBS layout, geologic hazards, hydrology, and existing fish passage conditions. MLA (2016b) provides a detailed description of the LBS.

### 2.4.1 LBS Layout

Figure 2-4 and Figure 2-5 presents an aerial image of the LBS and mapped boulder complexes. Figure 2-6 presents the LBS profile. In the first two figures, water flows from right to left. Overall, the LBS is more linear than the UBS with respect to flow direction. Flow at the LBS is concentrated on river right (looking downstream) as it passes from Pool 5, down the primary drop, into Pool 4, through Sieve B [a sieve is a gap under boulders that convey substantial flow], into Pool 3, through Sieve A, into Pool 2, and then finally into Pool 1, which marks the downstream end of the LBS reach. The water surface elevation (WSE) difference between Pools 4 and 5, which encompasses the primary drop, is approximately 8.4 feet under low flow (~35 cfs) conditions. The primary drop is approximately 34.5 feet long.

### 2.4.2 LBS Geologic Conditions and Hazards

CSA (2016) conducted a qualitative geologic assessment of the LBS and Smelser (2012) conducted a more in-depth characterization of the LBS (in the channel). The two studies provide information helpful to understand the geologic hazards that exist at the LBS.

In general, the LBS is more geologically stable than the UBS but still includes some active toppling. Along the south canyon wall (river left) two very large blocks have a high failure potential and a thinner block or flake also has a high failure potential. These features are above the LBS and located within the Eagle Canyon Basalt layer adjacent to the PG&E footpaths above the LBS. The Eagle Canyon Basalt layer has pervasive, near-vertical cooling joints that result in relatively large bocks that can topple. There are other blocks and columns within this layer near the LBS, but they have a moderate failure potential (could fail within 50 – 100 years).

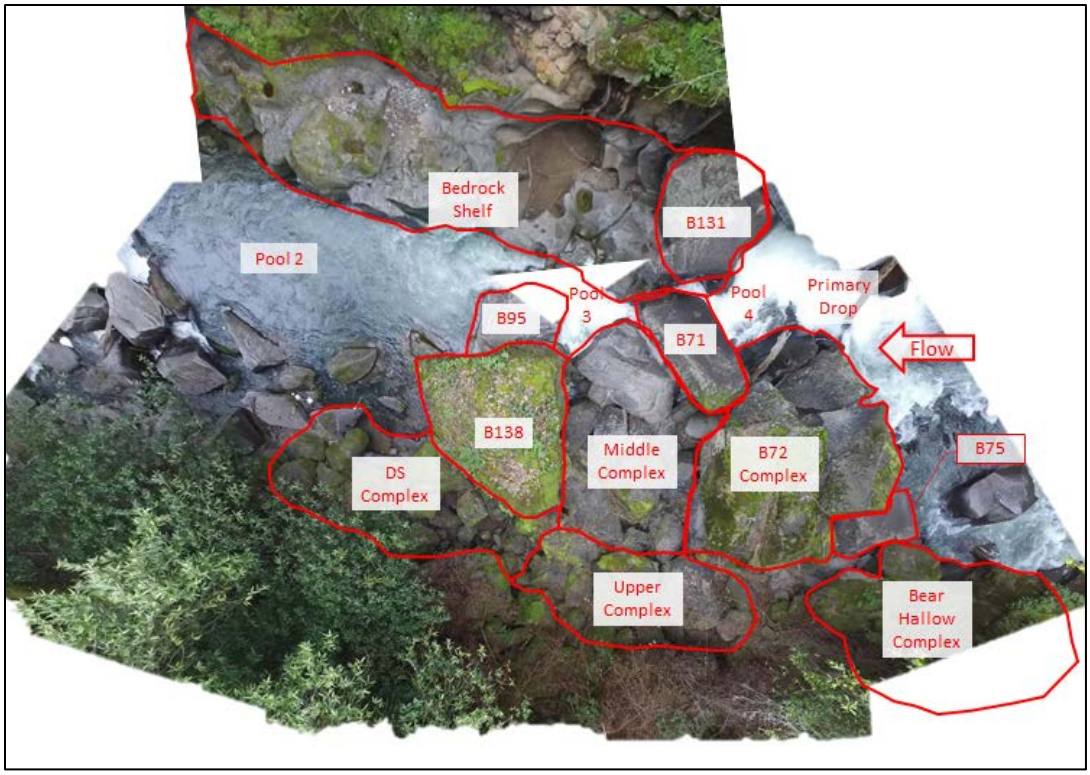



**Figure 2-4. Aerial image of the Lower Barrier Site showing mapped boulder complexes.**

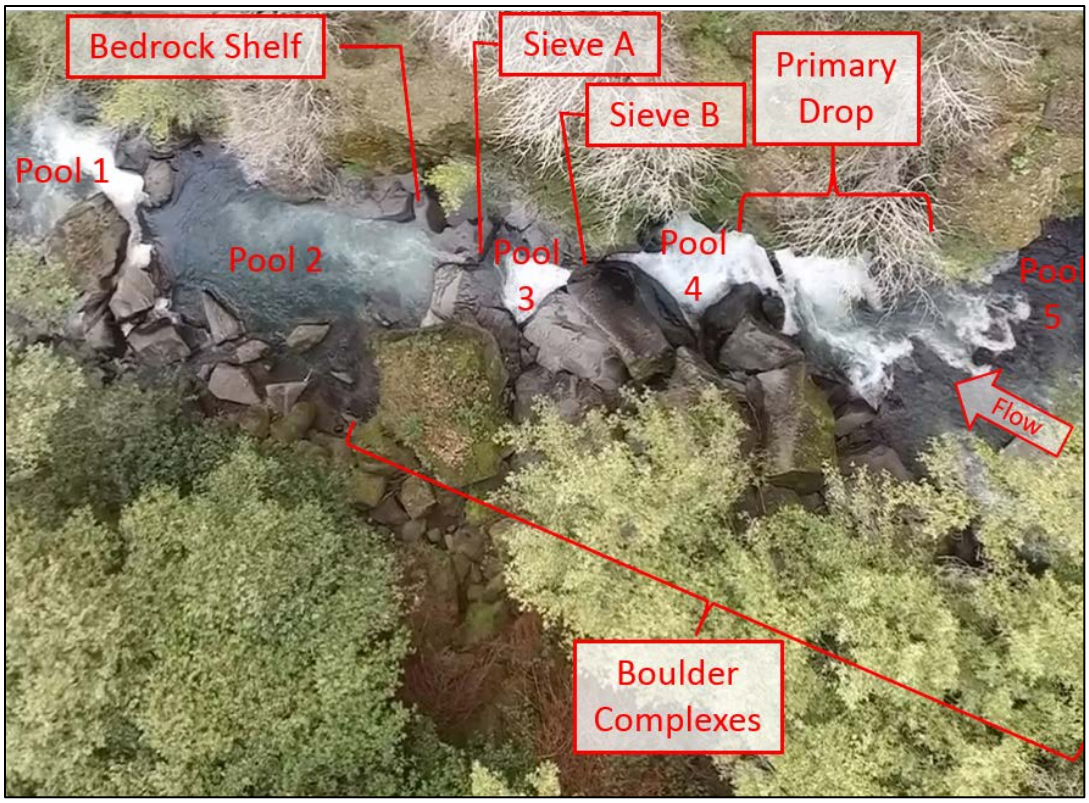



**Figure 2-5. Aerial image of the Lower Barrier Site taken on February 10, 2016 at a flow of 120 cfs.**

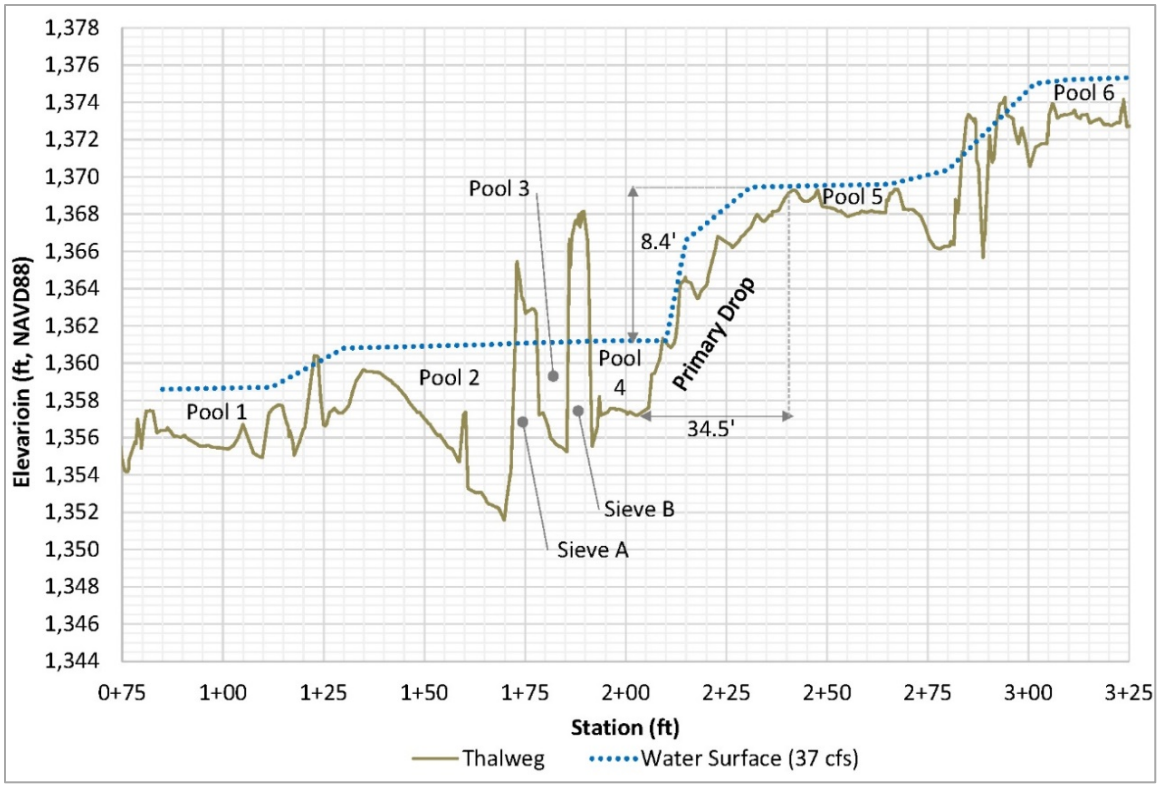



**Figure 2-6. Lower Barrier Site channel profile.**

CSA could not access the north canyon face due to landowner access permissions, but was able to view the face from PG&E's walkways on the south rim and from aerial photography. The north canyon can be separated into two distinct vertical walls (referred to as upper and lower) with a sloped area between. CSA noted some detached boulders laying on the sloped area with approximately 3 feet diameters and if mobilized, they would potentially tumble into the LBS.

CSA completed field and laboratory tests to quantify the characteristics of the boulders within the channel with respect to hardness. In general, the basalt boulder strength varied from very strong (unconfined compressive strength between 14,500 and 36,250 psi) to extremely strong (unconfined compressive strength greater than 36,000 psi).

### 2.4.3 LBS Site Hydrology

*Peak Flows*

Peak flows were estimated from the work completed by USBR (2001). The LBS peak flows are presented in Table 2-3. The flows were derived by scaling the USBR peak flows for Eagle Canyon Dam to the LBS drainage area, which is approximately 188 square miles.

**Table 2-3. LBS peak flows for selected return periods.**

| Return Period (years) | 2 | 2.33 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| Flow (cfs) | 2,504 | 2,905 | 4,407 | 5,709 | 7,512 | 8,914 | 10,216 |

*Daily Average Flow Duration Curves*

Flow duration curves are often used to determine fish passage design flows and evaluate fish passage delays due to low or high flow conditions. The annual 1% exceedance flow is often used in northern California to set the high fish passage design flow for adult anadromous salmonids (CDFG 2002; NMFS 2001).

Figure 2-7 presents flow duration curves (FDCs) constructed for the LBS. The FDC is based on daily average flow records for 16 water years collected at the BNF gage. Flows are scaled to the drainage area of the LBS. In summary, two different approaches were used to develop the FDC. The first is based on the traditional approach, which is a ranking of all of the daily average flow data to determine the exceedance flows. When applying this method, Water Year 2006 was identified as a high-flow outlier, such that eliminating this year decreased the 1% exceedance flow by 32%. Therefore, data from 2006 was excluded from the FDC, resulting in a 1% exceedance flow of 382 cfs.

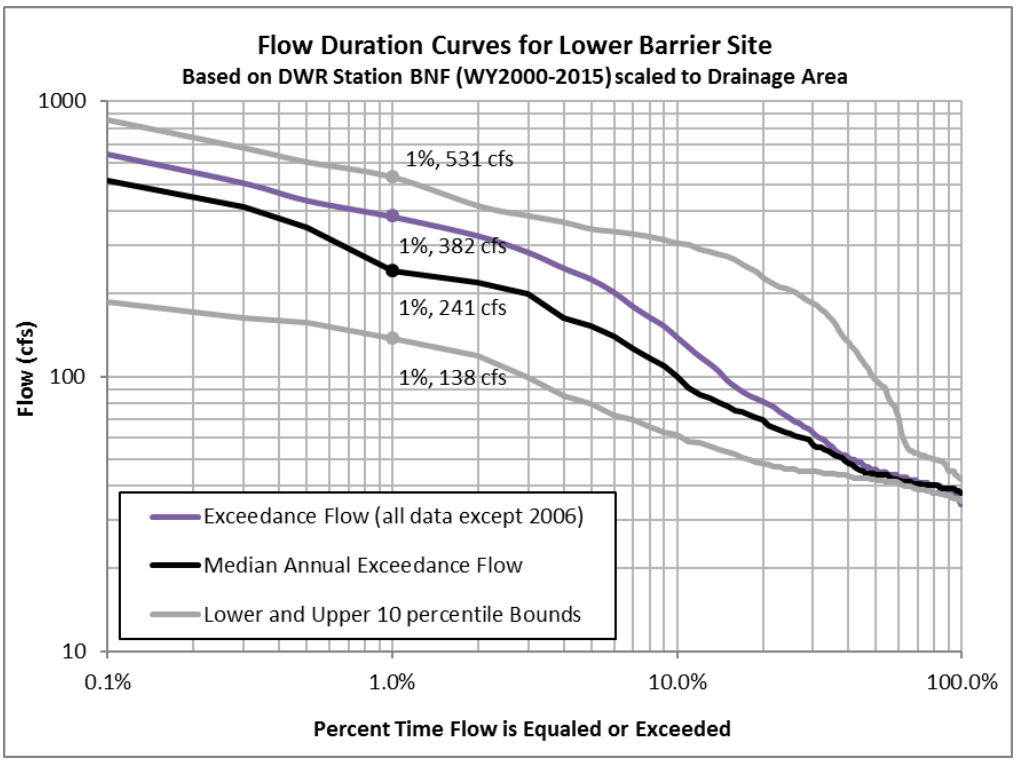



**Figure 2-7. Flow duration curves for Lower Barrier Site based on DWR BNF daily average flows, calculated using all data except WY2006 (outlier) and using the median of the annual flow duration curves. For 80% of the water years the annual exceedance flows will fall between the lower and upper curves.**

The alternative approach used to create the FDC is based on methods outlined by Vogel and Fennessey (1994). This approach better describes annual variability and allows for calculation of annual statistics and confidence intervals. It involves constructing individual FDCs for each of the 16 water years, and then calculating the median FDC. As seen in Figure 2-7, the median 1% annual exceedance flow is 241 cfs. This means that for half of the water years, from the period of record, the 1% annual exceedance flow was less than 241 cfs and the other half was

a higher. For 80% of the water years, the 1% annual exceedance flow was between 531 cfs and 138 cfs.

### 2.4.4 LBS Fish Passage Conditions

MLA (2016b) concluded that the primary drop is a complete barrier to migrating salmon and steelhead. The barrier conclusion was based on field observations and two-dimensional hydraulic modeling results. The two-dimensional model results within the primary drop portion of the channel, were compared to swimming speeds based on developed equations (Hunter and Mayor, 1986) for differing fish body size and time to exhaustion for Chinook salmon. The comparison did identify that salmon in good condition could overcome the flow velocity within the primary drop prior to becoming exhausted under certain flow conditions, but the model does not capture the extreme flow turbulence that occurs throughout the primary drop.

Based on several site visits and from time-lapse photography, the turbulence within the primary drop is extreme within the primary drop and Pool 4. Therefore, although the hydraulic model and fish swimming equations may indicate that fish passage is possible, the addition of the extreme turbulence makes the primary drop a complete barrier.

## 2.5 Upper Barrier Site Summary of Existing Conditions

This section summarizes the UBS layout, geologic hazards, hydrology, and existing fish passage conditions. MLA (2016b) provides a detailed description of the UBS.

### 2.5.1 UBS Layout

Figure 2-8 presents an aerial image and profile for the UBS. The flow is from left to right. The UBS is more complex than the LBS with respect to both flow paths and boulder arrangements. Upstream of the primary drop, flow moves through Pool 9 and then Pool 8 and then plunges over the primary drop into the shallow and fragmented Pool 7. From Pool 7, depending on flow rate, water moves through one of two sieves. One sieve connects to Pool 6 while the other travels along an unknown path that is believed to exit into Pool 6 just upstream of Pool 5. Pool 6 water, depending on flow rate, primarily flows out along two paths: (1) to Pool 5 along the primary alignment or (2) along the secondary alignment to Pool 3. From Pool 5 water flows into Pool 4. Flow from Pool 4 and Pool 3 meet in Pool 2; Digger Creek flow also enters Pool 2. Finally, flow moves into Pool 1, which is the downstream boundary of the UBS.

In total, thirteen sieves have been identified that convey flow under one or more large boulders. Flow in these sieves can be open-channel or pressurized, depending on streamflow conditions. The sieves complicate the flow description above. For example, several sieves move water from the secondary alignment to the primary alignment. There is also a sieve that moves water from upstream of Pool 5 along an undetermined route under boulders and discharges along the river left of Pool 4.
The primary drop is approximately 12.5 feet long and tall. The face of the drop consists of several large boulders protruding into the flow path. The lower portion of the drop is nearly vertical. The receiving pool below the drop is extremely shallow given the drop height, and a high level of turbulence is generated throughout this area.

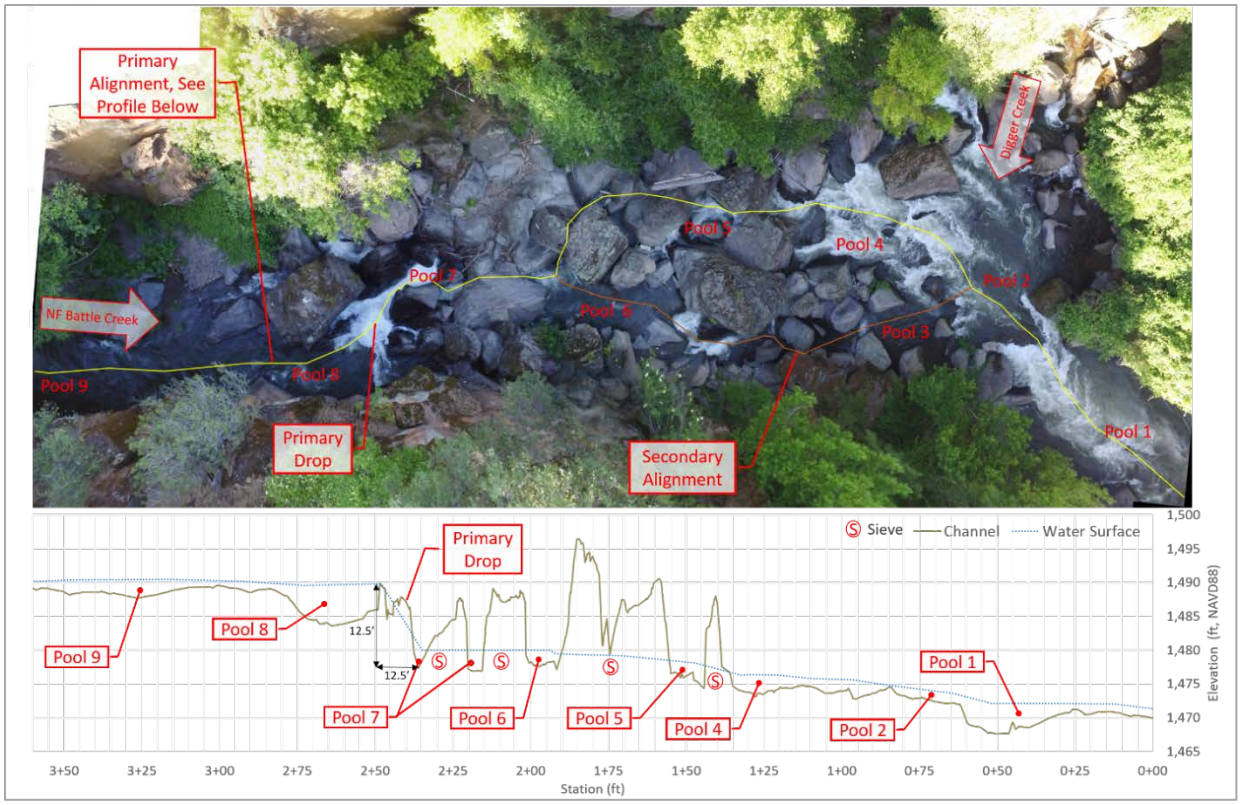



**Figure 2-8. Upper Barrier Site overview aerial image and profile. Photograph when flow within NFBC approximately 195 cfs upstream of Digger Creek.**

### 2.5.2 UBS Geologic Conditions and Hazards

CSA (2016) completed a robust geological investigation of the UBS. The UBS is underlain by the Eagle Canyon Basalt formation, which is characterized by a thick-bedded to massive, lightly weathered to fresh, very hard and very strong basalt.

CSA found multiple locations along the canyon walls where rock failure was either high (failure could occur at any time, but likely within 10 years), moderate to high (failure likely within 10 to 50 years), and moderate (failure likely within 50 to 100 years). The locations of the high potential failures were located at different locations along the entire UBS reach and on both sides of the channel. Many of these rockfall hazards consist of extremely large blocks of basalt.

CSA completed field and laboratory tests to quantify the characteristics of the boulders within the channel as well as the canyon walls with respect to hardness and joint characterization. The basalt boulder strength varied from very strong (unconfined compressive strength between 14,500 and 36,250 psi) to extremely strong (unconfined compressive strength greater than 36,000 psi). The rock exposed in both canyon walls is generally non-vascular basalt with a structure that varies from thin (less than 1 foot thick) to massive. The canyon rock is generally fresh to slightly weathered, with fractures that vary from widely spaced (3 feet to 10 feet) to extremely widely spaced (greater than 10 feet).

Rock joints, although infrequent, are moderately continuous (10 feet to 30 feet in length) to highly continuous (30 feet to 100 feet). Joint openings varied from tight to up to 2 inches wide and were generally open ¼ to ½ inch.

### 2.5.3 UBS Site Hydrology

*Peak Flows*

Peak flows were estimated from work completed by USBR (2001). The UBS and Digger Creek peak flows associated with specified return periods are presented in Table 2-4. The UBS flows were derived by scaling the USBR peak flows for Feeder Dam to the UBS drainage area, which is approximately 148 square miles. The Digger Creek, with a drainage area of 40 square miles, flows were derived by subtracting Eagle Canyon Dam peak flows from UBS flows. This approach likely underestimates the actual return period flows for Digger Creek, as Digger Creek likely peaks prior to North Fork Battle Creek due to its smaller drainage area. Therefore, the data presented in Table 2-4 should be interpreted as the flow within Digger Creek at the time the UBS' flow is peaking.

**Table 2-4. UBS and Digger Creek peak flows for select return periods.**

| Return Period (year) | 2 | 2.33 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| UBS Flow (cfs) | 2,332 | 2,665 | 4,109 | 5,331 | 6,996 | 8,329 | 9,551 |
| Digger Creek Flow (cfs)* | 168 | 235 | 291 | 369 | 504 | 571 | 649 |

**Estimated using difference between Eagle Canyon Dam and UBS peak flows.*

*Daily Average Flow Duration Curves*

To assist with establishing fish passage design flows and evaluating potential low-flow and high-flow passage delays, a flow duration curve (FDC) was constructed (Figure 2-9). The FDC was created using daily average flow records from the DWR gage, BNF, scaled to the drainage area of the UBS. The first approach constructed a FDC using all of the daily average flow data sorted and ranked for the entire period of record, excluding outlier water year 2006 (similar to LBS). This resulted in a 1% exceedance flow of 293 cfs.

The second approach used to develop the FDC was constructed using the same methods described for the LBS (Section 2.4.3) and as presented in MLA (2016b). The median FDC is constructed using the median of the exceedance flows from each annual FDCs from each of the 16 water years. This means that for half of the water years, from the period of record, the 1% annual exceedance flow was less than 182 cfs and the other half was a higher. For 80% of the water years, the 1% annual exceedance flow was between 100 cfs and 410 cfs.

### 2.5.4 UBS Fish Passage Conditions

Figure 2-10 provides a graphical interpretation of the fish passage conclusions for selected UBS feature. A question mark indicates that a particular bound has not been identified, but the color gradient for that feature indicates when passage may remain suitable (blue) while it moves to less than suitable (white). See MLA (2016b) for additional details.

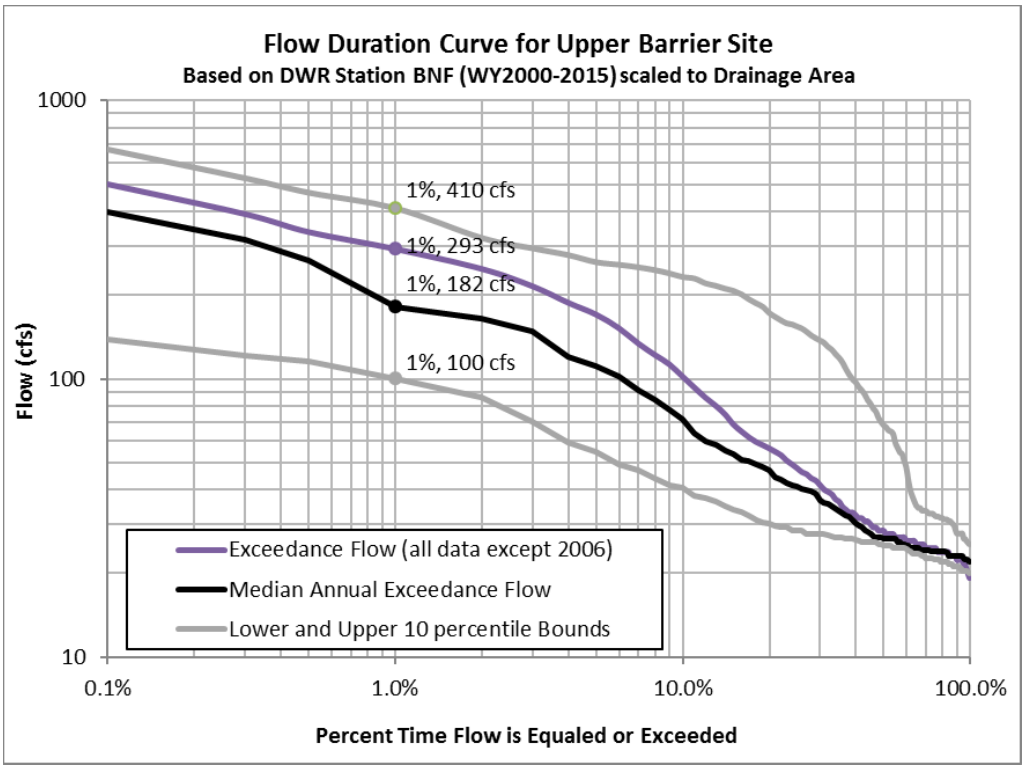



**Figure 2-9. Flow duration curves for Upper Barrier Site based on DWR BNF daily average flow record, calculated using all data except WY2006 (outlier) and using the median of each annual flow duration curve. For 80% of the water years the annual exceedance flows will fall between the lower and upper curves.**

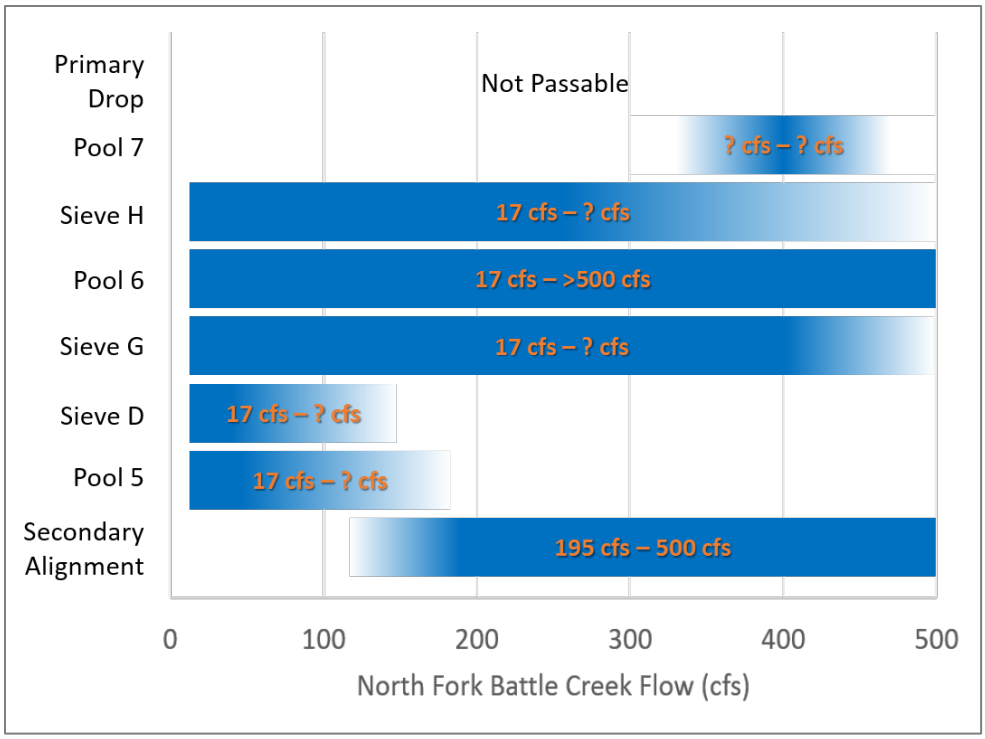



**Figure 2-10. UBS fish passage conclusions for selected features (MLA, 2016b: Figure 8-18).**

Based on observations, it is our opinion that passage conditions are suitable under most flows up to about 500 cfs for fish to reach Pool 6, although there is some uncertainty with respect to the conditions within Pool 5 and through Sieve D and when the secondary alignment becomes passable. Pool 6 appears to maintain favorable passage/holding conditions up to at least 500 cfs. Sieve H does appear to provide suitable passage conditions up to flows of 300 cfs, but data is lacking to quantify the upper bound for when conditions become less than suitable.

Pool 7 is undefined on both ends of the spectrum with respect to passage conditions. At low to moderate flows, the pool has insufficient depth or remains disconnected into sub-pools separated by large boulders, making in very difficult for a fish to approach the bottom of the primary drop. At higher flows the pool becomes very turbulent which may disorient fish and make holding difficult.

The primary drop appears to be a complete barrier at all flows. Passage improvements should focus passage between Pool 6 and Pool 8, including the primary drop.

# 3 PROJECT GOALS, OBJECTIVES, AND FISH PASSAGE DESIGN CRITERIA

This section presents the project goal, objectives, fish passage design criteria, and fish passage design flows.

## 3.1 Project Goal

The project goal is to improve upstream passage for adult Chinook salmon and steelhead at the Lower Barrier Site and Upper Barrier Site located in Eagle Canyon on North Fork Battle Creek near Manton, California.

## 3.2 Project Objectives

The project objectives are:

- to increase water depth at low fish passage flows,
- to reduce channel velocity,
- to reduce vertical drops,
- to increase existing pools or create new pools,
- to reduce the overall slope of the channel, and
- to create variable swim paths.

## 3.3 Fish Passage Design Criteria and Design Flows

MLA (2016b) and MLA (2017) include robust discussions with respect to fish passage flows, and findings are summarized here. Initially, CDFW provided high and low fish passage design flows of 1,600 cfs and 35 cfs, respectively. Based on field observations and hydraulic modeling, it appears fish would be unable to migrate upstream at 1,600 cfs due to extreme velocities and turbulence occurring throughout the canyon. Therefore, the high fish passage design flow for the project was changed to the annual 1 percent exceedance flow, which is the current CDFW (CDFG, 2002) and NMFS (2001) high passage design flow criteria for Northern California for adult salmon and steelhead. Based on the flow duration curve constructed using all of the daily average flow data, but excluding outlier water year 2006, this is 382 cfs for the Lower Barrier Site and 293 cfs for the Upper Barrier Site (see Sections 2.4.3 and 2.5.3, respectively). The low

fish passage design flow remains as initially set by CDFW for this project, at 35 cfs for both sites based in part on PG&E minimum instream flow requirements. The fish passage design flows are presented in Table 3-1.

MLA (2016b) and MLA (2017) also present discussions on design criteria for other parameters such as depth, velocity, and drop heights. During the development of those documents, it was not clear if the preferred alternative would be a modification or a technical fishway. Therefore, the criteria discussed included the standard criteria and guidelines from CDFW (CDFG, 2002), NMFS (2001) and NMFS (2011). Because the preferred alternatives for both sites are modifications of natural barriers, the technical fishway criteria are thought to be too stringent and alternative criteria and guidelines based on published swimming abilities of the target fish have been adopted for this project (Table 3-2). The following section presents a general discussion on how these criteria and guidelines were applied to evaluate this project's designs.

**Table 3-1. Selected fish passage design flows for the LBS and UBS.**

| Criteria | Lower Barrier Site | Upper Barrier Site |
|---|---|---|
| Low Fish Passage Design Flow | 35 cfs | 35 cfs |
| High Fish Passage Design Flow | 382 cfs | 293 cfs |

**Table 3-2. General fish passage criteria and guidelines for this project.**

| Fish Passage Criteria/Guidelines | Value |
|---|---|
| Minimum Water Depth over a feature[1] | 0.5 ft |
| Minimum Pool Depth | 2 ft |
| Maximum Velocity | See Section 3.4 |
| 1. Such as a boulder or chute | |

## 3.4 General Fish Passage Performance Evaluation Method

This section presents a discussion on the methods used to evaluate fish passage performance for the two sites. This analysis followed the same procedures as detailed in Section 4 of MLA (2016b).

Designs for both sites included the development of an SRH-2D hydraulic model to be used for fish passage assessment purposes (as well as design development). Using the hydraulic model results, a fish routing model was developed. The hydraulic model was also used to evaluate other hydraulic conditions.

The intricacies of each SRH-2D model is discussed in each site's relative section below and in MLA (2016b), but in general the model surfaces were developed to mimic the anticipated channel shape after construction is complete. The SRH-2D model provides a detailed simulation of the channel hydraulics covering a wide range of flows, which can in turn be used to evaluate the anticipated fish passage conditions.

A map was developed for each evaluated flow from the SRH-2D model presenting the velocity field where the depth criterion was met. Using the map, a preferred swim route was selected through the velocity field that routed the fish through the lower velocity regions that provided adequate depth (the swim path never moves in a downstream direction). The water velocities at each SRH-2D node along that swim path were then inputted into the fish locomotion and energetics model.

The fish locomotion and energetics model is based on the methods outlined by Castro-Santos (2006) to swim the fish from node to node along a selected route. The approach requires a swim speed equation for the fish, which relates time exhaustion (fatigue) for the fish when swimming at the given speed. The swimming equation used in this analysis was for burst swimming of adult Chinook salmon developed by Hunter and Mayor (1986) based on data from Weaver (1963):

$$V_{Burst} = 11.49 L_{TL}^{0.32} t^{-0.5} \qquad \textbf{Equation 3-1}$$

Where;

$V_{Burst}$ = Fish burst speed (m/s)
$L_{TL}$ = Total fish length (m)
$t$ = time to exhaustion (s); such that 1 s$\leq t \leq$ 30 s

The time required to swim between two nodes is then calculated as a percent of the time to exhaustion at the selected swim speed. The cumulative percent of exhaustion is summed along the route. If the fish is able to swim the entire route without exceeding 100% exhaustion, then passage is successful for that fish.

For this project, the fish locomotion and energetics model swam the fish at a distance-optimizing speed. Between each node the time to exhaustion was optimized, such that the resulting swim speed of the fish minimized the fish's physical exertion, as describe by "percent exhaustion." The analysis was performed for varying sizes of Chinook salmon to determine the smallest fish able to successfully pass through the site.

Additional discussion specific to the LBS and the UBS are included in Sections 4.3.1 and 5.4.1, respectively. The results of the evaluations for the LBS and UBS are presented in Sections 4.3 and 5.4, respectively.

# 4 LOWER BARRIER SITE PROJECT

The preferred alternative for the Lower Barrier Site was Alternative B, as described in MLA (2017). The following sections present the proposed project for the LBS based on the 90% Design Drawings and Specifications. The 90% Drawings are included as Attachment 1.

## 4.1 LBS Project Description

The existing LBS primary drop is a narrow chute that drops into the shallow and narrow Pool 4. Boulders on the south bank and the bedrock wall on the north bank constrict both the chute and pool. The constriction creates conditions for extreme turbulence and high velocities

across the entire wetted channel and throughout the water column. The extreme turbulence is likely a primary condition that blocks fish passage.

The LBS design includes removing approximately 190 cubic yards of boulders and a minor amount of bedrock. This involves removing boulders B71, B131, B72 Complex boulders and additional boulders within Pool 4 and the primary drop chute (Figure 4-1, Attachment 1). The rock will be lifted out of the canyon and disposed at the top of the canyon rim or hauled off-site. Removing the large boulders, along with some minor bedrock modification, will widen the primary drop, create multiple pathways for fish to ascend, and widen Pool 4, which will create more pool volume. Reducing the constriction and increasing the pool volume should result in less turbulence, decreased velocity, and additional holding areas for fish.

As part of the boulder removal, the design includes the creation of two new chutes (referred to as the north and south chutes) that extend upstream of Pool 4, see Attachment 1. The north chute is intended to provide a low-flow passage path; at higher flows the south chute is anticipated to have better passage conditions.

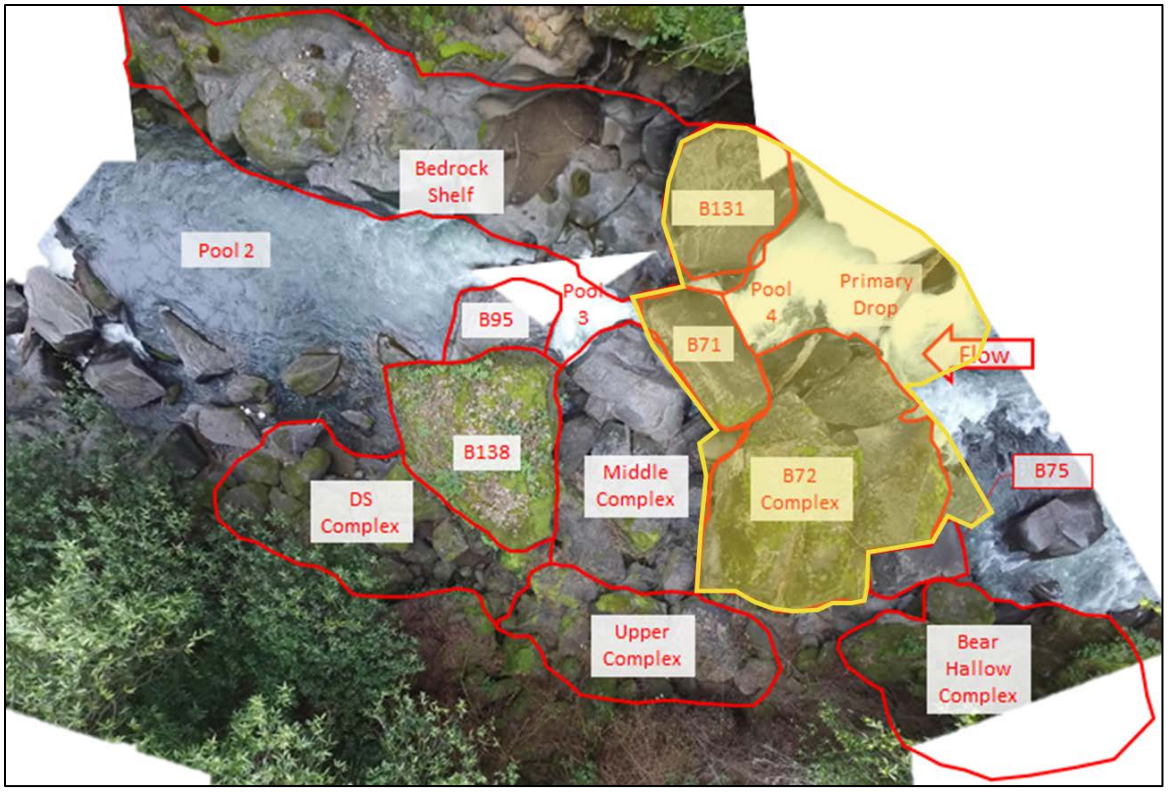



**Figure 4-1. LBS Alternative B plan view of rock to be removed (yellow hatching), including B71, B131, B72 Complex boulders and some additional boulders within the Primary Drop and Pool 4.**

The north chute is anticipated to be constructed within bedrock. Therefore, it is anticipated that the construction will be able to meet the design dimensions for the chute, as presented in the design drawings (Attachment 1, Sheet 11). The north chute is a trapezoidal channel with a bottom with of approximately 2 feet and a depth of at least 1 foot. The side slopes will vary. The profile includes two grade breaks. The initial slope, extending upstream from Pool 4, is approximately 80% and 8 feet long. Although steep, it is anticipated that this lower section will be backwatered by Pool 4 under most flow conditions. The middle section of the north chute has a slope that is approximately 25% and is approximately 19 feet long. Although this is still steep, passage over similar features downstream of the LBS within Eagle Canyon exist and provide passage. The final section is approximately 11 feet long and has no slope. Field adjustments may be made based on conditions reveled during rock removal.

The south chute is shorter than the north chute but has similar design characteristics. The material comprising the south chute is unknown (boulders verses bedrock), and field adjustments may be required. The general approach is to construct the chute with a minimum 2.5 feet width and with a minimum depth of 1 foot. Like the north chute, there are two profile grade breaks. The downstream section, extending from Pool 4, has a slope of 80% and is approximately 8 feet long. The lower section is anticipated to be backwatered at most flows. The middle section has an approximate slope of 25% and is approximately 8 feet long. The upstream section is approximately 8 feet long and has a 10% slope.

Pool 4 is anticipated to double or triple in width. This increased width will create low-velocity areas for fish to approach the primary drop and stage their attempt to move upstream.

### 4.2 Construction

Construction techniques are covered in detail in previously completed documents (SRD, 2016a, SRD 2016b, MLA, 2017). For reference, a summary is provided here.

Site access is extremely limited to the LBS. It is assumed that a skyline yarding system or crane (removal system) will be used to deliver materials and equipment to the site and to remove rock from the site. The lifting capabilities of such systems varies, but 8,000 lbs is a conservative estimate.

Prior to beginning the rock removal process, rockfall hazards will be mitigated. This will likely involve scaling off smaller rocks and anchoring in-place, with rock bolts, larger rocks that are at risk of falling during construction. The *Engineering Geologic Investigation Technical Memorandum* (CSA, 2016) provides additional rock stability details.

Rock will be removed by first drilling holes into the boulders and bedrock and then either using hydraulic rock splitters, blasting, or other techniques to break the rock into pieces that are small enough to be lifted by the removal system.

Existing trees in the stream riparian area, along the canyon walls, and up on the canyon rim will need to be removed and/or limbed to accommodate the removal system. This includes trimming the bay trees present along the south bank of Battle Creek at the LBS.

A dewatering system will be installed to bypass streamflow around the worksite. This may not need to be installed until the larger boulders that are outside of the wetted channel are removed. It is assumed that the water bypass will be installed in mid-summer when flows are close to the minimum bypass flow of 35 cfs. Materials for the dewatering system may be brought in by the removal system or by helicopter.

## 4.3 Anticipated Fish Passage Performance

### 4.3.1 Methods

A general discussion on the methods used to evaluate potential fish passage performance within the LBS was presented in Section 3.4. As discussed there, a SRH-2D hydraulic model based on the 90% design drawings was developed and executed using a wide range of flows. The LBS model follows the same development procedures as presented in MLA (2016b) and MLA (2017).

Once the model runs were complete, two potential fish passage swim paths were digitized: one swim path followed the north chute and the other followed the south chute. The swim paths were routed through the lowest water velocities while having sufficient depth for passage. A fish routing spreadsheet model was then used to identify the smallest sized Chinook salmon that could swim through the velocity field without becoming exhausted based on the swim speed equations developed by Hunter and Mayor (1986). The results are presented in the next section.

### 4.3.2 Results

The water surface profiles for flows from 35 cfs (low fish passage design flow) to 382 cfs (high fish passage design flow) for the LBS design are provided in Figure 4-2. To assess the change in flow conditions associated with rock removal, maps of the SRH-2D output were created for existing and proposed conditions for 35 cfs, 120 cfs 250 cfs, 382 cfs, and 1,600 cfs in Figure 4-3 through Figure 4-7. The figures show water velocities when depths are greater than 0.5 feet. The figures show that Pool 4 is substantially widened along the south side of the channel and produces a reverse circulation (back-eddy) flow pattern at all analyzed flows. It also shows that there are multiple pathways fish could use to swim up the primary drop at most flows. At 120 cfs and higher, velocities in the primary drop and flow patterns in Pool 4 suggest that fish will be able to hold in the pool and swim up the south chute while most of the turbulence and high velocities will be on the opposite side of the channel.

Table 4-1 summarizes the hydraulic conditions along the selected fish passage path at each evaluated flow. It also lists the smallest size (length) of Chinook salmon capable of swimming through the velocity field it encounters along the fish passage path.

At the low passage design flow of 35 cfs the north chute provides sufficient depth for passage, while the south chute does not. At all other flows the south chute provides sufficient depth and lower water velocities, making it the preferred passage route. At flows from 35 cfs to 250 cfs, the analysis predicts that even smaller, weaker swimming Chinook salmon could swim through the north chute and south chute, respectively. Based on the spring Chinook length data provide by USFWS for Battle Creek, 90 to 100% of the fish will be able to swim through one of the two chutes at flows between 35 cfs and 250 cfs. At the high passage design flow of

382 cfs, only the larger (top 30 percentile) Chinook salmon are predicted to have the swimming abilities to burst through the velocities in the south chute, while the north chute will be too swift for any fish to pass. This design is considered to provide passage from 35 cfs to 250 cfs, while larger salmon and steelhead will be able to pass at even higher flows.

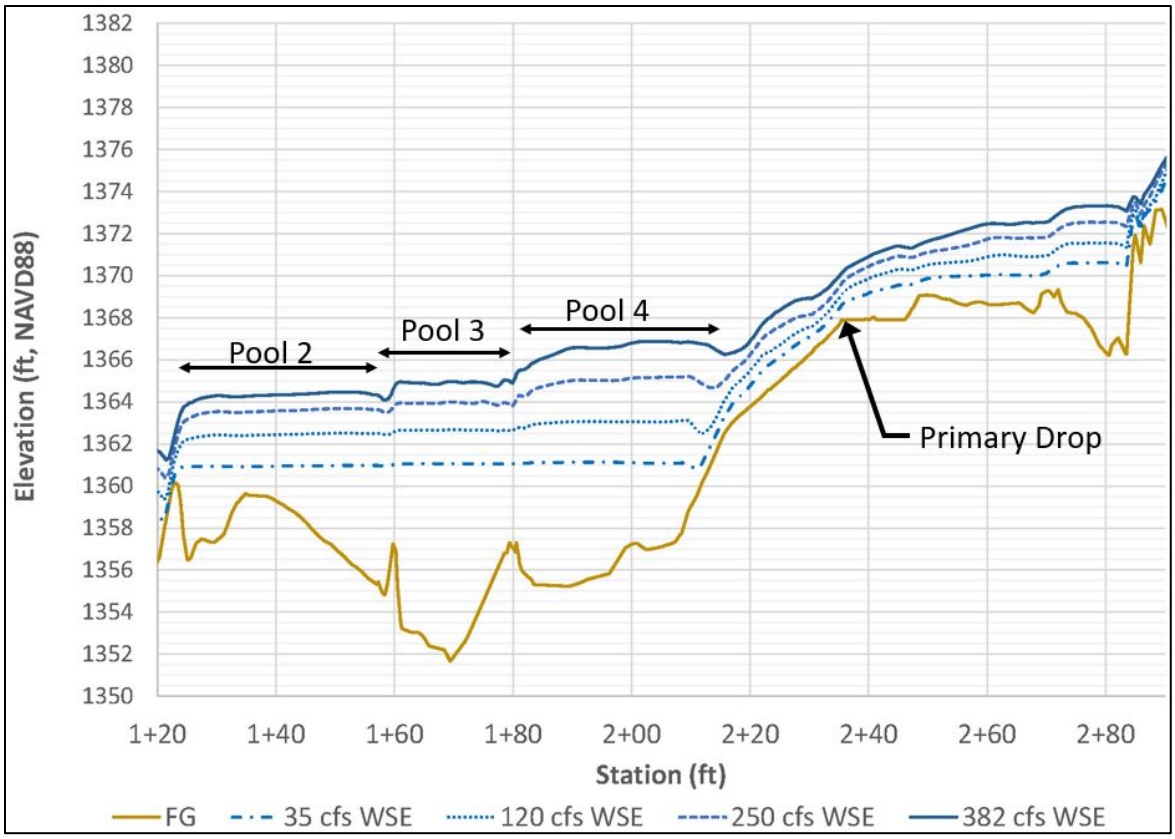
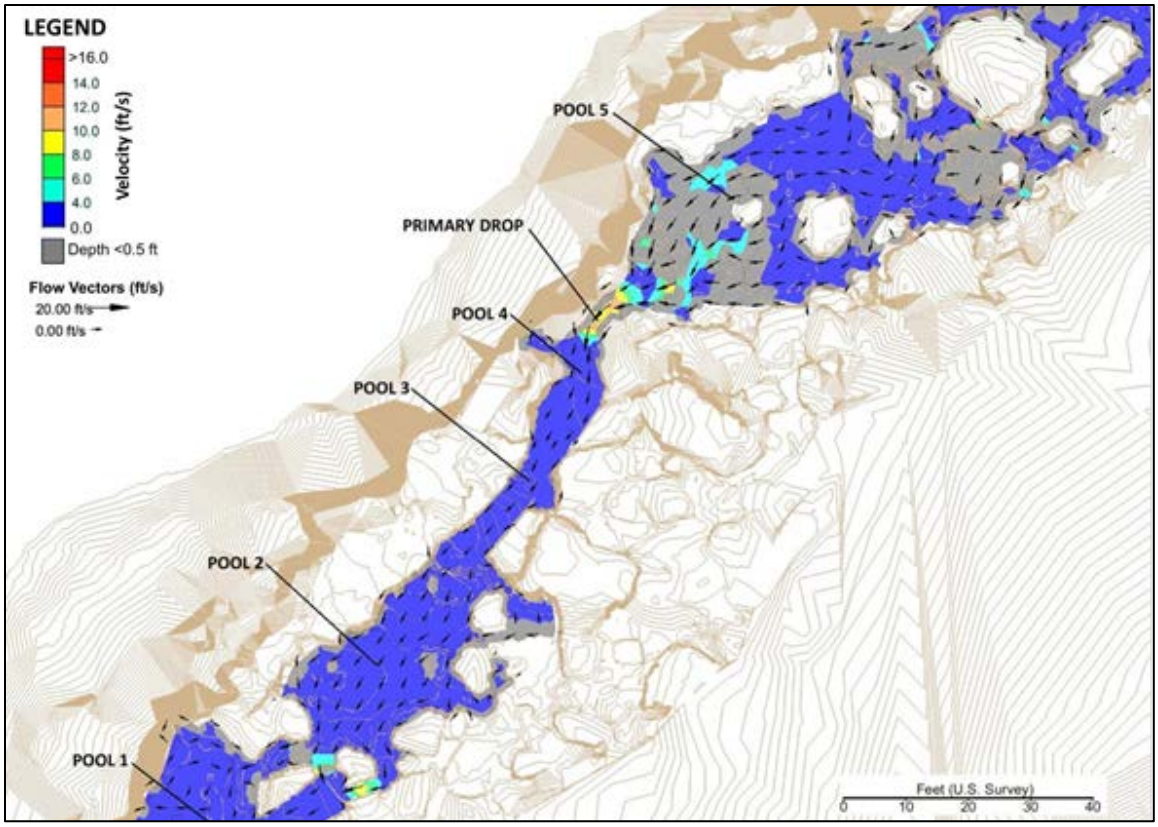
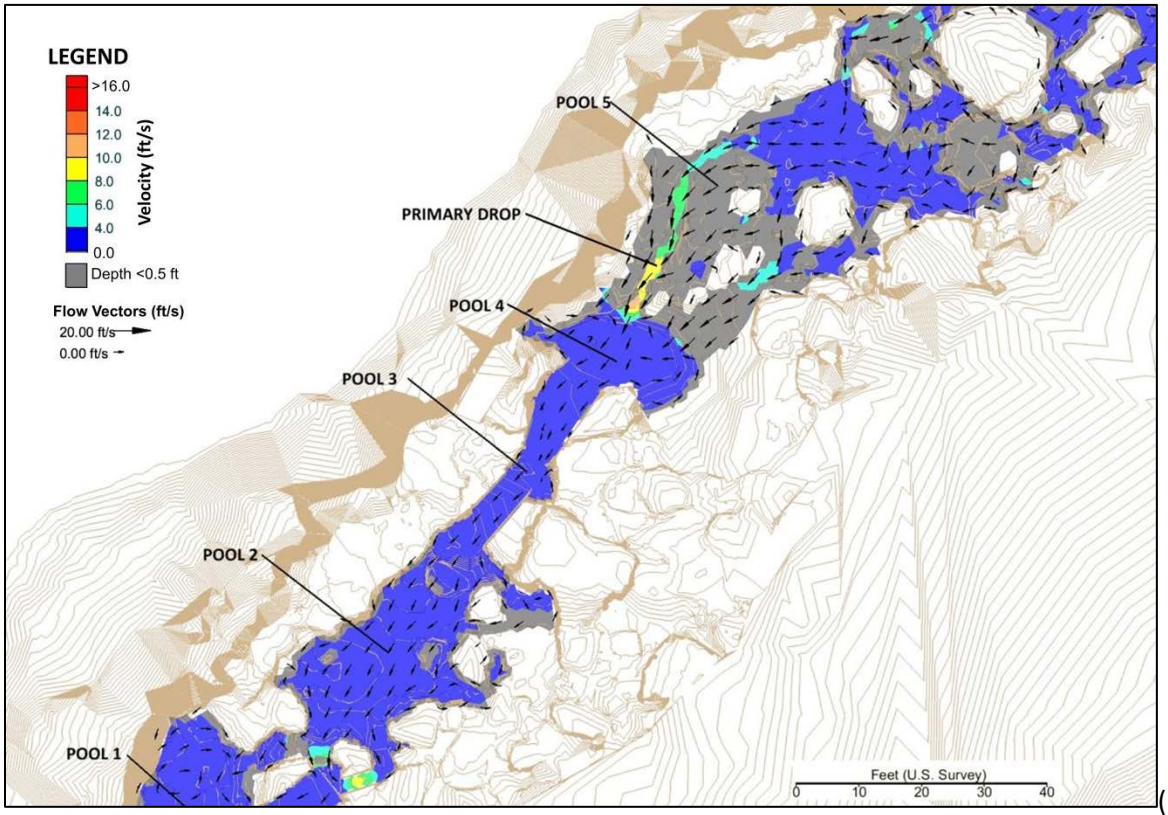



**Figure 4-2. LBS water surface profiles for the LBS proposed conditions based on SRH-2D results.**

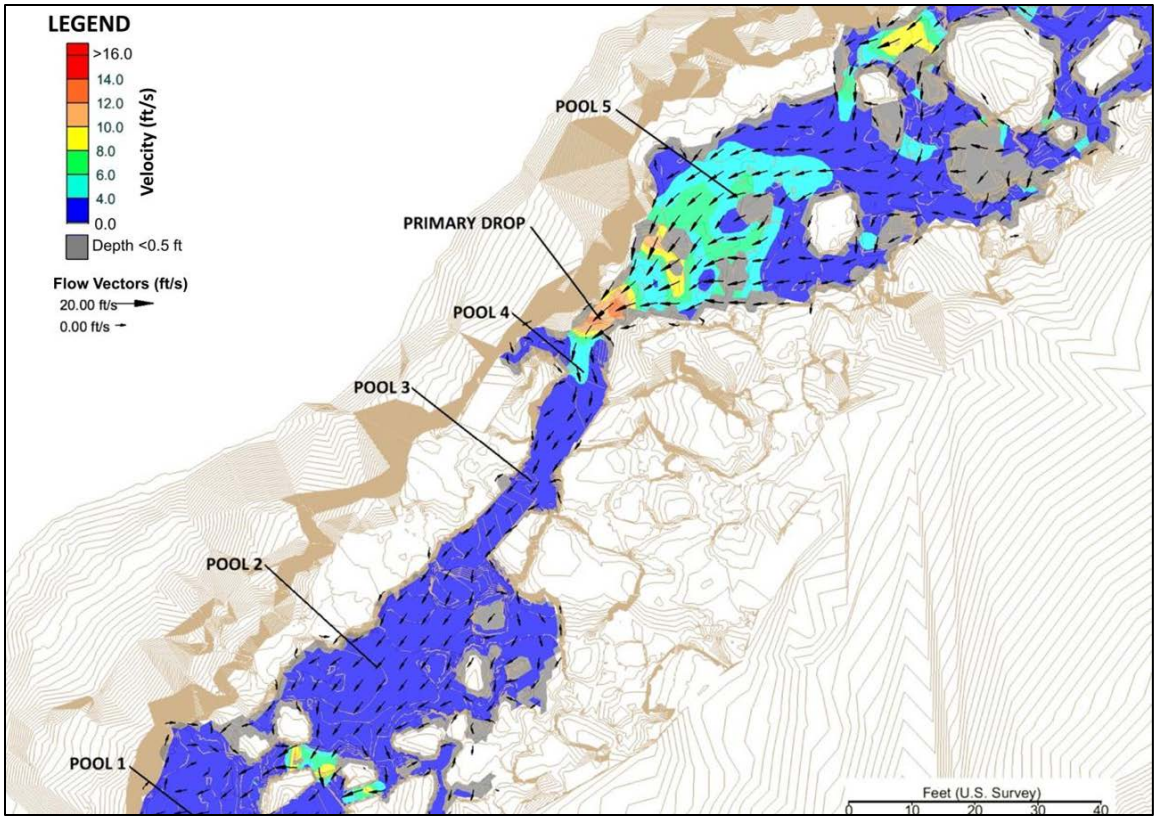



(a)

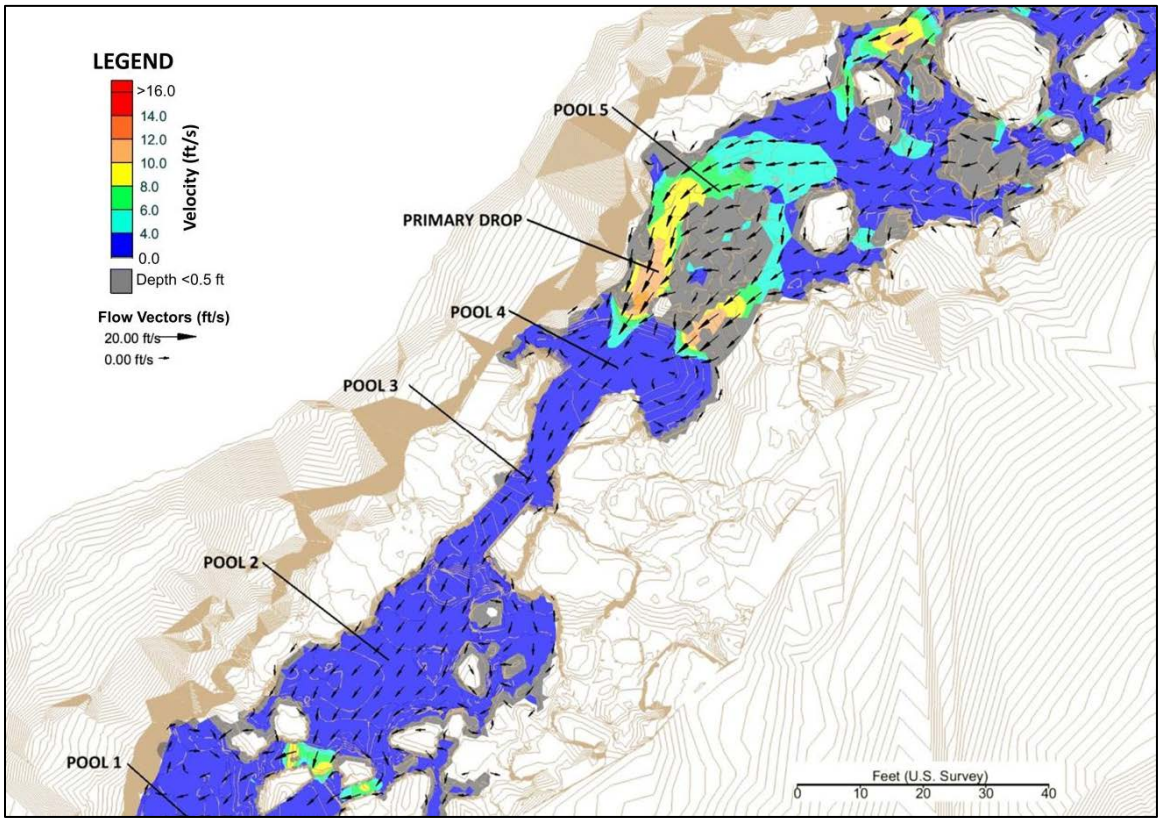



(b)

**Figure 4-3. LBS at 35 cfs for (a) existing and (b) proposed conditions.**

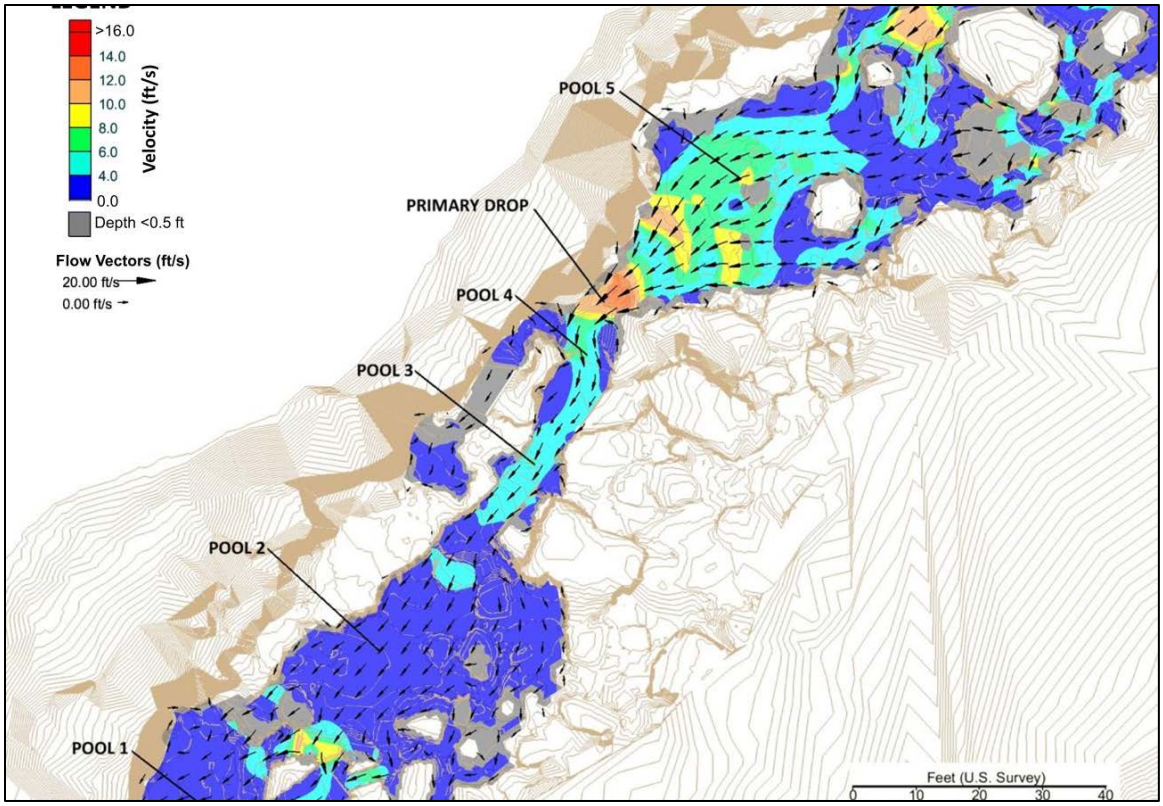



(a)

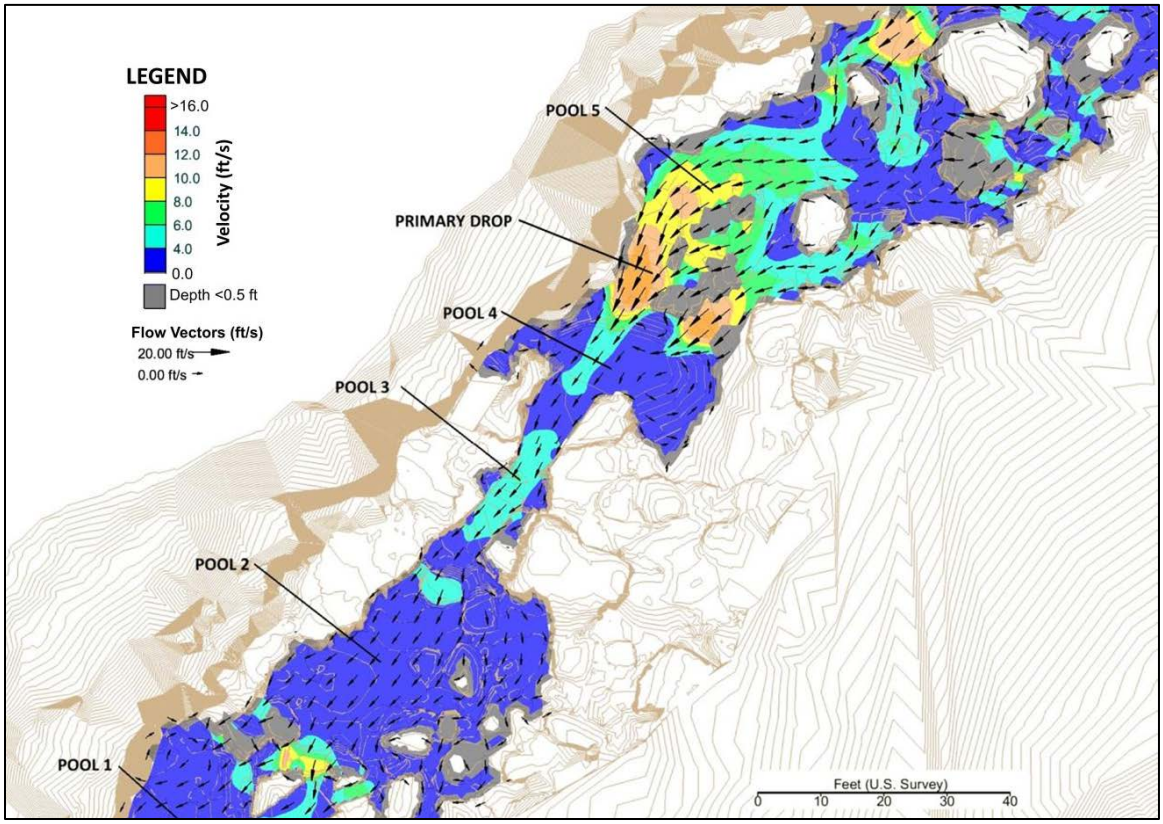



(b)

**Figure 4-4. LBS at 120 cfs for (a) existing and (b) proposed conditions.**

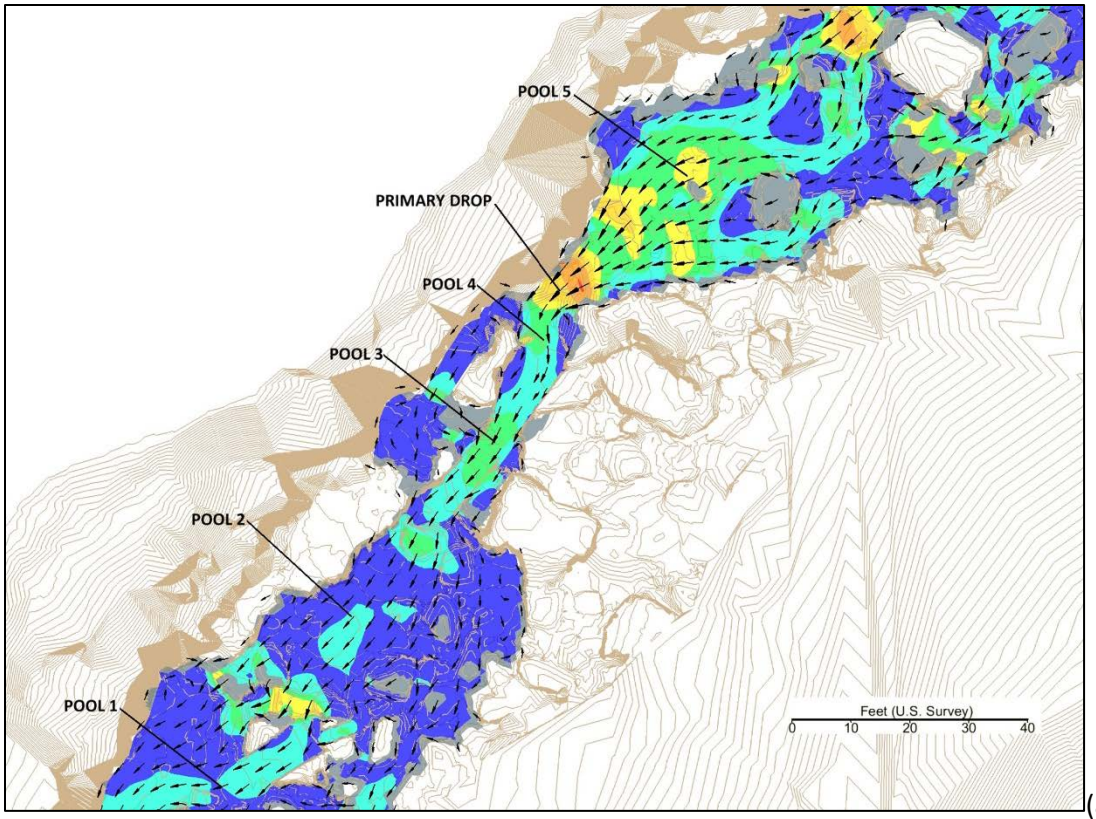


(a)

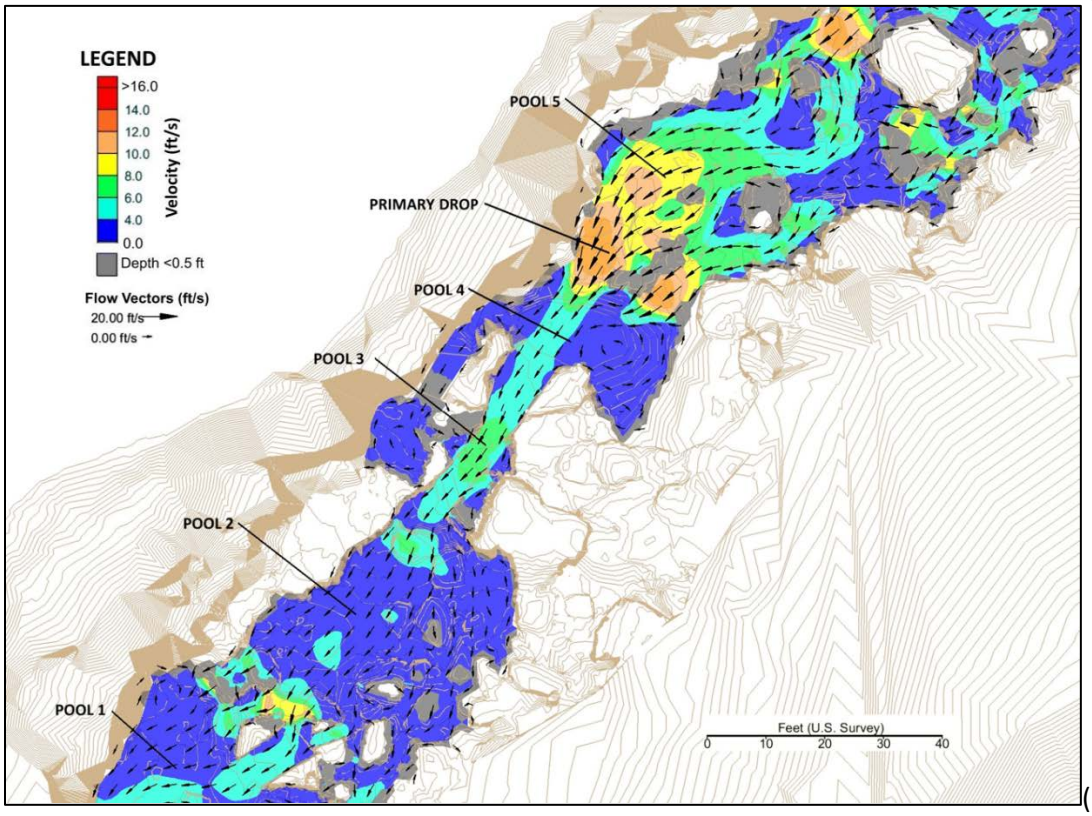


(b)

**Figure 4-5. LBS at 250 cfs for (a) existing and (b) proposed conditions.**

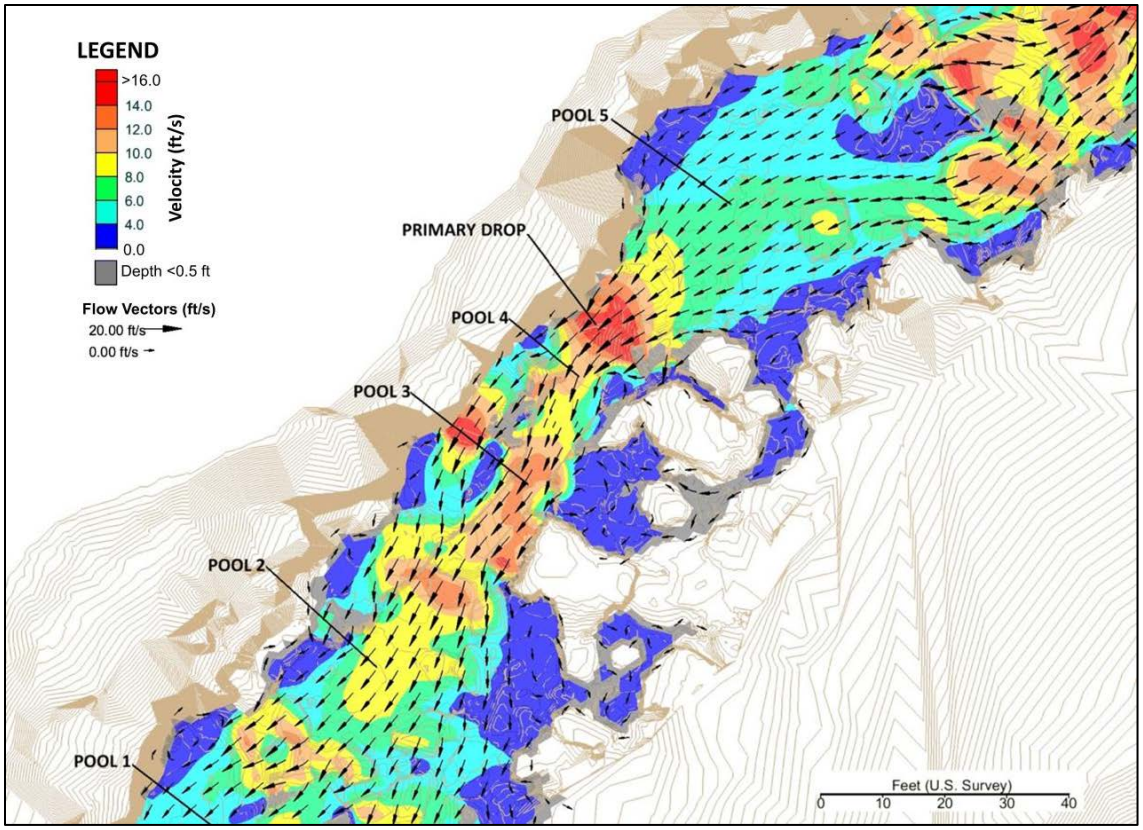



(a)

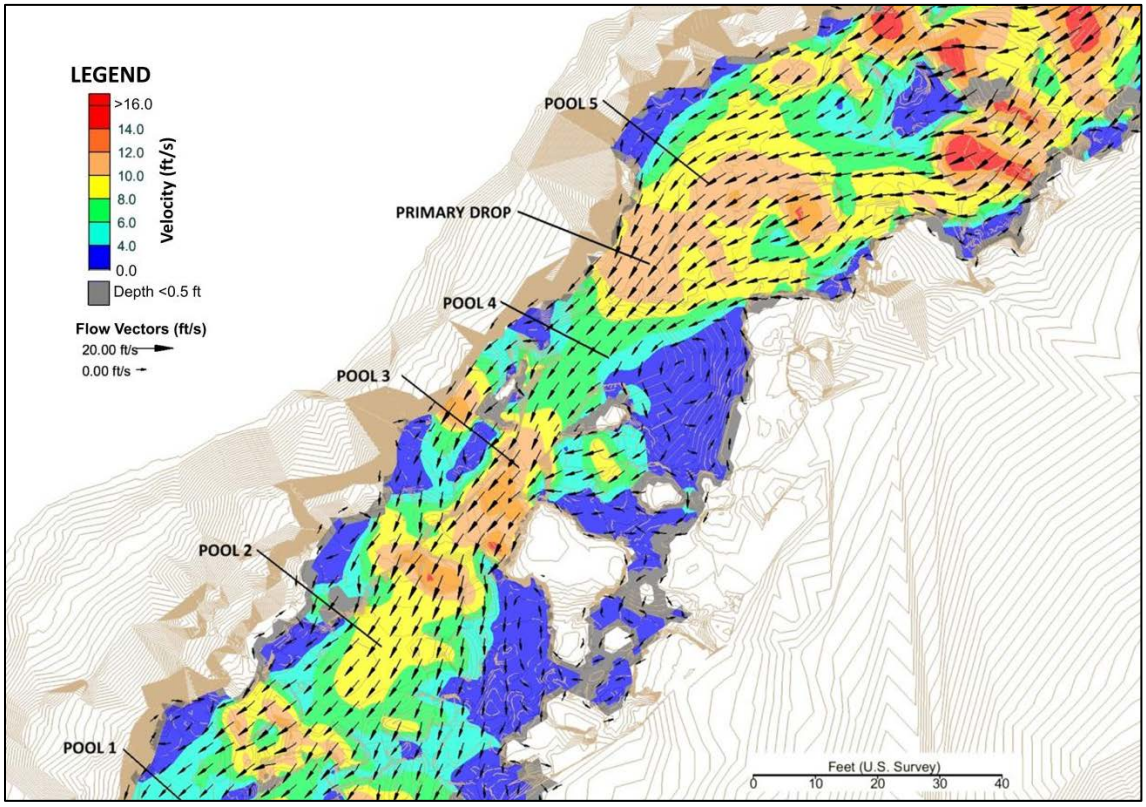



(b)

**Figure 4-6. LBS at 382 cfs for (a) existing and (b) proposed conditions.**




(a)




(b)

**Figure 4-7. LBS at 1,600 cfs for (a) existing and (b) proposed conditions.**

Table 4-1. Summary for LBS fish passage hydraulics for existing conditions and proposed conditions. Also provided is the size of Chinook salmon able to swim through the velocities within the primary drop without reaching exhaustion.

| Parameter | Flow | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35 cfs | | 120 cfs | | 250 cfs | | 382 cfs | | 500 cfs | | 1,600 cfs | |
| | Existing Cond. | Prop Cond.[1] | Existing Cond. | Prop Cond. | Existing Cond. | Prop Cond. | Existing Cond. | Prop Cond. | Existing Cond. | Prop Cond. | Existing Cond. | Prop Cond. |
| Drop Height (ft)[1] | 8.0 | 8.7 | 7.0 | 7.4 | 5.6 | 6.0 | 4.6 | 4.8 | 3.7 | 5.1 | 4.0 | 4.0 |
| Length of Drop (ft)[1] | 31 | 31 | 30 | 30 | 16 | 28 | 16 | 25 | 14 | 20 | 14 | 20 |
| Ave. Slope of Water Surface Drop[1] | 26% | 28% | 23% | 25% | 35% | 21% | 29% | 19% | 26% | 25% | 29% | 20% |
| Average Depth (ft) | 1 | 1.8 | 1.8 | 2.7 | 2.9 | 3.8 | 3.6 | 4.6 | 4.6 | 5.4 | 10.7 | 9.9 |
| Min. Depth (ft) | 0.5 | 0.5 | 0.8 | 0.5 | 1.5 | 0.9 | 1.8 | 1.1 | 2.4 | 1.3 | 8.58 | 5.3 |
| Average Velocity (fps) | 7.3 | 5.4 | 7.7 | 4.8 | 7.9 | 6.0 | 8.2 | 6.5 | 8.4 | 6.9 | 10.1 | 7.9 |
| Max Velocity (fps) | 10.9 | 10.5 | 12.9 | 11.0 | 13.9 | 12.7 | 14.3 | 13.5 | 14.1 | 13.7 | 15.5 | 9.9 |
| Min Chinook Size for Passing through Velocity Field (cm) | 46 | 55 | 77 | 33 | 87 | 61 | 93 | 79 | 95 | 86 | >110 | >110 |
| Proportion of Chinook Larger than Min Size | 98% | 93% | 38% | 100% | 10% | 90% | 5% | 30% | 3% | 13% | 0 | 0 |

[1] Proposed condition results are for the north chute at 35 cfs. For all other flows, proposed condition results are for the south chute.

## 4.4 Expected Design Life

The LBS design is anticipated to function as constructed for an indefinite period, which could be for hundreds of years. The exact life expectancy is uncertain and dependent on future rockfall. Rockfall may occur at any time, and can be triggered by strong ground shaking from earthquakes. In most cases, maintenance in the form of rock removal could restore fish passage functionality.

## 4.5 Anticipated Maintenance Requirements

The LBS design will likely require little to no debris or sediment removal. There is the possibility a large log or other woody debris could become lodged between rocks in an orientation that creates undesirable passage conditions, requiring removal. This has occurred at other locations within North Fork Battle Creek.

Access for inspection and maintenance will be along the south bank of the channel. Improved site access, from the flume catwalk down to the channel, could be installed if desired and acceptable to PG&E. Removal of debris or demolition of rock fallen into the channel needing to be removed will be infrequently but likely need to occur during the low-flow season, after the fish migration period. Therefore, it may be difficult to perform timely maintenance.

The LBS design has a low susceptibility to rockfall hazards. In the event that rocks do fall into the channel after construction, they will likely only cause minor changes to fish passage hydraulics and could even improve passage conditions. There is the potential for very large boulders to fall onto the chute or into the pool, creating undesirable passage conditions that require repair in the form of rock removal.

The LBS is generally not susceptible to damage from boulders that could be mobilized by flow. Flows that mobilize them are likely infrequent and involve extreme depths and velocities. Boulders in transport during these events are expected to pass through the LBS without coming to rest, similar to existing conditions. The design is also not considered susceptible to scour. Field observations of the channel upstream of the project suggest the channel bed is primarily bedrock, with some large boulders. This material is anticipated to be stable and resistant to scour and headcutting, preventing headcutting extending to the next upstream boulder drop.

If a large boulder were to move or fall into the channel reach and create undesirable fish passage conditions, then removal of the boulder will be necessary. Depending on the size, location and orientation of the boulder, several methods could be used to break the rock into small pieces rather than remove it completely. If removal from the canyon is necessary, then large equipment (e.g. crane) will be necessary.

## 4.6 Recommended Post-Construction Monitoring

### 4.6.1 As-Built Survey

Immediately following construction, or as construction is finalized, it is recommended that a survey of flow paths and other key channel elements be completed. This will form the basis for follow up surveys. Due to the relatively high flows and dangerous conditions in the channel much of the year, follow up surveys will be conducted during the low flow period. The follow up surveys should focus on the same key flow paths and channel elements and capture any new developments.

### 4.6.2 Startup Monitoring

Channel adjustments around existing boulders in response to the implemented project is most likely to occur following the first several high-flow events. It is recommended that during the year following construction the site be inspected following each major flow event (> 1,000 cfs) and any changes to the site configuration and flow patterns be noted. In addition to visual inspection, time-lapse cameras should be installed at the LBS to document passage conditions at various flows. This monitoring should be extended if there are only a few high-flow events during the first year, or if channel adjustments are noted.

### 4.6.3 Biological Monitoring

Monitoring for fish migration through the project site will help indicate whether it is successful. Adult Chinook salmon and steelhead currently reach Pool 2 at the LBS. The monitoring could include field spawning and snorkel surveys upstream and downstream of the LBS to document passage success. Another means to document passage conditions is through implementing a study plan that challenges individual fish to pass through the site. This may involve transport and release of radio-tagged adult Chinook salmon immediately downstream of the site and monitoring their passage attempts. This could be conducted across a range of flows.

### 4.6.4 Inspection and Maintenance

After the first year, site inspection may occur less frequently, possibly only after the high-flow season. The inspection will be focused on identifying any debris that has accumulated and potentially negatively impacts passage conditions. It will also be used to identify any rockfall or boulder shifting/scour that has changed passage conditions.

## 4.7 Design Limitations and Uncertainties

The complexity of the LBS and nature of the selected approach for restoring fish passage introduces several notable design limitations and uncertainties for the LBS project. The primary limitation is with respect to the unknown subsurface conditions, boulder interactions related to stability, and presence of bedrock (or lack-of). The design, as presented, is based on the best available data and observations from multiple site visits. The data was captured and site visits occurred during varying flow conditions. Boulders were individually studied and their relationship with adjacent boulders noted, but uncertainty remains with how the boulders will behave once the removal process begins and what additional boulders or bedrock may be exposed once the surface boulders are removed.

For example, during the last site visit to the LBS, of many, a new sieve had formed in a location that had previously appeared comprised of interlocked boulders, cobbles, and gravel. The sieve formed near the upstream end of the south chute, allowing flow to be conveyed under boulder B75, among others. Although this new sieve did not result in a design change, it demonstrates the unpredictable nature of the project site.

Related to the above discussion, the actual final dimensions of Pool 4 after construction may be smaller than shown in the design drawings. This may result for a couple reasons. First, the inter-dependence of indicated boulders to be removed may be significant enough that removal of the boulders cause the south bank to become unstable. There are many boulders outside the approximate limits of grading that have diameters in the tens of feet that should remain in place. Second, the boulders that are indicated to be removed may not go as deep as indicated by the finish

grade contours. This is less of a concern because any in-situ boulder buried under the current boulders could be modified or removed to meet the design intent.

Construction of the two chutes is also related to the unknown subsurface concerns. The north chute is assumed will be constructed within bedrock. If the bedrock is not present, then the chute will need to be constructed through boulders, which may be less stable and require more field adjustments during construction than bedrock. The south channel will be constructed into an unknown material (boulder or bedrock). It is assumed that the chute will be constructed out of boulders, either in-situ or placed. The long-term stability of the chute is uncertain.

Substantial instability in the upstream end of the channel modification could cause upstream channel adjustments in the form of headcutting. Although this is a possibility, it is anticipated that any headcut will be arrested by existing large boulders or bedrock. If a headcut propagates upstream, potential exists for an increase in the water surface drop at the next upstream boulder constriction, potentially degrading passage conditions. If field conditions encountered during construction differ than those assumed in design, field modifications may need to be made.

The design condition hydraulics also cause uncertainty. The hydraulics are complex and subtle differences between the design-condition and the final project configuration could negatively affect fish passage hydraulics, especially turbulence. A lower water level in Pool 4 than anticipated will also require fish to navigate a higher overall water surface drop to reach Pool 5. Care should be taken during construction to avoid excess removal of boulders at the downstream end of Pool 4 to ensure the anticipated backwater from Pool 4 is achieved.

Although these uncertainties exist, the design intent is clear and field-adjustments during construction can mitigate these uncertainties design has addressed them to the extent practical. Additional hydraulic analysis by the fish passage engineer during construction may be needed to characterize resulting conditions associated with contemplated field changes. During construction, it will be essential for the contractor to work directly with the fish passage engineer on a daily basis so that field adjustments can be made that will result in the best project possible.

# 5 UPPER BARRIER SITE PROJECT

The preferred alternative for the Upper Barrier Site was Alternative C, as described in MLA (2017). The following sections present the proposed project for the UBS based on the 90% Design Drawings and Specifications. The 90% Drawings are included as Attachment 1.

## 5.1 UBS Project Description

The UBS design is a nature-like channel regrade to improve passage over the existing primary drop. The design objective is to regrade the channel to create hydraulic conditions that are within the swimming and leaping abilities of the target fish at passage design flows.

The regrade and typical boulder arrangements for the UBS design were based on a reference reach approach, which is similar to the stream simulation design approach described in CDFG (2009). For the UBS design, reference reaches within NFBC that have a similar overall slope (10 percent) and are considered suitable for fish passage at some or all migration flows were studied from the ground and using aerial photography techniques. The primary reference reach is located between Eagle Canyon Diversion Dam and Digger Creek. A secondary reference reach a short distance

downstream of the LBS, was also studied. The reference reach observations indicate how hydraulic controlling structures form and remain relatively stable, which becomes the basis for the regrade design. The reference reaches are comprised of boulder steps and cascades.

The UBS design requires the removal of approximately 720 cubic yards of boulder material, and potentially some bedrock (Figure 5-1, Attachment 1 Sheet 20). Most of the rock will be lifted out of the canyon and disposed at the top of the canyon rim or hauled off-site. The remainder of the material will be reused to construct the new regraded channel.

The regraded channel extends approximately 55 feet upstream and downstream of the existing primary drop, is located along the right side of the canyon (looking downstream), and overcomes approximately 11 vertical feet. The overall slope is approximately 10 percent. Five channel-spanning rock structures, herein referred to as hydraulic structures, will control the channel grade and the water surface profile. The hydraulic structures include boulder steps and bedrock chutes, which are similar to reference reach structures. The hydraulic structures create water surface drops between 2 and 3 feet in height. Each hydraulic structure is designed with three different flow paths, each with specific elevations or specific relationships to other defined flow path elevations, including vertical tolerances (Table 5-1 and Attachment 1, Sheets 22 and 23).

The purpose of the different flowline elevations is to create variable swimming paths. As flows increase, some paths may become less favorable for passage while others improve. To ensure that the hydraulic structure functions as designed, each structure must have its voids sealed with smaller material so that water does not pipe through the structure.

There are two design configurations for boulder steps: Type A) boulder constriction and Type B) boulder double slot (Attachment 1, Sheet 24). Type C refers to bedrock chutes. It is important to note that the layout presented within Attachment 1 is considered conceptual. The layout is based on the best information available during design. Much is unknown with respect to the subsurface boulder and bedrock layout. The different hydraulic structure "types" are to be used as a guide to fit field conditions during construction. Regardless of the final plan layout of the hydraulic structures, they must still preform the role of grade and water surface control, and therefore the flowline elevations presented in Table 5-1 still apply.

The Type A and Type B hydraulic structures assume the placement of large rock up to 8,000 lbs, which have diameters between 4 and 5 feet. When feasible, in-situ boulders and bedrock should be used. As seen on Sheet 22 (Attachment 1), the drawings have already indicated several in-situ boulders specifically to remain: boulders B14, B15, B30, B63, and B59. In-situ boulders may need to be modified to help meet the specified flowline elevations and overall design intent.

The Type A hydraulic structure, boulder constrictor, includes placing two properly shaped "constriction" boulders against one another to create a narrow slot that allows a limited amount of flow-through. "Footer" rocks are placed below the constriction boulders, as needed, to limit scour and support the boulders. In many cases, the footer rocks may be in-situ boulders shaped to serve as footers. "Buttress" rocks are placed on the downstream side of the constriction rocks to hold them in place. This hydraulic structure can create two to three feet of drop across it.

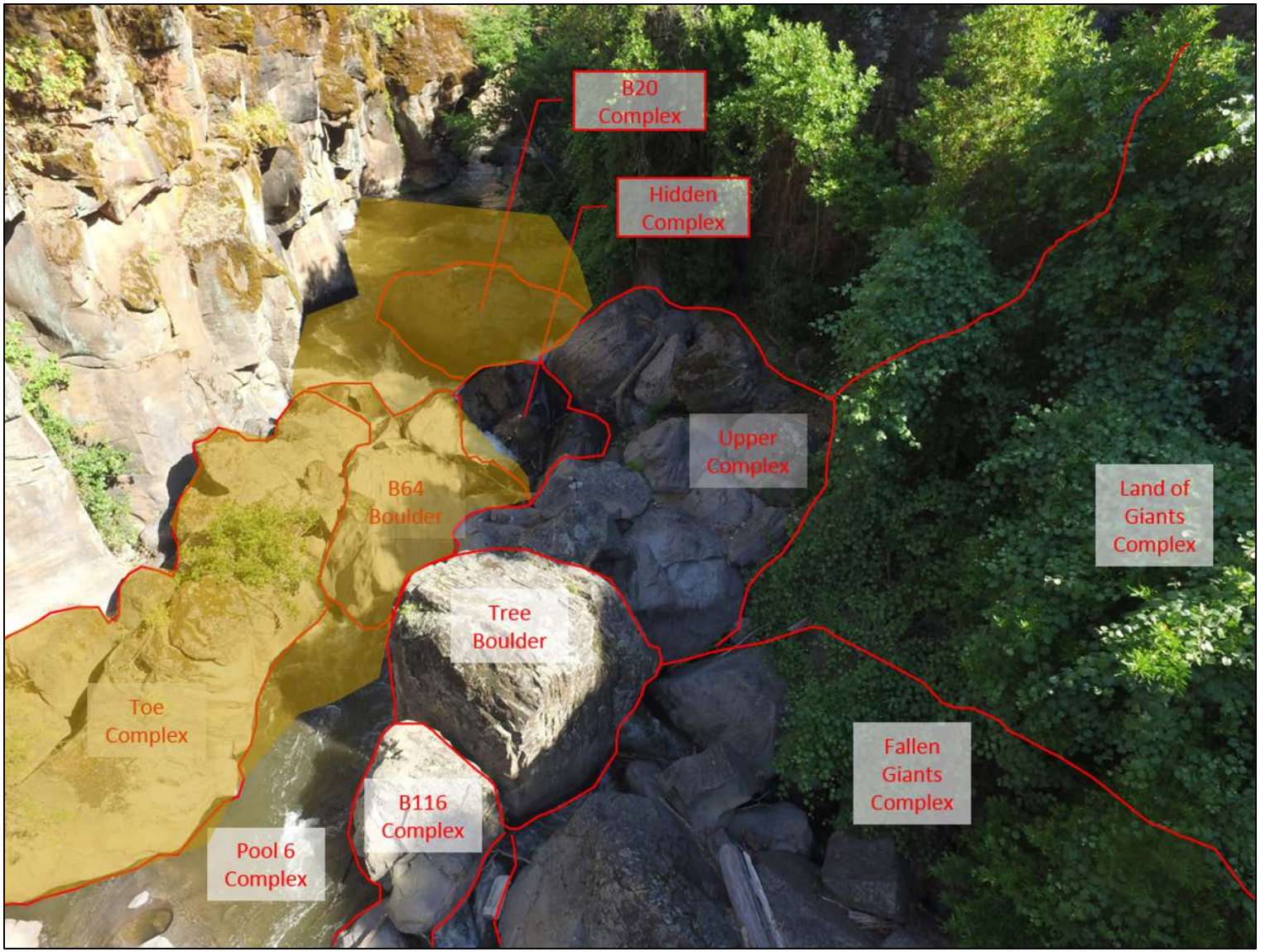



Figure 5-1. UBS boulder and boulder complexes to be removed for regrade. Approximate limits of regrade shaded yellow.

**Table 5-1. UBS Hydraulic Structure Layout Table (see Attachment 1, Sheet 22 for Flowline locations).**

| FLOWLINE (FL) ID | STRUCTURE TYPE | FLOWLINE DESCRIPTION | POOL BOTTOM DOWNSTREAM OF FLOWLINE |
|---|---|---|---|
| **HYDRAULIC STRUCTURE 1** | | | |
| FL1-1 | TYPE 'B' | EL 1480.3+/-0.5 FT | MIN 3 FT LOWER THAN FL1-1 |
| FL1-2 | TYPE 'A' | 1 FT+/-0.5 FT ABOVE FL1-1 | MIN 3 FT LOWER THAN FL1-1 |
| FL1-3 | TYPE 'A' AGAINST CANYON WALL | 1 FT+/-0.5 FT ABOVE FL1-2 | MIN 3 FT LOWER THAN FL1-1 |
| **HYDRAULIC STRUCTURE 2** | | | |
| FL2-1 | TYPE 'B' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT | MIN 3 FT LOWER THAN FL1-1 |
| FL2-2 | EXISTING FL, TO REMAIN UNCHANGED | CONTACT BETWEEN B30 AND B36 AT APPROX EL 1483.5 FT | EXISTING POOL TO REMAIN |
| FL2-3 | TYPE 'A' AGAINST CANYON WALL | 1 FT+/-0.5 FT ABOVE FL2-2 | MIN 3 FT LOWER THAN FL1-3 |
| **HYDRAULIC STRUCTURE 3** | | | |
| FL3-1 | TYPE 'C' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT, BUT NO GREATER THAN 2.5 FT ABOVE FL2-1 | MIN 3 FT LOWER THAN FL2-1 |
| FL3-2 | BEDROCK CONDITIONS PERMITTING | 1 FT+/-0.5 FT ABOVE FL3-1 | MIN 3 FT LOWER THAN FL2-2 |
| FL3-3 | | 1 FT+/-0.5 FT ABOVE FL3-2 | MIN 3 FT LOWER THAN FL2-3 |
| **HYDRAULIC STRUCTURE 4** | | | |
| FL4-1 | TYPE 'A' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT | MIN 3 FT LOWER THAN FL3-1 |
| FL4-2 | TYPE 'A' | 1 FT+/-0.5 FT ABOVE FL4-1 | MIN 3 FT LOWER THAN FL3-1 |
| FL4-3 | TYPE 'A' | 1 FT+/-0.5 FT ABOVE FL4-2 | MIN 3 FT LOWER THAN FL3-3 |
| **HYDRAULIC STRUCTURE 5** | | | |
| FL5-1 | TYPE 'A' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT | MIN 3 FT LOWER THAN FL4-1 |
| FL5-2 | TYPE 'B' (USE IN-SITU BOULDERS AS FEASIBLE) | 1 FT+/-0.5 FT ABOVE FL1-1. | MIN 2 FT LOWER THAN FL4-3 |
| FL5-3 | TYPE 'B' | 1 FT+/-0.5 FT ABOVE FL1-2. DEFINED AT CONTACT BETWEEN B14 AND B15 | MIN 2 FT LOWER THAN FL3-3 |

The Type B hydraulic structure, boulder double slot, is designed with a relatively flat "sill" boulder placed lower than the "keystone" boulders flanking it. A taller "dividing" boulder is placed upstream of the sill boulder to split the flow. As a result, water begins to draw down as it goes around the dividing boulder, before spilling into a receiving pool. This spreads the water surface drop over a longer distance so that fish can leap onto the sill boulder and swim through the remaining water surface drop. The sill boulder creates a 3- to 4-foot wide broad crested weir that creates more hydraulic capacity than the boulder constriction structure. The overall water surface drop across this structure could be up to 3 feet, with the drop spread out as described above. Buttress rocks and footer rocks are also used to give the structure stability.

Below each hydraulic structure flowline, a pool will be constructed. The pool's minimum residual depth will be 2 feet. Additional pool details are presented in Table 5-1.

The Type C hydraulic structure, bedrock chute, will be used in the event that bedrock is encountered with suitable elevations to create the flowlines. The bedrock will be shaped to create multiple chutes each having approximately 2 feet of drop across them. The chute lengths will vary depending on site conditions, but could be as short as 5 feet in length. The flowline elevation of each chute will vary such that there will be low-flow, mid-flow, and high-flow passageways for fish (Table 5-1). A pool will be constructed below the bedrock chutes with a minimum residual depth of 2 feet.

Between the hydraulic structures the channel bed will include large boulders either placed or in-situ. The channel should be rough and additional pools may be necessary.

Pool 6 is located at the downstream end of the channel regrade. Pool 6 was selected as the downstream transition because it is believed that fish can navigate the lower section of the UBS over a wide range of flows, including the fish passage design flows (MLA, 2016b). In addition, Pool 6 is adequate in size and depth to dissipate the flow's energy downstream of the channel regrade and it provides numerous places for fish to hold and stage before swimming upstream. Additionally, during large infrequent flow events (i.e. 1,600 cfs to 100-year flow) Pool 6 backwaters the upstream channel due to boulder constrictions surrounding it. This backwater will reduce the velocities and forces acting on the boulders placed within the regraded reach upstream of Pool 6 (MLA, 2016b).

Pool 9 is located at the upstream end of the channel regrade. Extending the channel regrade further upstream was evaluated but dismissed because it would require the removal of additional large boulders and due to the overall slope of the existing channel, would require a much longer regrade channel reach. Pool 9 provides ample volume for fish to recover after navigating the UBS channel regrade.

Lastly, a small concrete weir structure will be built downstream of the regraded channel (Attachment 1, Sheets 25 and 26). The purpose of the weir structure is to keep water from flowing out of the secondary alignment corridor under low to moderate flows. This will improve the flow and fish passage conditions within the secondary alignment corridor under these flow conditions.

## 5.2 Construction

Construction techniques are covered in detail in previously completed documents (SRD, 2016a, SRD 2016b, MLA, 2017). For reference, a summary is provided here.

Construction at the UBS will be extremely challenging given limited site access and rockfall hazards. It is envisioned that worker site access will be via an improved foot trail down to the site from the western rim of the canyon. Construction access for importing equipment, removing rock, and moving and placing boulders in the channel will be through the use of either a skyline yarding system or a crane (See Attachment 1, Sheets 14 and 15).

A skyline yarding system could be installed with the boom on the western rim downstream of the Digger Creek confluence and the other end anchored to bedrock on the northern canyon wall located upstream of the UBS.

A crane may be used instead of a yarding system, with it placed as close to the western rim as possible. A crane will allow for more maneuverability and control for rock removal and rock placement during construction, which is a key component of the design.

Prior to construction, rockfall hazards will be mitigated using various techniques, including scaling rocks off the cliff and anchoring rocks using rock bolts, as described in the geologic report (CSA, 2016). It is not known if the large block of basalt, referred to in the geologic report as the "wave," will need to be stabilized for construction safety. This block is upstream of the regrade but potentially in the vicinity of a coffer dam for site dewatering.

A streamflow bypass system will need to be installed prior to rock demolition, although some rock may be removed in the dry prior to dewatering to establish a route with suitable grade to lay the pipes. The bypass system will likely include a coffer dam placed upstream of the regraded channel constructed of super-sandbags, a water-filled bladder, or other materials that span the entire canyon wall to wall. The water will be bypassed in a gravity fed pipe around the entire work area. This may require moving the pipe several times during the course of construction. Installation could involve use of a helicopter to bring in the pipe segments and super sandbags.

Rock will be removed by first drilling holes into the boulders and bedrock and then either using hydraulic rock splitters, blasting, or other techniques to break the rock into pieces small enough to be lifted by the removal system.

Once the subgrade is daylighted, it may need to be manipulated to build the hydraulic structures. The hydraulic structures will be built using a combination of moving boulders into position using the yarding or crane system and using existing rock left in-place and potentially split/blasted to the desired size and shape. Rock used to build the structure could be salvaged during the splitting of larger rock during the demolition phase, providing some control as to the size and shape of the boulder. These rocks may be temporarily stockpiled in the canyon or may need to be lifted out and stored above the canyon before being lowered back down and into place.

Building the hydraulic structures will require close coordination between the resident fish passage engineer and the contractor to achieve the desired conditions. It is assumed that the yarding system or crane used for the project will have a minimum lifting capacity of 8,000 lbs, but having a higher lift capacity will provide more flexibility in building the hydraulic structures.

## 5.3 Stability Analysis of Placed Boulders

MLA (2017) presented a detailed analysis of the stability of the UBS design and concluded that hydraulic conditions within the channel regrade reach are not expected to mobilize the 4- to 5-foot diameter boulders used to construct the hydraulic structures.

The MLA (2017) methods only consider the hydraulic forces necessary to mobilize the boulders forming the structures. Boulder mobility due to collapse of a structure from downstream erosion or impacts from another boulder were not evaluated. Additionally, the methods may underestimate the vertical forces (uplift) associated with the turbulent hydraulics within the regraded channel. Therefore, a conservative approach should be taken to construct the hydraulic structures, and the largest rock that can be practically moved into the desired positions should be used. In addition, boulder shape should be considered; boulders that are more block-like are less prone to rolling and provide more surface area in contact with adjacent rock, and therefore may be more stable.

## 5.4 Anticipated Fish Passage Performance

### 5.4.1 Methods

A general discussion on the methods used to evaluate potential fish passage performance within the UBS was presented in Section 3.4. As discussed there, a SRH-2D hydraulic model based on the 90% design drawings was developed and ran using a wide range of flows. The UBS hydraulic model follows the same development procedures as presented in and MLA (2017).

Once the model runs were complete, each flow map was analyzed and a potential fish passage swim path was digitized. The swim paths were routed through the lowest water velocities while having sufficient depth for passage. A fish routing spreadsheet model was then used to identify the smallest sized Chinook salmon that could swim through the velocity field without becoming exhausted based on the swim speed equations developed by Hunter and Mayor (1986).

The primary difference between the LBS approach and the UBS fish routing modeling approach is the inclusion of resting. It is assumed that if a fish reaches a region with a velocity less than or equal to 1.5 body lengths per second (BL/s), then the fish can rest and recover from exhaustion. This is based on work completed by Paulik and DeLacy (1958) and Weaver (1963) in which fish swimming in water moving at 1.5 to 1.8 BL/s did not become exhausted. Therefore, if a fish begins to be exhausted as it navigates a particular feature and reaches an area that has a velocity equal to or less than 1.5 BL/s, then the fish's exhaustion is set back to zero. The model does not include the time it would take for the fish to recover fully before moving further upstream.

The model does not consider the velocity direction. As seen in the next section, eddies form within the project reach. Therefore, there may be instances when a fish is moving in the same direction as the flow as it moves upstream, or the fish could be moving lateral to the primary flow direction. In either case, the magnitude of the velocity is used in the equation. This is a conservative approach because in some cases the fish would use less energy to move a particular distance because it is not swimming against the full magnitude of the velocity. The results of the modeling are presented in the next section.

### 5.4.2 Results

Unlike the LBS, the UBS's complex layout of boulders and sieves made development of an existing conditions two-dimensional hydraulic model infeasible (MLA, 2016b). Therefore, a pre- and post-construction comparison based on model results cannot be made. MLA (2016b) provides a detailed discussion on existing fish passage conditions, which is summarized in Section 2.5.4 of this memorandum.

Table 5-2 presents a results summary table of the regraded channel hydraulics and fish passage assessment. The table includes average water surface slope, average water depth, minimum water depth, average water velocity, maximum water velocity, minimum Chinook salmon able to navigate the regrade channel, and the portion of Chinook salmon that are larger than the minimum size that navigated the channel based on historic data.

**Table 5-2. Summary of UBS fish passage hydraulics and assessment results for the selected swim paths or alignment.**

| | Flow | | | | |
|---|---|---|---|---|---|
| **Parameter** | **35 cfs** | **120 cfs** | **293 cfs** | **500 cfs** | **1,600 cfs** |
| Average Water Surface Slope | 6% | 5% | 5% | 4% | 3% |
| Average Depth (ft) | 2.3 | 3.4 | 4.6 | 5.6 | 10.5 |
| Min. Depth (ft) | 0.6 | 1.0 | 1.9 | 1.3 | 2.1 |
| Average Velocity (fps) | 3.3 | 3.5 | 4.0 | 4.2 | 6.1 |
| Max Velocity (fps) | 7.4 | 7.8 | 9.0 | 7.2 | 9.0 |
| Min Chinook Size for Passing through Velocity Field (cm) | 40 | 40 | 40 | 40 | NA |
| Proportion of Chinook Larger than Min Size | 100% | 100% | 100% | 100% | NA |

Figure 5-2 through Figure 5-5 present a plan and profile view of the SRH-2D hydraulic model results and cumulative fish exhaustion results for 35 cfs (low fish passage design flow), 120 cfs, 293 cfs (high fish passage design flow), and 500 cfs, respectively. On each plan view map, a potential swim path has been selected. The profile shows the water velocity and fish exhaustion along that swim path. In each case, the size of fish analyzed is a 40 cm Chinook salmon. MLA (2016b) showed that a 40 cm fish is just smaller than the smallest Chinook within the recorded data provided by USFWS for spring-run Chinook salmon in Battle Creek. Based on the fish performance evaluation methodology applied to this project, if a 40 cm salmon can navigate the reach, then a larger fish can also navigate the channel. The evaluation shows that a 40 cm can navigate the UBS regraded reach for each analyzed flow.

The selected swim path when the flow is 35 cfs and 120 cfs are nearly identical. Starting at the downstream end, the fish moves up the river left side of the channel and through the most left bedrock chute. Upstream of the bedrock chute, the fish moves laterally to the river right side of the channel and navigates the remainder of the reach on this side of the channel. Results show that the maximum the exhaustion at 35 cfs is 37% and occurs at the downstream end of the reach. Other features do not cause the fish to exceed 20% exhaustion. At 120 cfs, the maximum exhaustion is

49% and occurs near the downstream end of the channel, but the fish experiences a similar exhaustion near Station 45 and several times exceeds 20% exhaustion.

At the high fish passage design flow (293 cfs), the swim path is a similar path as described above. The maximum exhaustion occurs near Station 45, at 85%. The fish regularly exceeds 50% exhaustion but is able to recover between efforts due to slow water between hydraulic structures.

Potential fish passage conditions were evaluated at 500 cfs, which is greater than the high design flow, to see if the regraded channel may still provide hydraulic conditions suitable for passage. According to the approach applied for this project, a 40 cm Chinook can navigate the channel. The maximum exhaustion occurred at the upstream end of the channel, as the fish crosses Pool 9. The velocity within this section of the channel is more a result of the existing boulder configuration at the head of Pool 9 than the configuration of new hydraulic structures. Further, a less direct path across Pool 9 could have been selected, routing the fish through slower water. Regardless, the findings with respect to velocity and its effect on fish are promising.

Figure 5-6 presents the ground and water surface profiles along the selected fish swim path for each analyzed passage flow. The results indicate that the design is working as intended where there are water surface drops across hydraulic structures approximately 2 to 3 feet in height. The depth over all features appears to meet the depth criterion (0.5 ft). The minimum pool depth criterion (2 ft) also appears to be met.

Figure 5-7 presents the results of the SRH-2D model in plan and profile view for 1,600 cfs. Unlike Figure 5-2 through Figure 5-5, no swim path was digitized for this flow because it is believed that fish are not able to reach the regraded channel due to extreme velocities and turbulence occurring immediately downstream, and throughout Eagle Canyon. Instead, the profile shown is along the design alignment. The profile shows the ground and water surface elevations through the regraded reach. As seen, the water surface profile is backwatered from existing downstream controls formed by very large boulders.

The average water surface slope across the regraded channel reach gradually decreases as the flow increases, and the slope is always less than the overall channel bed slope (~10 percent). The average and minimum depth meet design criteria (0.5 ft) for all flows. Although there was not a velocity criterion set for this project, the maximum velocities are well within the short burst capabilities of salmon and steelhead. The maximum velocities occur at hydraulic structures and are short in length. Finally, the minimum Chinook salmon evaluated was 40 cm, which passed through the evaluation reach for flows between 35 cfs and 500 cfs; fish passage was not assessed at the 1,600 cfs flow.

## 5.5 Expected Design Life

The UBS design is anticipated to function as constructed for an indefinite period. The exact life expectancy is uncertain and dependent on the stability of the constructed hydraulic structures in the regraded channel and future rockfall. If structures break-apart during high flows, this could negatively affect fish passage conditions. Rockfall may occur at any time, and can be triggered by strong ground shaking from earthquakes. In most cases, maintenance in the form of rock removal could restore fish passage functionality.

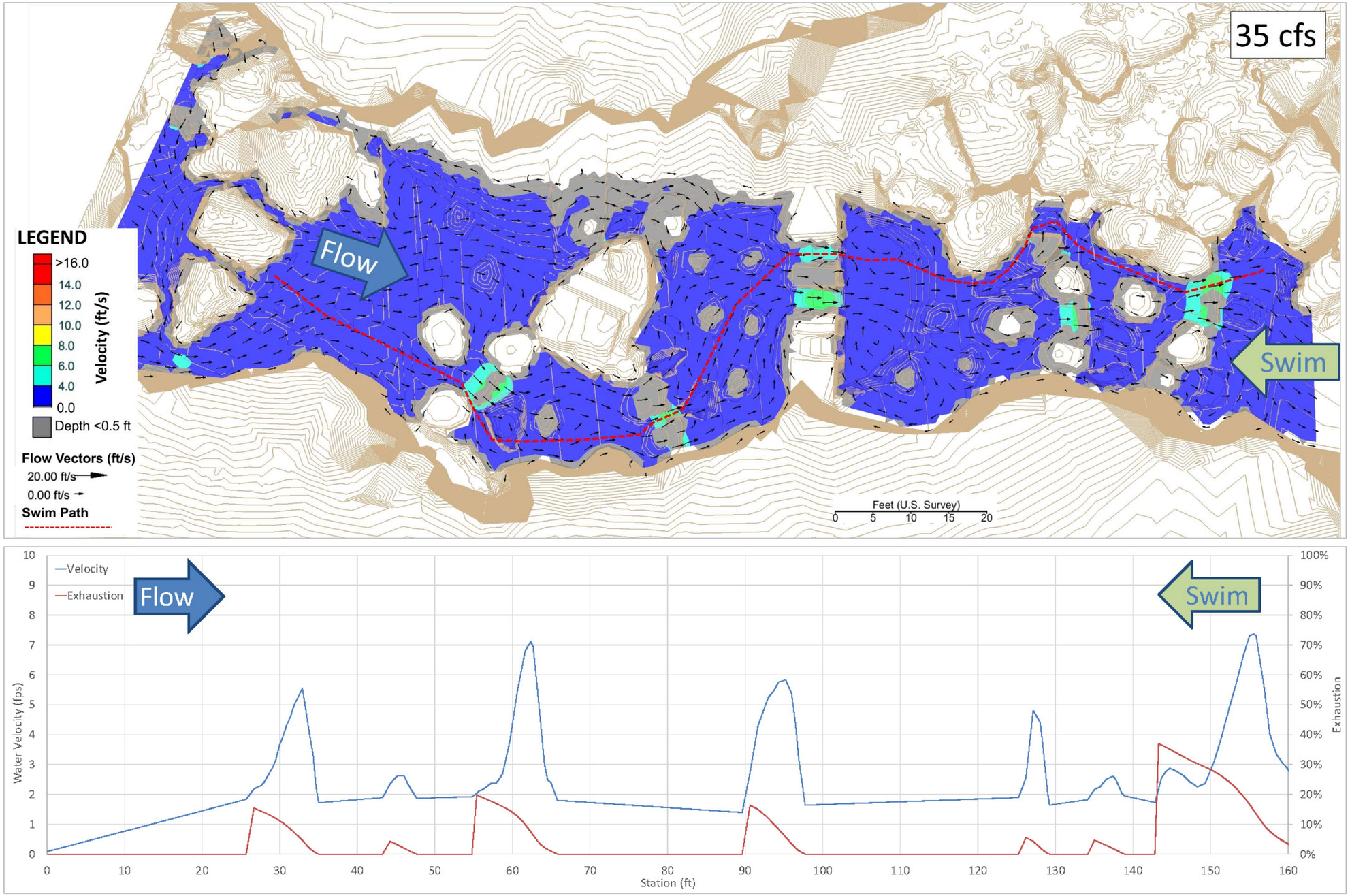
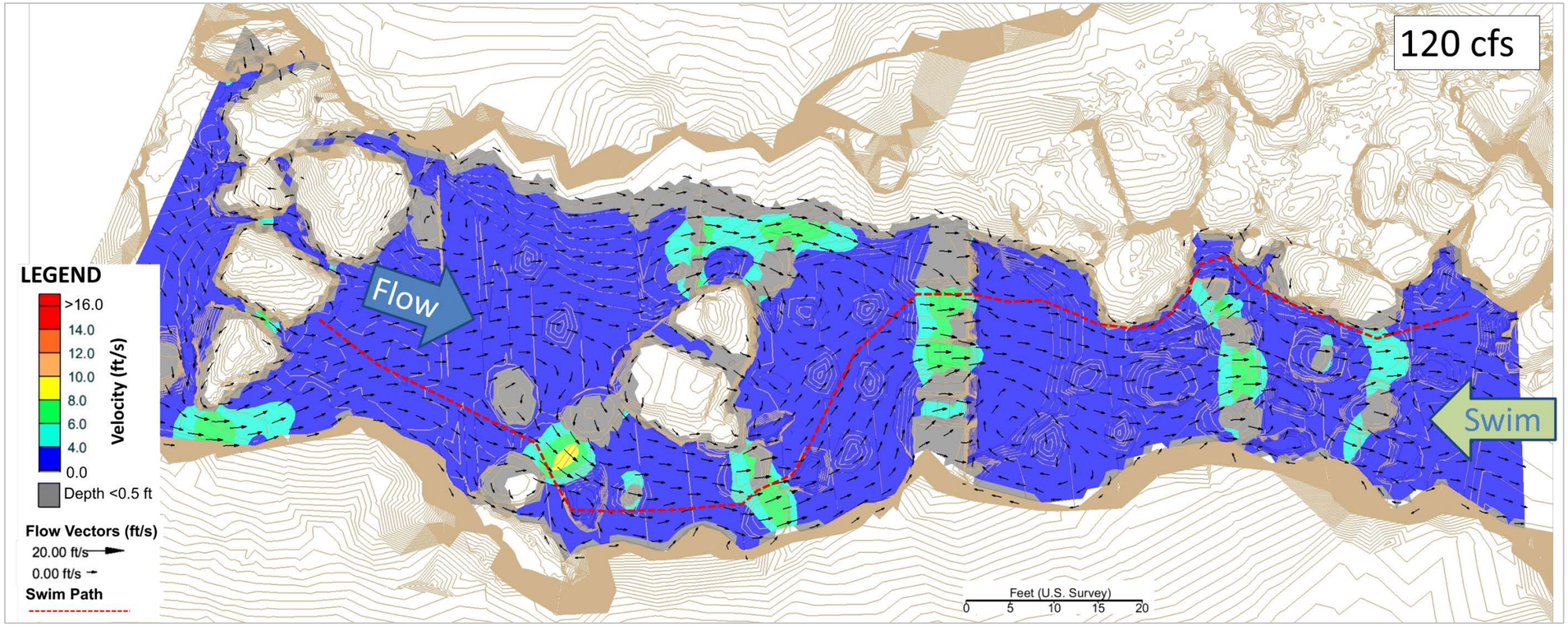
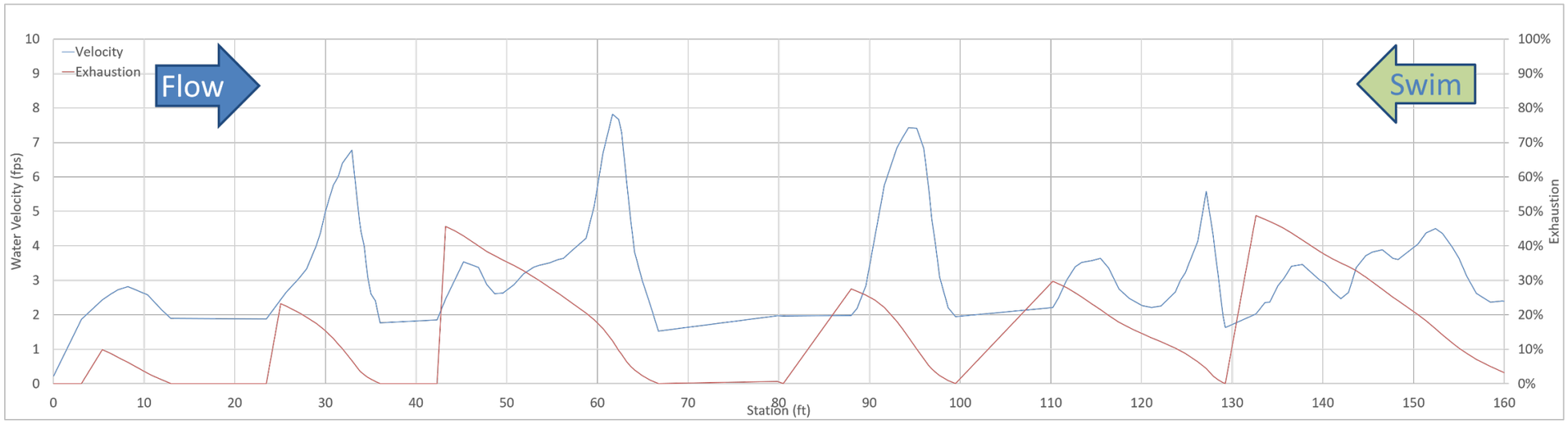



**Figure 5-2. Predicted SRH-2D water velocity and fish passage exhaustion results for a 40 cm Chinook salmon at 35 cfs. (a) Plan view (b) Swim path profile.**




(a)




(b)

**Figure 5-3. Predicted SRH-2D water velocity and fish passage exhaustion results for a 40 cm Chinook salmon at 120 cfs. (a) Plan view (b) Swim path profile.**

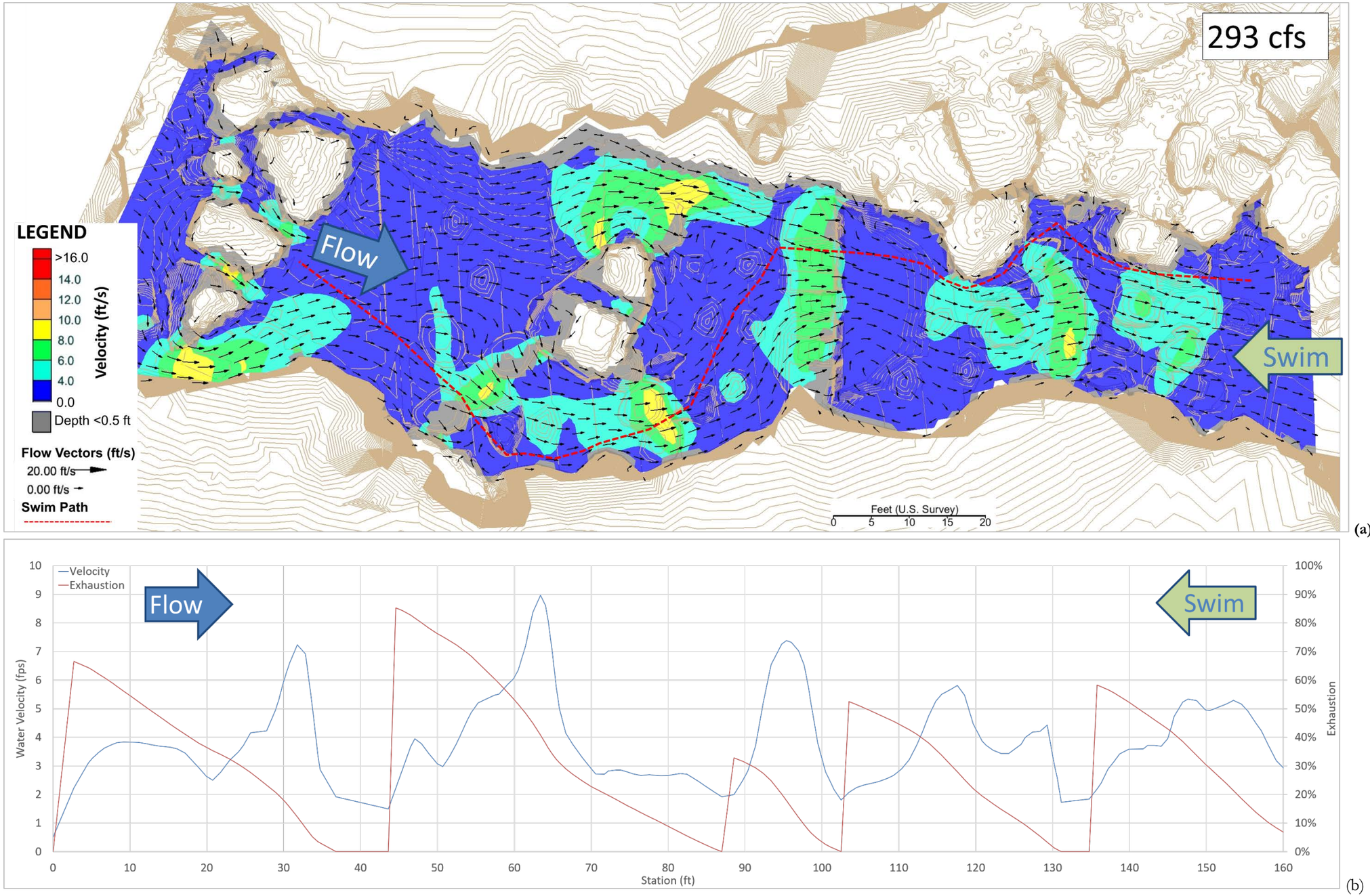



**Figure 5-4. Predicted SRH-2D water velocity and fish passage exhaustion results for a 40 cm Chinook salmon at 293 cfs. (a) Plan view (b) Swim path profile.**

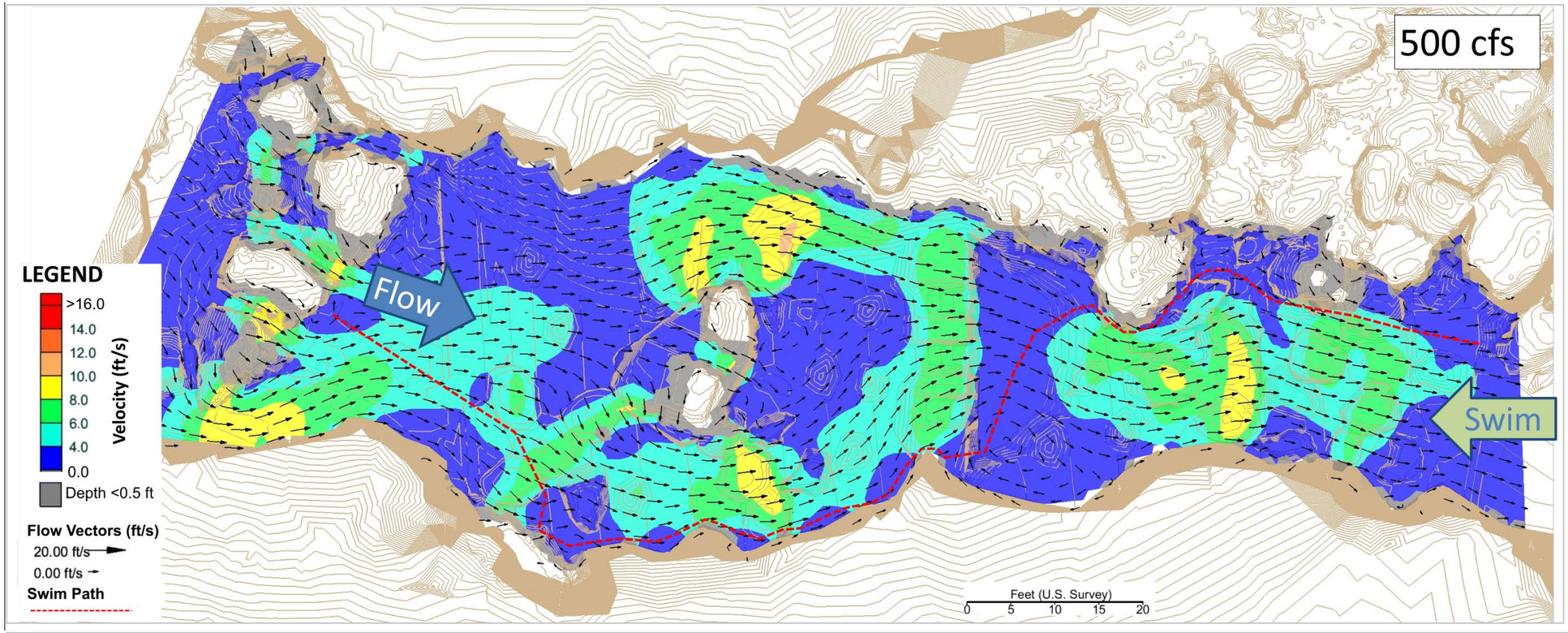



**Figure 5-5. Predicted SRH-2D water velocity and fish passage exhaustion results for a 40 cm Chinook salmon at 500 cfs. (a) Plan view (b) Swim path profile.**

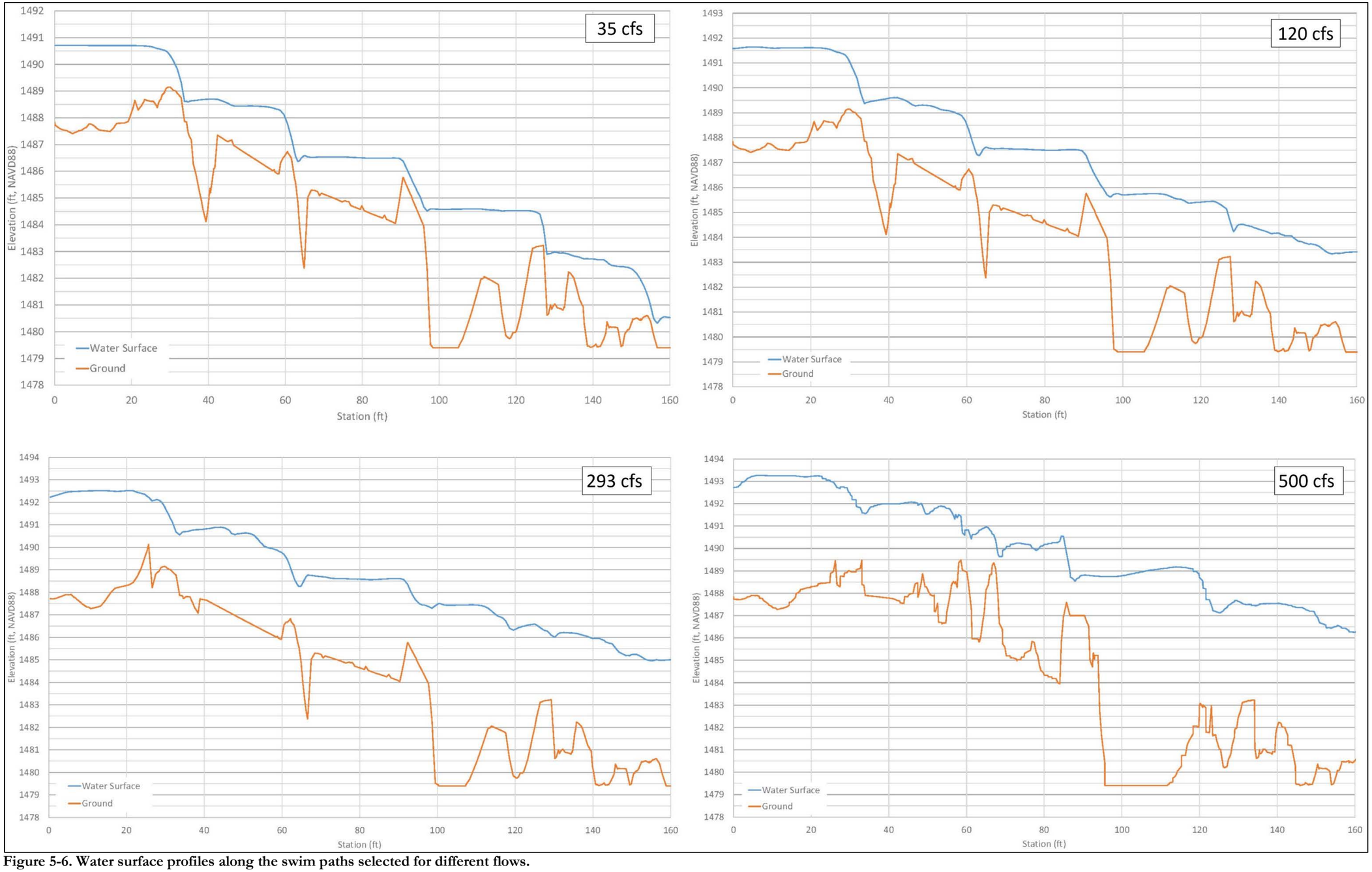
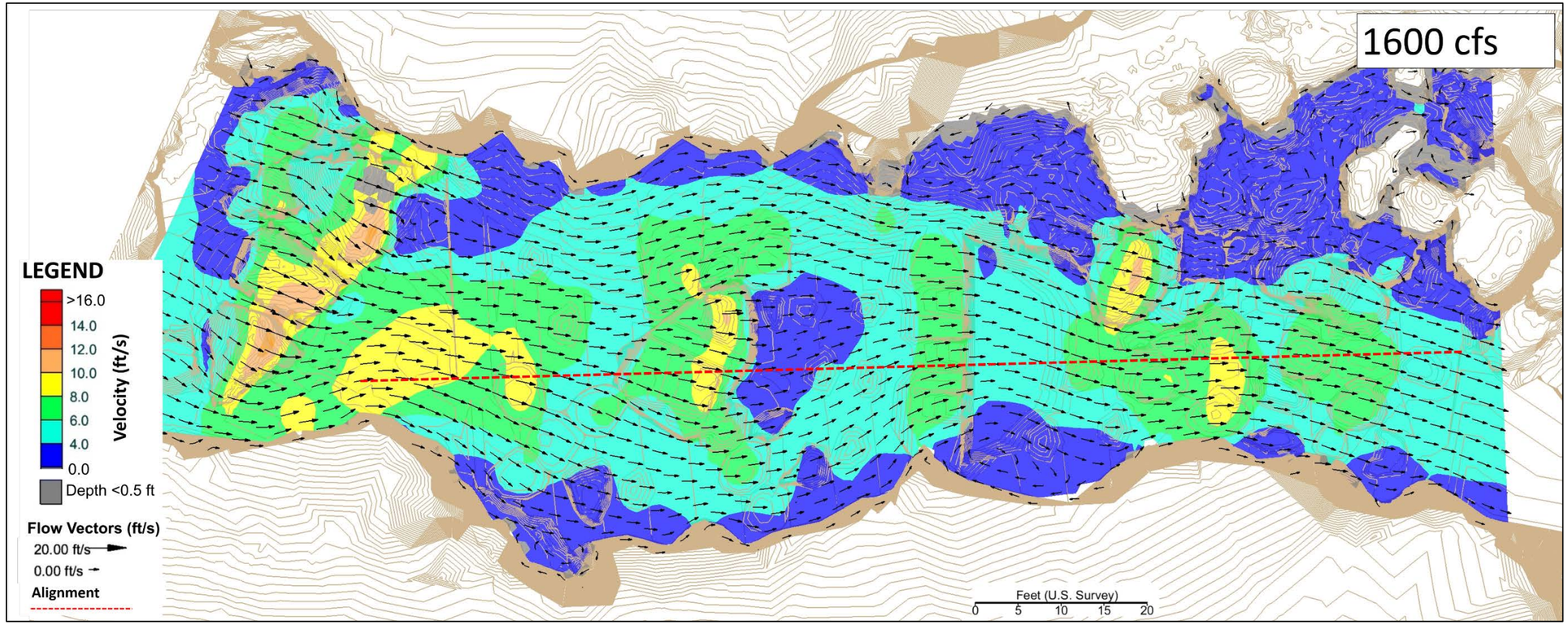
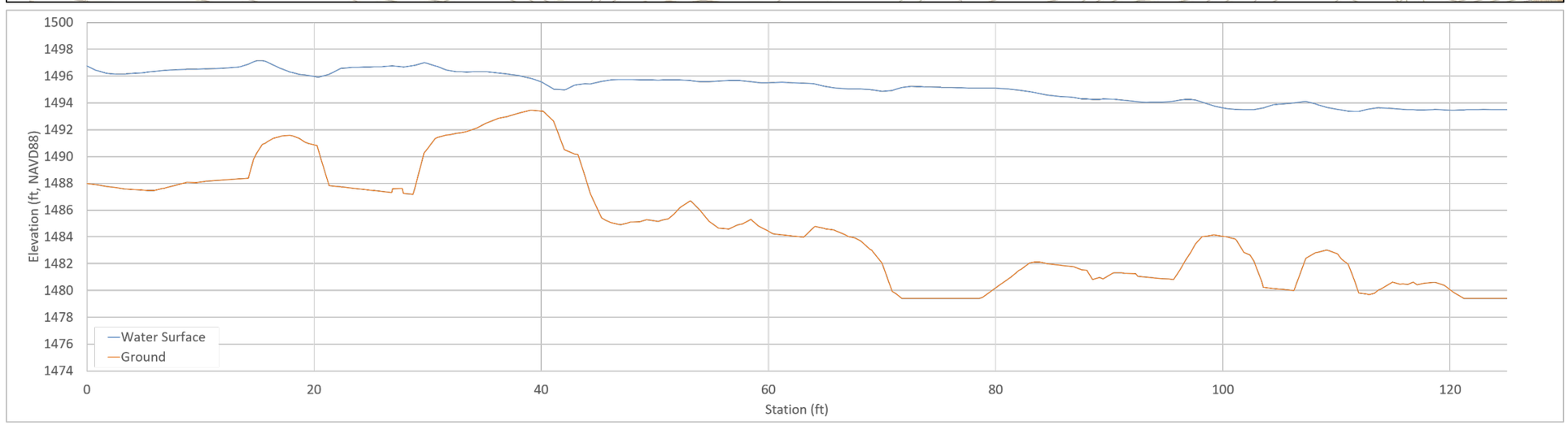



**Figure 5-6. Water surface profiles along the swim paths selected for different flows.**




(a)




(b)

**Figure 5-7. Predicted SRH-2D at 1,600 cfs, (a) plan view of velocity (b) ground and water surface profile along alignment.**

## 5.6 Anticipated Maintenance Requirements

The UBS design will likely require little to no debris or sediment removal. There is the possibility that a large log or other woody debris could get jammed between rocks in an orientation that creates undesirable passage conditions, requiring removal. This has occurred at other locations within North Fork Battle Creek. If a log needs to be removed, it could be accomplished by hand crews.

Analyses suggest that the hydraulic structures constructed in the regraded channel will be stable during extreme flows. However, the hydraulic environment is difficult to fully characterize. If the hydraulic structures break apart during high flows and do not reform, then fish passage conditions could degrade, requiring mobilization of a crane or yarding system to reconstruct the hydraulic structures or implement other fish passage improvements.

There is a higher likelihood of rocks falling into the channel at the UBS than at the LBS. In the event that rocks do fall into the channel after construction, they will likely only cause minor changes to fish passage hydraulics and could even improve passage conditions.

The UBS is generally not susceptible to damage from boulders that could be mobilized. Flows that mobilize them are likely infrequent and involve extreme depths and velocities. Boulders in transport during these events will likely pass through the UBS without coming to rest. The design is also not considered susceptible to scour, except in the event that small sieves are formed under boulders due to scour, potentially degrading low-flow passage conditions.

If a large boulder were to move into the channel reach and create undesirable fish passage conditions, then removal of the boulder will be necessary. Depending on the size, location and orientation of the boulder, several methods could be used to break-up the rock rather than remove it completely from the canyon. If removal from the canyon is necessary, then large equipment (e.g. crane) will be necessary. This is not anticipated to occur frequently, if at all.

Access for inspection and maintenance will remain primitive after construction. Improved site access could be installed if desired and approved by the landowner. Other means for inspection could include UAV aerial photography techniques.

## 5.7 Recommended Post-Construction Monitoring

### 5.7.1 As-Built Survey

Immediately following construction, or as construction is finalized, it is recommended that a survey of flow paths and other key channel elements be completed. This will form the basis for follow up surveys. Due to the relatively high flows and dangerous conditions in the channel much of the year, follow up surveys should be conducted during the low-flow period. The follow up surveys should focus on the same key flow paths and channel elements and capture any new developments.

### 5.7.2 Startup Monitoring

Channel adjustments associated with placed and existing boulders is most likely to occur following the first several high-flow events. It is recommended that during the first year following construction the site be inspected following each major flow event (> 1,000 cfs) and any changes to the site configuration and flow patterns be noted. In addition to visual inspection, time-lapse cameras

should be installed at the UBS to document passage conditions at various flows. This monitoring should be extended if there are only a few high-flow events during the first year, or if channel adjustments are noted.

### 5.7.3 Biological Monitoring

Monitoring for fish migration through the project site will help indicate whether it is successful. The monitoring could include field spawning and snorkel surveys upstream and downstream of the UBS to document passage success. Another means to document passage conditions is through implementing a study plan that challenges individual fish to pass through the site. This may involve transport and release of radio-tagged adult Chinook salmon in Pool 2, downstream of the site and monitoring their passage attempts. This could be conducted across a range of flows.

### 5.7.4 Inspection and Maintenance

After the first year, site inspection may occur less frequently, possibly only after the high-flow season. The inspection will focus on noting any shifting in boulders forming the hydraulic controls and identifying any debris that has accumulated and potentially negatively impacts passage conditions. It will also be used to identify any rockfall that has changed passage conditions. Establishing photo monitoring points would be useful tool for conducting the inspections.

## 5.8 Design Limitations and Uncertainties

The complexity of the UBS and nature of the selected approach for restoring fish passage introduces several notable design limitations and uncertainties for the UBS project. The primary limitation is with respect to the unknown subsurface conditions, boulder interactions related to stability, and presence of bedrock (or lack-of). The design, as presented, is based on the best available data and observations from multiple site visits. The data was captured and site visits occurred during varying flow conditions. Boulders were individually studied and their relationship with adjacent boulders noted, but uncertainty remains with how the boulders will behave once the removal process begins and what additional boulders or bedrock may be exposed once the surface boulders are removed.

Several boulders have been specifically identified to remain even though they are within the regrade footprint. In most cases, only a portion of the identified boulder is visible, often only the top. Assumptions were made as to the size of the boulder beyond the visible limits. If these assumptions are proved inaccurate during the construction, then field adjustments will be necessary.

During construction, controlling the placement of large boulders accurately will be very important but uncertainty remains as to whether the equipment can achieve this, in a timely manner. Placement of boulders may require several attempts with a single boulder or several attempts with multiple boulders to get the contact and elevations desired so that the design intent is met.

The stability of the hydraulic structures was mentioned above, but should be reiterated here. The analysis concluded that the large boulders used to construct the structures should remain stable, even under very high flow events, but uncertainty does exist (see Section 5.3). If a structure should fail, the remaining structures, especially the ones upstream, may be in-danger of failing as well.

There is the possibility that at the lowest flows water could leak through the placed boulders around Boulder B63 and drain into the large sieve that connects to Pool 6. This could result in inadequate

flow and depth over the downstream most hydraulic structure. Care will need to be given to seal voids between boulders in this location.

The channel hydraulics are based on a rating curve developed for Pool 6 (downstream boundary condition) constructed through direct observations and surveys. Although we believe the rating curve is based on sound principles, the Pool 6 water surface may not behave as anticipated. Based on hydraulic analysis results, minor fluctuations in the behavior of Pool 6 should be mute but if there is a large shift in the behavior of Pool 6, then there could be consequences for the regraded channel, primarily associated with hydraulic structure stability. A large shift would likely be caused by a large boulder moving downstream of, or near, Pool 6. Although this is assumed to have a low likelihood of occurring, removing the upstream boulders for the project may have unforeseen consequences to the stability of the downstream boulders.

Although these uncertainties exist, the design intent is clear and field-adjustments during construction can mitigate these uncertainties to the extent practical. Additional hydraulic analysis by the fish passage engineer during construction may be needed to characterize resulting conditions associated with contemplated field changes. During construction, it will be essential for the contractor to work directly with the fish passage engineer on a daily basis so that field adjustments can be made that will result in the best project possible.

# 6 REFERENCES


Castro-Santos, T. (2006). Modeling the effect of varying swim speeds on fish passage through velocity barriers. *Transactions of the American Fisheries Society, 135*(5), 1230-1237.

CDFG. (2002). *Culvert Criteria for Fish Passage.* Tech. rep., California Department of Fish and Game.

CDFG. (2004). Part IX: Fish Passage Evaluation at Stream Crossings. In *California Salmonid Stream Habitat Restoration Manual* (4th ed., Vol. II). California Department of Fish and Game. Retrieved from http://www.dfg.ca.gov/fish/resources/habitatmanual.asp

CDFG. (2009). Part XII: Fish Passage Design and Implementation. In *California Salmonid Stream Habitat Restoration Manual* (4th ed., Vol. II). California Department of Fish and Game. Retrieved from http://www.dfg.ca.gov/fish/resources/habitatmanual.asp

CSA. (2016). *Engineering Geologic Investigation Technical Memorandum Eagle Canyon Fish Passage Improvement in Battle Creek.* Tech. rep., Cotton, Shires and Associates, Inc. for California Department of Fish and Wildlife.

Earley, L. A. (2014, March). *Summary of the Pilot Assessment of Three Potential Fish Barriers on Battle Creek.* Tech. rep., U.S. Fish and Wildlife Service, Red Bluff.

Froese, R., & Pauly, D. (2016, June). Fishbase. *Fishbase.* Retrieved from www.fishbase.org

GMA. (2016). *North Fork Battle Cr Eagle Canyon Survey Report.* Tech. rep., GMA Hydrology, Inc. for California Department of Fish and Wildlife.

Hunter, L. A., & Mayor, L. (1986). *Analyis of Fish: Swimming Performance Data.* Tech. rep.

MLA. (2016a). *Final Eagle Canyon Fish Passage Improvement Project; Task 2: Topographic Surveying and Boulder Mapping Results.* Tech. rep., Michael Love \& Associates.

MLA. (2016b). *Eagle Canyon Fish Passage Improvmeents in Battle Creek Lower and Upper Barrier Sites: Exisitng Site and Hydraulic Characterization Technical Memorandum.* Tech. rep., Michael Love \& Associates for CDFW.

MLA. (2017). *Eagle Canyon Fish Passage Improvmeents in Battle Creek Lower and Upper Barrier Sites: Alternative Analysis Report.* Tech. rep., Michael Love \& Associates for CDFW.

MOU. (1999). *Memorandum of Understanding: To Memorialize the Agreement Regarding the Proposed Battle Creek Chinkook Salmon and Steelhead Restoration Project, Loacted in the Battle Creek Watershed in Tehama and Shasta Counties, California.* Tech. rep., National Marine Fishereies Service, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game, and Pacific Gas and Electric Company.

NMFS-NW. (2011). *Anadromous Salmonid Passage Facility Design.* National Marine Fisheries Service, Northwest Region.

NMFS-SW. (2001, September). *Guidelines for Salmonid Passage at Stream Crossings.* Tech. rep., NOAA National Marine Fisheries.

Paulik, G. J., DeLacy, A. C., & Stacy, E. F. (1957). *The Effect of Rest on the Swimming Performance of Fatigued Adult Silver Salmon.* Tech. rep.

Reynolds, F. L., Mills, T. J., Benthin, R., & Low, A. (1993). *Restoring Central Valley streams: a plan for action.* Department of Fish and Game.

Schaffter, R. G. (1980). *Fish occurrence, size, and distribution in the Sacramento River near Hood, California during 1973 and 1974.* Calif. Department of Fish and Game.

Smelser, M. C. (2012). *Draft - Engineering Geologic Investigation and Analysis, Eagle Canyon Fish Passage Barrier, Battle Creek, Tehama County, California.* Tech. rep., California Department of Fish and Wildlife.

SRD. (2016a). *Eagle Canyon Fish Passage Improvements Alternative Analysis Constructability Review Memorandum.* Tech. rep., SR Diversified.

SRD. (2016b). *Eagle Canyon Fish Passage Improvements Alternative Class 4 Estimate Narrative.* Tech. rep., SR Diversified.

SRD. (2017). *Eagle Canyon Fish Passage Improvements Construction Cost Estimate (AACE Class 2) Narrative.* Tech. rep., SR Diversified.

TRPA. (1998). *Battle Creek Fisheries Investigations; Task 4: Surveys of Barriers to the Upstream Migration of Anadromous Fish.* Tech. rep., Thomas R. Payne and Associates.

USBR. (2001, April). *Hydrology of North and South Fork Battle Creeks.* Tech. rep., U.S. Department of the Interior Bureau of Reclamation.

USFS. (2006). *FishXing Users Manual.* Tech. rep., U.S. Department of Agriculture, U.S. Forest Service. Retrieved from http://www.fsl.orst.edu/geowater/FX3/help/FX3_Help.html

Vogel, D., & Marine, K. (1991). *Guide to Upper Sacramento River Chinook salmon life history.* Tech. rep., Prepared for U.S. Bureau of Reclamation by CH2MHill.

Vogel, R. M., & Fennessey, N. M. (1994). Flow-duration curves. I: New interpretation and confidence intervals. *Journal of Water Resources Planning and Management, 120*(4), 485-504.

Ward, M. B., & Kier, W. M. (1999). *Battle Creek Salmon and Steelhead Restoratioin Plan.* Tech. rep., Kier Associates for Battle Creek Working Group.

Weaver, C. (1963). Influence of water velocity upon orientation and performance of adult migrating salmonids. *U.S. Fish and Wildlife Service, Fishery Bulletin, 63*(1), 97-121.

**(Page intentionally left blank)**

# Attachment 1
# 90% Design Drawings

# CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

*PLANS FOR CONSTRUCTION OF*

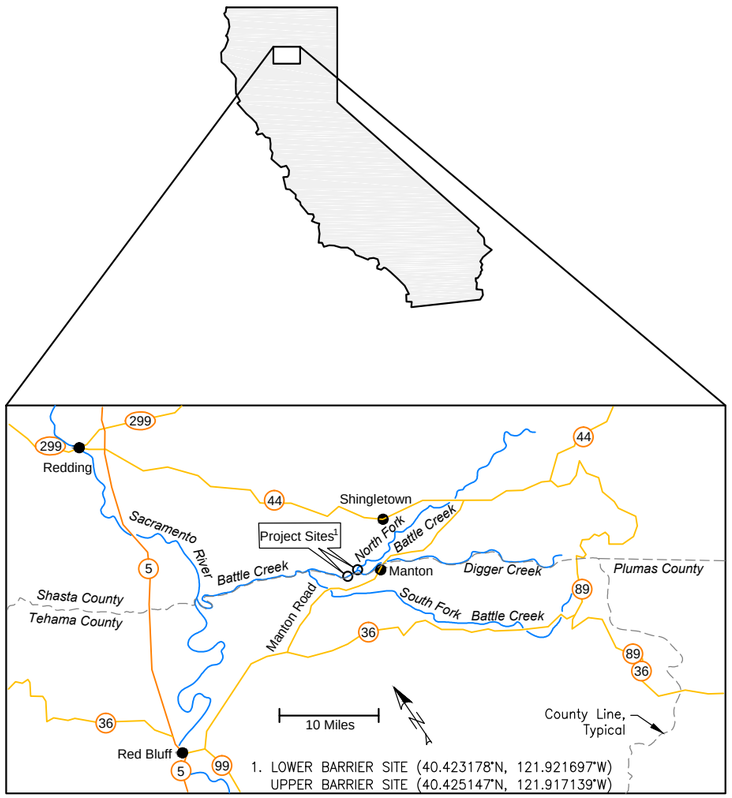
## *NORTH FORK BATTLE CREEK*
## *EAGLE CANYON FISH PASSAGE IMPROVEMENT*

***FEBRUARY 2017***

***90% SUBMITTAL***

**Prepared For:**

**CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE**
**AGREEMENT NUMBER: D1499019**




***PROJECT LOCATION MAP***

**APPROVALS**

***Michael Love and Associates, Inc.***

**Michael Love, P.E., Principal Engineer**

_____

**P. Travis James, P.E., Project Engineer**

_____

***California Department of Fish and Wildlife***

**Approved by:**

_____

**PRELIMINARY**
NOT FOR CONSTRUCTION


**Michael Love & Associates, Inc.**
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**Department of Fish and Wildlife**
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**PROJECT TITLE SHEET**

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 1 of 27 |

**G-1**

# LEGEND AND SYMBOLS

## EXISTING

- FENCE LINE
- EXISTING CONTOUR AND ELEVATION
- SPOT ELEVATION
- CHANNEL THALWEG OR DRAINAGE
- ALIGNMENT STATIONING (FEET)
- TREE DRIP LINE
- CONTROL POINT/TEMPORARY BENCH MARK
- FLOW DIRECTION
- STUMP
- TREE
- CULVERT
- SIDEWALK
- ROCK SLOPE PROTECTION (RSP)
- STORM DRAIN
- TOP OF BANK
- SIEVE (VOID UNDER BOULDERS)
- B65 INDIVIDUAL BOULDER I.D.
- BOULDER COMPLEX
- FL2-1 FLOW LINE ID

## NEW

- SURVEY CONTROL POINT
- LIMIT OF DISTURBANCE
- FENCE LINE
- CONTOUR AND ELEVATION
- SPOT ELEVATION
- STATIONING ALONG ALIGNMENT (FEET)
- CHANNEL THALWEG OR DRAINAGE
- TEMPORARY ISOLATION MEASURE
- SLOPE LINE
- RIPARIAN PLANTING AREA
- STAGING AREA
- LOG/LARGE WOOD STRUCTURE
- WATER SURFACE
- BOULDER OR BEDROCK REMOVAL OR MODIFICATION
- APPROXIMATE VEGETATION REMOVAL LIMITS

## ABBREVIATIONS

| | |
|---|---|
| AKA | ALSO KNOWN AS |
| APPROX, ~ | APPROXIMATELY |
| BLDR | BOULDER |
| CA | CALIFORNIA |
| CGL | CHANNEL GRADE LINE |
| CL | CENTERLINE |
| CMP | CORRUGATED METAL PIPE |
| CO | CONTRACT OWNER |
| COR | CONTRACT OWNER REPRESENTATIVE |
| CP | SURVEY CONTROL POINT |
| CY | CUBIC YARDS |
| DIA | DIAMETER |
| DWG | DRAWING |
| EG | EXISTING GROUND |
| EL | ELEVATION |
| (E) | EXISTING |
| FG | FINISHED GROUND |
| ' | FOOT OR FEET |
| HDPE | HIGH DENSITY POLYETHYLENE |
| HGL | HYDRAULIC GRADE LINE |
| " | INCH |
| I.D., ID | IDENTIFICATION |
| LBS | LOWER BARRIER SITE |
| LOD | LIMIT OF DISTURBANCE |
| MAX/MIN | MAXIMUM/MINIMUM |
| (N) | NEW |
| NF | NORTH FORK |
| NTS | NOT TO SCALE |
| OZ | OUNCE |
| O.C. | ON CENTER |
| RD | ROAD |
| SF | SOUTH FORK |
| STA | STATION |
| SY | SQUARE YARDS |
| TBM | TEMPORARY BENCHMARK |
| TOC | TOP OF CONCRETE |
| TYP | TYPICAL |
| UBS | UPPER BARRIER SITE |
| VEG | VEGETATION |
| W/ | WITH |
| (1.5:1) | (HORIZONTAL:VERTICAL) SLOPE |
| % | PERCENT |

A LOCATION AND ORIENTATION OF PHOTOGRAPH

1 / C-1 — SECTION, DETAIL OR TYPICAL NAME (LETTER INDICATES SECTION, NUMBER INDICATES DETAIL OR TYPICAL); DWG NO. ON WHICH SECTION, TYPICAL, OR DETAIL APPEARS

NOTE: CONTACT ENGINEER FOR ABBREVIATIONS OR SYMBOLS NOT LISTED

### GENERAL

| Sheet Number | DWG | Sheet Title |
|---|---|---|
| 1 | G-1 | PROJECT TITLE SHEET |
| 2 | G-2 | DRAWING LIST AND LEGEND |
| 3 | G-3 | EXISTING COND., SHEET INDEX & ACCESS MAP |

### LOWER BARRIER SITE

| Sheet Number | DWG | Sheet Title |
|---|---|---|
| 4 | C-1 | CONTRACTOR ACCESS & USE AREA OPTION 1 |
| 5 | C-2 | CONSTRUCTION ACCESS & SITE USE OPTION 2 |
| 6 | C-3 | EAGLE CANYON SECTION |
| 7 | C-4 | HORIZONTAL AND VERTICAL CONTROL |
| 8 | C-5 | WATER MANAGMENT PLAN & PROFILE |
| 9 | C-6 | DEMO PLAN |
| 10 | C-7 | DEMO PHOTOGRAPHS |
| 11 | C-8 | DESIGN PLAN, PROFILE, DETAILS, & NOTES |
| 12 | C-9 | SECTIONS, 1 OF 2 |
| 13 | C-10 | SECTIONS, 2 OF 2 |

### UPPER BARRIER SITE

| Sheet Number | DWG | Sheet Title |
|---|---|---|
| 14 | C-11 | ACCESS & USE AREA OPTION 1 PLAN |
| 15 | C-12 | ACCESS & USE AREA OPTION 2 PLAN |
| 16 | C-13 | ACCESS & USE AREA OPTIONS 1 & 2 SECTIONS |
| 17 | C-14 | HORIZONTAL AND VERTICAL CONTROL |
| 18 | C-15 | WATER MANAGEMENT, 1 OF 2 |
| 19 | C-16 | WATER MANAGEMENT, 2 OF 2 |
| 20 | C-17 | DEMO PLAN |
| 21 | C-18 | DEMO PHOTOGRAPHS |
| 22 | C-19 | CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE |
| 23 | C-20 | CHANNEL MODIFICATION NOTES |
| 24 | C-21 | HYDRAULIC STRUCTURE TYPICALS |
| 25 | C-22 | WEIR CONSTRUCTION PLAN & PHOTOS |
| 26 | C-23 | CONCRETE WEIR SECTION & DETAIL |

### DETAILS

| Sheet Number | DWG | Sheet Title |
|---|---|---|
| 27 | C-24 | PROJECT DETAILS AND TYPICALS |

Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

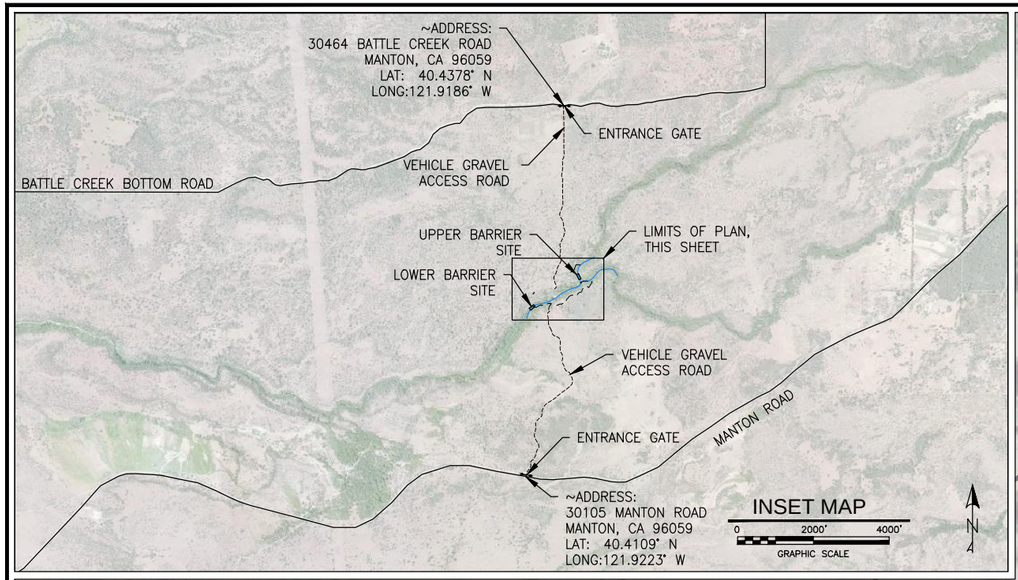
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**DRAWING LIST AND LEGEND**

DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
2 of 27

**G-2**




NOTES:

1. PERMISSION REQUIRED TO ACCESS BARRIER SITES.
2. ACCESS TO SOUTH RIM MUST FOLLOW PG&E'S ACCESS PROTOCOL, SEE SPECIFICATION 01 14 10 SITE USE
3. KEEP ACCESS CLEAR FOR PG&E
4. KEEP ACCESS CLEAR FOR LANDOWNERS



Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER & LOWER BARRIER SITES
# EXISTING COND. SHEET INDEX & ACCESS MAP

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 3 of 27 |

**G-3**

**NOTES:**

1. THIS DRAWING PRESENTS CONSTRUCTION ACCESS OPTION 1 OF 2.
2. FOLLOW PG&E ACCESS PROTOCOL, SEE SPECIFICATION 01 14 10
3. KEEP ACCESS ROADS CLEAR
4. MINIMIZE VEGETATION CLEARING TO AMOUNT NECESSARY FOR CONSTRUCTION

**LEGEND**

APPROX LIMITS OF CHANNEL MODIFICATION

OPTION 1 VEGETATION CLEARING LIMITS

5+70
5+50
5+00
4+50
4+00
3+50
3+00
2+50
2+00
1+50
1+00
0+50
0+00

1575
1550
1475
1425
1400
1450
1375

NORTH FORK BATTLE CREEK

FLOW!

CANYON SECTION, SEE DWG C-3

APPROXIMATE LIMITS OF CHANNEL MODIFICATION

APPROXIMATE LOCATION OF (E) PG&E ACCESS WALKWAYS AND STAIRS.

**OPTION 1:** APPROXIMATE LIMITS OF VEGETATION REMOVAL FOR OPERATING CRANE

**OPTION 1:** APPROXIMATE CRANE PAD LOCATION

100' RADIUS

200' RADIUS

300' RADIUS

CONTRACTOR USE AREA

CONTRACTOR USE AREA

VEGETATION REMOVAL WITHIN CONTRACTOR USE AREA PER SPECIFICATIONS

(E) GRAVEL VEHICLE ACCESS ROAD

PLAN

0 50' 100'

GRAPHIC SCALE

N


**Michael Love & Associates, Inc.**
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**Department of Fish and Wildlife**
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE
# CONTRACTOR ACCESS & USE AREA OPTION 1

| | |
|---|---|
| DATE | |
| FEBRUARY 2017 | SUBMITTAL |
| 90% DESIGN | DESIGN |
| ML, pTJ | DRAWN |
| pTJ, NN | SHEET |
| 4 of 27 | |

**C-1**

2/6/2017 9:56:05 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_LB_ConstructionStaging_Option1.dwg

**NOTES:**

1. THIS DRAWING PRESENTS CONSTRUCTION ACCESS OPTION 2 OF 2.
2. FOLLOW PG&E ACCESS PROTOCOL, SEE SPECIFICATION 01 14 10
3. KEEP ACCESS ROADS CLEAR
4. MINIMIZE VEGETATION CLEARING TO AMOUNT NECESSARY FOR CONSTRUCTION

**LEGEND**

APPROX LIMITS OF CHANNEL MODIFICATION

OPTION 2 VEGETATION CLEARING LIMITS

(E) GRAVEL VEHICLE ACCESS ROAD

APPROXIMATE LOCATION FOR SKYLINE YARDING ANCHOR

5+70

5+50

5+00

4+50

4+00

3+50

3+00

2+50

2+00

1+50

1+00

0+50

0+00

NORTH FORK BATTLE CREEK

FLOW

APPROXIMATE LOCATION OF (E) PG&E ACCESS WALKWAYS AND STAIRS.

**OPTION 2:** POTENTIAL SKYLINE SPAN, FOR CANYON SECTION SEE DWG C-3

APPROXIMATE LIMITS OF CHANNEL MODIFICATION

**OPTION 2:** APPROXIMATE SKYLINE YARDER TRAVEL PATH

**OPTION 2:** APPROXIMATE LIMITS OF VEGETATION REMOVAL FOR YARDER OPERATION

CONTRACTOR USE AREA

CONTRACTOR USE AREA

VEGETATION REMOVAL WITHIN CONTRACTOR USE AREA PER SPECIFICATIONS

1575 1550 1475 1425 1400 1375 1405.00

PLAN

0 50' 100'

GRAPHIC SCALE

N

2/6/2017 9:56:40 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_LB_ConstructionStaging_Option2.dwg


**Michael Love & Associates, Inc.**
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**Department of Fish and Wildlife**
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

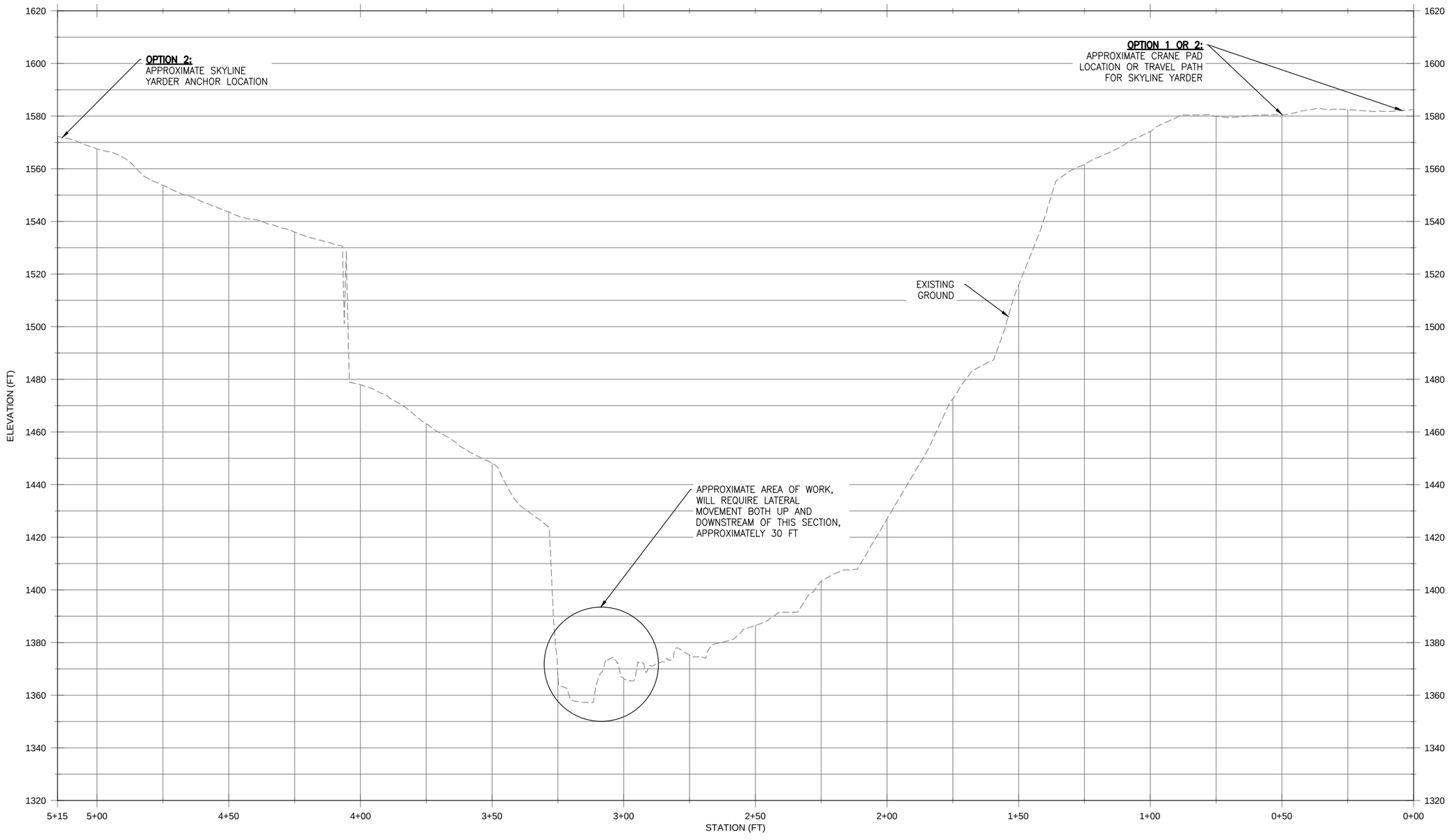

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE
# CONSTRUCTION ACCESS & SITE USE OPTION 2

| | |
|---|---|
| DATE | |
| FEBRUARY 2017 | SUBMITTAL |
| 90% DESIGN | DESIGN |
| ML, pTJ | DRAWN |
| pTJ, NN | SHEET |
| 5 of 27 | |

**C-2**




## CANYON SECTION (LOOKING UPSTREAM)

0 20' 40'
GRAPHIC SCALE

2/6/2017 9:57:14 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_LB_ConstructionStaging_Option1.dwg


**Michael Love & Associates, Inc.**
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**Department of Fish and Wildlife**
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

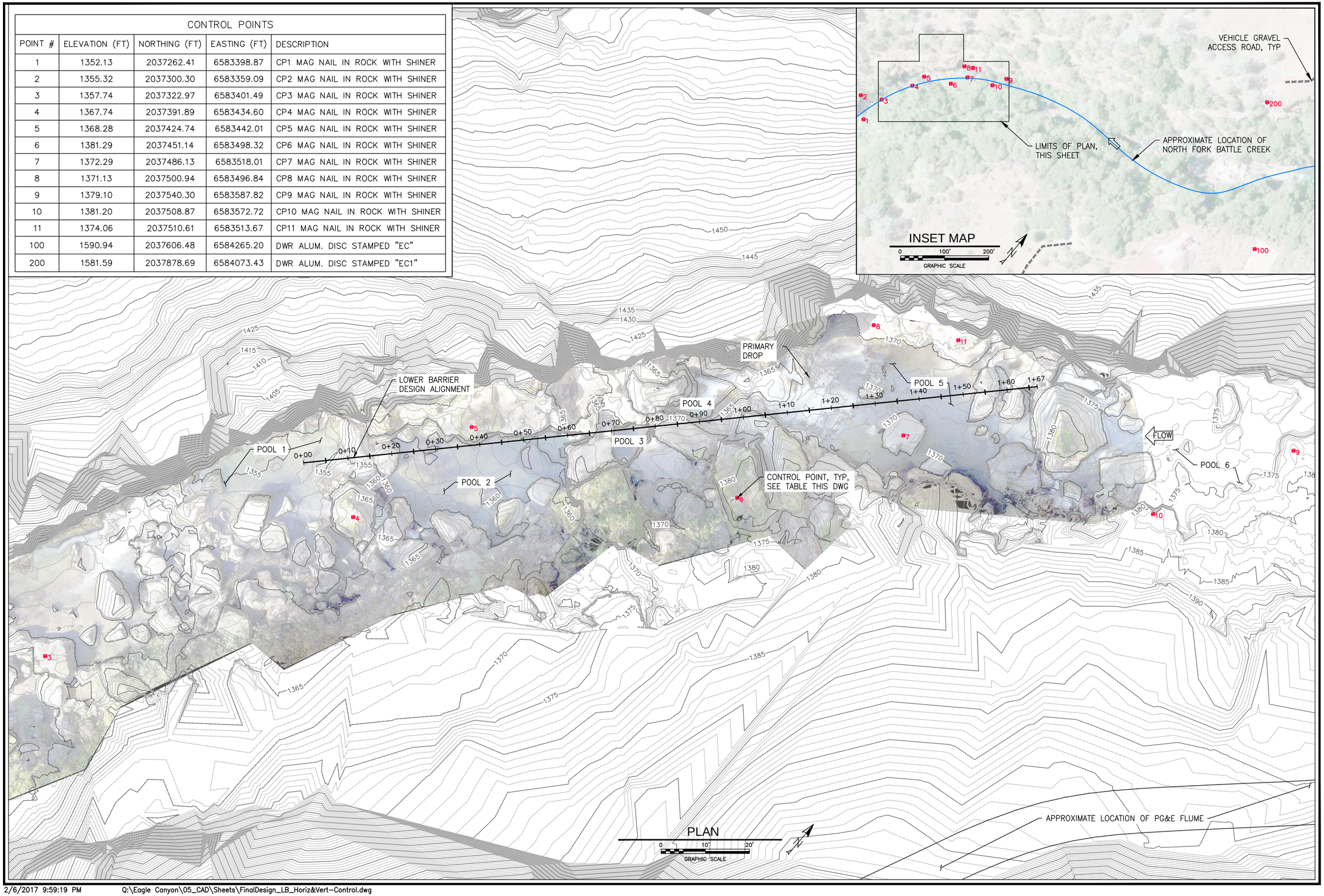
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE
# EAGLE CANYON SECTION

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 6 of 27 |

**C-3**

| CONTROL POINTS | | | | |
|---|---|---|---|---|
| POINT # | ELEVATION (FT) | NORTHING (FT) | EASTING (FT) | DESCRIPTION |
| 1 | 1352.13 | 2037262.41 | 6583398.87 | CP1 MAG NAIL IN ROCK WITH SHINER |
| 2 | 1355.32 | 2037300.30 | 6583359.09 | CP2 MAG NAIL IN ROCK WITH SHINER |
| 3 | 1357.74 | 2037322.97 | 6583401.49 | CP3 MAG NAIL IN ROCK WITH SHINER |
| 4 | 1367.74 | 2037391.89 | 6583434.60 | CP4 MAG NAIL IN ROCK WITH SHINER |
| 5 | 1368.28 | 2037424.74 | 6583442.01 | CP5 MAG NAIL IN ROCK WITH SHINER |
| 6 | 1381.29 | 2037451.14 | 6583498.32 | CP6 MAG NAIL IN ROCK WITH SHINER |
| 7 | 1372.29 | 2037486.13 | 6583518.01 | CP7 MAG NAIL IN ROCK WITH SHINER |
| 8 | 1371.13 | 2037500.94 | 6583496.84 | CP8 MAG NAIL IN ROCK WITH SHINER |
| 9 | 1379.10 | 2037540.30 | 6583587.82 | CP9 MAG NAIL IN ROCK WITH SHINER |
| 10 | 1381.20 | 2037508.87 | 6583572.72 | CP10 MAG NAIL IN ROCK WITH SHINER |
| 11 | 1374.06 | 2037510.61 | 6583513.67 | CP11 MAG NAIL IN ROCK WITH SHINER |
| 100 | 1590.94 | 2037606.48 | 6584265.20 | DWR ALUM. DISC STAMPED "EC" |
| 200 | 1581.59 | 2037878.69 | 6584073.43 | DWR ALUM. DISC STAMPED "EC1" |





Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

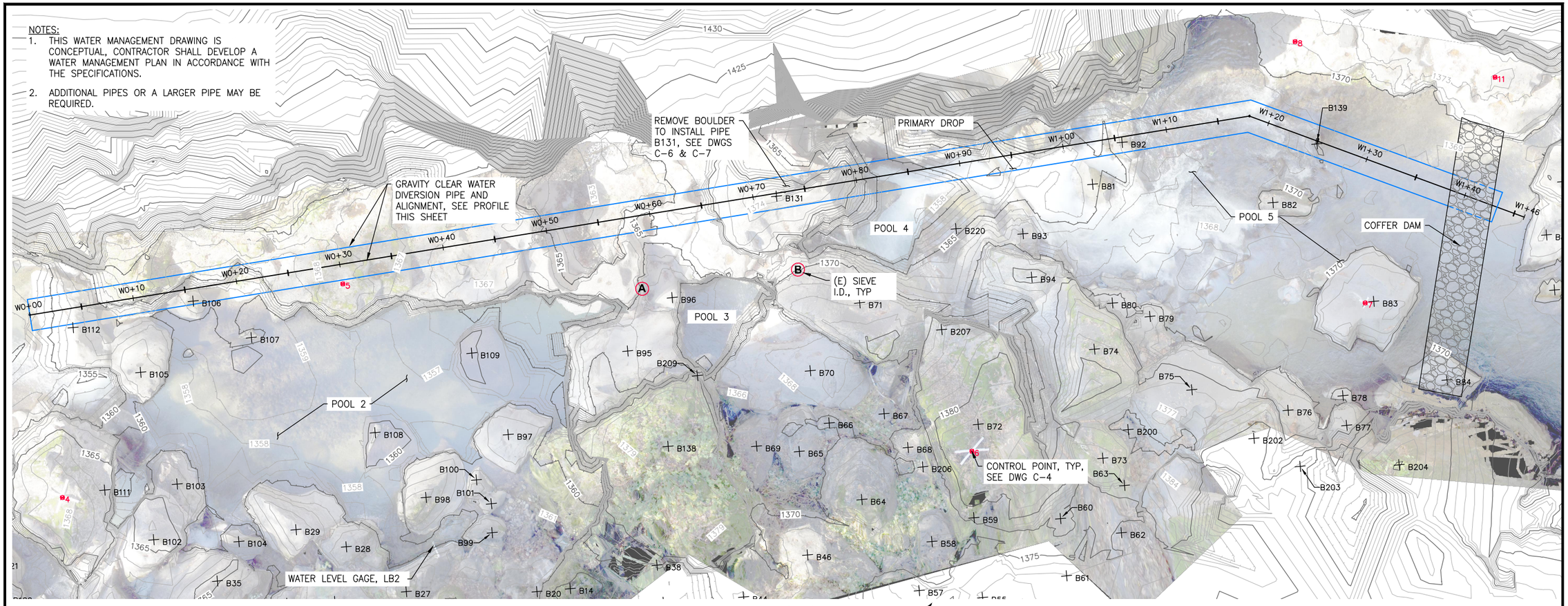
# LOWER BARRIER SITE
# HORIZONTAL AND VERTICAL CONTROL

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 7 of 27 |

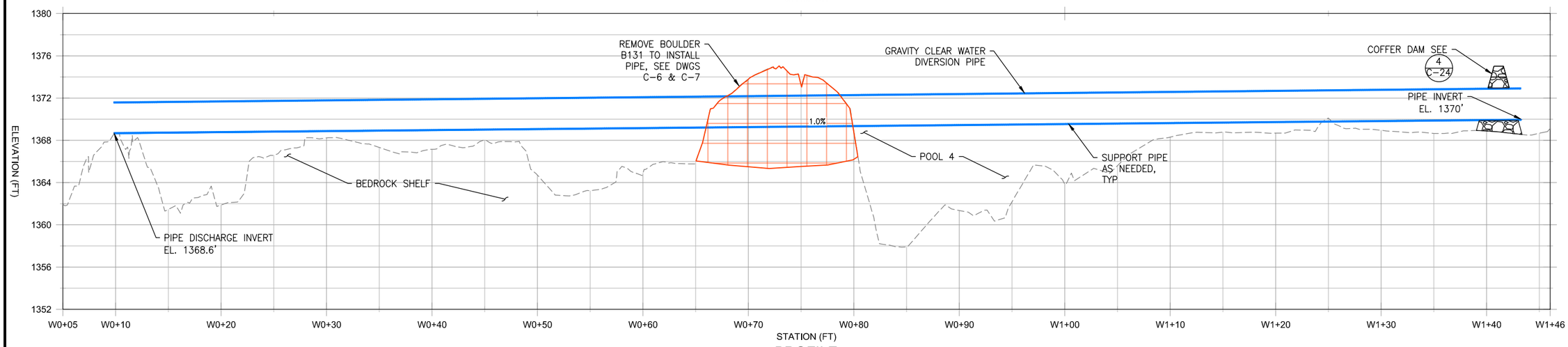
**C-4**

2/6/2017 9:59:19 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_LB_Horiz&Vert-Control.dwg

NOTES:
1. THIS WATER MANAGEMENT DRAWING IS CONCEPTUAL, CONTRACTOR SHALL DEVELOP A WATER MANAGEMENT PLAN IN ACCORDANCE WITH THE SPECIFICATIONS.
2. ADDITIONAL PIPES OR A LARGER PIPE MAY BE REQUIRED.




PLAN
0 5' 10'
GRAPHIC SCALE




PROFILE
0 5' 10'
GRAPHIC SCALE


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411


Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE
# WATER MANAGMENT PLAN & PROFILE

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 8 of 27 |

**C-5**

| Complex | Boulder | Axis Dimensions (ft)[3] a | b | c | Volume (CY)[4] | Weight (Ton)[5] |
|---|---|---|---|---|---|---|
| Middle Complex | B206 | 6.4 | 3.0 | 2.0 | 1.4 | 3.2 |
| | B68 | 3.6 | 3.2 | 3.0 | 0.8 | 1.7 |
| B72 Complex | B72 | 14.3 | 10.1 | 6.6 | 35.3 | 78.4 |
| | B221 | 4.3 | 3.7 | 2.9 | 1.7 | 3.8 |
| | B208 | 4.4 | 4.0 | 2.7 | 1.8 | 3.9 |
| | B59 | 8.6 | 4.7 | 1.7 | 2.5 | 5.6 |
| | B207 | 8.0 | 3.9 | 3.2 | 1.8 | 4.1 |
| | B74 | 11.8 | 6.1 | 5.0 | 13.3 | 29.6 |
| | B73 | 4.5 | 3.9 | 3.9 | 2.5 | 5.6 |
| | B79 | 4.8 | 3.8 | 2.2 | 1.5 | 3.3 |
| | B80 | 4.6 | 6.8 | 4.2 | 2.4 | 5.4 |
| | B94 | 7.6 | 7.2 | 4.8 | 9.7 | 21.6 |
| | B93 | 4.5 | 4.4 | 3.2 | 1.2 | 2.6 |
| | B220[1] | ? | ? | ? | 9.5 | 21.1 |
| Boulder B131 | B131 | 12.0 | 11.8 | 6.0 | 31.5 | 69.8 |
| Boulder B71 | B71 | 14.6 | 10.1 | 6.2 | 33.9 | 75.2 |
| Misc. | B92 | 5.9 | 2.8 | 2.0 | 0.6 | 1.4 |
| | B81 | 5.5 | 3.0 | 2.0 | 1.2 | 2.7 |
| North Chute Grading[6] | B131 | NA | NA | NA | 10.0 | 22.2 |
| South Chute Grading[6] | B71 | NA | NA | NA | 7.0 | 15.5 |
| Unseen[2] | NA | NA | NA | NA | 17.0 | 37.7 |
| **Estimated volume of rock to be removed: 187 cubic yards, 414 tons** | | | | | | |

1. Survey lacks definition for this boulder. Based on photograph review, the boulder is estimated to be similar to B94.
2. Some boulders to be removed are below the visible boulders. The volume of this rock is not know and for estimating purposes is assumed to be equal to 10% of the visible boulder total.
3. See Detail 2 on Drawing C-24. All dimensions are approximate & should be verified by the Contractor.
4. Volume calculated by various means (e.g. rectangular cuboid, sphere, etc.), therefore additional dimensions may have been utilized than are shown in the table. Axes dimensions shown are for informational purposes (i.e. to understand general shape and size of the boulder).
5. Estimate of tonnage based on assumed rock density of 2.2 tons/CY
6. May include removal or modificiation of bedrock.

LEGEND

APPROXIMATE BOULDER AND BEDROCK REMOVAL AREA

BOULDER COMPLEX (COMPRISED OF ONE OR MORE BOULDERS)

NOTE:
1. THE LIMITS OF CHANNEL MODIFICATION ARE APPROXIMATE AND TO BE USED AS A GENERAL GUIDE.
2. SEE CONSTRUCTION NOTES ON DWG C-8

PLAN

0 5' 10'
GRAPHIC SCALE

2/6/2017 10:03:44 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_LB_Demo.dwg


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE DEMO PLAN

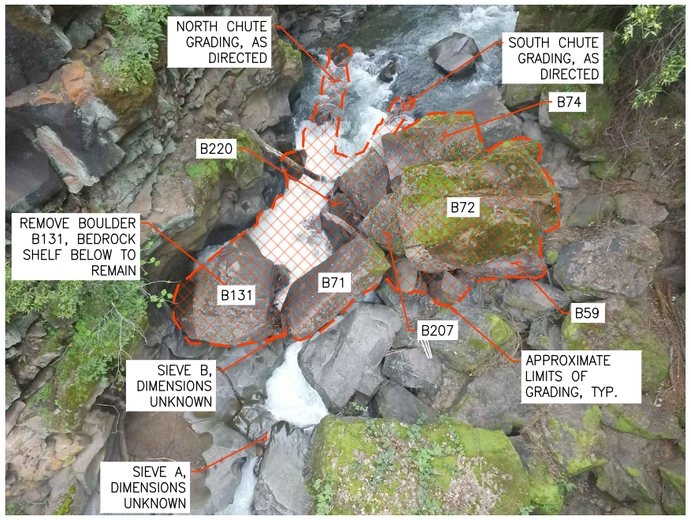
| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 9 of 27 |

**C-6**

NOTE:
1. THE LIMITS OF CHANNEL MODIFICATION ARE APPROIXMATE AND TO BE USED AS A GENERAL GUIDE.
2. SEE DRAWING C-6 FOR LOCATION WHERE PHOTOGRAPH TAKEN

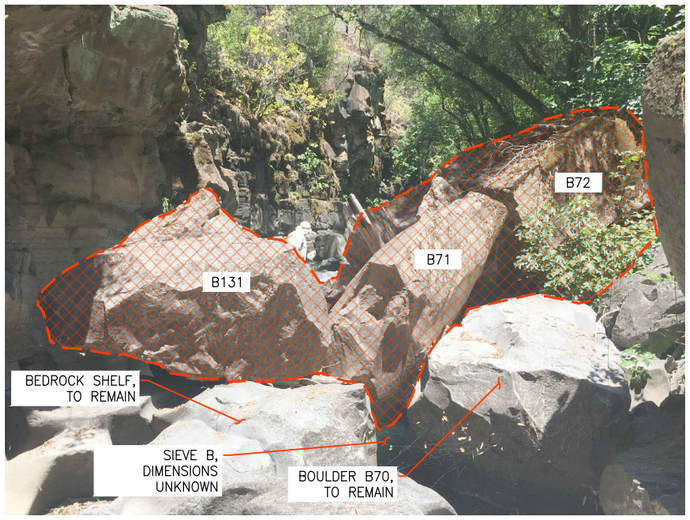
LEGEND

APPROXIMATE LIMITS OF CHANNEL MODIFICATION



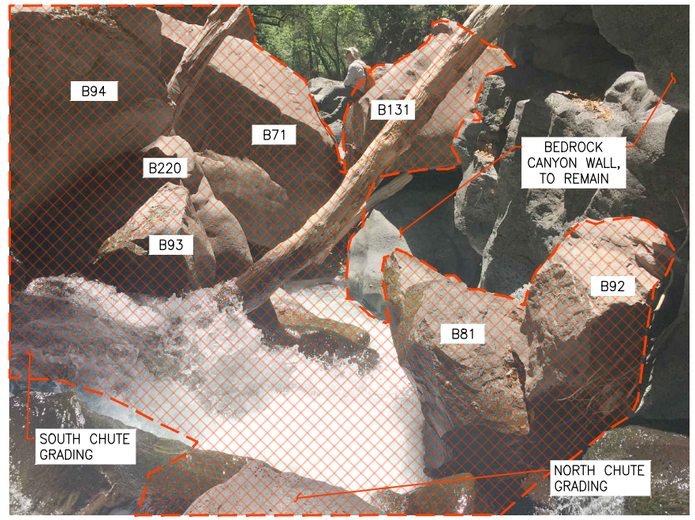

PHOTOGRAPH A

AERIAL, LOOKING UPSTREAM



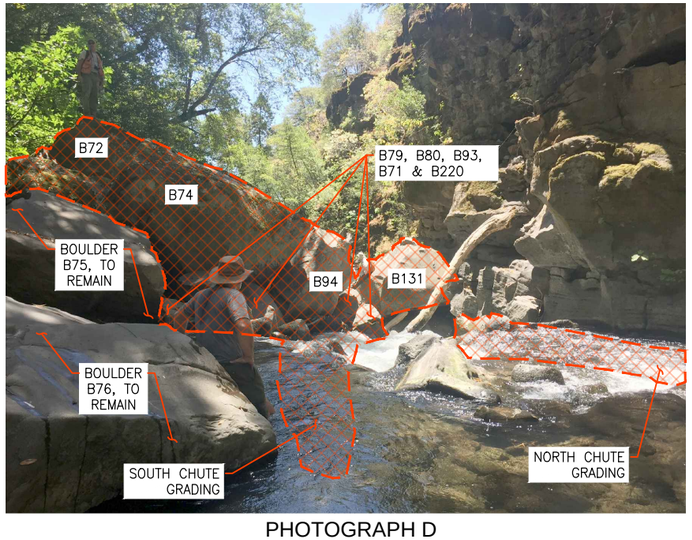

PHOTOGRAPH B

LOOKING UPSTREAM



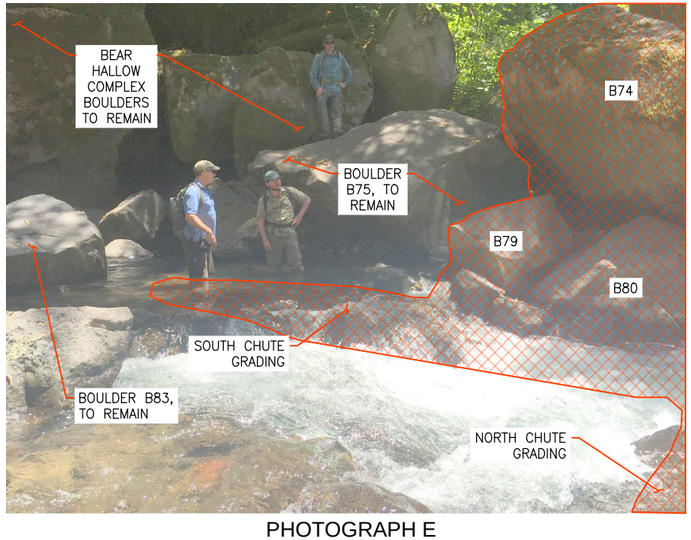

PHOTOGRAPH C

LOOKING DOWNSTREAM




PHOTOGRAPH D

LOOKING DOWNSTREAM




PHOTOGRAPH E

LOOKING TO SOUTH BANK


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

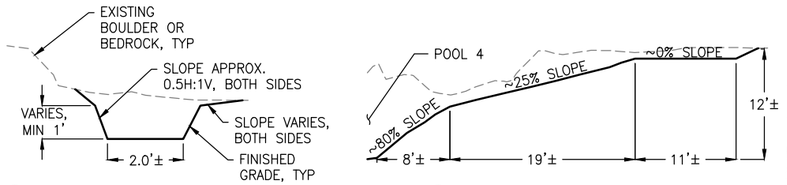

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**LOWER BARRIER SITE**
**DEMO PHOTOGRAPHS**

DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
10 of 27

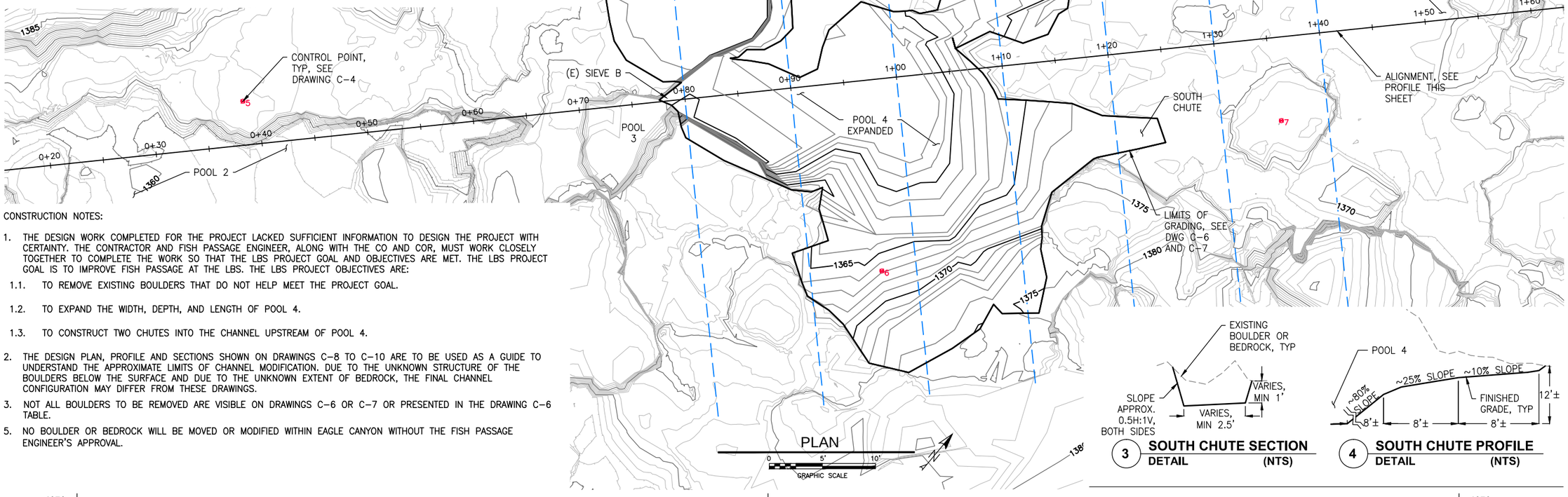
**C-7**




1 **NORTH CHUTE SECTION DETAIL (NTS)**




2 **NORTH CHUTE PROFILE DETAIL (NTS)**




CONSTRUCTION NOTES:

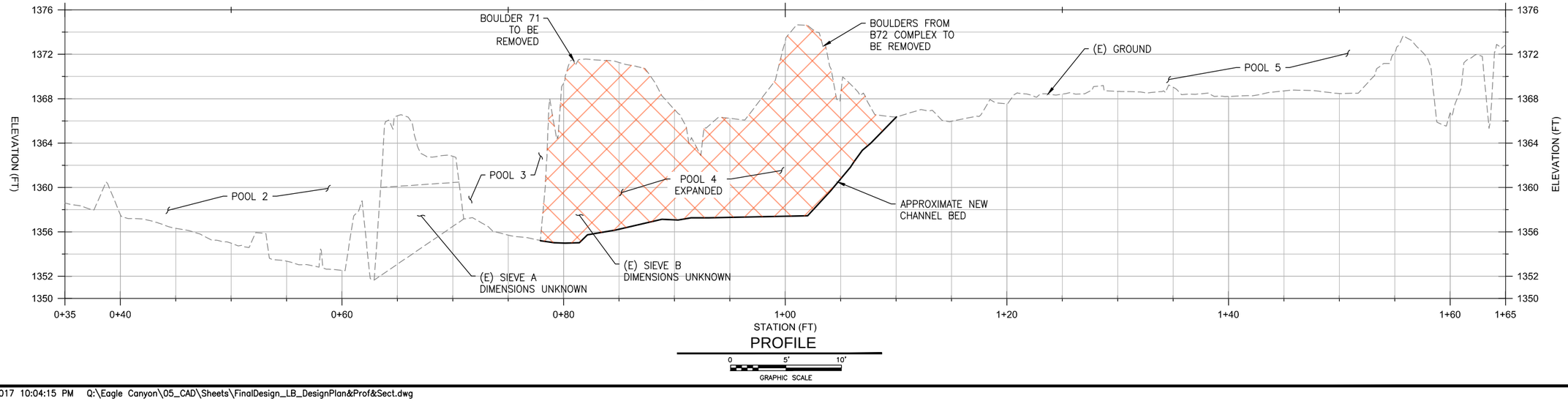
1. THE DESIGN WORK COMPLETED FOR THE PROJECT LACKED SUFFICIENT INFORMATION TO DESIGN THE PROJECT WITH CERTAINTY. THE CONTRACTOR AND FISH PASSAGE ENGINEER, ALONG WITH THE CO AND COR, MUST WORK CLOSELY TOGETHER TO COMPLETE THE WORK SO THAT THE LBS PROJECT GOAL AND OBJECTIVES ARE MET. THE LBS PROJECT GOAL IS TO IMPROVE FISH PASSAGE AT THE LBS. THE LBS PROJECT OBJECTIVES ARE:
   - 1.1. TO REMOVE EXISTING BOULDERS THAT DO NOT HELP MEET THE PROJECT GOAL.
   - 1.2. TO EXPAND THE WIDTH, DEPTH, AND LENGTH OF POOL 4.
   - 1.3. TO CONSTRUCT TWO CHUTES INTO THE CHANNEL UPSTREAM OF POOL 4.
2. THE DESIGN PLAN, PROFILE AND SECTIONS SHOWN ON DRAWINGS C-8 TO C-10 ARE TO BE USED AS A GUIDE TO UNDERSTAND THE APPROXIMATE LIMITS OF CHANNEL MODIFICATION. DUE TO THE UNKNOWN STRUCTURE OF THE BOULDERS BELOW THE SURFACE AND DUE TO THE UNKNOWN EXTENT OF BEDROCK, THE FINAL CHANNEL CONFIGURATION MAY DIFFER FROM THESE DRAWINGS.
3. NOT ALL BOULDERS TO BE REMOVED ARE VISIBLE ON DRAWINGS C-6 OR C-7 OR PRESENTED IN THE DRAWING C-6 TABLE.
5. NO BOULDER OR BEDROCK WILL BE MOVED OR MODIFIED WITHIN EAGLE CANYON WITHOUT THE FISH PASSAGE ENGINEER'S APPROVAL.




3 **SOUTH CHUTE SECTION DETAIL (NTS)**




4 **SOUTH CHUTE PROFILE DETAIL (NTS)**





Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

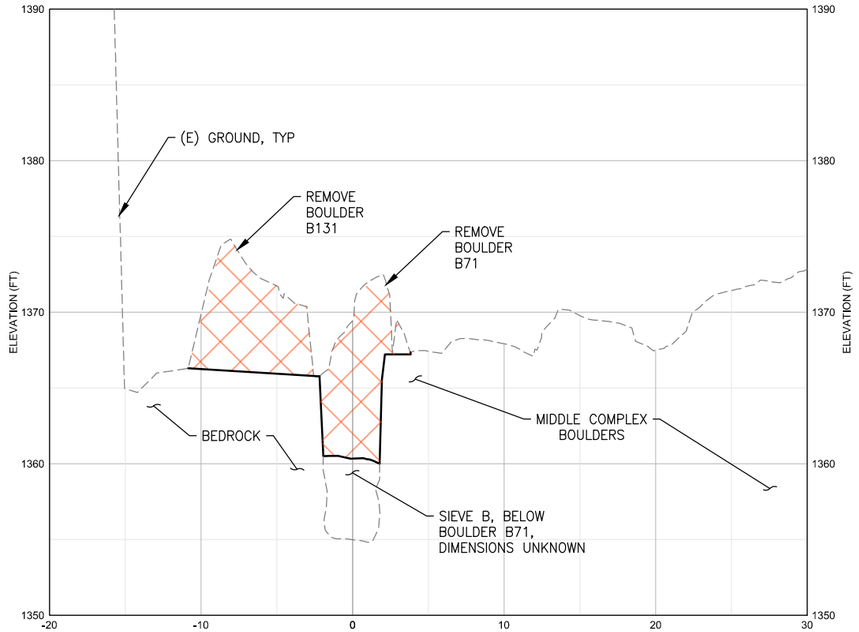

VERIFY SCALE — THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE
# DESIGN PLAN, PROFILE, DETAILS, & NOTES

| | |
|---|---|
| DATE | |
| FEBRUARY 2017 | SUBMITTAL |
| 90% DESIGN | DESIGN |
| ML, pTJ | DRAWN |
| pTJ, NN | SHEET |
| 11 of 27 | |

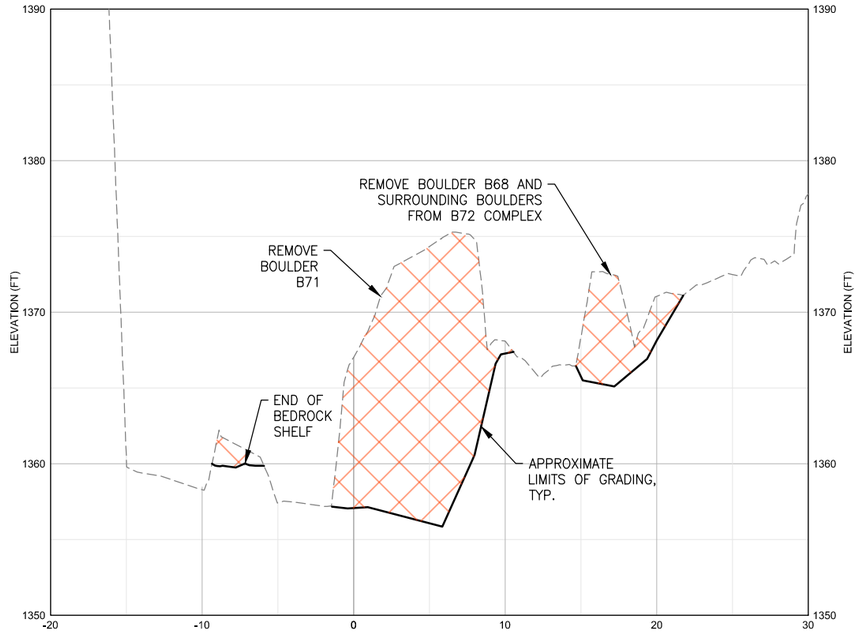
**C-8**




**STATION 0+80 (LOOKING UPSTREAM)**

0 5' 10'

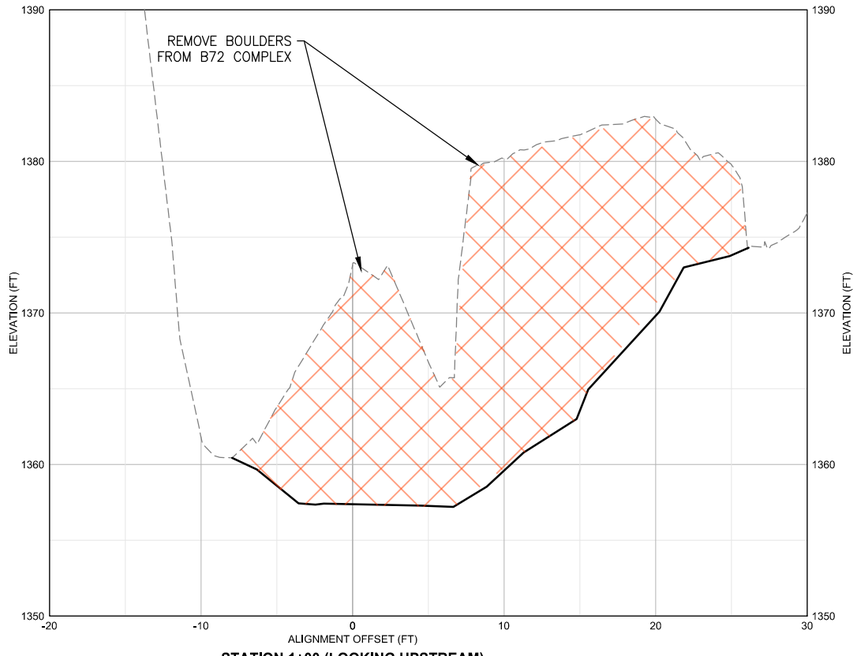
GRAPHIC SCALE




**STATION 0+90 (LOOKING UPSTREAM)**

0 5' 10'

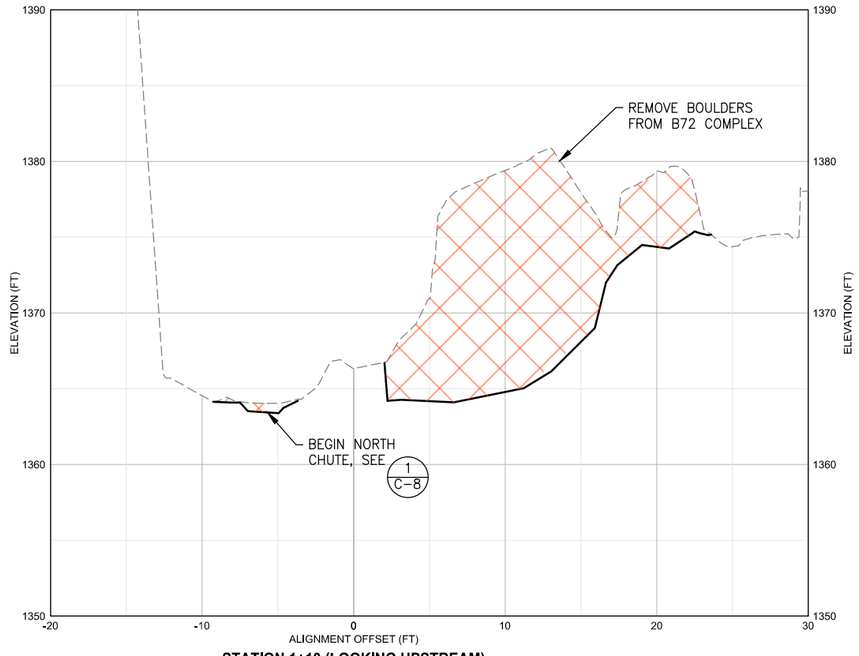
GRAPHIC SCALE




**STATION 1+00 (LOOKING UPSTREAM)**

0 5' 10'

GRAPHIC SCALE




**STATION 1+10 (LOOKING UPSTREAM)**

0 5' 10'

GRAPHIC SCALE


**Michael Love & Associates, Inc.**
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**Department of Fish and Wildlife**
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

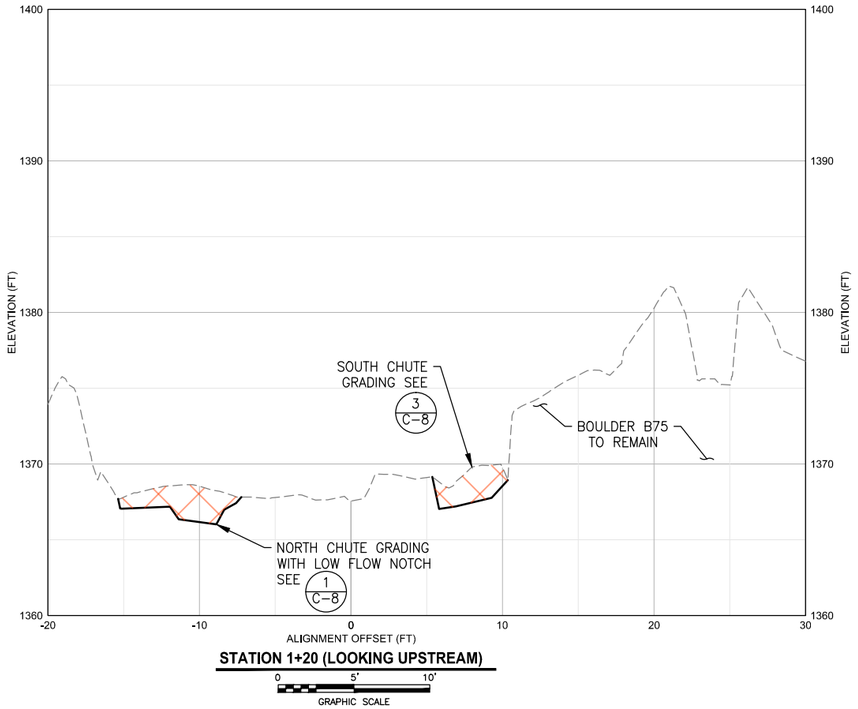

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE SECTIONS, 1 OF 2

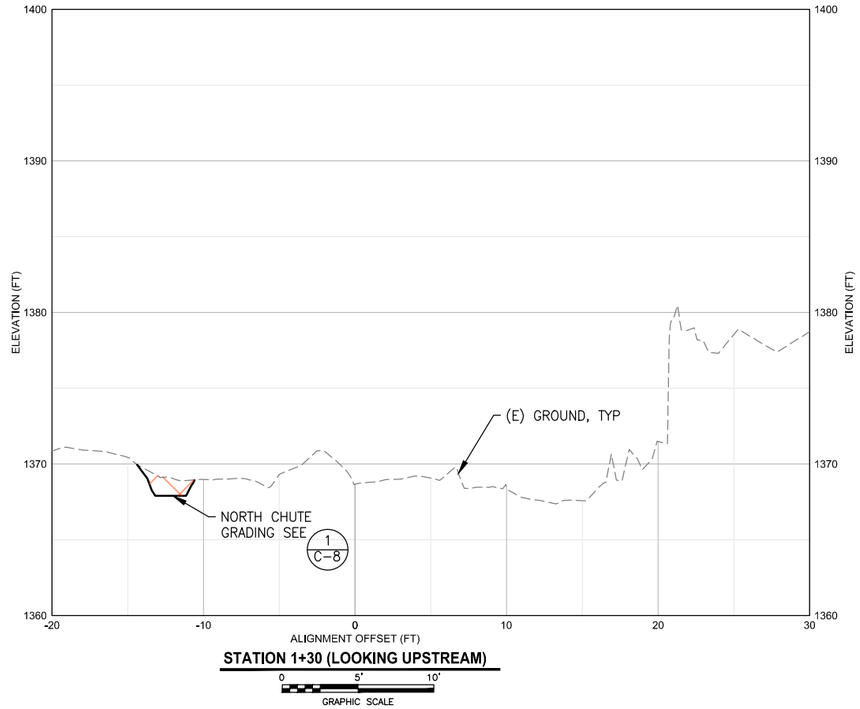
| | |
|---|---|
| DATE | |
| SUBMITTAL | FEBRUARY 2017 |
| DESIGN | 90% DESIGN |
| DRAWN | ML, pTJ |
| SHEET | pTJ, NN |
| | 12 of 27 |

**C-9**



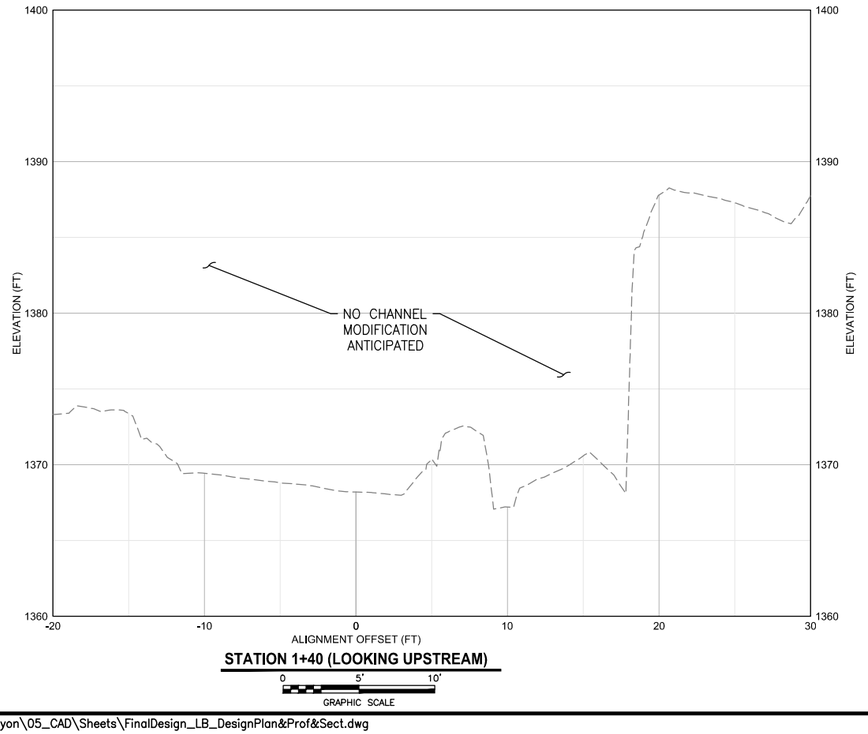

**STATION 1+20 (LOOKING UPSTREAM)**

0 5' 10'
GRAPHIC SCALE




**STATION 1+30 (LOOKING UPSTREAM)**

0 5' 10'
GRAPHIC SCALE




**STATION 1+40 (LOOKING UPSTREAM)**

0 5' 10'
GRAPHIC SCALE


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# LOWER BARRIER SITE SECTIONS, 2 OF 2

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 13 of 27 |

**C-10**

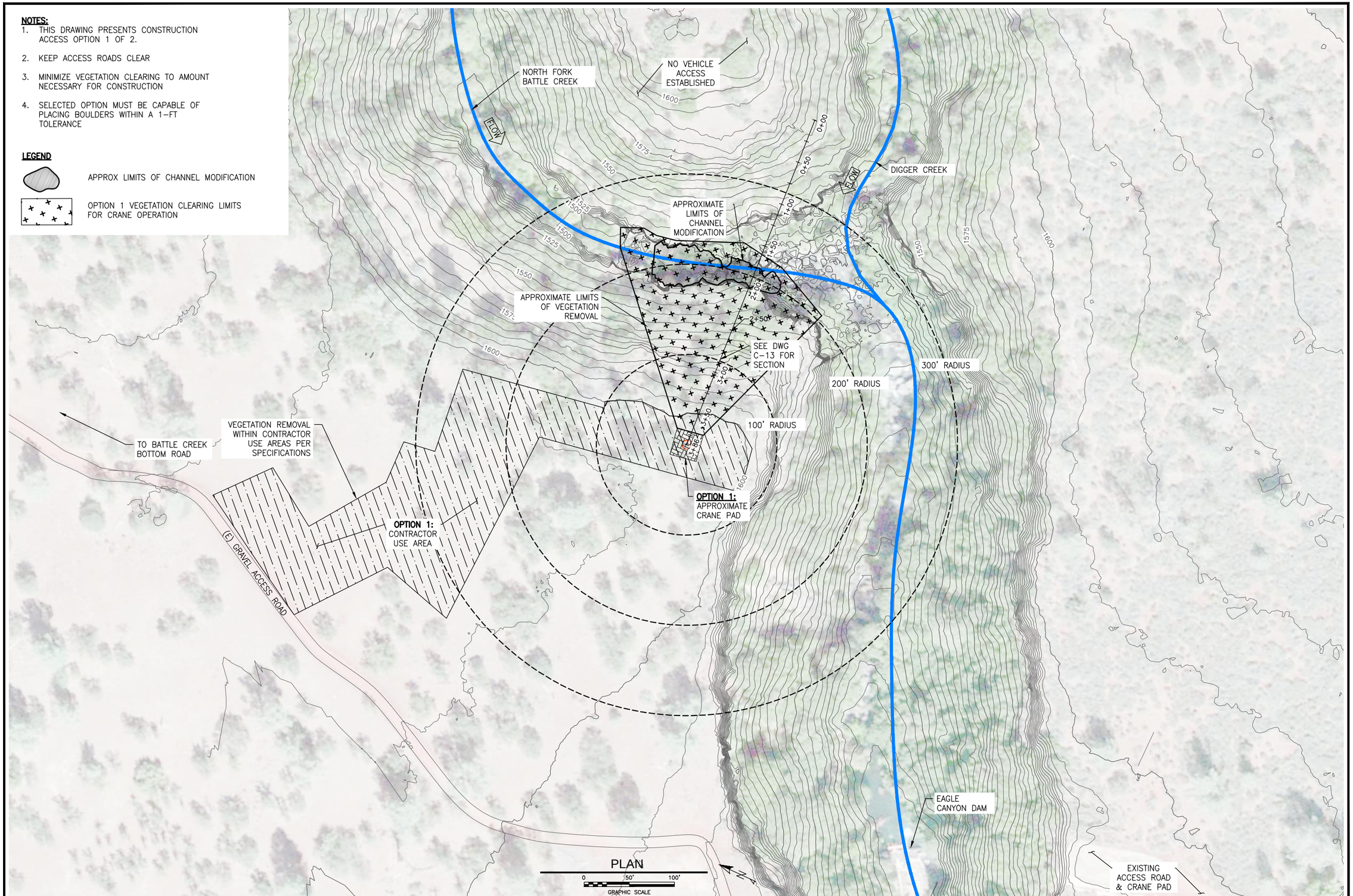
**NOTES:**

1. THIS DRAWING PRESENTS CONSTRUCTION ACCESS OPTION 1 OF 2.
2. KEEP ACCESS ROADS CLEAR
3. MINIMIZE VEGETATION CLEARING TO AMOUNT NECESSARY FOR CONSTRUCTION
4. SELECTED OPTION MUST BE CAPABLE OF PLACING BOULDERS WITHIN A 1–FT TOLERANCE

**LEGEND**

APPROX LIMITS OF CHANNEL MODIFICATION

OPTION 1 VEGETATION CLEARING LIMITS FOR CRANE OPERATION




PLAN

0 50' 100'

GRAPHIC SCALE


**Michael Love & Associates, Inc.**
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

**Department of Fish and Wildlife**
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE
# ACCESS & USE AREA OPTION 1 PLAN

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 14 of 27 |

**C-11**

2/6/2017 10:05:03 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_UB_ConstructionStaging–1.dwg

**NOTE:**

1. THIS DRAWING PRESENTS CONSTRUCTION ACCESS OPTION 2 OF 2
2. KEEP ACCESS ROADS CLEAR
3. MINIMIZE VEGETATION CLEARING TO AMOUNT NECESSARY FOR CONSTRUCTION
4. SELECTED OPTION MUST BE CAPABLE OF PLACING BOULDERS WITHIN A 1-FT TOLERANCE

**LEGEND**

APPROX LIMITS OF CHANNEL MODIFICATION

OPTION 2 VEGETATION CLEARING LIMITS FOR SKYLINE YARDER OPERATION

NORTH FORK BATTLE CREEK

NO VEHICLE ACCESS ESTABLISHED

FLOW

**OPTION 2:** SKYLINE YARDER SPAN, SEE DWG C-13 FOR SECTION

DIGGER CREEK

APPROXIMATE LIMITS OF CHANNEL MODIFICATION

**OPTION 2:** POTENTIAL SKYLINE YARDER TRAVEL FOOTPRINT

**OPTION 2:** APPROXIMATE LOCATION OF SKYLINE YARDER ANCHOR POINT

**OPTION 2:** CONTRACTOR USE AREA

VEGETATION REMOVAL FOR CONTRACTOR USE AREA AND FOR ACCESS ROAD PER SPECIFICATIONS

**OPTION 2:** (N) TEMPORARY ACCESS ROAD (5 / C-24)

(E) GRAVEL ACCESS ROAD

TO BATTLE CREEK BOTTOM ROAD

EAGLE CANYON DAM

EXISTING ACCESS ROAD & CRANE PAD

TO MANTON ROAD

PLAN

0 50' 100'

GRAPHIC SCALE

2/6/2017 10:05:32 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_UB_ConstructionStaging-2.dwg


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

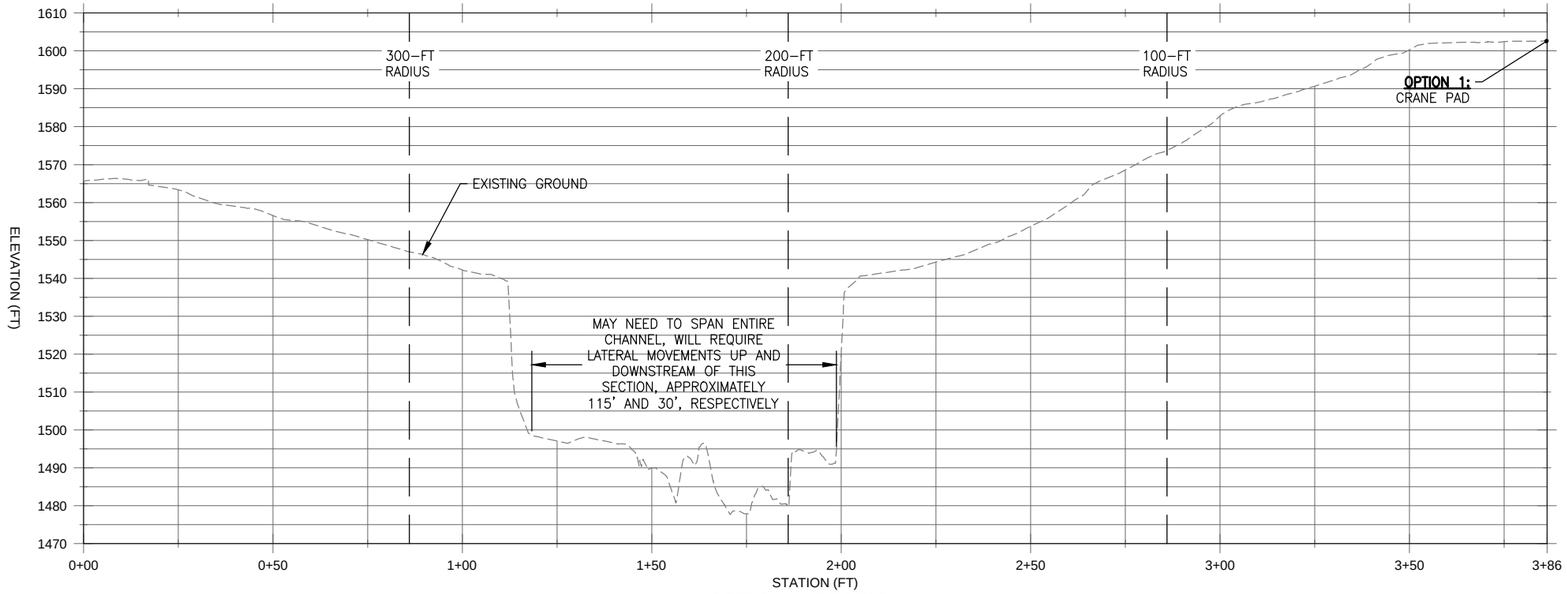

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE
# ACCESS & USE AREA OPTION 2 PLAN

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 15 of 27 |

**C-12**

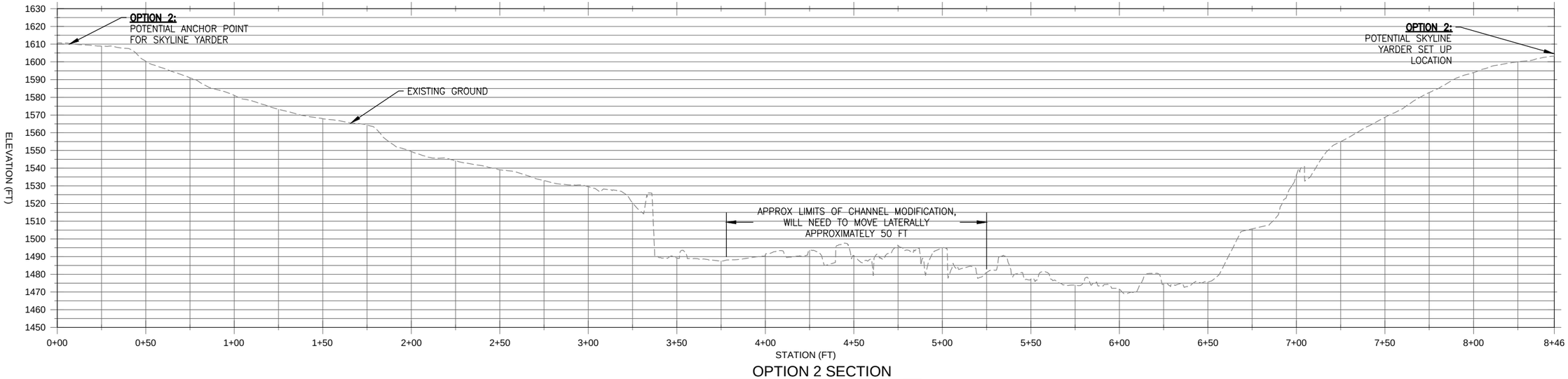



OPTION 1 SECTION

SEE DRAWING C-11 FOR ALIGNMENT

0 20' 40'

GRAPHIC SCALE




OPTION 2 SECTION

SEE DRAWING C-12 FOR ALIGNMENT

0 30' 60'

GRAPHIC SCALE


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE

THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**UPPER BARRIER SITE**

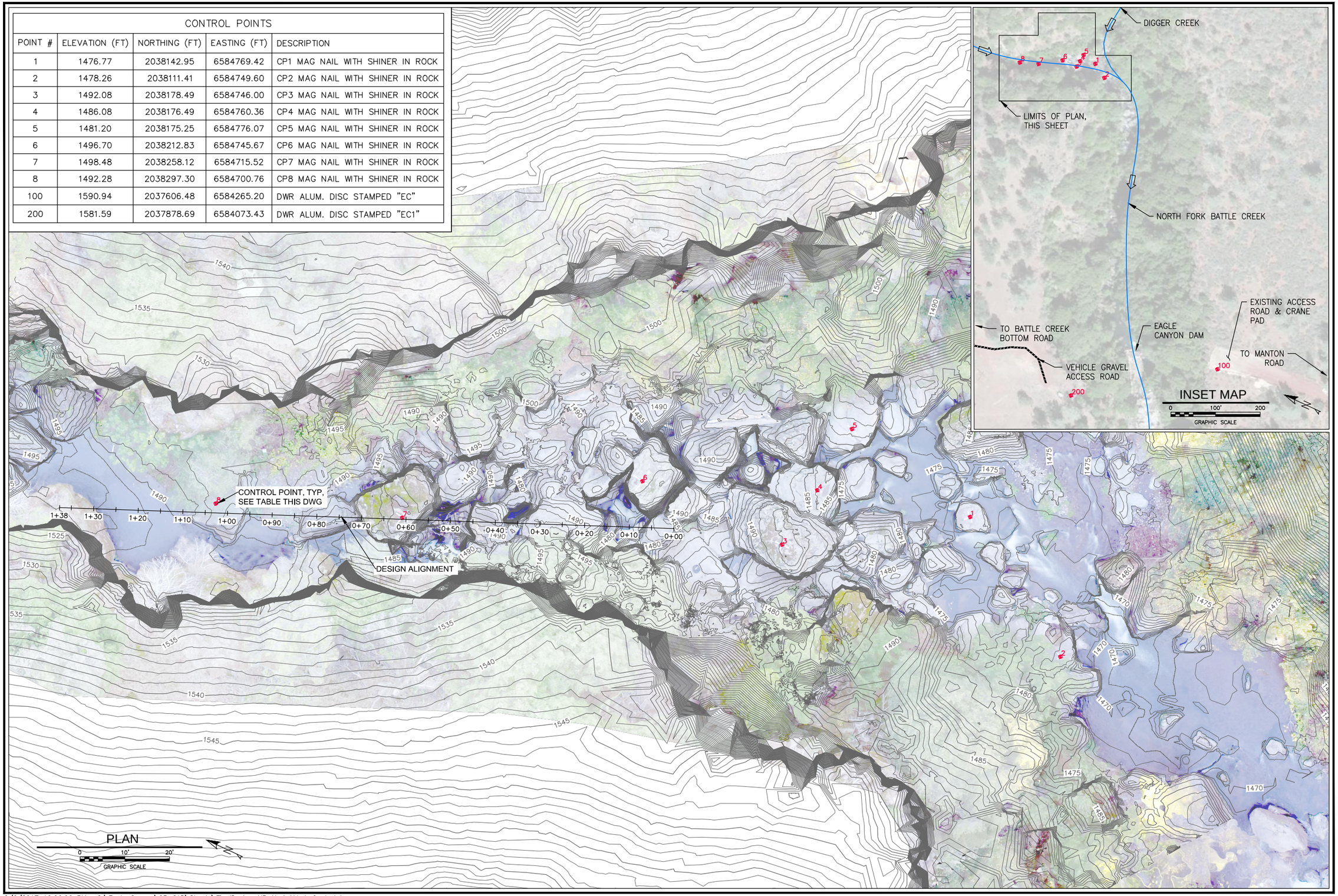
**ACCESS & USE AREA OPTIONS 1 & 2 SECTIONS**

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 16 of 27 |

**C-13**

2/6/2017 10:05:39 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_UB_ConstructionStaging-2.dwg

| CONTROL POINTS | | | | |
|---|---|---|---|---|
| POINT # | ELEVATION (FT) | NORTHING (FT) | EASTING (FT) | DESCRIPTION |
| 1 | 1476.77 | 2038142.95 | 6584769.42 | CP1 MAG NAIL WITH SHINER IN ROCK |
| 2 | 1478.26 | 2038111.41 | 6584749.60 | CP2 MAG NAIL WITH SHINER IN ROCK |
| 3 | 1492.08 | 2038178.49 | 6584746.00 | CP3 MAG NAIL WITH SHINER IN ROCK |
| 4 | 1486.08 | 2038176.49 | 6584760.36 | CP4 MAG NAIL WITH SHINER IN ROCK |
| 5 | 1481.20 | 2038175.25 | 6584776.07 | CP5 MAG NAIL WITH SHINER IN ROCK |
| 6 | 1496.70 | 2038212.83 | 6584745.67 | CP6 MAG NAIL WITH SHINER IN ROCK |
| 7 | 1498.48 | 2038258.12 | 6584715.52 | CP7 MAG NAIL WITH SHINER IN ROCK |
| 8 | 1492.28 | 2038297.30 | 6584700.76 | CP8 MAG NAIL WITH SHINER IN ROCK |
| 100 | 1590.94 | 2037606.48 | 6584265.20 | DWR ALUM. DISC STAMPED "EC" |
| 200 | 1581.59 | 2037878.69 | 6584073.43 | DWR ALUM. DISC STAMPED "EC1" |








Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

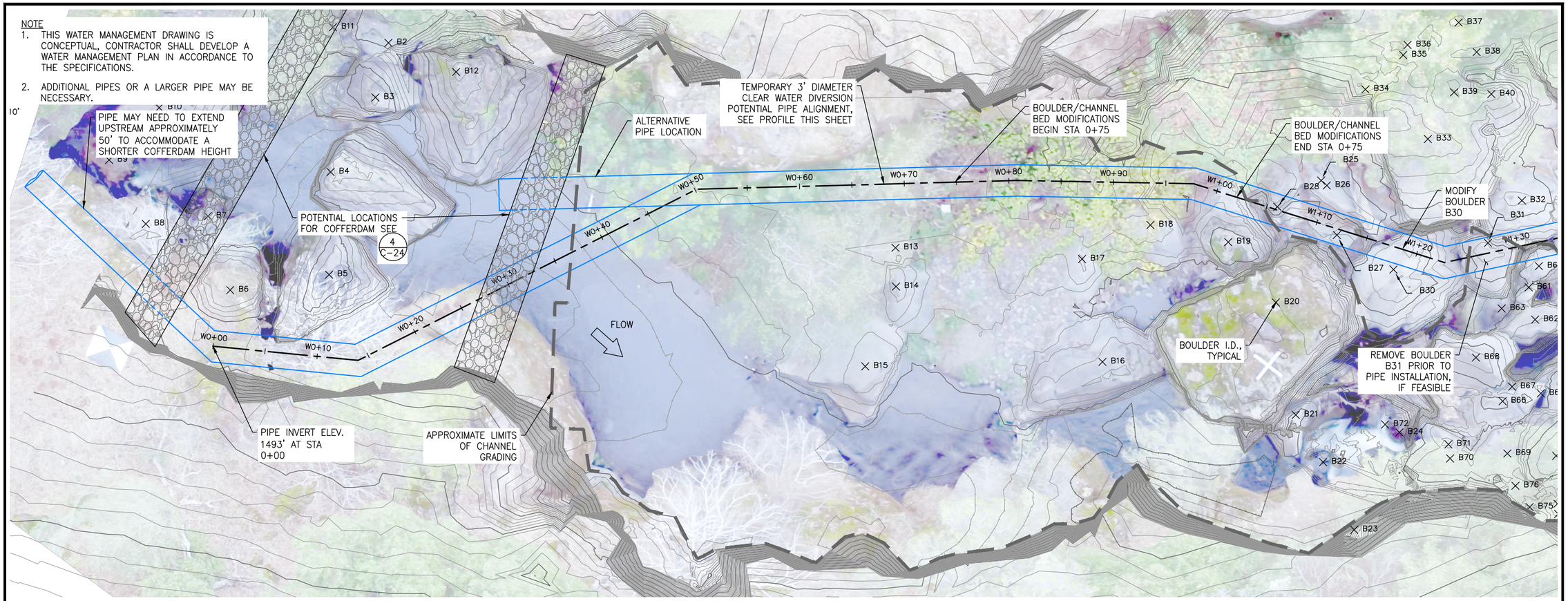
# UPPER BARRIER SITE
# HORIZONTAL AND VERTICAL CONTROL

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 17 of 27 |

**C-14**

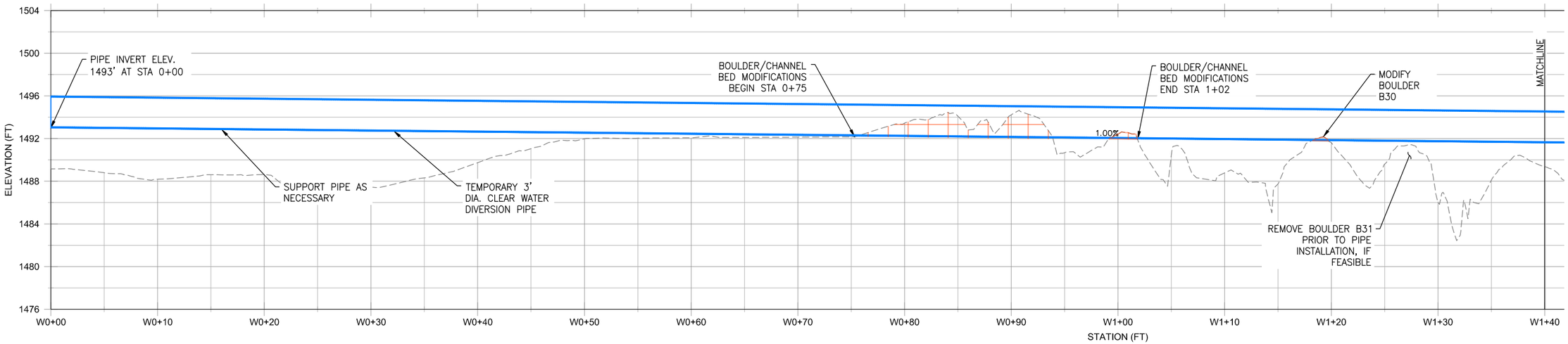
2/6/2017 10:06:06 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_UB_Horiz&Vert-Control.dwg

NOTE
1. THIS WATER MANAGEMENT DRAWING IS CONCEPTUAL, CONTRACTOR SHALL DEVELOP A WATER MANAGEMENT PLAN IN ACCORDANCE TO THE SPECIFICATIONS.
2. ADDITIONAL PIPES OR A LARGER PIPE MAY BE NECESSARY.




## CONCEPTUAL TEMPORARY PIPE PLAN

0 5' 10'
GRAPHIC SCALE




## CONCEPTUAL TEMPORARY PIPE PROFILE

0 5' 10'
GRAPHIC SCALE


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

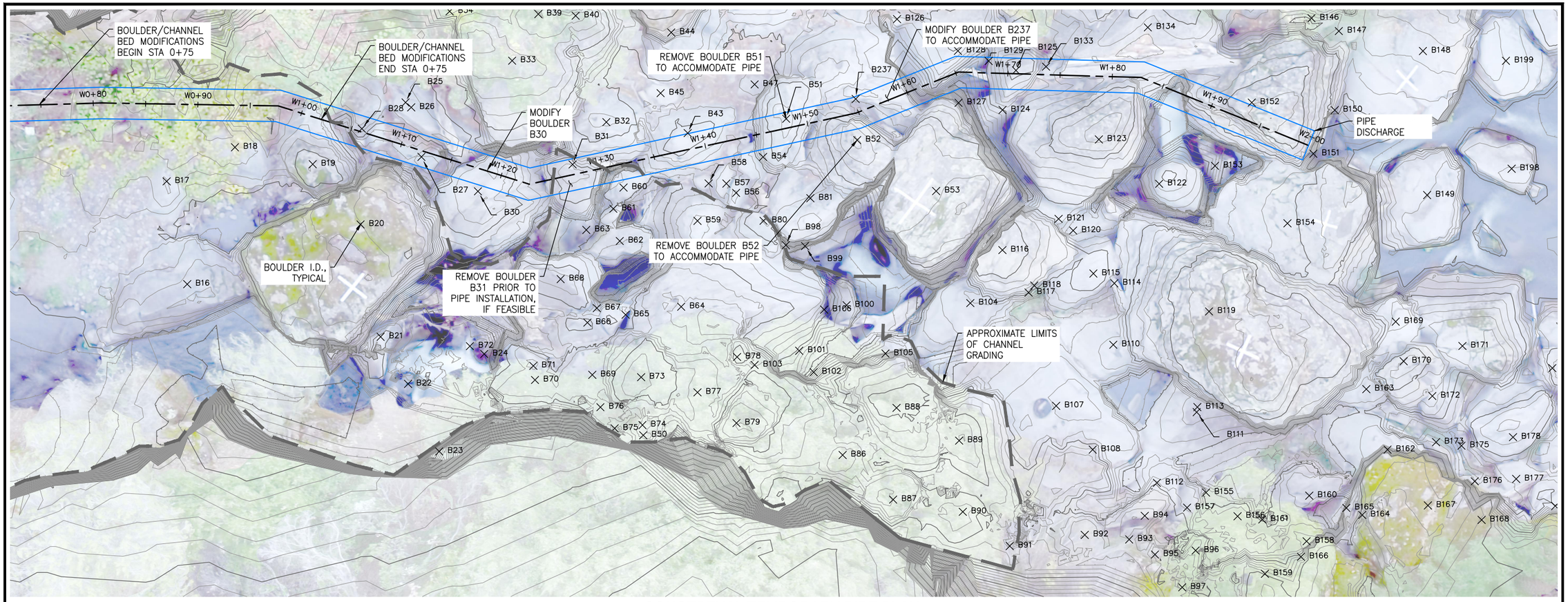
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE
# WATER MANAGEMENT, 1 OF 2

| | |
|---|---|
| DATE | FEBRUARY 2017 |
| SUBMITTAL | 90% DESIGN |
| DESIGN | ML, pTJ |
| DRAWN | pTJ, NN |
| SHEET | 18 of 27 |

**C-15**

2/6/2017 10:20:48 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_UB_WaterMgmt.dwg




## CONCEPTUAL TEMPORARY PIPE PLAN

0 5' 10'
GRAPHIC SCALE




## CONCEPTUAL TEMPORARY PIPE PROFILE

0 5' 10'
GRAPHIC SCALE

2/6/2017 10:20:55 PM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_UB_WaterMgmt.dwg


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE
# WATER MANAGEMENT, 2 OF 2

DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
19 of 27

**C-16**

| Complex | Boulder | Axis Dimensions (ft)[4] a | b | c | Volume (CY)[5] | Weight (Ton)[6] |
|---|---|---|---|---|---|---|
| B20 Complex | B16[1] | 13.6 | 7.0 | 8.0 | 22.1 | 50.3 |
| | B17[1] | 3.4 | 3.0 | 3.0 | 1.1 | 2.6 |
| | B18[1] | 4.2 | 4.0 | 4.0 | 2.5 | 5.7 |
| | B19 | 6.2 | 5.9 | 3.7 | 5.0 | 11.4 |
| | B20 | 15.9 | 11.0 | 9.1 | 51.4 | 117.1 |
| Pool 7 Complex | B21[1,2] | 6.7 | 5.5 | 3.7 | 5.0 | 11.5 |
| | B22[1,2] | 5.5 | 4.3 | 4.1 | 1.9 | 4.4 |
| | B24[1] | 2.8 | 2.5 | 2.3 | 0.4 | 1.0 |
| | B72[1] | 5.4 | 5.2 | 2.3 | 2.4 | 5.4 |
| | B61 | 2.1 | 2.0 | 1.0 | 0.1 | 0.2 |
| | B62 | 3.0 | 3.9 | 3.5 | 1.5 | 3.4 |
| | B64 | 14.4 | 8.8 | 5.4 | 25.3 | 57.7 |
| | B65 | 3.0 | 2.7 | 2.7 | 0.4 | 0.9 |
| | B66[1] | 6.0 | 2.6 | 2.3 | 1.7 | 3.8 |
| | B67[1] | 6.0 | 4.3 | 2.4 | 2.3 | 5.2 |
| | B68 | 9.0 | 6.0 | 7.0 | 14.0 | 31.9 |
| | B69 | 5.7 | 3.2 | 2.4 | 1.6 | 3.7 |
| | B70 | 5.2 | 4.2 | 2.1 | 1.7 | 3.9 |
| | B71 | 4.1 | 3.6 | 2.0 | 1.1 | 2.5 |
| | B73 | 5.6 | 4.9 | 3.8 | 3.9 | 8.8 |
| | B74 | 2.0 | 1.5 | 1.0 | 0.1 | 0.3 |
| | B75 | 2.0 | 1.5 | 0.8 | 0.1 | 0.2 |
| | B76 | 2.1 | 2.1 | 1.9 | 0.3 | 0.7 |
| | B80 | 4.3 | 3.2 | 2.4 | 1.2 | 2.8 |
| Toe Complex | B77 | 6.6 | 5.6 | 5.0 | 6.8 | 15.6 |
| | B78 | 6.2 | 2.5 | 2.5 | 1.4 | 3.3 |
| | B79 | 12.0 | 8.3 | 6.0 | 11.1 | 25.2 |
| | B86 | 3.7 | 3.2 | 2.1 | 0.5 | 1.2 |
| | B87 | 5.5 | 4.3 | 3.8 | 3.3 | 7.6 |
| | B88 | 11.2 | 7.9 | 7.1 | 23.3 | 53.0 |
| | B89 | 8.0 | 6.8 | 4.8 | 9.7 | 22.0 |
| | B90 | 7.0 | 3.4 | 2.5 | 2.2 | 5.0 |
| | B101[1] | ? | ? | ? | 2.0 | 4.6 |
| | B102[1] | 7.0 | 4.0 | 2.3 | 2.4 | 5.4 |
| | B103[1] | 7.4 | 6.0 | 5.0 | 8.2 | 18.7 |

| Complex | Boulder | Axis Dimensions (ft)[4] a | b | c | Volume (CY)[5] | Weight (Ton)[6] |
|---|---|---|---|---|---|---|
| Pool 6 Complex | B100[1] | 4.0 | 3.0 | 3.0 | 1.3 | 3.0 |
| | B105 | 5.5 | 5.2 | 4.1 | 2.6 | 5.9 |
| Upper Complex | B51 | 6.1 | 3.8 | 5.1 | 4.4 | 10.0 |
| | B52 | 5.7 | 5.6 | 5.3 | 3.3 | 7.5 |
| | B56[1] | 2.4 | 1.8 | 1.6 | 0.3 | 0.6 |
| | B57[1] | 2.0 | 2.1 | 2.0 | 0.3 | 0.7 |
| | B58[1] | 2.0 | 2.1 | 2.0 | 0.3 | 0.7 |
| | B81[1] | 10.0 | 7.0 | 5.8 | 15.0 | 34.2 |
| Upstream Complex Grading | NA | NA | NA | NA | NA | 453 | 1031 |
| Unseen[3] | NA | NA | NA | NA | 18 | 40 |

**Estimated volume of rock to be removed or modified: 716 cubic yards, 1630 tons**

1. Some of boulder dimensions are not visible (e.g. below other boulders, under water) and are estimated.
2. May be bedrock.
3. Some boulders to be removed/moved/modified are located below the visible boulders, primarily beneath the Toe Complex boulders. The volume of this rock is not known and for estimating purposes is assumed to be 25% of the Toe Complex boulder subtotal.
4. See Detail 2 on Drawing C-24. All dimensions are approximate & should be verified by the Contractor.
5. Volume calculated by various means (e.g. rectangular cuboid, sphere, etc.), therefore additional dimensions may have been utilized than are shown. Axes dimensions shown are for informational purposes (e.g. to understand general shape and size of the boulder).
6. Weight based on assumed rock density of 2.3 tons/CY

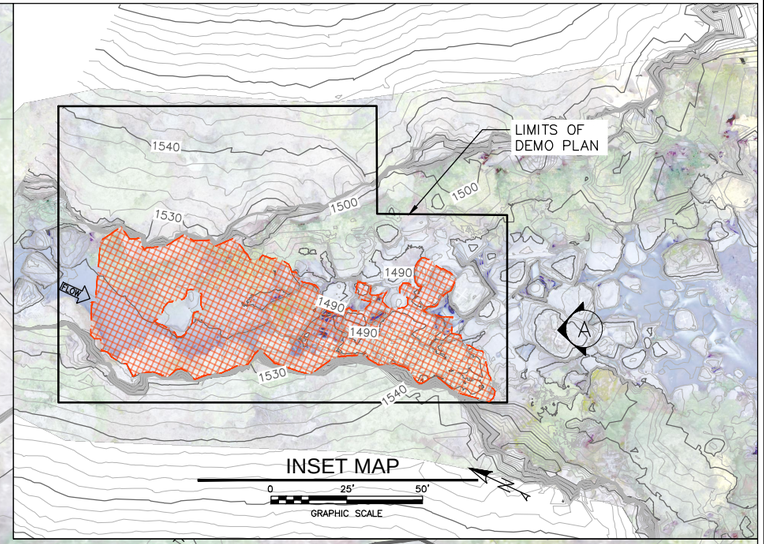
LEGEND

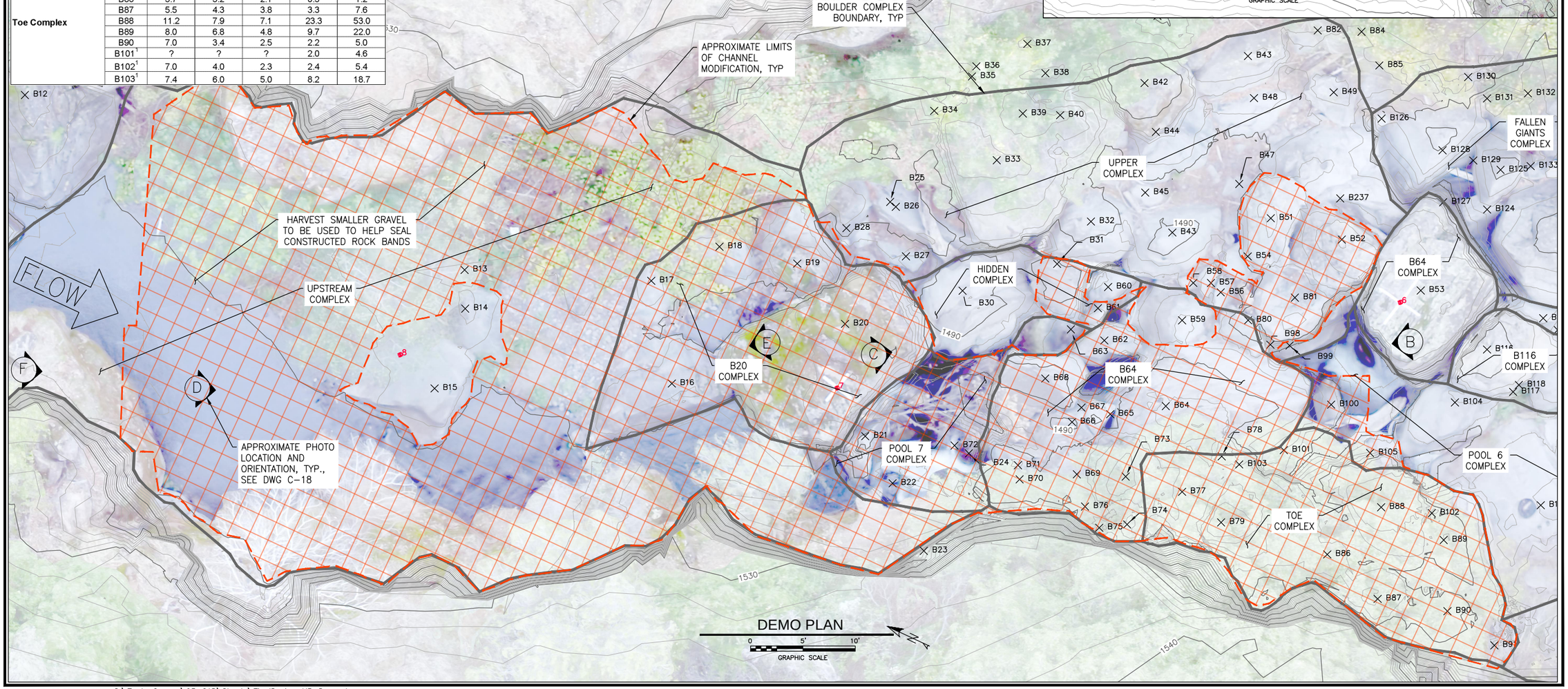
ROCK TO BE REMOVED OR MODIFIED

BOULDER COMPLEX (COMPRISED OF ONE OR MORE BOULDERS)

NOTE:

1. THE LIMITS OF CHANNEL MODIFICATION ARE APPROXIMATE AND TO BE USED AS A GENERAL GUIDE.
2. SEE CONSTRUCTION NOTES ON DWG C-20





Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov


VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE DEMO PLAN

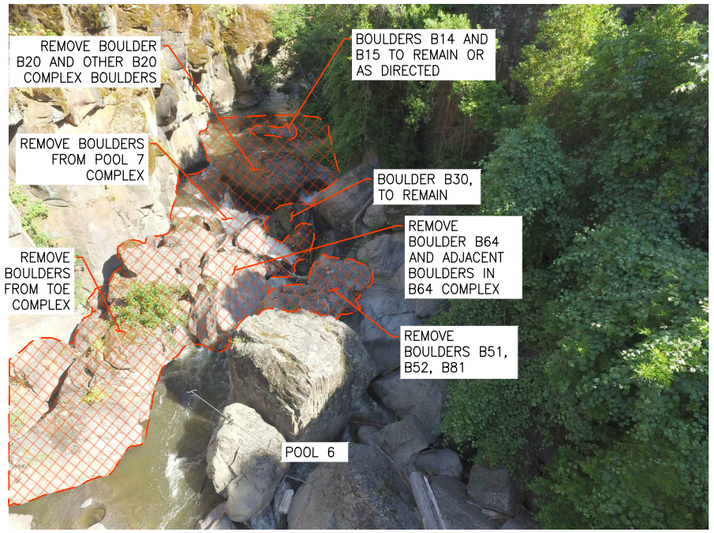
| | |
|---|---|
| Date | FEBRUARY 2017 |
| Submittal | 90% DESIGN |
| Design | ML, pTJ |
| Drawn | pTJ, NN |
| Sheet | 20 of 27 |

**C-17**

NOTE:
1. THE LIMITS OF CHANNEL MODIFICATION ARE APPROIXMATE AND TO BE USED AS A GENERAL GUIDE.
2. SEE DRAWING C–17 FOR LOCATION AND ORIENTATION OF PHOTOGRAPH.
3. SEE NOTES ON DWG C–21

LEGEND

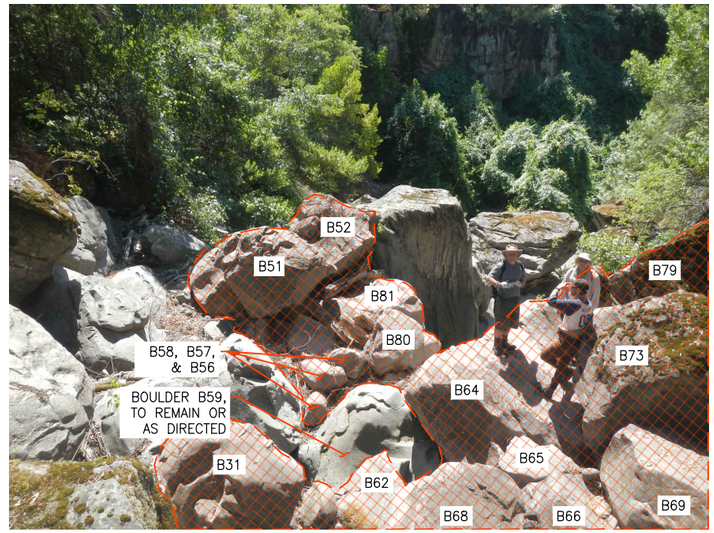
APPROXIMATE LIMITS OF CHANNEL MODIFICATION



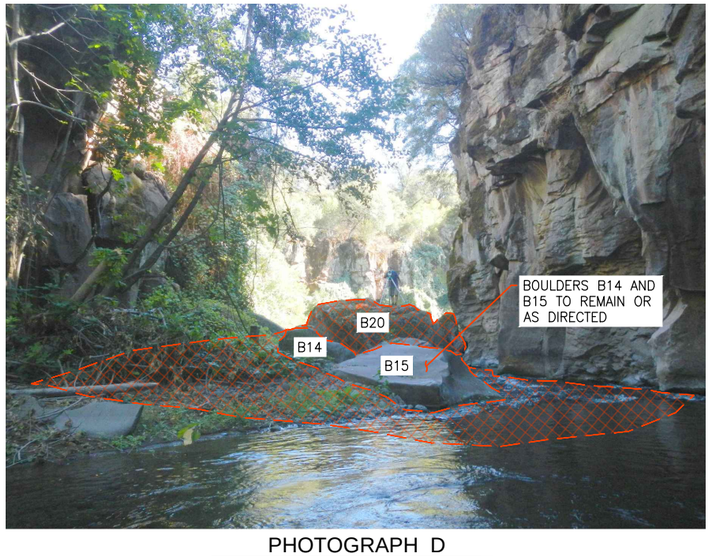

PHOTOGRAPH A
LOOKING UPSTREAM



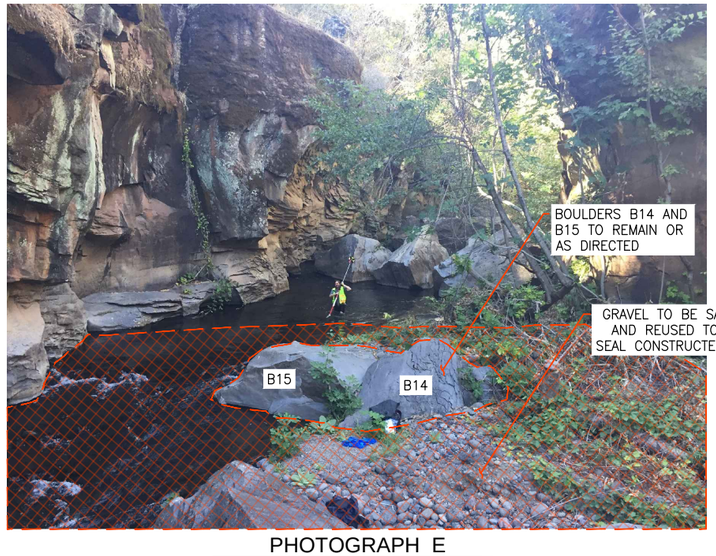

PHOTOGRAPH B
LOOKING UPSTREAM



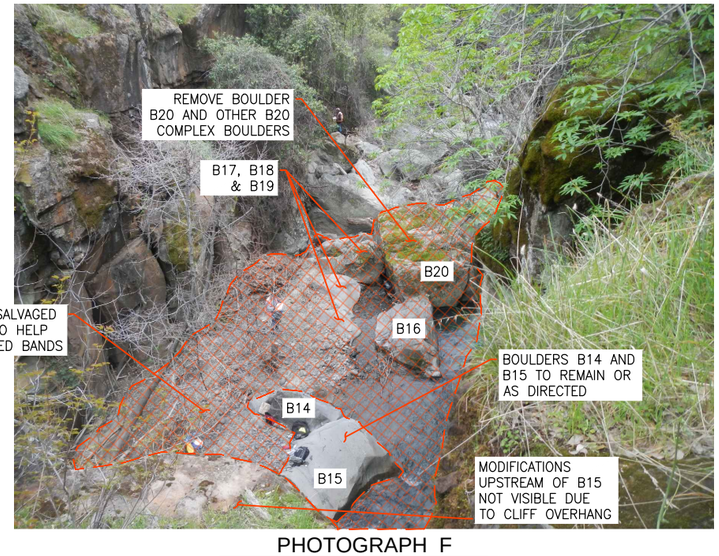

PHOTOGRAPH C
LOOKING DOWNSTREAM




PHOTOGRAPH D
LOOKING DOWNSTREAM




PHOTOGRAPH E
LOOKING UPSTREAM




PHOTOGRAPH F
LOOKING DOWNSTREAM


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411
Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

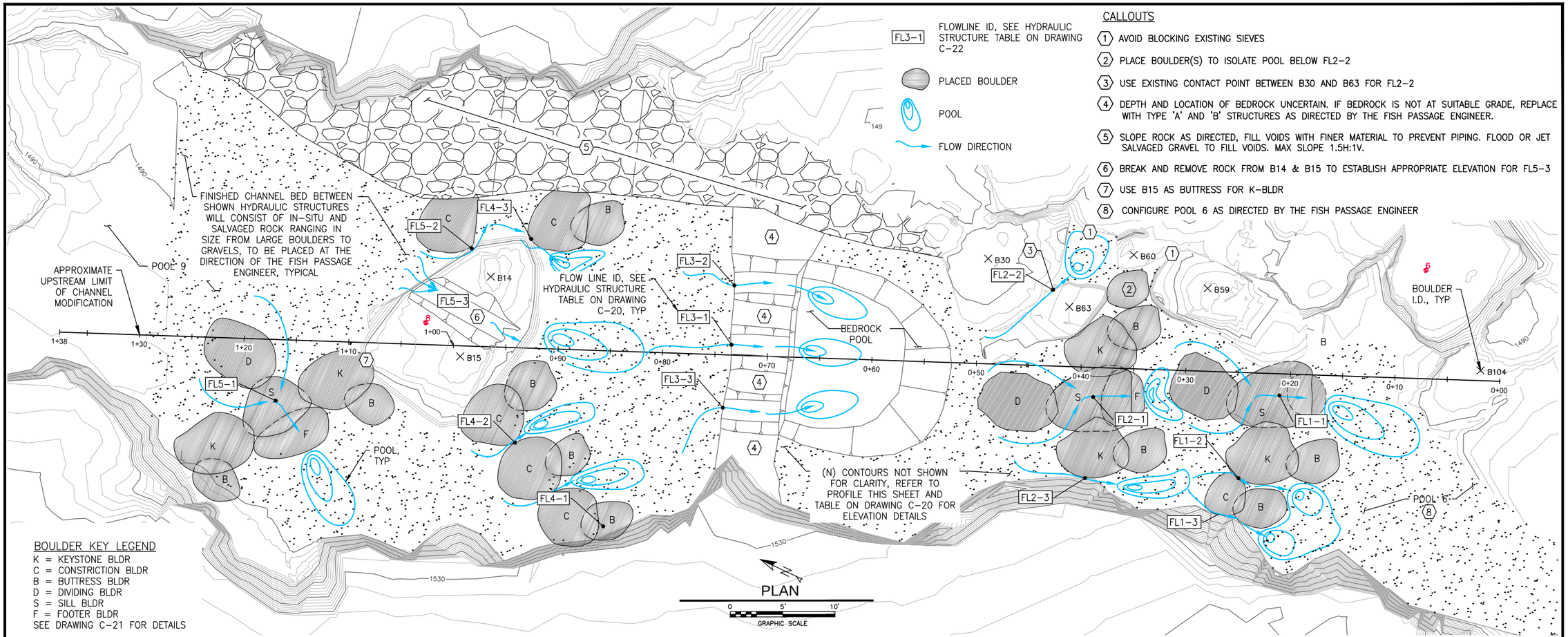

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE
# DEMO PHOTOGRAPHS

| | |
|---|---|
| DATE | |
| FEBRUARY 2017 | SUBMITTAL |
| 90% DESIGN | DESIGN |
| ML, pTJ | DRAWN |
| pTJ, NN | SHEET |
| 21 of 27 | |

**C-18**




Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411
Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER BARRIER SITE
# CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE

| | |
|---|---|
| DATE | |
| SUBMITTAL | FEBRUARY 2017 |
| DESIGN | 90% DESIGN |
| DRAWN | ML, pTJ |
| SHEET | pTJ, NN |
| | 22 of 27 |
| | C-19 |

CONSTRUCTION NOTES:

1. REFER TO SPECIFICATION 31 05 16.
2. THE DESIGN WORK COMPLETED FOR THE PROJECT, ALTHOUGH THOROUGH, LACKED SUFFICIENT INFORMATION TO DESIGN THE PROJECT WITH CERTAINTY. THE CONTRACTOR AND FISH PASSAGE ENGINEER, ALONG WITH THE CO AND COR, MUST WORK CLOSELY TOGETHER TO COMPLETE THE WORK SO THAT THE UBS PROJECT GOAL AND OBJECTIVES ARE MET. THE UBS PROJECT GOAL IS TO IMPROVE FISH PASSAGE AT THE UBS. THE UBS PROJECT OBJECTIVES ARE:
   - 2.1. TO REMOVE EXISTING BOULDERS THAT TO SUPPORT CHANNEL RECONSTRUCTION.
   - 2.2. TO RECONSTRUCT THE CHANNEL USING EXISTING MATERIAL TO CREATE MULTIPLE DROPS OVER BOULDERS AND BEDROCK WITH ADEQUATE POOLS BELOW EACH DROP.
   - 2.3. TO CONSTRUCT EACH HYDRAULIC STRUCTURE PER THE DESIGN ELEVATIONS WITHIN THE ALLOWED TOLERANCES.
   - 2.4. TO CONSTRUCT EACH HYDRAULIC STRUCTURE SO THAT EACH BOULDER PLACED RESTS AGAINST ADJACENT BOULDERS OR BEDROCK TO COUNTERACT GRAVITATIONAL AND HYDRAULIC FORCES.
3. THE CONCEPTUAL DESIGN DRAWING (DRAWING C–19) IS TO BE USED AS A GUIDE TO AID IN THE CONSTRUCTION OF THE CHANNEL. DUE TO THE UNKNOWN STRUCTURE OF THE BOULDERS AND BEDROCK BELOW THE SURFACE AND DUE TO THE UNKNOWN SHAPE AND SIZE OF THE EXISTING BOULDERS AFTER THEY HAVE BEEN MODIFIED, THE FINISHED CHANNEL MAY DIFFER FROM THE CONCEPTUAL DRAWING.
4. NOT ALL BOULDERS TO BE REMOVED, MOVED, OR MODIFIED ARE VISIBLE ON DRAWINGS C–17 OR C–18 OR PRESENTED IN THE DRAWING C–17 TABLE.
7. NO BOULDER OR BEDROCK WILL BE MOVED OR MODIFIED WITHIN EAGLE CANYON WITHOUT THE FISH PASSAGE ENGINEER'S APPROVAL.
8. THE CONTRACTOR SHALL AVOID DISTURBING THE EXISTING CHANNEL BELOW THE CHANNEL GRADE LINE. USE EXISTING IN–SITU BOULDERS AND OTHER ROCK FOR THE FINISHED CHANNEL AS MUCH AS PRACTICAL.
10. WHERE OVER EXCAVATION OCCURS THE CONTRACTOR MUST, AFTER PLACING LARGER ROCK, MUST FILL VOIDS AND SEAL THE FINISHED CHANNEL TO PREVENT WATER FROM GOING SUBSURFACE.
7. BOULDERS MAY REQUIRE MODIFICATION TO MOVE. MODIFICATION WILL BE CONDUCTED SO THAT THE RESULTING BOULDER FRAGMENTS REMAIN AS LARGE AS POSSIBLE WHILE STILL ALLOWING THE FRAGMENT TO BE MOVED AS NECESSARY, UNLESS OTHERWISE APPROVED BY THE FISH PASSAGE ENGINEER.
8. ALTHOUGH BEDROCK IS SHOWN ON DRAWING C–19, BEDROCK MAY NOT BE ENCOUNTERED.
15. THE CONTRACTOR MAY NEED TO MOVE BOULDERS TO A TEMPORARY STAGING LOCATION WHILE PREPARING THE SUBGRADE FOR THE FINAL BOULDER PLACEMENT IN THE CONSTRUCTED CHANNEL.
16. COLLECT AND STOCKPILE GRAVELS FOR USE IN RECONSTRUCTING THE CHANNEL.
17. EACH BOULDER WITHIN A HYDRAULIC STRUCTURE WILL BE IN CONTACT WITH ADJACENT BOULDERS WITH AT LEAST THREE (3) POINTS OF CONTACT.
18. EACH BOULDER WITHIN A HYDRAULIC STRUCTURE WILL BE PLACED SO THAT IT IS STABLE AND RESISTANT TO FORCES ACTING ON IT IN A DOWNSTREAM DIRECTION.
19. EACH HYDRAULIC STRUCTURE MUST BE BACKFILLED WITH NATIVE MATERIALS TO FILL VOIDS AND HYDRAULICALLY SEAL THE STRUCTURE, SO THAT WATER POOLS UPSTREAM OF THE STRUCTURE. THE FISH PASSAGE ENGINEER WILL REQUIRE THE CONTRACTOR TO SHOW THAT THE STRUCTURE IS SEALED BY ADDING WATER.
20. EACH HYDRAULIC STRUCTURE WILL BE CONSTRUCTED, WITHIN THE PERMITTED TOLERANCES, TO THE RELATIVE ELEVATIONS SHOWN IN THE HYDRAULIC STRUCTURE LAYOUT TABLE, THIS SHEET.
21. THE FISH PASSAGE ENGINEER RESERVES THE RIGHT TO MODIFY THE HYDRAULIC STRUCTURE TABLE AT ANY TIME.
22. THE CONTRACTOR NEEDS TO PROVIDE MEANS TO ACCURATELY PLACE BOULDERS AT ANY LOCATION WITHIN THE PROJECT'S CHANNEL MODIFICATION AREA.
23. THE CONTRACTOR NEEDS TO PROVIDE MEANS TO ROTATE A BOULDER WHILE SUSPENDED SO A BOULDER MAY BE PLACED IN AN APPROPRIATE ORIENTATION.
24. POOLS SHALL BE CONSTRUCTED INTO THE CHANNEL BED DOWNSTREAM OF EACH FLOW LINE.
25. ADDITIONAL POOLS MAY BE CREATED BASED ON FIELD CONDITIONS.
26. THE CONTRACTOR MAY NEED TO REPOSITION BOULDERS AFTER PLACEMENT.
27. THE CONTRACTOR MAY NEED TO MODIFY EXISTING IN–SITU BOULDERS.
28. PORTIONS OF IN–SITU BOULDERS MAY NEED TO BE REMOVED TO MEET FINISHED GRADE, CREATE SUITABLE SUBGRADE FOR PLACEMENT OF BOULDERS IN HYDRAULIC STRUCTURES OR TO CREATE DESIRED FLOWLINES.
29. THE SURFACE OF THE FINISHED CHANNEL BED SHALL BE ROUGH WITH SOME BOULDERS PROTRUDING ABOVE THE CHANNEL GRADE LINE.

**UPPER BARRIER HYDRAULIC STRUCTURE LAYOUT TABLE**

| FLOWLINE (FL) ID | ROCK STRUCTURE TYPE | FLOWLINE DESCRIPTION | POOL BOTTOM DOWNSTREAM OF FLOWLINE |
|---|---|---|---|
| **HYDRAULIC STRUCTURE 1** | | | |
| FL1-1 | TYPE 'B' | EL 1480.3+/-0.5 FT | MIN 3 FT LOWER THAN FL1-1 |
| FL1-2 | TYPE 'A' | 1 FT+/-0.5 FT ABOVE FL1-1 | MIN 3 FT LOWER THAN FL1-1 |
| FL1-3 | TYPE 'A' AGAINST CANYON WALL | 1 FT+/-0.5 FT ABOVE FL1-2 | MIN 3 FT LOWER THAN FL1-1 |
| **HYDRAULIC STRUCTURE 2** | | | |
| FL2-1 | TYPE B | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT | MIN 3 FT LOWER THAN FL1-1 |
| FL2-2 | EXISTING FL, TO REMAIN UNCHANGED | CONTACT BETWEEN B30 AND B36 AT APPROX EL 1483.5 FT | EXISTING POOL TO REMAIN |
| FL2-3 | TYPE 'A' AGAINST CANYON WALL | 1 FT+/-0.5 FT ABOVE FL2-2 | MIN 3 FT LOWER THAN FL1-3 |
| **HYDRAULIC STRUCTURE 3** | | | |
| FL3-1 | TYPE 'C' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT, BUT NO GREATER THAN 2.5 FT ABOVE FL2-1 | MIN 3 FT LOWER THAN FL2-1 |
| FL3-2 | BEDROCK CONDITIONS PERMITTING | 1 FT+/-0.5 FT ABOVE FL3-1 | MIN 3 FT LOWER THAN FL2-2 |
| FL3-3 | | 1 FT+/-0.5 FT ABOVE FL3-2 | MIN 3 FT LOWER THAN FL2-3 |
| **HYDRAULIC STRUCTURE 4** | | | |
| FL4-1 | TYPE 'A' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT | MIN 3 FT LOWER THAN FL3-1 |
| FL4-2 | TYPE 'A' | 1 FT+/-0.5 FT ABOVE FL4-1 | MIN 3 FT LOWER THAN FL3-1 |
| FL4-3 | TYPE 'A' | 1 FT+/-0.5 FT ABOVE FL4-2 | MIN 3 FT LOWER THAN FL3-3 |
| **HYDRAULIC STRUCTURE 5** | | | |
| FL5-1 | TYPE 'A' | SET BASED ON HYDRAULIC GRADELINE+/-0.5 FT | MIN 3 FT LOWER THAN FL4-1 |
| FL5-2 | TYPE 'B' (USE IN-SITU BOULDERS AS FEASIBLE | 1 FT+/-0.5 FT ABOVE FL1-1. | MIN 2 FT LOWER THAN FL4-3 |
| FL5-3 | TYPE 'B' | 1 FT+/-0.5 FT ABOVE FL1-2. DEFINED AT CONTACT BETWEEN B14 AND B15 | MIN 2 FT LOWER THAN FL3-3 |

Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411
Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

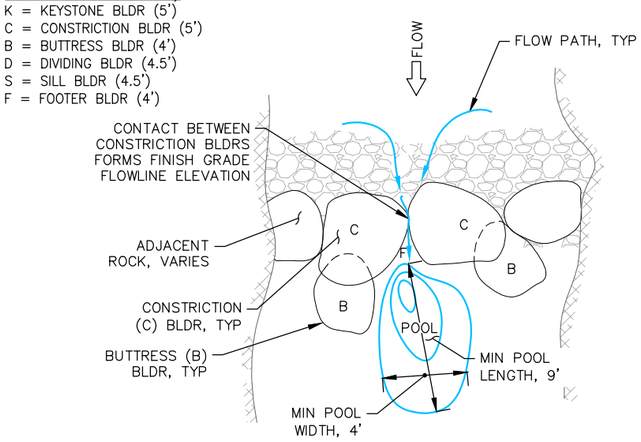
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**UPPER BARRIER SITE**
**CHANNEL MODIFICATION NOTES**

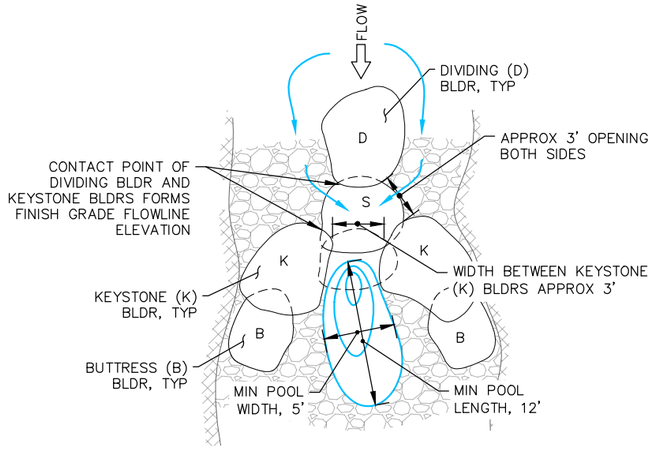
DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
23 of 27

**C-20**

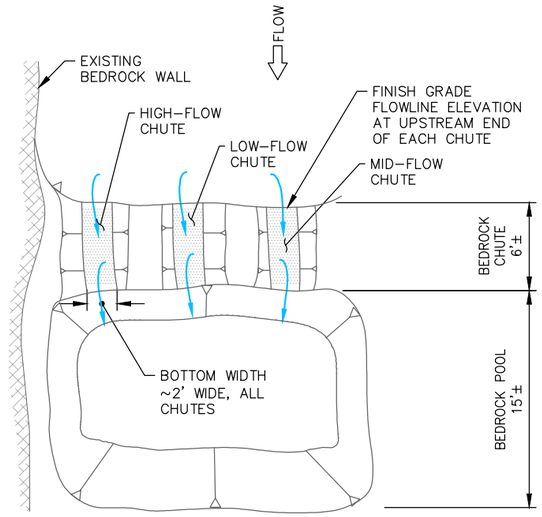
BOULDER KEY LEGEND
(MIN BLDR B-AXIS, SEE DETAIL 2, DWG C-24)
K = KEYSTONE BLDR (5')
C = CONSTRICTION BLDR (5')
B = BUTTRESS BLDR (4')
D = DIVIDING BLDR (4.5')
S = SILL BLDR (4.5')
F = FOOTER BLDR (4')



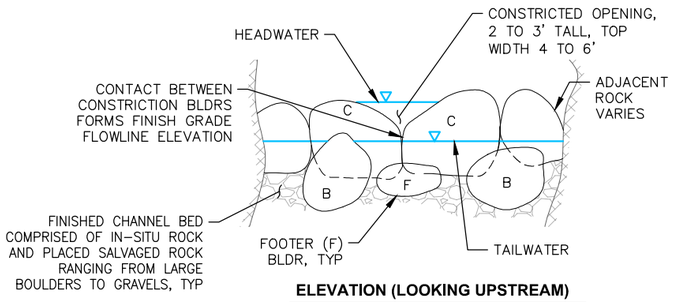

**PLAN**



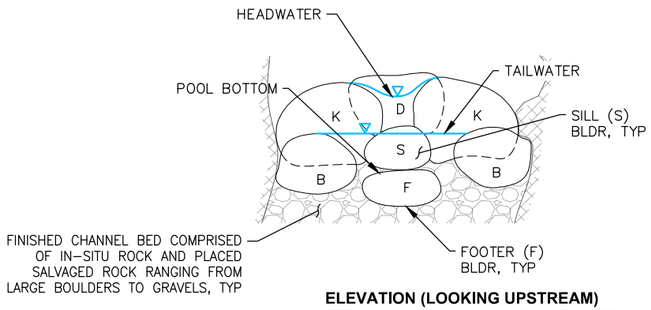

**PLAN**



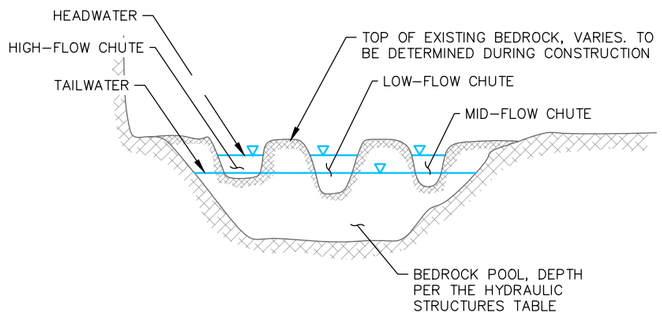

**PLAN**



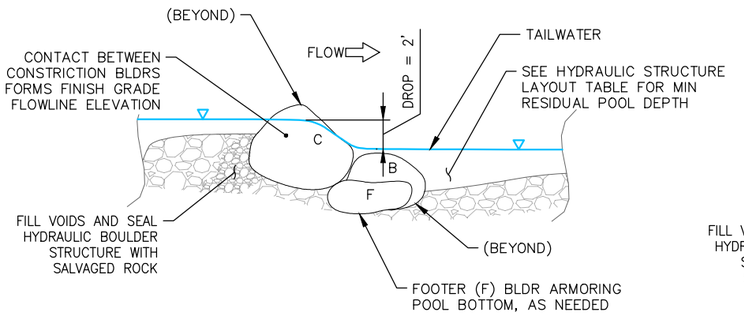

**ELEVATION (LOOKING UPSTREAM)**



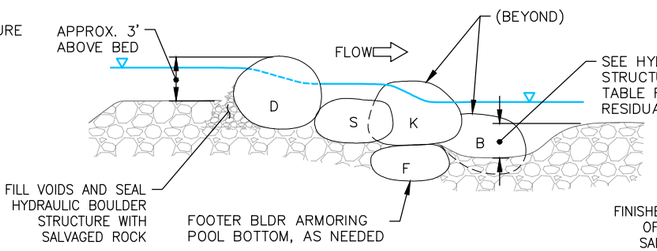

**ELEVATION (LOOKING UPSTREAM)**



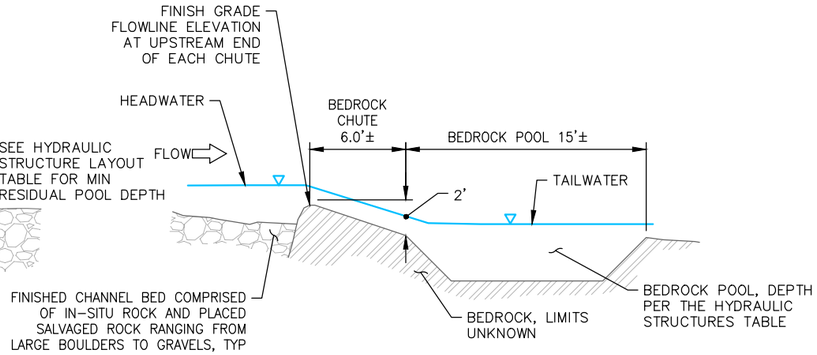

**ELEVATION (LOOKING UPSTREAM)**




**CENTERLINE PROFILE**




**CENTERLINE PROFILE**




**CHUTE PROFILE**

**1 TYPE 'A' HYDRAULIC STRUCTURE**
**BOULDER CONSTRICTION**
**TYPICAL (NTS)**

**2 TYPE 'B' HYDRAULIC STRUCTURE**
**BOULDER DOUBLE SLOT**
**TYPICAL (NTS)**

**3 TYPE 'C' HYDRAULIC STRUCTURE**
**BEDROCK CHUTES AND POOLS**
**TYPICAL (NTS)**


Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411



Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

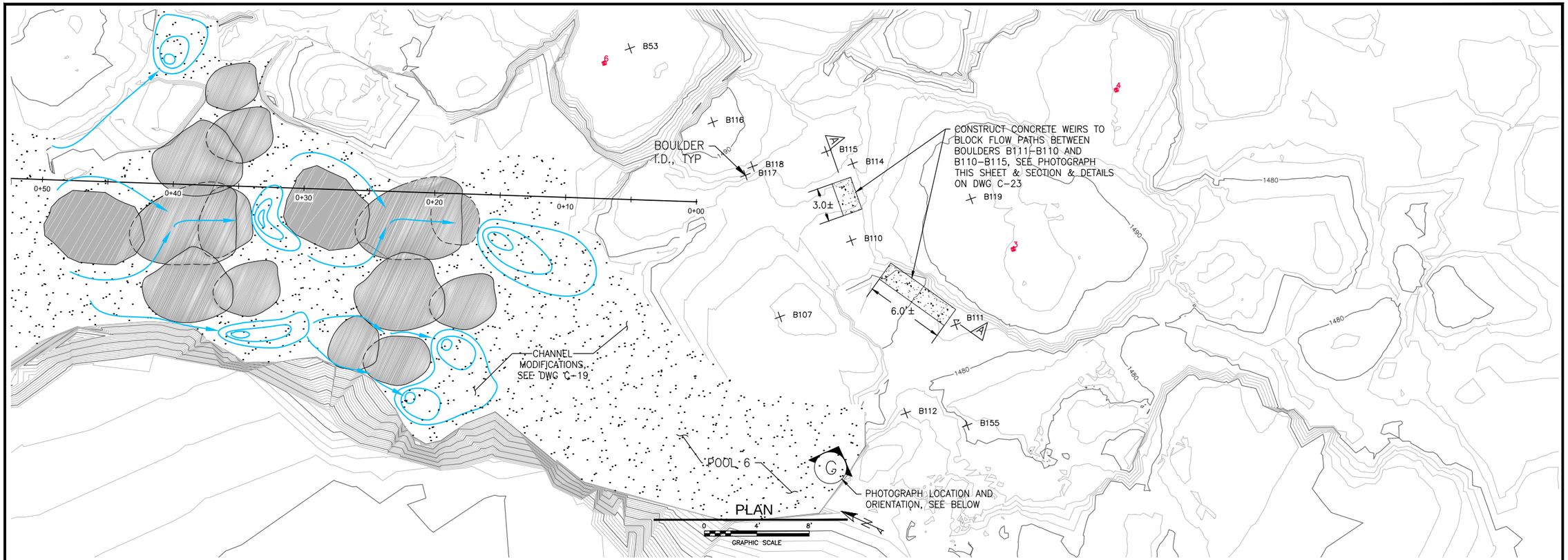

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**UPPER BARRIER SITE**
**HYDRAULIC STRUCTURE TYPICALS**

DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
24 of 27

**C-21**







PHOTOGRAPH G EXISTING CONDITIONS

NOT TO SCALE




PHOTOGRAPH G EXISTING CONDITIONS WITH (N) WEIR

NOT TO SCALE

Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

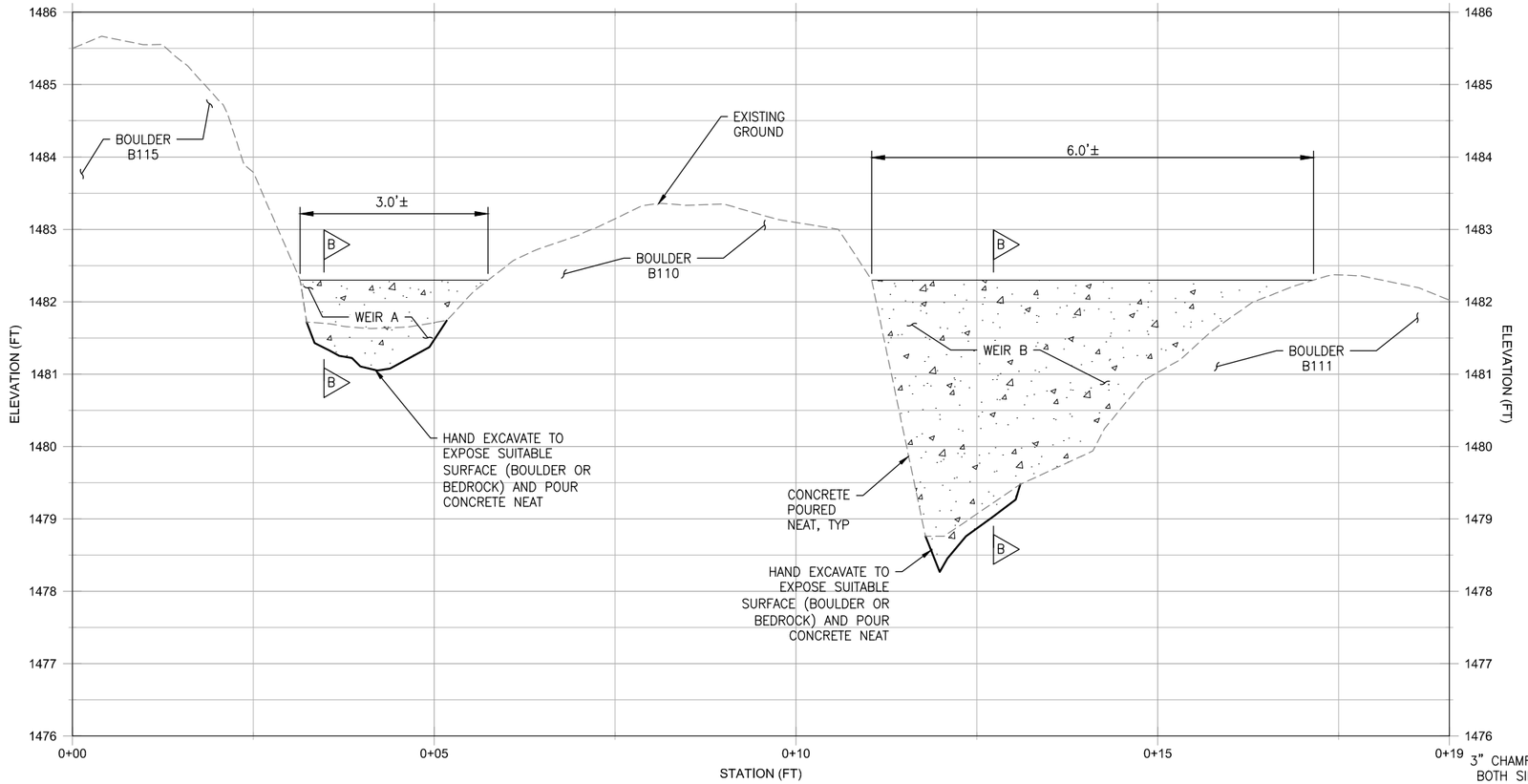
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**UPPER BARRIER SITE**
**WEIR CONSTRUCTION PLAN & PHOTOS**

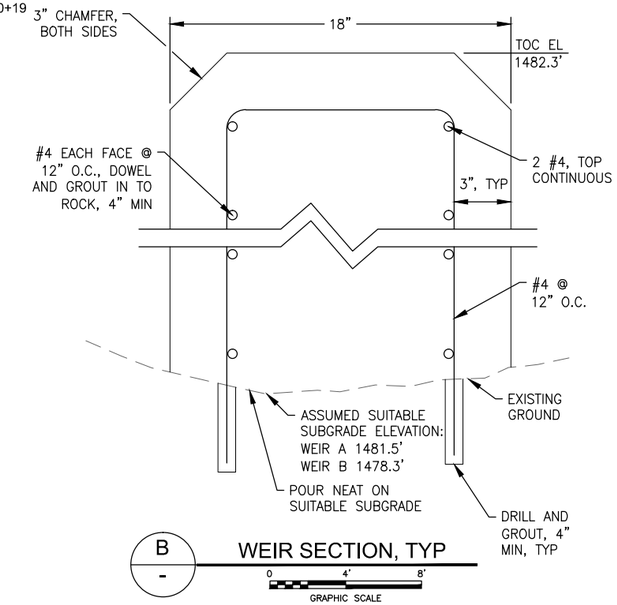
DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
25 of 27

**C-22**




A / C-22 WEIR SECTION

GRAPHIC SCALE 0 1' 2'




B / - WEIR SECTION, TYP

GRAPHIC SCALE 0 4' 8'

PHOTOGRAPH G EXISTING CONDITIONS

NOT TO SCALE

PHOTOGRAPH G EXISTING CONDITIONS WITH (N) WEIR

NOT TO SCALE

Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

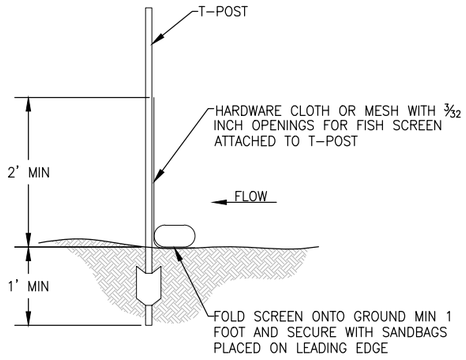
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

**UPPER BARRIER SITE**
**CONCRETE WEIR SECTION & DETAIL**

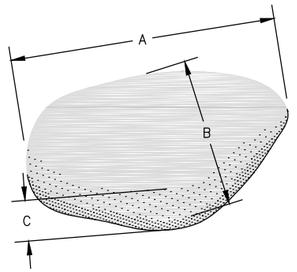
| | |
|---|---|
| DATE | |
| SUBMITTAL | FEBRUARY 2017 |
| DESIGN | 90% DESIGN |
| DRAWN | ML, pTJ |
| SHEET | pTJ, NN |
| | 26 of 27 |

**C-23**

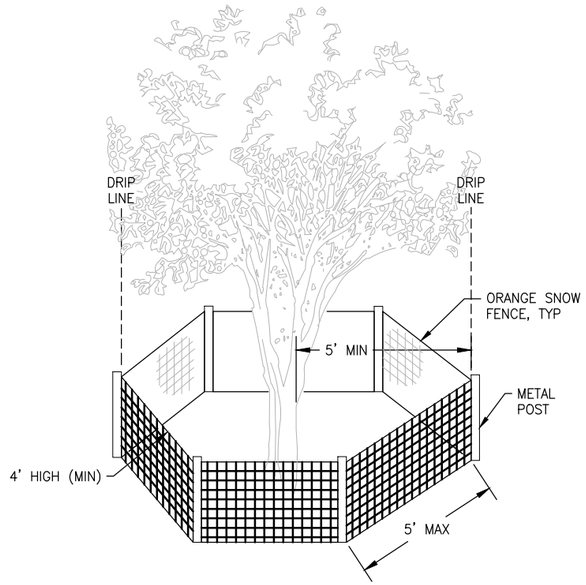



## 1 TEMPORARY FISH SCREEN
**TYPICAL PROFILE (NTS)**

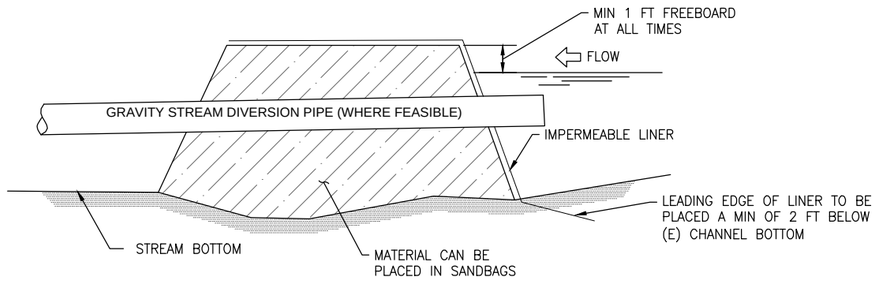
ROCK MEASUREMENT
A LONG AXIS
B INTERMEDIATE AXIS
C SHORT AXIS



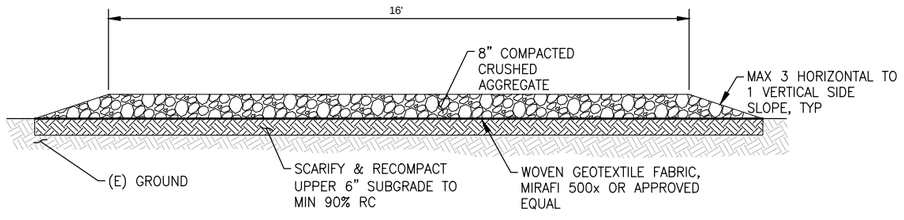

## 2 BOULDER AXIS
DETAIL, NTS



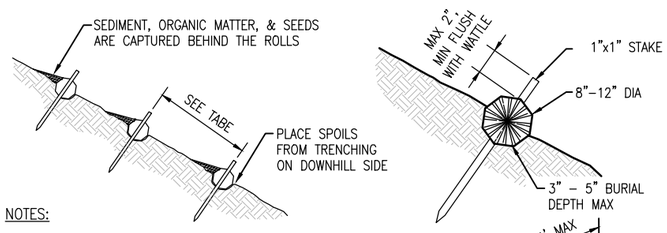

## 3 TEMPORARY VEGETATION FENCING
NTS




## 4 TEMPORARY COFFERDAM
**TYPICAL PROFILE (NTS)**




## 5 GRAVEL ACCESS ROAD SECTION
NTS

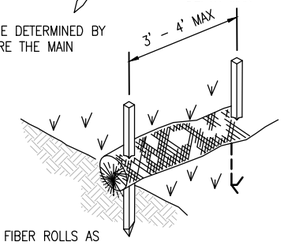



NOTES:

1. VERTICAL SPACING FOR SLOPE INSTALLATION SHOULD BE DETERMINED BY SITE CONDITIONS: SLOPE STEEPNESS AND SOIL TYPE ARE THE MAIN FACTORS. A GOOD RULE OF THUMB IS:

| | | |
|---|---|---|
| 1:1 SLOPES (100%) | = | 10 FEET APART |
| 2:1 SLOPES (50%) | = | 20 FEET APART |
| 3:1 SLOPES (33%) | = | 30 FEET APART |
| 4:1 SLOPES (25%) | = | 40 FEET APART |

2. ADJACENT ROLLS SHALL TIGHTLY ABUT, DO NOT OVERLAP ROLLS.
3. USE BIODEGRADABLE NETTING, OR REMOVE & REPLACE FIBER ROLLS AS SOON AS STRAW FILLING BEGINS TO DEGRADE
4. REFER TO MANUFACTURERS INSTALLATION INSTRUCTIONS FOR TYPE 2 INSTALLATION USING ROPE AND STAKES
5. WHEN CALLED FOR IN DRAWINGS, STRAW WATTLE IS TO BE SECURELY ATTACHED TO BASE OF TEMPORARY SECURITY FENCING OR STAKED JUST INSIDE SECURITY FENCING AT SPACING CALLED FOR IN SKETCH ABOVE. STRAW WATTLE IS TO BE PLACED ON INSIDE OF FENCE TO MINIMIZE PUBLIC TAMPERING.




## 6 STRAW WATTLE
DETAIL, NTS

Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411
Department of Fish and Wildlife
1416 9th Street, 12th Floor
Sacramento, CA 95814
http://www.dfg.ca.gov

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

# UPPER AND LOWER BARRIER SITES
# PROJECT DETAILS AND TYPICALS

DATE
FEBRUARY 2017
SUBMITTAL
90% DESIGN
DESIGN
ML, pTJ
DRAWN
pTJ, NN
SHEET
27 of 27

**C-24**

# Attachment 2
# Annotated Bibliography of Previous Battle Creek Studies and Reports

**(Page intentionally left blank)**

Annotated Bibliography for
Eagle Canyon Fish Passage Improvements in Battle Creek Lower and Upper Barrier Sites: Alternative Analyis Report

| Year | Author | Title | Brief Description |
|---|---|---|---|
| 1991 | Payne & Associates | Anadromous Fish Migration Barrier Survey Battle Creek, Shasta and Tehama Counties | A survey of barriers, total, partial, and temporal along Battle Creek, both natural and man made, including diversions of fish into hatcheries. |
| 1997 | CADWR | North Fork Battle Creek Eagle Canyon Diversion Preliminary Engineering Fish Passage Project | Discusses man made conditions, geologic conditions, and possible project alternatives including ladders and screens. |
| 1998 | Payne & Associates | Battle Creek Fisheries Studies Task 1: Instream Flow Study | Hydrologic study, habitat mapping, and hydraulic modeling of multiple reaches of Battle Creek |
| 1998 | Yoshiyama et al. | Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California | Journal Article, Discusses the decline of fall, late fall, winter and spring runs of Central Valley chinook salmon and contributing factors of overfishing and effects habitat reduction due to mining activities, dams and water diversions. |
| 1999 | Michael Black, Ph.D. | Shasta Salmon Salvage Efforts: Coleman National Fish Hatchery on Battle Creek, 1895-1992 | A history of Battle Creek Watershed 1895-1992 |
| 1999 | Kier Associates | Battle Creek Salmon and Steelhead Restoration Plan | Restoration Plan prepared for the Battle Creek Working Group |
| 1999 | Multiple Agencies | Memorandum of Understanding | Memorandum of Understanding for Battle Creek between multiple agencies |
| 1999 | Battle Creek Working Group | Final Agreement in Principle | MOU Monthly Minimum Flow Agreement |
| 2000 | USFWS | Battle Creek Anadromous Salmonid Monitoring Projects | Proposal for monitoring project |
| 2000 | CADWR | Battle Creek Salmon and Steelhead Restoration Project - Technical Report | Technical study of fish ladders, fish screens, diversions, and preliminary engineering concepts |
| 2000 | CADWR | Battle Creek Salmon and Steelhead Restoration Project - Technical Report | Technical study of fish ladders, fish screens, diversions, and preliminary engineering concepts |
| 2001 | USDAFS | Aquatic Condition Report for the Upper Battle Creek Watershed | Summary of Aquatic habitat, evaluation of riparian habitat, and identification of road related erosion sites |
| 2001 | USBR | Hydrology of North and South Fork Battle Creeks | Analysis of flows, hydrological conditions, and hydraulics at structures |
| 2001 | USBR | Sediment Impact Analysis of the Removal of Coleman, South, and Wildcat Diversion Dams on the South and North Fork Battle Creeks | Technical study of impacts on North and South Fork Battle Creeks from sediment loading as a result of dam removal |
| 2001 | Red Bluff USF&W | Project Report: Interim Screening for the Intakes at Coleman National Fish Hatchery | A report on efforts to preclude entrainment of wild juveniles into fish hatchery intake structures |
| 2003 | U.S. Dept of the Interior, USBR, CAWRCB | Battle Creek Salmon and Steelhead Restoration Project Draft Environmental Impace Statement / Environmental Impact Report, Section 4.3 Hydrology | Hydrologic discussion of Battle Creek, its tributaries, hydraulics and sediment, and impacts from diversions and hydroelectric developments as well as potential dam removal. |
| 2003 | Bay Delta Program | Battle Creek Steelhead Restoration Project Ecosystem Restoration Amendment | Description of project, Memorandum of Understanding, and budget changes |
| 2004 | Terraqua, Inc. | Battle Creek Watershed Assessment: Characterization of stream conditions and an investigation of sediment source factors in 2001 and 2002. | Documents existing sediment source conditions to provide a baseline for comparison and priorities for treatment |
| 2004 | Terraqua, Inc. | Passage Objective 3 | Adaptive Management addendum for passage objective 3 - natural barriers |
| 2004 | Terraqua, Inc. | Draft - Battle Creek Salmon and Steelhead Restoration Project - Adaptive Management Plan | Adaptive Management Plan for Battle Creek by multiple agencies |
| 2004 | Busack et al. | Compatibility of Coleman National Fish Hatchery Operations and Restoration of Anadromous Salmonids in Battle Creek | An independent evaluation of scientific issues related to the restoration of Battle Creek |

| Year | Author | Title | Brief Description |
|---|---|---|---|
| 2004 | Brown and Kimmerer | A Summary of the October 2003 Battle Creek Workshop | Summary of presentations, discussions including slides and notes taken during sessions. |
| 2005 | CA Bay Delta Authority | Initial Study and Proposed Mitigated Negative Declaration for the Fish Barrier Weir and Ladder Modification at the Coleman National Fish Hatchery | Initial Study and Proposed Mitigated Negative Declaration for the Fish Barrier Weir and Ladder Modification at the Coleman National Fish Hatchery |
| 2006 | McFarland et al. | Battle Creek Watershed Restoration Planning Broad Scale Analysis to Develop Sub-Watershed Priorities | Battle Creek sub watershed priorities for restoration |
| 2007 | USFWS / Brown & Alston | Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California from November 2002 through November 2003 | Presentation and alalysis of monitoring studies for the purpose of informing further studies and fisheries management on Battle Creek |
| 2007 | Unk. | Water Year 2007 - Schematic | Single page schematic of NF and SF Battle Creeks and Cow Creek and assockated diversions, canals and reservoirs |
| 2008 | USFWS/Newton et al. | Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California from March through November 2007 | Presentation of monitoring studies for the purpose of informing an adaptive management program on Battle Creek |
| 2008 | USFWS/Whitton et al. | Juvenile Salmonid Monitoring in Battle Creek, California, November 2007 through June 2008 | Monitoring study conducted with the purpose of restoring populations of threatened and endangered species of salmonids |
| 2008 | Terraqua, Inc./Ward et al. | Battle Creek Stream Condition Monitoring Plan | Description of a program for monitoring streams within the Battle Creek watershed |
| 2008 | Terraqua, Inc./Tussing & Ward | Battle Creek Stream Condition Monitoring - 2006 Data Analysis Report and Correction to the 1002 and 2002 Watershed Assessment | Reporting of stream condition monitoring including invertebrate, riparian and stream condition surveys, water temp monitoring, meteorological monitoring, and monitoring of changes in land cover |
| 2011 | USFWS / Watershed Sciences | LiDAR Remote Sensing & Orthophoto Data Collection | Presents airborne survey data and supporting information from data collection through final product including instrumentation and accuracy assessment |
| 2011 | Multiple Agencies | Fish Returning to Battle Creek | Publicity release following removal of Wildcat Diversion Dam |
| 2011 | Multiple Agencies | A Rapid Assessment of Sediment Delivery from Clearcut Timber Harvest Activities in the Battle Creek Watershed, Shasta and Tehama Counties, California | An interagency task force review of clearcut practices and potential impacts on the restoration efforts in the Battle Creek watershed |
| 2011 | Cal Fire | Land Stewardship Proposal | A proposal of Cal Fire's land stewardship goals |
| 2012 | USBR | Battle Creek Salmon and Steelhead Restoration Project | Brief overview of project and funding sources |
| 2012 | Stewardship Council | Fee Title Recommendation Battle Creek Planning Unit | Recommendations for Land Stewardship Proposals |
| 2012 | CHSRG | CA Hatchery Review Report | Coleman section of the hatchery review for CA |
| 2012 | CDFG - M. Smelser | Draft -Engineering Geologic Investigation and Analysis, Eagle Canyon Fish Passage Barrier, Battle Creek, Tehema County, California | Memo discussing regional geology, channel characteistics, barrier characterization, proposed improvements |
| 2013 | Unk. | Coleman National Fish Hatchery Adaptive Management Plan | Public Summary of Adaptive Management Plan for Coleman National Fish Hatchery on Battle Creek |
| 2014 | USFWS / Earley | Summary of the Pilot Assessment of Three Potential Fish Barriers on Battle Creek | Selection, measurement, descriptions and assessment of Barriers on Battle Creek |
| 2015 | USFWS / Bottaro & Brown | Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California from March through November 2014 | Fisheries monitoring and analysis for the purpose of informing adaptive management efforts |
| Unk. | Thomas E. Hepler P.E. | Changes to Battle Creek Hydroelectric Project to Facilitate Fish Passage | NEPA/CEQA Compliance process, final design, and construction status for project dam removal and fish ladder installations |

**Attachment 3**

*Eagle Canyon Fish Passage Improvements; Alternative Analysis Constructability Review Memorandum* **(SRD, 2016a)**

**(Page intentionally left blank)**

# 1 Consultants Scope of Work

As requested by Michael Love and Associates, SR Diversified is responding to a request to provide Early Contractor Involvement (ECI) support to for the removal of two fish passage barriers on North Battle Creek upstream and downstream of PG&E Eagle Canyon Diversion Dam near Manton, CA. As with the engineer's memorandums, the two locations will be described as Upper Barrier and Lower Barrier. Phase 1 will include the following specific tasks:

| Task No. | Task Description |
|---|---|
| 1 | Attend Kickoff Meeting and Initial Site Visit |
| 2 | Prepare Alternative Analysis Constructability Memorandum |
| 3 | Discuss and/or Attend Memorandum Review Meeting |

# 2 Overview

On September 13, 2016, Chris Cornell and Steve Lindstrom of SR Diversified met with Michael Love and Travis James of Michael Love & Associates to conduct a site walk to review the conditions of the two reaches for fish passage improvements on North Battle Creek. Both locations are in remote areas accessible only by foot. At the time of our visit, it was verified that the flows in Battle Creek were approximately 35 cubic feet per second.

A meeting was conducted at CDFW office in Sacramento to review rev2 of this Alternative Analysis on October 17, 2016. As a result of that meeting several issues were addressed. This memorandum (Task 2, rev 3) is based on a contractor's perspective on how to perform the work in compliance with typical environmental permit conditions when working in or near water and normal construction specifications and meeting discussions.

As previously noted, Chris Cornell as a Syblon Reid employee, was the initial Project Manager for construction of the North Battle Creek Feeder Diversion and Eagle Canyon Diversion Fish Ladders and Fish Screen. Much of the methodologies and compliance issues have been incorporated into this memorandum. In addition, Syblon Reid as the primary subcontractor to TNT Constructors, Inc. has been awarded the North Battle Screens and Ladders Completion work to begin in early 2017. Chris also helped developed means and methods for the proposal that led to the award of the project.

After the meeting in Sacramento and subsequent conference calls, SR Diversified has been requested to provide estimated costs for the various alternatives. The work descriptions and assumptions in this memorandum will be broken out into the equivalent of bid type items for that assignment.

# 3 Constructability Analysis

From a constructor's perspective, the work at both sites is almost identical. Our constructability analysis will largely cover removal of fish passage barriers simultaneously. However, there are some differences in access options between the sites that will be discussed separately.

## 3.1 Laydown Areas/Site Set Up

We see three options of how to achieve access to support removal of the fish passage barriers; (1) Helicopter, (2), Large Crane, and (3) Yarder. Each of these scenarios is described below.

Depending on the option selected, laydown areas approximately 150 to 200 feet square will need to be developed for parking and staging of equipment. It is our recommendation that any existing dirt roads or new roads be topped as necessary with crushed rock to minimize dust and provide an adequate surface during wet periods of the construction.

### 3.1.1 Option 1 – Helicopter

The advantage of the helicopter option is that there is some flexibility on where to stage a landing zone (LZ). For this exercise, we assume the LZ would be in the same location as previously used for the Eagle Canyon Diversion Fish Ladder/Fish Screen Project. However, we are aware that this site may be used for the completion of the work in 2017. Another advantage is vegetation removal is fairly limited to the local removal sites. Although there are some benefits with this scenario, we believe this will be the most costly means and methods to remove the barriers.

If this was the chosen option, we would recommend using a PJH UH 60A Utility Hawk from P.J. Helicopters in Red Bluff. This ship can lift 8,000 pounds at sea level. Larger helicopters, such as a CH-47 Chinook, could be used, but the hourly rate is nearly double that of the Utility Hawk.



### 3.1.2 Option 2 – Crane

As performed on the Eagle Canyon Diversion Fish Ladder/Fish Screen Project, we believe a 250 ton Manitowoc 999 could be used for the Lower Barrier rock removal.

However, we suspect the lifting capacity limit would be less than 8,000 pounds at the horizontal distances roughly assumed. Increased levels of work would be incurred if rock needed to be broken into smaller/lighter loads. In addition, care would need to be taken as to not hoist any loads over the PG&E flume sections in case of incidental debris fall. The main advantage to this option is that only one staging area along with a crane pad on

the south side of the rim would need to be developed. See ***Attachment 1*** for this potential layout.

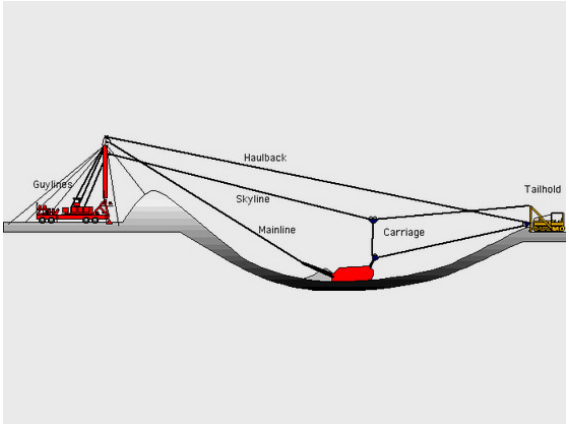



On the Upper Barrier, the horizontal distances from top of rim to top of rim over the creek canal are too great for even a large crane. However, we do believe that a smaller crane can be used on the north side of the rim if a road were to be developed down to just above the work area. At the terminal point of the road, a crane pad with a minimal width and length of 30 feet would have to be developed. A similar road was developed at North Battle Creek Feeder Diversion in 2010. See photo at left.

However, due to the high construction costs, additional ground disturbing activities and the lack of need of permanent access, we do not recommend the construction of a new road down to the rock barrier location **unless access can only be obtained from the north side.** See ***Attachment 2*** for this potential layout.

### *3.1.3 Option 3 – Yarder*

Based on the site observations and the overall project objectives, we believe the best approach to set equipment and remove rock debris from both the Upper and Lower Barriers is with the use of yarder logging type equipment. See schematic and photo below of yarder equipment.






For the yarder options, we assume that land use at the areas on both sides on the adjacent bluffs is obtainable.

In previous versions of this memorandum, we contacted Robinson Enterprises, a company that owns several of these machines. They can comfortably high line 8,000 pounds and span a

distance of 1,500 feet. However, both the yarder and load line on the opposite side need to be anchored. Anchoring can be achieved by the installation of the multiple rock anchors or by using large construction equipment as tail holds.

Further constructability reviews since the meeting in Sacramento with Robinson Enterprises were done to confirm yarder capabilities for various alignments to determine ground clearances with the rock loads coming up the slopes. Based on this review, they have indicated that all yarder scenarios alignments are reasonable. In addition, Robinson Enterprises indicated the yarder can swing 90 degrees with the load once it is received at the top of the bluff by putting some slack on the main load line. This will allow the yarder to sit closer to the edge of the bluff to provide better ground clearance of the rock loads coming up the hill. Below is some additional site specific information.

**Lower Barrier** - The alignment drawing provided by Michael Love and Associates for the Lower Barrier seems completely adequate. However, it may be necessary to install additional equipment anchors if rock relocation in the channel is required. See ***Attachment 3*** for plan and profile sketches.

**Upper Barrier** - On the Upper Barrier drawings, there are to possible alignments; east-west and north-south. Either alignment can provide adequate means of rock extraction from the channel. However and since there will be rock relocation some 80 feet in the channel at this location, the north/south alignment is preferred. See ***Attachment 4*** for the yarder alignment concepts with sketches.

## *3.2 Foot Access/Work Site Set Up*

It will be necessary to improve access foot routes from the bluff down to the creek. These improvements most likely will be a combination of hand digging a minimal trail width of about 2 feet or the installation of wood walk ramps or stairs. Once access to the creek is achieved, it may be necessary to install small walk bridges (most likely a 24 foot aluminum walk boards) over creek crossings. A trail, ramp or stairway up the creek channel at each barrier some 100 feet and 300 feet downstream of the work area would be necessary for safe access and egress assuming water quality monitoring is required.

As a safety precaution and as discussed at the meeting in Sacramento, we recommend doing a light rock scale of the hillsides above the barriers to ensure no lose boulders or tree roots are a threat to workers below. On the Eagle Canyon Diversion Screens and Ladders Project, it was necessary for a geologist to inspect the slope and he either dictated which rock to be removed or in some cases which rock had to be pinned with anchors and cable. There seemed to be consensus at the Sacramento meeting that this is a prudent measure to protect workers below.

All concepts above require some amount of tree and vegetation removal. Based on permit conditions on the Screens and Ladders Projects, vegetation removal was only allowed from early September through the end of January. This required two mobilizations with the 1st for vegetation and tree removal and a 2nd one to begin work in the late spring/early summer to begin work after spring runoff type flows down Battle Creek subsided sufficiently to maintain water control to perform the work in the dry.

Assuming that 2 mobilizations are required and rather than setting up a crane or yarder for the vegetation removal, we would recommend using a smaller helicopter such as a Bell 407 with a rated sling load of 2,500 pounds or a MD 530 with a rated load of 1500. It should be noted at this time on the Screens and Ladders Project that the Bureau of Reclamation implemented hazing techniques to insure bird nesting did not occur in the project areas between completion of the vegetation removal and beginning of the in stream type work activities.

If the ground disturbing areas exceed 1 acre in size, a formal SWPPP will need to be developed. The plan has to be done by a Qualified SWPPP Developer and implementation needs to be overseen by a Qualified SWPPP Practitioner. Whether a formal plan is required or not, it is prudent to implement or install certain BMPs regardless. These most likely would include pressure washing equipment prior to entering the sites to prevent importation of noxious weeds, silt fence, straw wattles, preservation fencing (especially around Elderberry Shrubs), exclusion fencing, stationary equipment such as generators, compressors and temporary sanitary facilities in secondary containment, and stationing of spill cleanup kits/oil booms in the water below the work areas.

On the Screens and Ladders Project, it was necessary to provide dust abatement to all non-paved project roads and laydown areas. The Bureau of Reclamation would not allow the contractor to obtain any construction water from either Battle Creek or PG&E canal systems. Therefore, it was necessary to purchase water from a local rancher that had a spring fed pond.

As required by law, the contractor is to provide sanitary facilities within a reasonable distance to the work. Sanitary facilities can be ordered with picking cages that allow them to be air lifted or lowered to the work areas via hoisting equipment. It may be prudent to build some small working decks that not only provide an adequate platform for the sanitary facilities, but also for placement of tools and other small equipment. At right is a photo of a work deck that could be constructed to accommodate the sanitary facilities and other tools/equipment necessary to perform the work on a project in a remote area.



Compressors for drilling operations and generators to operate hand held electrical tools and submersible pumps would most likely be stationed on the rim areas where they can be easily fueled and maintained. Lines would be laid down the canyon walls and secured as necessary.

Plans will need to be developed and implemented for both fire prevention and emergency evacuation at each barrier location.

## 3.3 Water Control/Water Quality

Work in live streams normally requires the contractor to develop means and methods to perform the work in the dry to be in compliance with allowable turbidity allowances and general resourced agency permit conditions. In the event necessary for this project, we would recommend a similar streamflow bypass system as was done for the previous mentioned projects on North Battle Creek. This system would largely be comprised of a super sack cofferdam and gravity flow bypass pipes. For this exercise, taking into the consideration of the amount of flows and the need for impact resistant materials, we will think that HDPE piping is the optimal choice to bypass water through the work areas.

As far as the cofferdam locations, it is really important is to pick locations that will seal, not only on the bottom, but also on the sides to the best extent possible. Obviously, a bed rock slot is ideal.

The super sack dam building process normally starts with hand clearing rocks and installation of a leveling course of small sand bags. The super sacks are usually filled with clean washed pea gravel and are placed on the leveling course of sand bags. The final height of the cofferdam is usually constructed with 2 feet of freeboard. Prior to completion of the dam, the HDPE pipes are placed at an invert elevation that allows a 1% minimum grade past the work area. Since water will filter through the sandbags and super sacks, plastic sheeting is typically laid down on the foundation before placing them and folded back over the cofferdam when complete.





At left is a photo of the same type of cofferdam structure with 30 inch HDPE gravity flow bypass piping used on the previous project at Screens and Ladders Project near Manton. Two of these pipes routed minimum stream flows around the work area and one was used to route water back into PG&Es flume for generation purposes while work was being done on the diversion dam. FERC requires all cofferdams to be designed and stamped by a professional engineer. Although it is our understanding that FERC jurisdiction is not applicable at these locations, it is prudent to have cofferdams designed and stamped by an engineer to ensure worker safety.

All cofferdams leak to some degree. It is most common to install electrical submersible pumps below the cofferdam to capture leakage water prior to the areas of disturbance. At left is a photo of a typical

leakage control system that captures water below the cofferdam but above the work area. Water is captured clean and pumped either back over the cofferdam or completely around the work area. If there is a nature pool below the cofferdam, these pumps can control the leakage water without the installation of a secondary cofferdam. However, these secondary cofferdams rarely exceed 2 feet in height.

Based on the time of year the work will be performed, the HDPE pipes need to be sized accordingly. Based on previous experience, at least two 30-inch diameter HDPE pipes needed to be installed to handle the required flows down Battle Creek. However, if the flows do not exceed 35 cubic feet per second as observed on the site walk, only one 30-inch pipe may be necessary.

However, it will be necessary to study the inflow information in detail and consult with PG&E to size the pipe accordingly to take into account multiple operations scenarios including outages to their generation facilities that divert water back into North Battle Creek or emergency trips to Volta 2 Powerhouse and feeder flumes.

As discussed after the site walk for this project, several scenarios have been discussed regarding the routing of the pipe around the barriers. A considerable amount of boulder demolition would be necessary to create an open path to allow the piping to have a minimal 1% grade drop to create a path for the bypass pipe. To take full advantage of the hydraulic characteristics of the pipe, it is important to eliminate as many sharp angles as possible. Each angle causes friction loss in the pipe and creates the strong possibility that the pipe needs to be anchored.

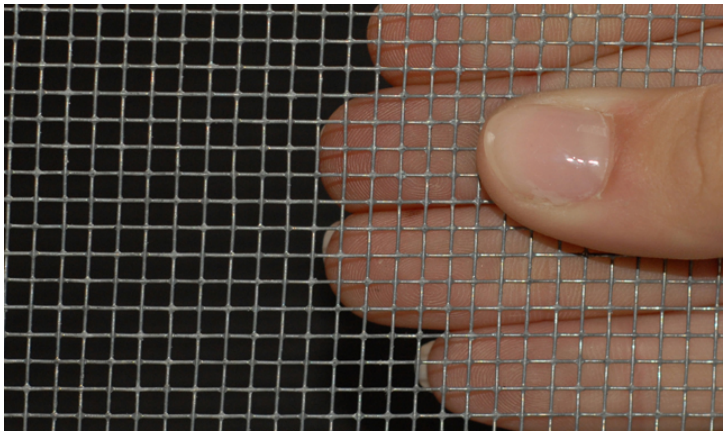
The 30 inch HDPE pipe can be “roped” on a radius of 100 feet without any negligible flow losses. In addition, the angles are pretty difficult to fabricate in the field. If we have to stick with a multi-angle bypass piping scenario, all the angle points would have to be shop fabricated from a precise lay out alignment. The entire pipe layout would need to be assembled on the bluff prior to deployment. An extensive analysis would need to be performed with the various angles in the pipe to determine flow capabilities. We suspect that there is a strong possibility that we would need to increase the pipe size greater than 30 inch if multi-angles were needed.

The pipes will be either hot fused together, flange connected, or employ the use of dresser type couplers. HDPE pipe needs to be supported every 10 feet or so to maintain gravity feed/unpressured characteristics. At these locations, it appears that the piping can be laid on the ground with little to no temporary support cribbing.

Although not recommended as a normal method, robust pumping systems can be set up to capture and divert entire river flows around the work areas using pumps and large rubber hoses and/or piping. If this were the preferred method, it is common to set up these systems with ample backup pumps and another generator with an automatic transfer switch that ensures flows do not overtop the cofferdams and flood the work areas. These systems typically run 24/7 until the work is complete in the stream channel. Fuel consumption is a major cost factor in this scenario.

As the cofferdam and bypass piping are near completion, it is typical to perform a fish rescue. Most fish rescue plans require this be done by professional biologists. Additional pumps are required to dewater various pools for this activity. It is not uncommon to have a requirement to screen the

dewatering pumps to avoid picking up small fish and other aquatic life. Below is a typical screen that meets NOAA guidelines.



Typical water quality criteria allow the contractor to perform in water work as long as he does not exceed 15 NTUs over background over a 4 hour to 24 hour averaging period. However, these allowances are not consistent and change considerably depending on the location and the watershed basin in which the work is performed. On the Battle Creek Screens and Ladders Project, the water quality certification requirements are limited to not exceed 20% over background. These are fairly stringent when dealing with background water that is virtually crystal clear to begin with.

## 3.4 Rock Demolition/Removal

In order to remove the rock from the stream channel, it must first be demolished into sizes that can handled by hand or equipment designated by the contractor. This equates to rock drilling and breaking /splitting the boulders into manageable pieces either mechanically or by blasting.



Whether jackhammers or air tracks (see photo at right) are the preferred drilling equipment, we recommend the rock to be drilled in what is commonly described as “line splitting” which is nothing more than a series of holes drilled close together in strait lines to split the rock into sized chunks rather than random demolition. We believe this to be a better approach to faster remove barrier rock and to keep it within a controlled area. Due to the size of the rock to be demolished, it will be necessary to install scaffolding for workers to safety drill on the upper areas of the rock when using jackhammers.

Using air track drilling equipment may be an option, but it would be necessary to build working decks adjacent to the rock or provide a leveling course of rock for the equipment to get set up to perform the drill work.

Although “dry drilling” can be done in a safety compliant manner, wet drilling is the preferred method in today’s environment. Wet drilling is nothing more than having a water injection line on the drilling equipment that virtually eliminates rock dust.

There are trade-offs with either method. Dry drilling requires additional respiratory protection and the rock dust is immediately air born which creates nuisance dust and in turn affects air quality but has less impact on water quality. Wet drilling is the preferred method today, but a small amount of

slurry is often created that migrates down toward the ground surface with the potential to affect water quality. However, bypassing streamflows around the work area typically mitigates this issue because it allows a means of cleanup of any slurry without making contact with flowing water.

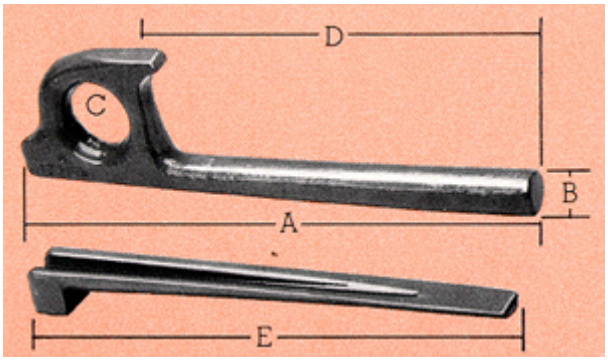
Once rock has been line drilled, it can be split by the use of mechanical rock splitters (i.e. Darda), expansive grouts, or explosives. The photo below shows rock demolition being performed with mechanical rock splitters.




It is our understanding that the use of expansive grouts was attempted on the rock with poor results. Therefore, we have not included this in our means and methods approach.

The use of explosives could be used as well and usually provides higher production rates. However, each time a "Shot" is planned, equipment must be removed from the immediate area and the rock to be blasted needs to be covered with a significant amount of blasting mats to contain the material in a reasonable area. From a safety perspective, personnel would need to leave the creek channel area and set up no entry zones to ensure public safety as well. Not to totally rule out, but in our assessment, there are significant risks with blasting because it may trigger addition rock movement from the adjacent slopes. Obviously, noise pollution is increased using this method.

Once the rock is demolished into manageable pieces, anchor pins with eyes could be installed to provide a positive means of connecting the load to the hoist line. A typical rock anchor used for this purpose is shown at right.




If we could devise an environmentally acceptable plan for rock demolition (splitting) in which it was not necessary to install the costly

cofferdam/ streamflow bypass piping, and if the rock was near or partially in the water, the rock anchor pin with a cable sling could be installed prior to splitting. In this manner the rock could be retrieved without significant impacts to water quality. The same technique could be used with blasting. However, there is high likelihood that the rock will not split according to plan. By nature of this method, we would expect increased turbidity and obviously a significant increase in noise pollution.

Obviously, there are trade-offs between mechanical rock splitting and the use of explosives. However, there is much more control using mechanical means.

Smaller rock fragments required to be removed would be hand loaded in a metal skip box and hoisted out of the creek channel or relocated as required.

Once the rock is received at the top of the bluff, it would be reloaded into dump trucks using an excavator or loader to be off hauled from the site or to be relocated locally.

## 3.5 Clean Up and Demobilization

Once the work in the stream channels is complete, all temporary facilities would be removed. The work sites and laydown areas would be completely cleaned up. We would expect all areas of ground disturbance be either hand seeded or hydro seeded. Although not expected at these sites, it is sometimes required to restore riparian areas with special plantings.

## Summary

As we have discussed in the past several weeks, if you and the CDFW agree or want to further explore our recommendation to select the yarder scenario as the preferred means and method for site set up, we believe it prudent to do another site walk down with the yarder equipment owner for the confirmation of capabilities at each location.

In addition, we also believe it prudent to conduct some performance testing using rock splitters on similar materials to confirm this means and method is not only productive, but much more a controlled means to rock demolition.

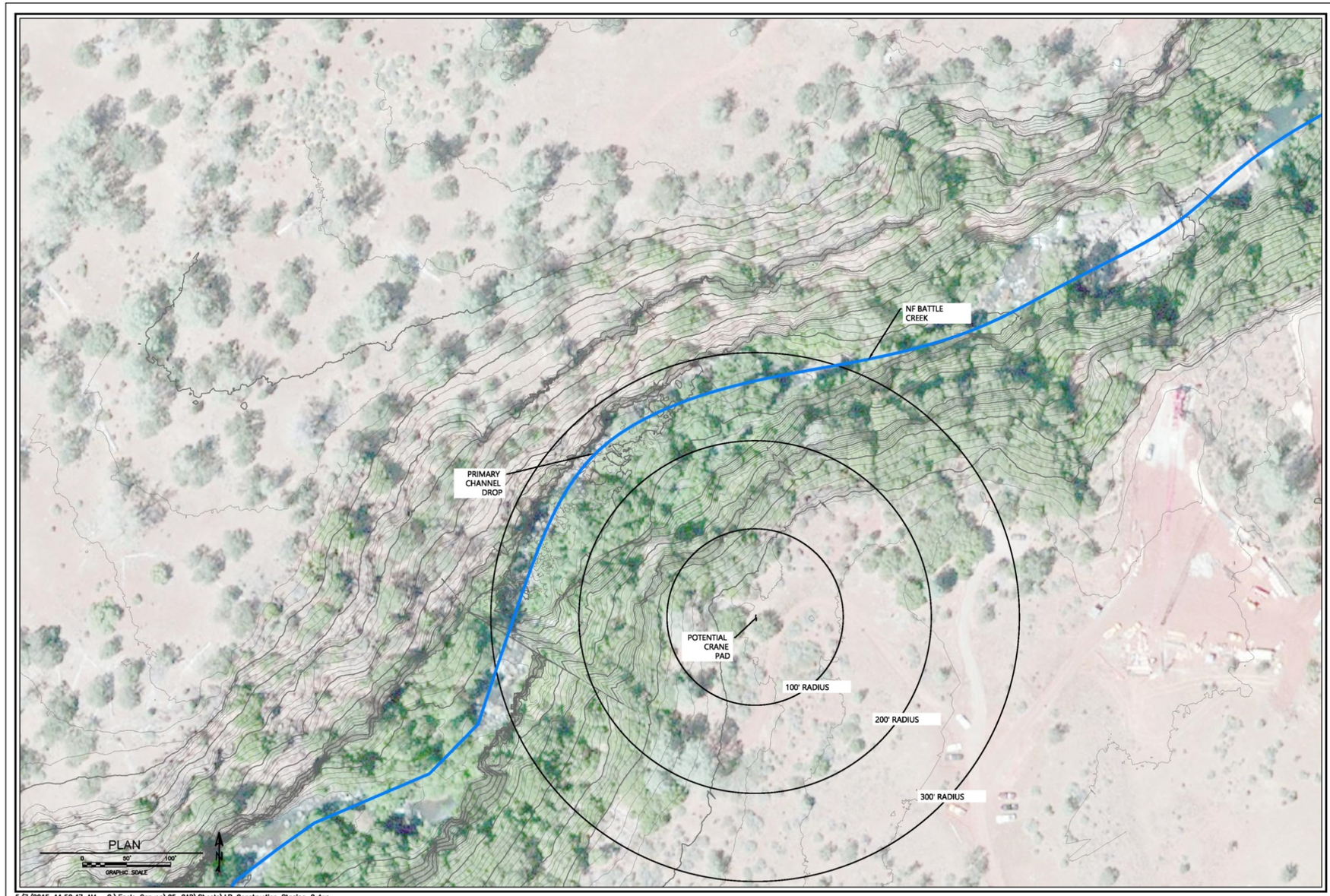
Should Michael Love and Associates want further information in regards to this memo and/or means and methods, please feel free to contact us.

***SR Diversified, LLC***

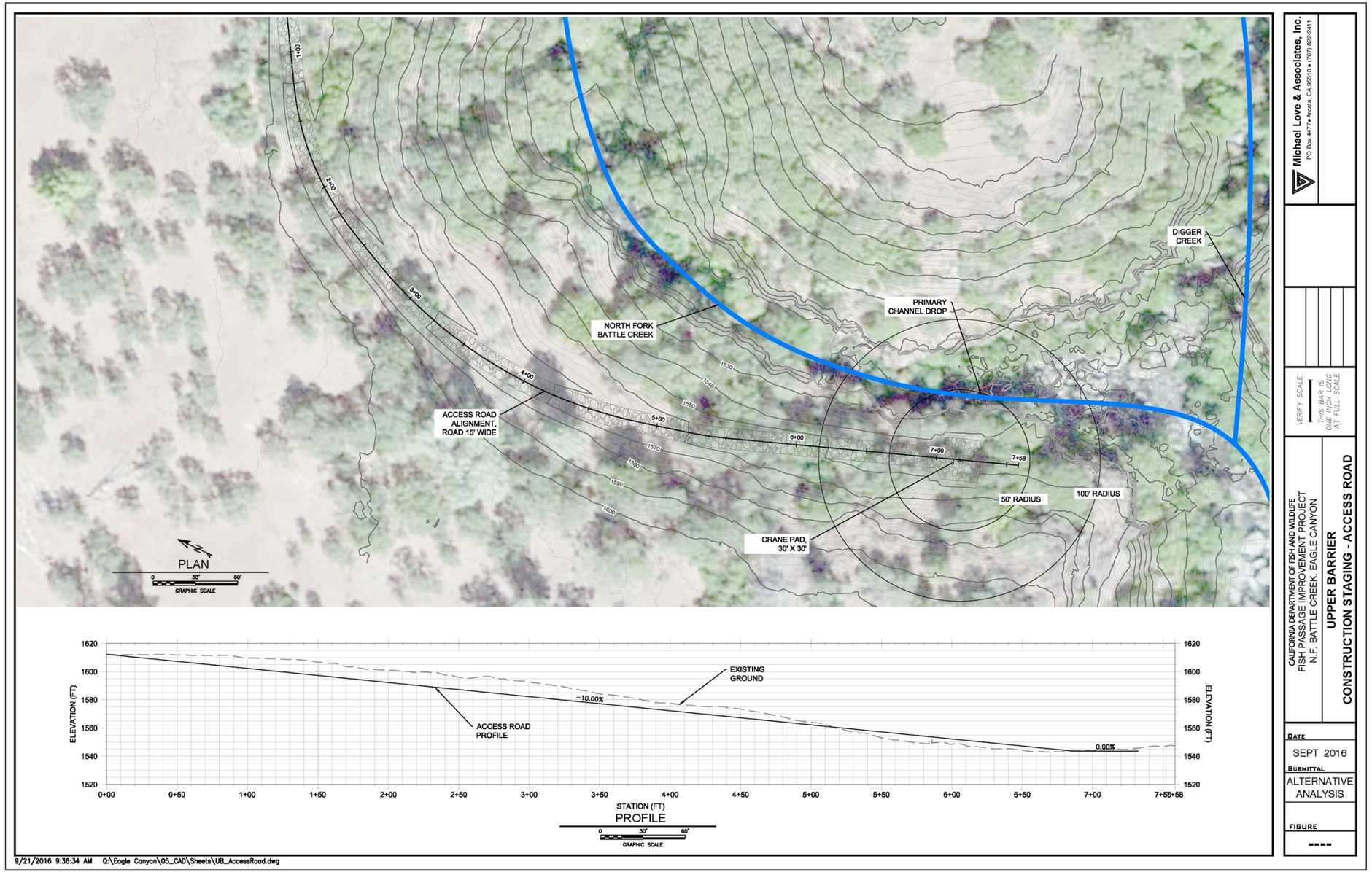


***Chris Cornell***
***Senior Project Manager***
(916) 351-0457 Office
(916) 765-7408 Mobile

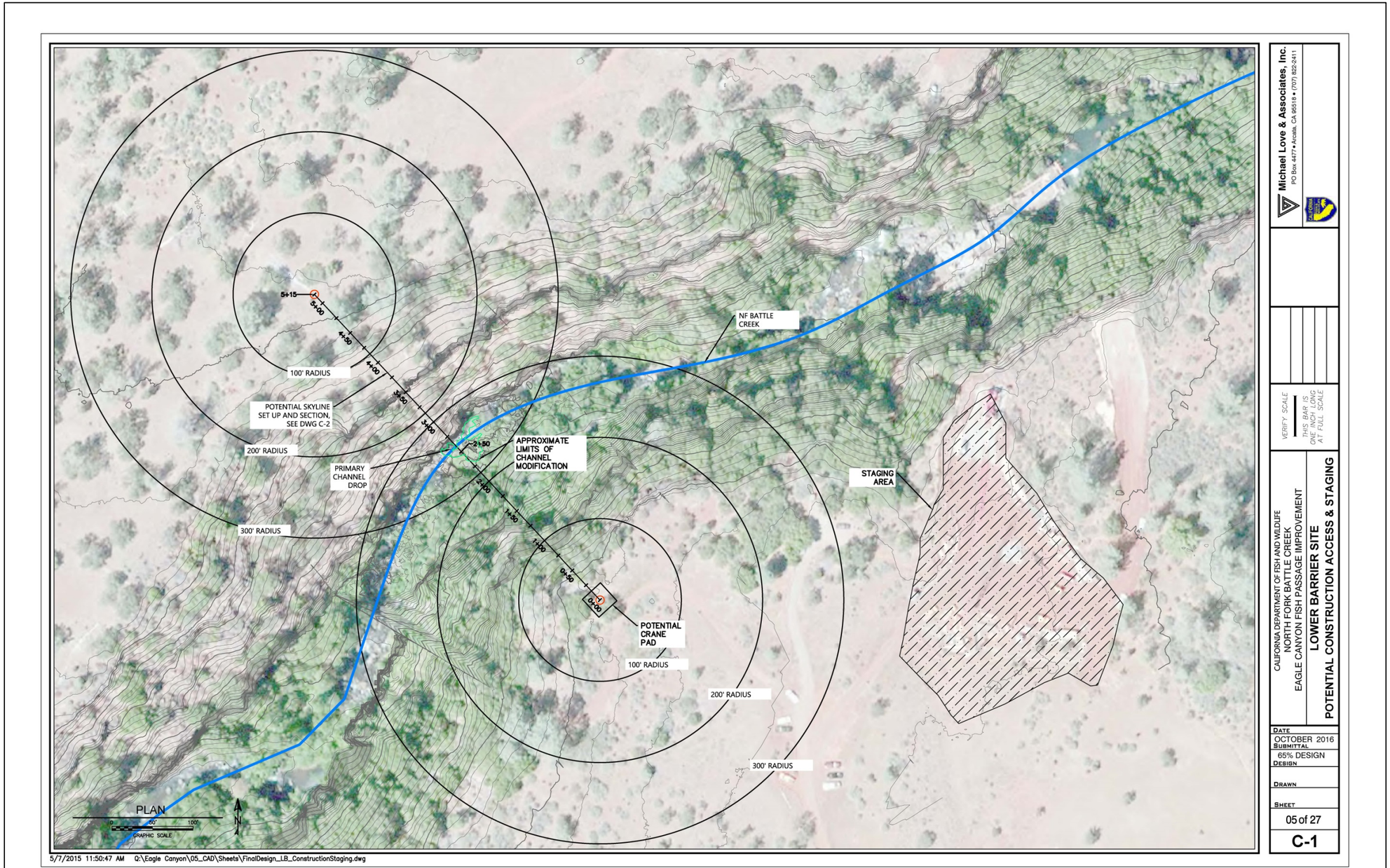
## *Attachment 1 – Lower Barrier Crane Concept*

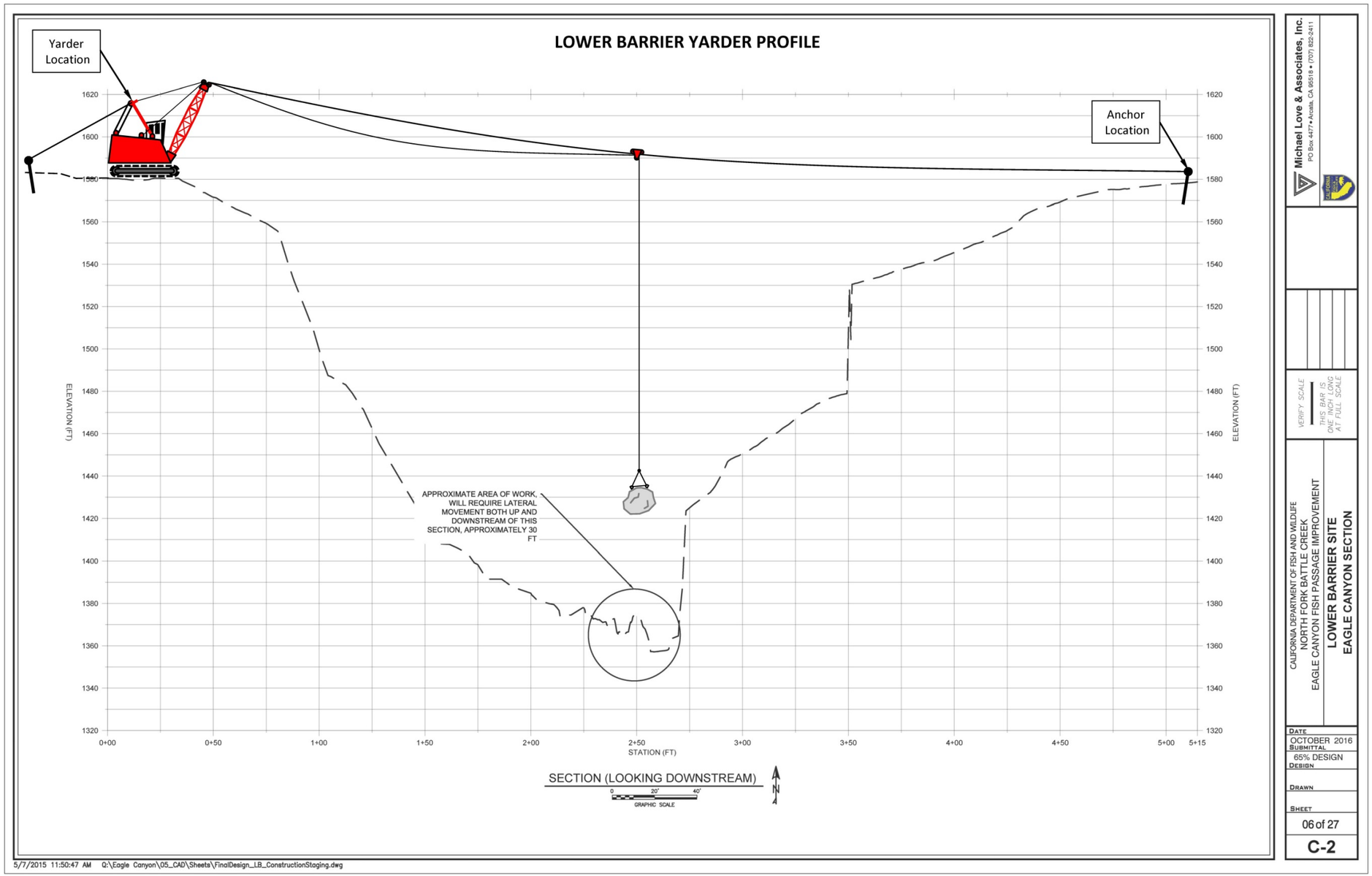


## *Attachment 2 – Upper Barrier Crane Concept*

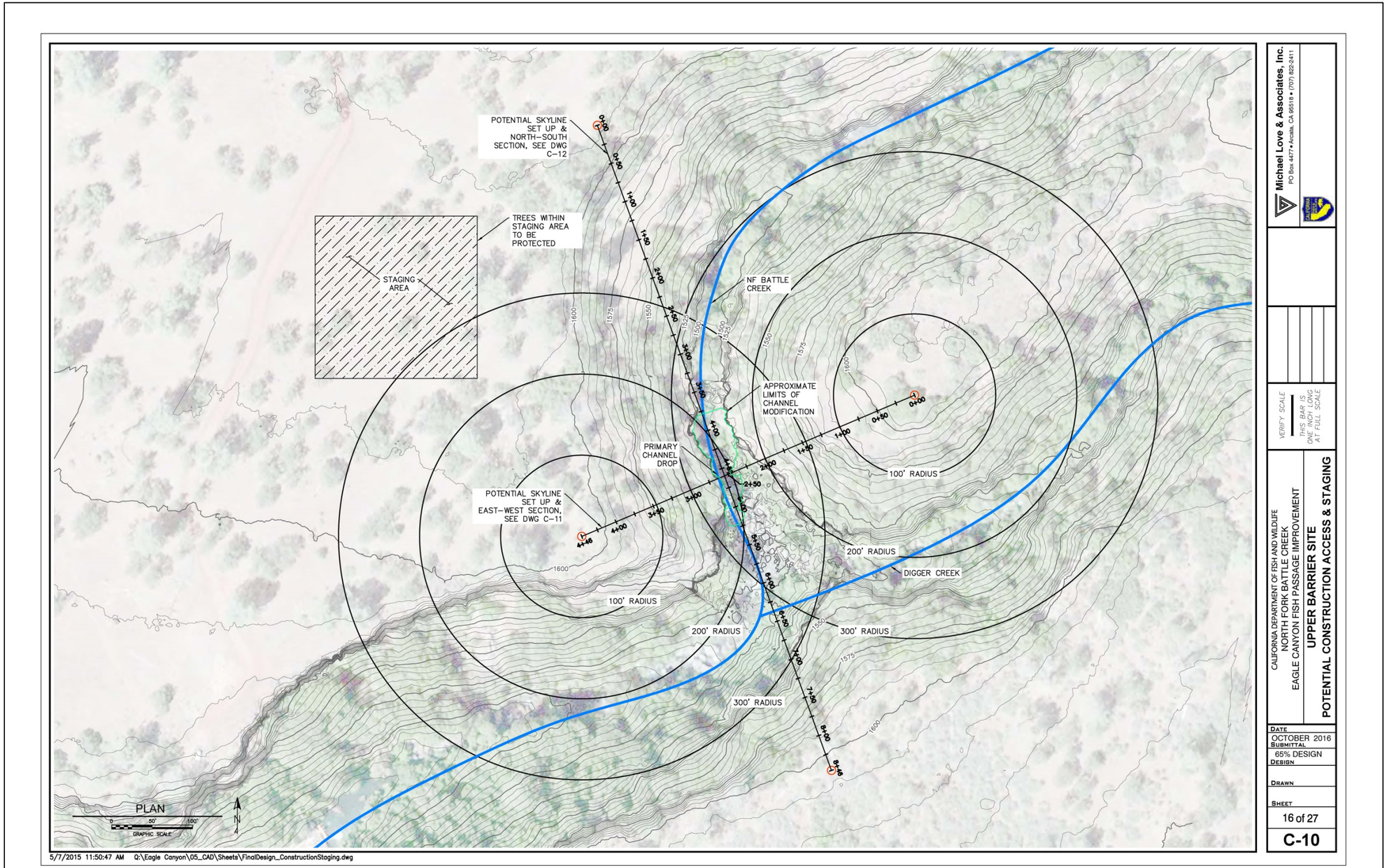


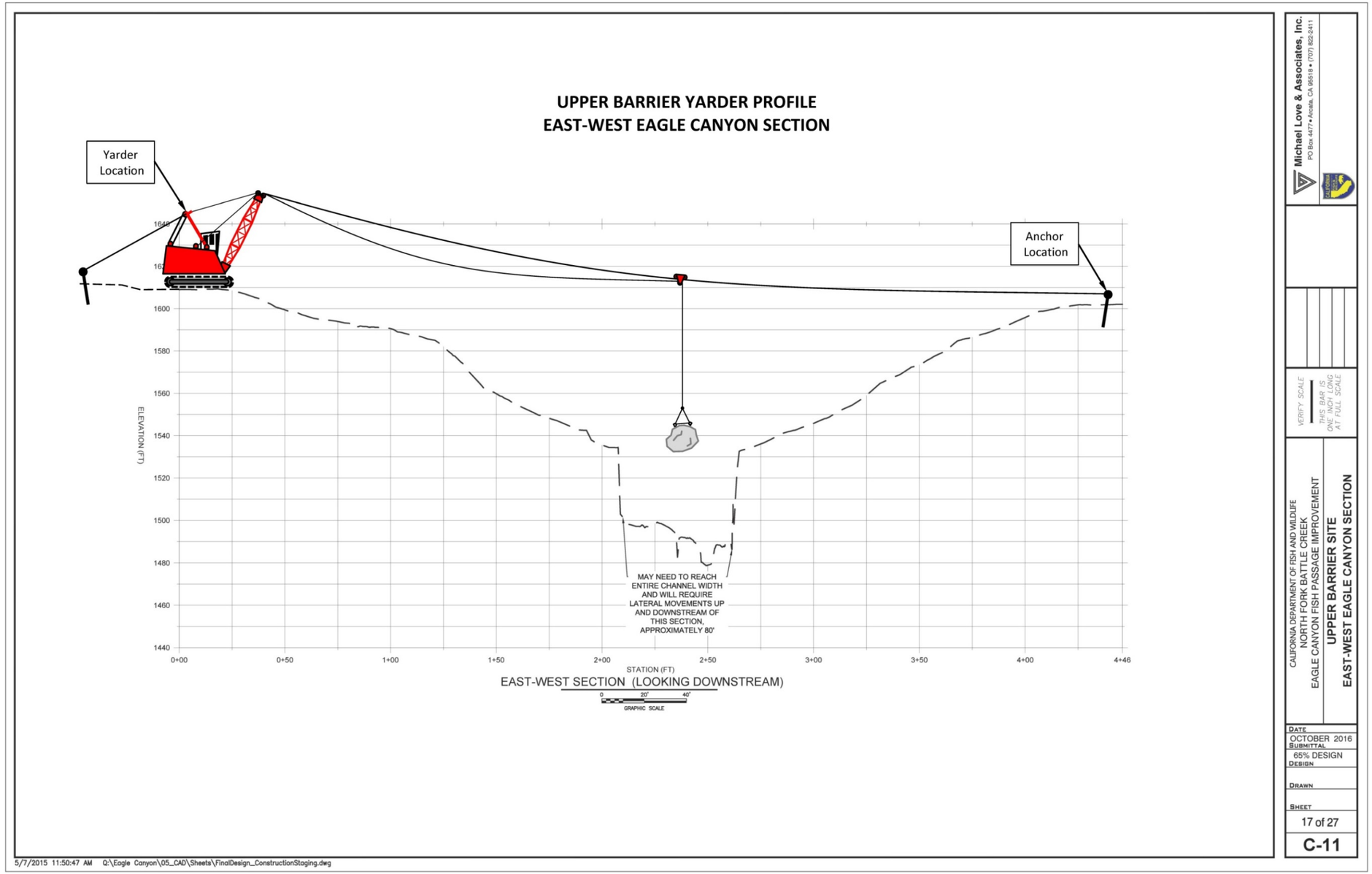
## *Attachment 3 – Lower Barrier Yarder Concept*

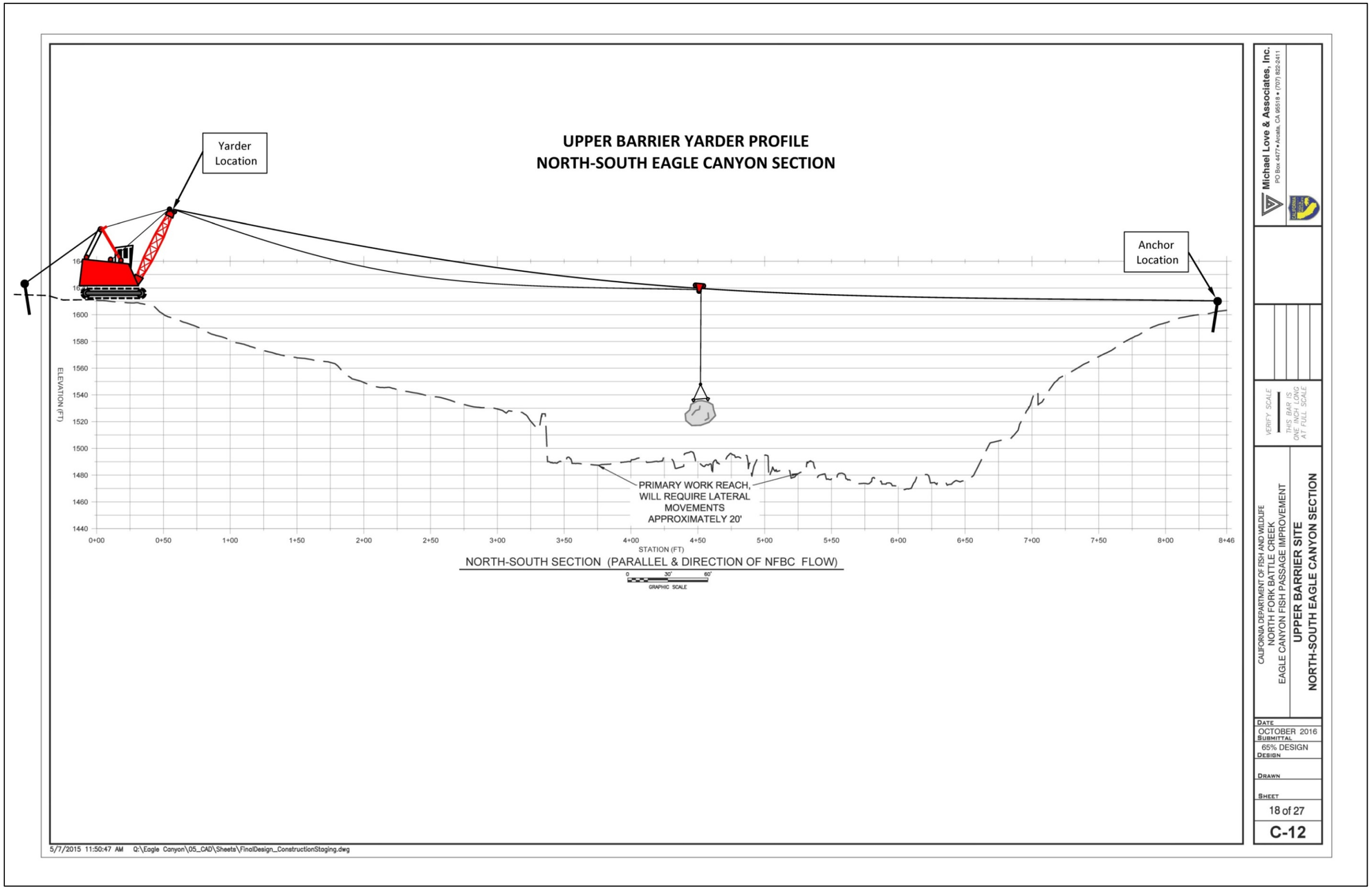



LOWER BARRIER YARDER PROFILE
Yarder Location
Anchor Location
APPROXIMATE AREA OF WORK, WILL REQUIRE LATERAL MOVEMENT BOTH UP AND DOWNSTREAM OF THIS SECTION, APPROXIMATELY 30 FT
ELEVATION (FT)
STATION (FT)
1620
1600
1580
1560
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+15
SECTION (LOOKING DOWNSTREAM)
0
20'
40'
GRAPHIC SCALE
N
Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2441
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
LOWER BARRIER SITE
EAGLE CANYON SECTION
DATE
OCTOBER 2016
SUBMITTAL
65% DESIGN
DESIGN
DRAWN
SHEET
06 of 27
C-2
5/7/2015 11:50:47 AM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_LB_ConstructionStaging.dwg

## *Attachment 4 – Upper Barrier Yarder Concept*




UPPER BARRIER YARDER PROFILE
EAST-WEST EAGLE CANYON SECTION
Yarder Location
Anchor Location
ELEVATION (FT)
1640
1600
1580
1560
1540
1520
1500
1480
1460
1440
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+46
STATION (FT)
MAY NEED TO REACH ENTIRE CHANNEL WIDTH AND WILL REQUIRE LATERAL MOVEMENTS UP AND DOWNSTREAM OF THIS SECTION, APPROXIMATELY 80'
EAST-WEST SECTION (LOOKING DOWNSTREAM)
0
20'
40'
GRAPHIC SCALE
Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
EAST-WEST EAGLE CANYON SECTION
DATE
OCTOBER 2016
SUBMITTAL
65% DESIGN
DESIGN
DRAWN
SHEET
17 of 27
C-11
5/7/2015 11:50:47 AM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_ConstructionStaging.dwg


UPPER BARRIER YARDER PROFILE
NORTH-SOUTH EAGLE CANYON SECTION
Yarder Location
Anchor Location
ELEVATION (FT)
1600
1580
1560
1540
1520
1500
1480
1460
1440
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+50
6+00
6+50
7+00
7+50
8+00
8+46
STATION (FT)
PRIMARY WORK REACH, WILL REQUIRE LATERAL MOVEMENTS APPROXIMATELY 20'
NORTH-SOUTH SECTION (PARALLEL & DIRECTION OF NFBC FLOW)
0
30'
60'
GRAPHIC SCALE
Michael Love & Associates, Inc.
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
NORTH-SOUTH EAGLE CANYON SECTION
DATE
OCTOBER 2016
SUBMITTAL
65% DESIGN
DESIGN
DRAWN
SHEET
18 of 27
C-12
5/7/2015 11:50:47 AM Q:\Eagle Canyon\05_CAD\Sheets\FinalDesign_ConstructionStaging.dwg

**Attachment 4**

*Eagle Canyon Fish Passage Improvements; Alternative Class 4 Estimate Narrative* **(SRD, 2016b)**

**(Page intentionally left blank)**

# 1 Early Contractor Involvement (ECI) Request

As requested by Michael Love & Associates, SR Diversified is responding to a request to provide additional Early Contractor Involvement (ECI) support for the removal of two fish passage barriers on North Battle Creek, upstream and downstream of PG&E Eagle Canyon Diversion Dam near Manton, California. As with the engineer's memorandums, the two locations will be described as Upper Barrier and Lower Barrier. This additional support is to develop three alternative Class 4 estimates as part of Phase 1.

This narrative can be supplemented further by the previously prepared "Alternative Analysis Constructability Review Memorandum, Rev 3" as prepared by Chris Cornell. As identified in the previously prepared alternative analysis memorandum, the three options to achieve access to support removal of the fish passage barriers are; (1) helicopter, (2) large crane, and (3) yarder. Per Michael Love & Associates' request, we have developed **Class 4** estimates based on boulder information provided by Michael Love & Associates, as well as our experience previously working in North Battle Creek/Eagle Canyon. For an overview and understanding of the various AACE estimate classifications, please see the table below.

| | ***Primary*** | ***Secondary Characteristic*** | | |
|---|---|---|---|---|
| **ESTIMATE CLASS** | **MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of | **END USAGE** Typical purpose of estimate | **METHODOLOGY** Typical estimating method | **EXPECTED ACCURACY RANGE** Typical variation in low and high ranges |
| **Class 5** | 0% to 2% | Concept screening | Capacity factored, parametric models, judgment, or analogy | L: -20% to -50%<br>H: +30% to +100% |
| **Class 4** | 1% to 15% | Study or feasibility | Equipment factored or parametric models | L: -15% to -30%<br>H: +20% to 50% |
| **Class 3** | 10% to 40% | Budget authorization or control | Semi-detailed unit costs with assembly level line items | L: -10% to -20%<br>H: +10% to 30% |
| **Class 2** | 30% to 75% | Control or bid/tender | Detailed unit cost with forced detailed take-off | L: -5% to -15%<br>H: +5% to +20% |
| **Class 1** | 65% to 100% | Check estimate or bid/tender | Detailed unit cost with detailed take-off | L: -3% to -10%<br>H: +3% to +15% |

## 1.1 Generic Cost Information/Estimate Approach

Rather than adding random costs for consumables, we have used 5% of the labor direct costs for this calculation under Construction Materials M&S. These costs cover a variety of miscellaneous supplies and consumables, such as personal protective equipment, cleaning supplies, safety supplies, power tools, hand tools, cutting wheels, etc.

Each scenario was estimated as a stand-alone project, which included site-specific mobilization/demobilization costs as well as work activity descriptions particular to each location.

**Important to note**, we have included a separate cost item to install cofferdams and provide stream flow bypasses at each site. This item would need to be an add-on cost to all three of the options estimated, if required.

All scenarios include Stormwater Pollution Prevent Program (SWPPP) and water quality type Best Management Practice (BMP) installations, as well as some clearing and grubbing, where required. We have included costs in our estimates to hydroseed areas of ground disturbance for erosion control and environmental restoration. The cost per acre was developed using subcontractor quotes based on setting up their equipment a maximum distance of 500 feet from the area of application.

Each scenario assumes a light rock scaling of the hillsides above the barriers for rock fall mitigation, as required to provide worker safety. We have also included $7,500 for Geologist recommendation/inspection time as part of the rock fall mitigation effort.

All scenarios assume the use of hand-held rock drills to line drill holes approximately one-foot apart and mechanically split the larger boulders into approximately 1.5 cubic yard boulders weighing approximately 7,000 pounds or less. This size was chosen based on the table of boulder information provided by Michael Love & Associates. The table shows a 1.5 cubic yard boulder should weigh on the order of 3.3 to 3.4 tons, or 6,600 to 6,800 pounds. Although the helicopter, large crane, and yarder used in our estimates are sized to lift 8,000 pounds, it is prudent to have some factor of safety. Based on the dimensions of the boulders provided, along with the 1.5 cubic yard target size and line drilling approximately one-foot apart, a quantity of drilled-feet was estimated for each boulder. It should be noted that some of the boulders included for removal are already smaller than 1.5 cubic yards and/or 7,000 pounds. It was assumed these smaller boulders would not need to be drilled and split into smaller sizes.

All scenarios assume some survey work is required; not only for construction layout and boulder identification, but also for recording as-built conditions after the work is complete.

For boulder off-haul trucking, all scenarios assume a one-hour round trip cycle time. In our experience we have found that rock boulders can have some value, particularly to plants that can process boulders into aggregates. Therefore, we have not included any disposal fees.

Permit conditions can have significant cost impacts depending on resource agency perceptions and objectives. We have included costs for water quality testing, however, additional cost impacts could arise based on permit conditions.

## *1.2 Indirect Cost Estimate Details and Assumptions*

For this Class 4 estimate, indirect costs have been factored in using a 20% mark up on the direct costs. A considerable amount of the “Indirect Costs” includes fuel, as well as Contractor Project Management. Fuel is one of the highest contributors that does not appear as a line item on the direct cost spreadsheets.

Besides Contractor Project Management and fuel, the indirect costs typically include the following items:

- Pre-Mobilization/Demobilization Preparation and Procurement activities at the Contractor's Headquarters
- Miscellaneous freight
- Overtime premium
- Travel and subsistence for staff and crew
- Office trailers, office supplies, and generator rentals
- Cargo van storage containers
- Cell phones and satellite communications
- Laydown area general dumpster rentals/fees
- Portable toilets and wash stations
- Contractor quality control management
- Escalation
- Main office overheads

## 1.3 Estimated Cost Summary Table

Below is a summary table of the estimated costs based on the available information. As mentioned above, we have included a separate cost item to install cofferdams and provide stream flow bypasses (one at the Lower Barrier and one at the Upper Barrier). This cost item would need to be an add-on cost to all three of the options estimated, if required. The details of the estimated costs in the table are included in ***Appendix A.***

| COST ITEM | DESCRIPTION | SRD ITEM COSTS WITH MARKUPS FROM GREEN SHEETS | SRD ITEM COSTS WITH 20% INDIRECTS & OVERHEADS |
|---|---|---|---|
| 1 | Remove Boulders via Helicopter and Rock Splitting | **1,999,723** | **2,399,668** |
| 2 | Remove Boulders via Cranes and Rock Splitting | **2,062,947** | **2,475,537** |
| 3 | Remove Boulders via Yarder and Rock Splitting | **1,859,500** | **2,231,400** |
| 4 | Add-on for Cofferdams and Streamflow Bypasses | **780,903** | **937,083** |

Note, the SR Diversified estimated costs do not include contingency. The range of accuracy for a Class 4 AACE estimate is -30% to +50%. Although not included in our estimated costs, at this phase we recommend a minimum of 25% contingency added to our estimates. However, Michael Love & Associates and/or California Department of Fish and Wildlife (CDFW) may want to apply a different amount.

## 1.4 Scenario Scope of Work Descriptions and Assumptions

Below are summaries of the option-specific scope of work assumptions included in the estimated costs for the various scenarios. To minimize redundancy, we will not repetitively describe generic cost information and assumptions described above in ***Section 1.1 Generic Cost Information/Estimate Approach.***

### Option 1 – Remove Boulders via Helicopter

The advantage of the helicopter option is that there is some flexibility as to where to stage a landing zone (LZ). Another advantage is that vegetation impact and removal should be fairly limited to the local Lower Barrier and Upper Barrier removal sites. This option has the least amount of ground disturbing activities, and as such, requires the least amount of erosion control BMP's (silt fence, wattles, etc.) and exclusionary fencing.

For this option we included placing aggregate base rock on the dirt road from the staging area south of the creek to the paved road (Long Road) to the south. This was assumed to not only provide winter access during the clearing and grubbing activities, but also help with dust control during the summer.

### Option 2 – Remove Boulders via Large Crane

For the Lower Barrier, we included the cost for using a Manitowoc 300-ton lattice boom rough terrain crane operating from a crane pad located on the south side of the rim. Our previous Eagle Canyon Diversion Fish Ladder and Fish Screen project was successfully performed and supported with this same crane setup.

It was assumed the horizontal distances from top of rim to the Upper Barrier site are too great, even for a large crane. For the Upper Barrier, we included the additional costs of clearing and grubbing, excavation, and restoration of a temporary access road from the north side of the rim to a crane pad adjacent to the Upper Barrier site that would accommodate a 100-ton rough terrain crane with a 100-foot working radius. These additional costs to accommodate the smaller crane are significant and substantially contributed to this option being highest estimated cost. ***However, if a crane pad could be established on the north rim to within a 275-foot radius, where the Manitowoc 300-ton crane could service the Upper Barrier, we believe this option could decrease by approximately $100,000 and compete better with the yarder and helicopter options***.

Based on the assumptions used, we have included placing aggregate base rock on the dirt road from Long Road to the staging area south of the creek to service the Lower Barrier; as well as placing base rock on the dirt road and new temporary crane access road on the north side of the creek to Battle Creek Bottom Road (to the north) to service the Upper Barrier.

Because this option includes the most ground disturbing activities, it also involves the most erosion control BMP's and exclusionary fencing. Based on permit conditions from previous projects in the area, vegetation removal was only allowed from early September through the end of January. This required two mobilizations, with the first for vegetation and tree removal, and the second for beginning work in late spring/early summer, after spring runoff flows subsided sufficiently to maintain water control and perform the work in the creek. As such, rather than mobilizing and

setting up the cranes for vegetation removal within the Lower Barrier and Upper Barrier sites, we have included costs using a smaller helicopter (Bell 407) with a rated sling load of 2,500 pounds at sea level.

### Option 3 – Remove Boulders via Yarder

For this option, we assumed a little more time would be required to remove trees from the Barrier sites along the hillsides to where the yarder would be set up. We also assumed there would be less erosion control BMP's required than the large crane option, but more than the helicopter option.

We have included two mobilizations for the yarder. The first for vegetation and tree removal, and the second for the actual fish passage improvements. If a smaller helicopter were to be used for vegetation and tree removal, the costs for this option would increase.

Also included in this option is the installation of rock anchors in support of the yarder operations. We have assumed three anchors on the yarder side of the canyon for yarder stability, and two anchors on the opposite side of the canyon for anchoring the skyline, for a total of 5 anchors at each barrier site. One disadvantage of using the yarder is its limited ability to work laterally once the yarder alignment is established and anchored. Additional anchors on the canyon rims, or supplemental winch type equipment, may be required to support working more laterally at the barrier sites with the yarder.

Although this option appears to be the most cost effective, the costs for this option are more likely to increase than decrease. As we developed the cost estimates for each of the three options, it became apparent the amount of time required to drill and split the boulders was much longer than the time required to actually remove the boulders from the creek. As such, equipment standby needed to be considered for both the crane and yarder options. In discussing a standby rate with Robinson Enterprises, a company that owns several yarders, they explained the equipment generates a significant amount of logging revenue for them during a good portion of the year. Because this is a Class 4 estimate, we quickly settled on a standby rate of 50% of the operated rate; however, due to the significant amount of standby time required, we could see this standby rate increasing.

### Cost Item 4 – Add-on for Cofferdams and Stream Flow Bypasses

As previously mentioned, we have included this separate cost item to install cofferdams and provide stream flow bypasses at each site. This item would need to be an add-on cost to all three of the options estimated, if required.

We previously installed cofferdams and stream flow bypasses for the North Battle Creek Feeder Diversion and Eagle Canyon Diversion Fish Ladders and Fish Screen project. For this Class 4 estimate, rather than detail estimated costs, we assumed the cost to install, maintain, and remove the cofferdams and stream flow bypasses for this Eagle Canyon Fish Passage Improvements project would be similar in magnitude to the previous projects.

## Exclusions

As we developed the estimated costs, we attempted to track items or exclusions that were not included. The major items are shown below.

- Contingency
- Design engineering (we have included minimal general construction engineering)
- SWPPP Plan development by a Qualified SWPPP Developer (QSD) and inspections by a Qualified SWPPP Practitioner (QSP).
- Additional dust control beyond placing base rock on the dirt roads (i.e. water truck)
- Roadway bridge Improvements for mobilization of large cranes/loads, if required
- Security
- Traffic control
- Permit fees
- Rental or purchase of lands for construction use
- Fish rescues by qualified biologists
- Removal or management of any hazardous wastes
- Restoration of riparian areas with special plantings

## Summary

As shown in ***Section 1.3 Estimated Cost Summary Table*** above, the yarder option appears to be the least expensive. However, as previously mentioned, this option has the most potential to increase in cost due to the likelihood of the standby rate used for the yarder to escalate, and the disadvantage of limited lateral movement. When adding the cofferdams and stream flow bypasses to each of the three options, the variances in estimated costs between any two options is less than 8%. With this in mind, and understanding these are Class 4 estimates, at this time it is difficult to completely rule out any one option.

The table below summarizes the advantages and disadvantages of each option.

| Option | Advantages | Disadvantages | Other |
|---|---|---|---|
| Helicopter | • Limited vegetation removal and ground disturbing activities | • More expensive than yarder option | • Could be most expensive (see crane notes) |
| Large Crane | • Flexibility of both lateral and vertical movements | • Most expensive primarily due to temporary access road to accommodate smaller crane at Upper Barrier site | • Potential to be less expensive than helicopter option if a crane pad could be established on north bluff within 275' radius to UBS |
| Yarder | • Currently estimated to be least expensive option | • Estimated costs has most potential to increase<br>• Limited in lateral working movement | |

At the present time, we believe it would be prudent to keep all three options open. As the project design develops and additional information becomes available, certain options may become more obvious while others may become more apparent to eliminate.

Should Michael Love & Associates want any further information regarding this Class 4 estimate, please feel free to contact us.

***SR Diversified, LLC***



***Steve Platt***

Green Sheet

**PROJECT NAME:** Eagle Canyon Fish Passage Class 4 Alternative Estimates

| Cost Item No. | Description | Qty | Unit | Labor U.C. | Labor Totals | Materials U.C. | Materials Totals | Constr. Materials M & S U.C. | Constr. Materials M & S Totals | Sub-Contractor U.C. | Sub-Contractor Totals | SRC Equipment U.C. | SRC Equipment Totals | O/S Rental EQ U.C. | O/S Rental EQ Totals | Other / (per diem) U.C. | Other / (per diem) Totals | Total U.C. | Total Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Remove Boulders via Helicopter and Rock Splitting** | 1 | LS | | | | | | | | | | | | | | | | |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Mobilization / Demobilization:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Mobe Men and Equip | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Safety and Environmental Training | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Setup Office Trailer, Generator, Cargo Van, Etc. | 32 | hr | 481.73 | $ 15,415 | | $ - | | $ - | | $ - | 26.60 | $ 851 | 329.96 | $ 10,559 | | $ - | | $ 26,825 |
| | Remove Office Trailer, Generator, Cargo Van, Etc. | 32 | hr | 481.73 | $ 15,415 | | $ - | | $ - | | $ - | 26.60 | $ 851 | 329.96 | $ 10,559 | | $ - | | $ 26,825 |
| | Demobe Men and Equip | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Site Prep:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Install BMP's (Silt Fence, Wattles, etc.) | 2,500 | lf | 2.33 | $ 5,826 | | $ - | | $ - | | $ - | 0.27 | $ 665 | | $ - | | $ - | | $ 6,491 |
| | Install Exclusionary Fencing | 2,500 | lf | 2.33 | $ 5,826 | | $ - | | $ - | | $ - | 0.27 | $ 665 | | $ - | | $ - | | $ 6,491 |
| | Develop Laydown Area (2 acres) | 10 | hr | 481.73 | $ 4,817 | | $ - | | $ - | | $ - | 26.60 | $ 266 | 329.96 | $ 3,300 | | $ - | | $ 8,383 |
| | Rock Access Rd (Creek to Long Rd. South) 5000 lf | 2,500 | tn | 3.14 | $ 7,840 | | $ - | | $ - | | $ - | 0.24 | $ 605 | 2.66 | $ 6,657 | | $ - | | $ 15,102 |
| | Improve Foot Access to LBS & UBS | 1,550 | lf | 17.59 | $ 27,264 | | $ - | | $ - | | $ - | 1.33 | $ 2,062 | | $ - | | $ - | | $ 29,325 |
| | Hand Clear & Grub @ LBS & UBS | 30 | hr | 372.46 | $ 11,174 | | $ - | | $ - | | $ - | 26.60 | $ 798 | | $ - | | $ - | | $ 11,972 |
| | Rock Fall Mitigation at LBS & UBS | 40 | hr | 351.79 | $ 14,072 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | | $ - | | $ - | | $ 15,136 |
| | Construct Work Platforms along Creek | 32 | hr | 406.91 | $ 13,021 | | $ - | | $ - | | $ - | 26.60 | $ 851 | | $ - | | $ - | | $ 13,872 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Lower Barrier Site (LBS):** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Scaffold up + down for Worker Safety | 20 | hr | 406.91 | $ 8,138 | | $ - | | $ - | | $ - | 26.60 | $ 532 | | $ - | | $ - | | $ 8,670 |
| | Drill & Split Large Rock into approx. 1.5 CY boulders | 2,257 | drill-ft | 28.44 | $ 64,184 | | $ - | | $ - | | $ - | 1.48 | $ 3,335 | 1.32 | $ 2,984 | | $ - | | $ 70,504 |
| | Drill & Install boulder lifting pins (Assume 3 per boulder) | 372 | ea | 30.28 | $ 11,262 | | $ - | | $ - | | $ - | 2.66 | $ 990 | 1.19 | $ 443 | | $ - | | $ 12,695 |
| | Fly out boulders support crew to landing area (112 + 10%) | 124 | ea | 37.25 | $ 4,619 | | $ - | | $ - | | $ - | 2.66 | $ 330 | | $ - | | $ - | | $ 4,948 |
| | Load boulders into trucks | 187 | cy | 5.11 | $ 956 | | $ - | | $ - | | $ - | 0.74 | $ 138 | 6.36 | $ 1,189 | | $ - | | $ 2,283 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Upper Barrier Site (UBS):** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Scaffold up + down for Worker Safety | 40 | hr | 406.91 | $ 16,276 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | | $ - | | $ - | | $ 17,340 |
| | Drill & Split Large Rock into approx. 1.5 CY boulders | 9,672 | drill-ft | 28.44 | $ 275,050 | | $ - | | $ - | | $ - | 1.48 | $ 14,293 | 1.32 | $ 12,789 | | $ - | | $ 302,132 |
| | Drill & Install boulder lifting pins (Assume 3 per boulder) | 1,710 | ea | 30.28 | $ 51,770 | | $ - | | $ - | | $ - | 2.66 | $ 4,549 | 1.19 | $ 2,035 | | $ - | | $ 58,354 |
| | Fly out boulders support crew to landing area (518 + 10%) | 570 | ea | 37.25 | $ 21,230 | | $ - | | $ - | | $ - | 2.66 | $ 1,516 | | $ - | | $ - | | $ 22,746 |
| | Load boulders into trucks | 716 | cy | 5.11 | $ 3,661 | | $ - | | $ - | | $ - | 0.74 | $ 529 | 6.36 | $ 4,552 | | $ - | | $ 8,742 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Materials / M&S:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Fire Tools | 3 | sets | | $ - | | $ - | 700 | $ 2,258 | | $ - | | $ - | | $ - | | $ - | | $ 2,258 |
| | Secondary Containment for Generators, Compressors, etc | 4 | ea | | $ - | | $ - | 450 | $ 1,935 | | $ - | | $ - | | $ - | | $ - | | $ 1,935 |
| | SWPP/BMP Mat'ls | 2,500 | lf | | $ - | | $ - | 4.00 | $ 10,750 | | $ - | | $ - | | $ - | | $ - | | $ 10,750 |
| | Exclusionary Fencing | 2,500 | lf | | $ - | | $ - | 1.00 | $ 2,688 | | $ - | | $ - | | $ - | | $ - | | $ 2,688 |
| | Buy / Haul AB for Access Roads | 2,500 | tn | | $ - | 25.00 | $ 67,188 | | $ - | | $ - | | $ - | | $ - | | $ - | | $ 67,188 |
| | Work Platforms Mat'ls | 2 | ea | | $ - | | $ - | 2,500 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | Scaffold Mat'ls | 1 | ls | | $ - | | $ - | 5,000 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | Rock Drills | 6 | ea | | $ - | | $ - | 2,000 | $ 12,900 | | $ - | | $ - | | $ - | | $ - | | $ 12,900 |
| | Drill Steel | 24 | ea | | $ - | | $ - | 150 | $ 3,870 | | $ - | | $ - | | $ - | | $ - | | $ 3,870 |
| | Drill Bits | 100 | ea | | $ - | | $ - | 25 | $ 2,688 | | $ - | | $ - | | $ - | | $ - | | $ 2,688 |
| | Darta Rock Splitters | 6 | ea | | $ - | | $ - | 20,000 | $ 129,000 | | $ - | | $ - | | $ - | | $ - | | $ 129,000 |
| | Rock lifting pins | 2,100 | ea | | $ - | | $ - | 20 | $ 45,150 | | $ - | | $ - | | $ - | | $ - | | $ 45,150 |
| | Misc Rigging | 1 | ls | | $ - | | $ - | 10,000 | $ 10,750 | | $ - | | $ - | | $ - | | $ - | | $ 10,750 |
| | Rock Fall Mitigation | 1 | ls | | $ - | | $ - | 5,000 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | M&S @ 5% of Labor | 1 | ls | | $ - | | $ - | $ 31,781 | $ 34,165 | | $ - | | $ - | | $ - | | $ - | | $ 34,165 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subcontractor / Other Costs:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Surveying | 10 | day | | $ - | | $ - | | $ - | 2,500 | $ 25,000 | | $ - | | $ - | | $ - | | $ 25,000 |
| | Misc Engineering | 1 | ls | | $ - | | $ - | | $ - | 10,000 | $ 10,000 | | $ - | | $ - | | $ - | | $ 10,000 |
| | Geologist Rock Fall Mitigation Recommendation/Inspection | 1 | ls | | $ - | | $ - | | $ - | 7,500 | $ 7,500 | | $ - | | $ - | | $ - | | $ 7,500 |

Green Sheet

**PROJECT NAME:** Eagle Canyon Fish Passage Class 4 Alternative Estimates

| Cost Item No. | Description | Qty | Unit | Labor U.C. | Labor Totals | Materials U.C. | Materials Totals | Constr. Materials M & S U.C. | Constr. Materials M & S Totals | Sub-Contractor U.C. | Sub-Contractor Totals | SRC Equipment U.C. | SRC Equipment Totals | O/S Rental EQ U.C. | O/S Rental EQ Totals | Other / (per diem) U.C. | Other / (per diem) Totals | Total U.C. | Total Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Develop Water Quality Testing Plan & Final Report | 1 | ls | | $ - | | $ - | | $ - | 5,000 | $ 5,000 | | $ - | | $ - | | $ - | | $ 5,000 |
| | Perform Water Quality Testing | 26 | wks | | $ - | | $ - | | $ - | 3,000 | $ 78,000 | | $ - | | $ - | | $ - | | $ 78,000 |
| | PJ Helicopter Service: | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Mobe Bell 407 for Clear & Grub (Assume 4 ea) | 4 | ea | | $ - | | $ - | | $ - | 2,100.00 | $ 8,400 | | $ - | | $ - | | $ - | | $ 8,400 |
| | Mobe Service Truck + Driver for Bell 407 | 4 | ea | | $ - | | $ - | | $ - | 137.00 | $ 548 | | $ - | | $ - | | $ - | | $ 548 |
| | Service Truck Driver for Bell 407 | 32 | hr | | $ - | | $ - | | $ - | 38.00 | $ 1,216 | | $ - | | $ - | | $ - | | $ 1,216 |
| | Fly out Trees/Vegetation | 4 | hr | | $ - | | $ - | | $ - | 2,100.00 | $ 8,400 | | $ - | | $ - | | $ - | | $ 8,400 |
| | Fly in Scaffold & Work Platform Mat'ls | 3 | hr | | $ - | | $ - | | $ - | 2,100.00 | $ 6,300 | | $ - | | $ - | | $ - | | $ 6,300 |
| | Fly out Scaffold & Work Platform Mat'ls | 3 | hr | | $ - | | $ - | | $ - | 2,100.00 | $ 6,300 | | $ - | | $ - | | $ - | | $ 6,300 |
| | Mobe UH-60A Utility Hawk (Assume 10 ea) | 10 | ea | | $ - | | $ - | | $ - | 3,200.00 | $ 32,000 | | $ - | | $ - | | $ - | | $ 32,000 |
| | Mobe Service Truck + Driver for UH-60A Utility Hawk | 10 | ea | | $ - | | $ - | | $ - | 137.00 | $ 1,370 | | $ - | | $ - | | $ - | | $ 1,370 |
| | Service Truck Driver for UH-60A Utility Hawk | 100 | hr | | $ - | | $ - | | $ - | 38.00 | $ 3,800 | | $ - | | $ - | | $ - | | $ 3,800 |
| | Fly out Boulders w/ UH-60A Utility Hawk | 70 | hr | | $ - | | $ - | | $ - | 6,400.00 | $ 448,000 | | $ - | | $ - | | $ - | | $ 448,000 |
| | Chip Trees / Vegetation | 1 | ls | | $ - | | $ - | | $ - | 10,000 | $ 10,000 | | $ - | | $ - | | $ - | | $ 10,000 |
| | Trucking to Dispose Boulders (Assume 1-hr roundtrip) | 2,044 | tn | | $ - | | $ - | | $ - | 7.00 | $ 14,308 | | $ - | | $ - | | $ - | | $ 14,308 |
| | Hydroseed | 2 | ac | | $ - | | $ - | | $ - | 4,000 | $ 8,000 | | $ - | | $ - | | $ - | | $ 8,000 |
| | Miscellaneous Debris Dumpster Loads | 6 | ea | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | 1,000 | $ 6,000 | | $ 6,000 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subtotal Bid Item Lump Sum** | | | $ 635,625 | | $ 67,188 | | $ 272,277 | | $ 674,142 | | $ 39,145 | | $ 94,661 | | $ 6,000 | | $ 1,789,038 | |
| | **Mark-up** | | | **15%** | **95,344** | **10%** | **6,719** | **10%** | **27,228** | **10%** | **67,414** | **10%** | **3,915** | **10%** | **9,466** | **10%** | **600** | **11.8%** | $ 210,685 |
| | **Item Totals** | | | | **730,969** | | **73,906** | | **299,505** | | **741,556** | | **43,060** | | **104,127** | | **6,600** | | **1,999,723** |
| 2 | **Remove Boulders via Cranes and Rock Splitting** | 1 | LS | | | | | | | | | | | | | | | | |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Mobilization / Demobilization:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Mobe Men and Equip | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Safety and Environmental Training | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Setup Office Trailer, Generator, Cargo Van, Etc. | 32 | hr | 481.73 | $ 15,415 | | $ - | | $ - | | $ - | 26.60 | $ 851 | 329.96 | $ 10,559 | | $ - | | $ 26,825 |
| | Remove Office Trailer, Generator, Cargo Van, Etc. | 32 | hr | 481.73 | $ 15,415 | | $ - | | $ - | | $ - | 26.60 | $ 851 | 329.96 | $ 10,559 | | $ - | | $ 26,825 |
| | Demobe Men and Equip | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Mobe/Assemble + Disassemble/Demobe Manitowoc 300 Ton Crane | 1 | ea | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | 54,000 | $ 54,000 | | $ 54,000 |
| | Mobe 110 Ton RT Crane In + Out | 1 | ea | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | 12,600 | $ 12,600 | | $ 12,600 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Site Prep:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Install BMP's (Silt Fence, Wattles, etc,) | 4,500 | lf | 2.33 | $ 10,487 | | $ - | | $ - | | $ - | 0.27 | $ 1,197 | | $ - | | $ - | | $ 11,684 |
| | Install Exclusionary Fencing | 4,500 | lf | 2.33 | $ 10,487 | | $ - | | $ - | | $ - | 0.27 | $ 1,197 | | $ - | | $ - | | $ 11,684 |
| | Develop Laydown Area (3 acres) | 15 | hr | 481.73 | $ 7,226 | | $ - | | $ - | | $ - | 26.60 | $ 399 | 329.96 | $ 4,949 | | $ - | | $ 12,574 |
| | Clear & Grub Access Rd to UBS | 30 | hr | 481.73 | $ 14,452 | | $ - | | $ - | | $ - | 26.60 | $ 798 | 329.96 | $ 9,899 | | $ - | | $ 25,149 |
| | Construct Access Rd to UBS | 1,000 | lf | 39.27 | $ 39,272 | | $ - | | $ - | | $ - | 1.77 | $ 1,773 | 39.99 | $ 39,993 | | $ - | | $ 81,039 |
| | Restore Access Rd to UBS at Completion | 1,000 | lf | 39.27 | $ 39,272 | | $ - | | $ - | | $ - | 1.77 | $ 1,773 | 39.99 | $ 39,993 | | $ - | | $ 81,039 |
| | Rock Access Rd (Creek to Long Rd. South) 5000 lf | 2,500 | tn | 3.14 | $ 7,840 | | $ - | | $ - | | $ - | 0.24 | $ 605 | 2.66 | $ 6,657 | | $ - | | $ 15,102 |
| | Rock Access Rd (UBS to BC Bottom Rd. North) 5500 lf | 2,570 | tn | 3.14 | $ 8,060 | | $ - | | $ - | | $ - | 0.24 | $ 621 | 2.66 | $ 6,843 | | $ - | | $ 15,524 |
| | Improve Foot Access to LBS & UBS | 1,550 | lf | 17.59 | $ 27,264 | | $ - | | $ - | | $ - | 1.33 | $ 2,062 | | $ - | | $ - | | $ 29,325 |
| | Hand Clear & Grub @ LBS & UBS | 30 | hr | 372.46 | $ 11,174 | | $ - | | $ - | | $ - | 26.60 | $ 798 | | $ - | | $ - | | $ 11,972 |
| | Rock Fall Mitigation at LBS & UBS | 40 | hr | 351.79 | $ 14,072 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | | $ - | | $ - | | $ 15,136 |
| | Construct Work Platforms along Creek | 32 | hr | 406.91 | $ 13,021 | | $ - | | $ - | | $ - | 26.60 | $ 851 | | $ - | | $ - | | $ 13,872 |
| | Build Crane Pads | 2 | ea | 2002.20 | $ 4,004 | | $ - | | $ - | | $ - | 106.40 | $ 213 | 1745.36 | $ 3,491 | | $ - | | $ 7,708 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Lower Barrier Site (LBS):** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Scaffold up + down for Worker Safety | 20 | hr | 406.91 | $ 8,138 | | $ - | | $ - | | $ - | 26.60 | $ 532 | | $ - | | $ - | | $ 8,670 |
| | Drill & Split Large Rock into approx. 1.5 CY boulders | 2,257 | drill-ft | 28.44 | $ 64,184 | | $ - | | $ - | | $ - | 1.48 | $ 3,335 | 1.32 | $ 2,984 | | $ - | | $ 70,504 |
| | Drill & Install boulder lifting pins (Assume 3 per boulder) | 372 | ea | 30.28 | $ 11,262 | | $ - | | $ - | | $ - | 2.66 | $ 990 | 1.19 | $ 443 | | $ - | | $ 12,695 |
| | Fly out boulders support crew to landing area (112 + 10%) | 124 | ea | 37.25 | $ 4,619 | | $ - | | $ - | | $ - | 2.66 | $ 330 | | $ - | | $ - | | $ 4,948 |
| | Load boulders into trucks | 187 | cy | 5.11 | $ 956 | | $ - | | $ - | | $ - | 0.74 | $ 138 | 6.36 | $ 1,189 | | $ - | | $ 2,283 |
| 216 hrs | Manitowoc 300 Ton Crane Rent (1 month + 1 weeks) | 1 | ls | | $ - | | $ - | | $ - | | $ - | | $ - | 50,000 | $ 50,000 | | $ - | | $ 50,000 |
| | Manitowoc 300 Ton Crane Oper Crew + Fuel | 40 | hr | 259.68 | $ 10,387 | | $ - | | $ - | | $ - | | $ - | 56.25 | $ 2,250 | | $ - | | $ 12,637 |

Green Sheet

**PROJECT NAME:** Eagle Canyon Fish Passage Class 4 Alternative Estimates

| Cost Item No. | Description | Qty | Unit | Labor U.C. | Labor Totals | Materials U.C. | Materials Totals | Constr. Materials M & S U.C. | Constr. Materials M & S Totals | Sub-Contractor U.C. | Sub-Contractor Totals | SRC Equipment U.C. | SRC Equipment Totals | O/S Rental EQ U.C. | O/S Rental EQ Totals | Other / (per diem) U.C. | Other / (per diem) Totals | Total U.C. | Total Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Upper Barrier Site (UBS):** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Scaffold up + down for Worker Safety | 40 | hr | 406.91 | $ 16,276 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | | $ - | | $ - | | $ 17,340 |
| | Drill & Split Large Rock into approx. 1.5 CY boulders | 9,672 | drill-ft | 28.44 | $ 275,050 | | $ - | | $ - | | $ - | 1.48 | $ 14,293 | 1.32 | $ 12,789 | | $ - | | $ 302,132 |
| | Drill & Install boulder lifting pins (Assume 3 per boulder) | 1,710 | ea | 30.28 | $ 51,770 | | $ - | | $ - | | $ - | 2.66 | $ 4,549 | 1.19 | $ 2,035 | | $ - | | $ 58,354 |
| | Fly out boulders support crew to landing area (518 + 10%) | 570 | ea | 37.25 | $ 21,230 | | $ - | | $ - | | $ - | 2.66 | $ 1,516 | | $ - | | $ - | | $ 22,746 |
| | Load boulders into trucks | 716 | cy | 5.11 | $ 3,661 | | $ - | | $ - | | $ - | 0.74 | $ 529 | 6.36 | $ 4,552 | | $ - | | $ 8,742 |
| 640 hrs | 100 Ton Crane Rent | 4 | mo | | $ - | | $ - | | $ - | | $ - | | $ - | 16,800 | $ 67,200 | | $ - | | $ 67,200 |
| | 100 Ton Crane Oper Crew + Fuel | 88 | hr | 163.14 | $ 14,356 | | $ - | | $ - | | $ - | | $ - | 30.00 | $ 2,640 | | $ - | | $ 16,996 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Materials / M&S:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Fire Tools | 3 | sets | | $ - | | $ - | 700 | $ 2,258 | | $ - | | $ - | | $ - | | $ - | | $ 2,258 |
| | Secondary Containment for Generators, Compressors, etc | 4 | ea | | $ - | | $ - | 450 | $ 1,935 | | $ - | | $ - | | $ - | | $ - | | $ 1,935 |
| | SWPP/BMP Mat'ls | 4,500 | lf | | $ - | | $ - | 4.00 | $ 19,350 | | $ - | | $ - | | $ - | | $ - | | $ 19,350 |
| | Exclusionary Fencing | 4,500 | lf | | $ - | | $ - | 1.00 | $ 4,838 | | $ - | | $ - | | $ - | | $ - | | $ 4,838 |
| | Buy / Haul AB for Access Roads | 5,070 | tn | | $ - | 25.00 | $ 136,256 | | $ - | | $ - | | $ - | | $ - | | $ - | | $ 136,256 |
| | Work Platforms Mat'ls | 2 | ea | | $ - | | $ - | 2,500 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | Scaffold Mat'ls | 1 | ls | | $ - | | $ - | 5,000 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | Rock Drills | 6 | ea | | $ - | | $ - | 2,000 | $ 12,900 | | $ - | | $ - | | $ - | | $ - | | $ 12,900 |
| | Drill Steel | 24 | ea | | $ - | | $ - | 150 | $ 3,870 | | $ - | | $ - | | $ - | | $ - | | $ 3,870 |
| | Drill Bits | 100 | ea | | $ - | | $ - | 25 | $ 2,688 | | $ - | | $ - | | $ - | | $ - | | $ 2,688 |
| | Darta Rock Splitters | 6 | ea | | $ - | | $ - | 20,000 | $ 129,000 | | $ - | | $ - | | $ - | | $ - | | $ 129,000 |
| | Rock lifting pins | 2,100 | ea | | $ - | | $ - | 20 | $ 45,150 | | $ - | | $ - | | $ - | | $ - | | $ 45,150 |
| | Misc Rigging | 1 | ls | | $ - | | $ - | 10,000 | $ 10,750 | | $ - | | $ - | | $ - | | $ - | | $ 10,750 |
| | Rock Fall Mitigation | 1 | ls | | $ - | | $ - | 5,000 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | M&S @ 5% of Labor | 1 | ls | | $ - | | $ - | $ 38,858 | $ 41,772 | | $ - | | $ - | | $ - | | $ - | | $ 41,772 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subcontractor / Other Costs:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Surveying | 10 | day | | $ - | | $ - | | $ - | 2,500 | $ 25,000 | | $ - | | $ - | | $ - | | $ 25,000 |
| | Misc Engineering | 1 | ls | | $ - | | $ - | | $ - | 10,000 | $ 10,000 | | $ - | | $ - | | $ - | | $ 10,000 |
| | Geologist Rock Fall Mitigation Recommendation/Inspection | 1 | ls | | $ - | | $ - | | $ - | 7,500 | $ 7,500 | | $ - | | $ - | | $ - | | $ 7,500 |
| | Develop Water Quality Testing Plan & Final Report | 1 | ls | | $ - | | $ - | | $ - | 5,000 | $ 5,000 | | $ - | | $ - | | $ - | | $ 5,000 |
| | Perform Water Quality Testing | 26 | wks | | $ - | | $ - | | $ - | 3,000 | $ 78,000 | | $ - | | $ - | | $ - | | $ 78,000 |
| | PJ Helicopter Service: | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Mobe Bell 407 for Clear & Grub (Assume 2 ea) | 2 | ea | | $ - | | $ - | | $ - | 2,100.00 | $ 4,200 | | $ - | | $ - | | $ - | | $ 4,200 |
| | Mobe Service Truck + Driver for Bell 407 | 2 | ea | | $ - | | $ - | | $ - | 137.00 | $ 274 | | $ - | | $ - | | $ - | | $ 274 |
| | Service Truck Driver for Bell 407 | 16 | hr | | $ - | | $ - | | $ - | 38.00 | $ 608 | | $ - | | $ - | | $ - | | $ 608 |
| | Fly out Trees/Vegetation | 4 | hr | | $ - | | $ - | | $ - | 2,100.00 | $ 8,400 | | $ - | | $ - | | $ - | | $ 8,400 |
| | Chip Trees / Vegetation | 1 | ls | | $ - | | $ - | | $ - | 30,000 | $ 30,000 | | $ - | | $ - | | $ - | | $ 30,000 |
| | Trucking to Dispose Boulders (Assume 1-hr roundtrip) | 2,044 | tn | | $ - | | $ - | | $ - | 7.00 | $ 14,308 | | $ - | | $ - | | $ - | | $ 14,308 |
| | Hydroseed | 4 | ac | | $ - | | $ - | | $ - | 4,000 | $ 16,000 | | $ - | | $ - | | $ - | | $ 16,000 |
| | Miscellaneous Debris Dumpster Loads | 6 | ea | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | 1,000 | $ 6,000 | | $ 6,000 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subtotal Bid Item Lump Sum** | | | $ 777,159 | | $ 136,256 | | $ 290,635 | | $ 199,290 | | $ 45,521 | | $ 318,620 | | $ 72,600 | | $ 1,840,081 | |
| | **Mark-up** | | | **15%** | **116,574** | **10%** | **13,626** | **10%** | **29,063** | **10%** | **19,929** | **10%** | **4,552** | **10%** | **31,862** | **10%** | **7,260** | **12.1%** | $ 222,866 |
| | **Item Totals** | | | | **893,733** | | **149,882** | | **319,698** | | **219,219** | | **50,074** | | **350,482** | | **79,860** | | **2,062,947** |
| **3** | **Remove Boulders via Yarder and Rock Splitting** | **1** | **LS** | | | | | | | | | | | | | | | | |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Mobilization / Demobilization:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Mobe Men and Equip | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Safety and Environmental Training | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |
| | Setup Office Trailer, Generator, Cargo Van, Etc. | 32 | hr | 481.73 | $ 15,415 | | $ - | | $ - | | $ - | 26.60 | $ 851 | 329.96 | $ 10,559 | | $ - | | $ 26,825 |
| | Remove Office Trailer, Generator, Cargo Van, Etc. | 32 | hr | 481.73 | $ 15,415 | | $ - | | $ - | | $ - | 26.60 | $ 851 | 329.96 | $ 10,559 | | $ - | | $ 26,825 |
| | Demobe Men and Equip | 40 | hr | 481.73 | $ 19,269 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | 329.96 | $ 13,198 | | $ - | | $ 33,532 |

Page 3 of 5

Green Sheet

**PROJECT NAME:** Eagle Canyon Fish Passage Class 4 Alternative Estimates

| Cost Item No. | Description | Qty | Unit | Labor U.C. | Labor Totals | Materials U.C. | Materials Totals | Constr. Materials M & S U.C. | Constr. Materials M & S Totals | Sub-Contractor U.C. | Sub-Contractor Totals | SRC Equipment U.C. | SRC Equipment Totals | O/S Rental EQ U.C. | O/S Rental EQ Totals | Other / (per diem) U.C. | Other / (per diem) Totals | Total U.C. | Total Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Site Prep:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Install BMP's (Silt Fence, Wattles, etc,) | 3,500 | lf | 2.33 | $ 8,156 | | $ - | | $ - | | $ - | 0.27 | $ 931 | | $ - | | $ - | | $ 9,087 |
| | Install Exclusionary Fencing | 3,500 | lf | 2.33 | $ 8,156 | | $ - | | $ - | | $ - | 0.27 | $ 931 | | $ - | | $ - | | $ 9,087 |
| | Develop Laydown Area (2 acres) | 10 | hr | 481.73 | $ 4,817 | | $ - | | $ - | | $ - | 26.60 | $ 266 | 329.96 | $ 3,300 | | $ - | | $ 8,383 |
| | Clear Canyon Slopes for Yarder Alignments | 60 | hr | 372.46 | $ 22,348 | | $ - | | $ - | | $ - | 26.60 | $ 1,596 | | $ - | | $ - | | $ 23,944 |
| | Rock Access Rd (Creek to Long Rd. South) 5000 lf | 2,500 | tn | 3.14 | $ 7,840 | | $ - | | $ - | | $ - | 0.24 | $ 605 | 2.66 | $ 6,657 | | $ - | | $ 15,102 |
| | Rock Access Rd (UBS to BC Bottom Rd. North) 5500 lf | 2,570 | tn | 3.14 | $ 8,060 | | $ - | | $ - | | $ - | 0.24 | $ 621 | 2.66 | $ 6,843 | | $ - | | $ 15,524 |
| | Improve Foot Access to LBS & UBS | 1,550 | lf | 17.59 | $ 27,264 | | $ - | | $ - | | $ - | 1.33 | $ 2,062 | | $ - | | $ - | | $ 29,325 |
| | Hand Clear & Grub @ LBS & UBS | 30 | hr | 372.46 | $ 11,174 | | $ - | | $ - | | $ - | 26.60 | $ 798 | | $ - | | $ - | | $ 11,972 |
| | Rock Fall Mitigation at LBS & UBS | 40 | hr | 351.79 | $ 14,072 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | | $ - | | $ - | | $ 15,136 |
| | Construct Work Platforms along Creek | 32 | hr | 406.91 | $ 13,021 | | $ - | | $ - | | $ - | 26.60 | $ 851 | | $ - | | $ - | | $ 13,872 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Lower Barrier Site (LBS):** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Scaffold up + down for Worker Safety | 20 | hr | 406.91 | $ 8,138 | | $ - | | $ - | | $ - | 26.60 | $ 532 | | $ - | | $ - | | $ 8,670 |
| | Drill & Split Large Rock into approx. 1.5 CY boulders | 2,257 | drill-ft | 28.44 | $ 64,184 | | $ - | | $ - | | $ - | 1.48 | $ 3,335 | 1.32 | $ 2,984 | | $ - | | $ 70,504 |
| | Drill & Install boulder lifting pins (Assume 3 per boulder) | 372 | ea | 30.28 | $ 11,262 | | $ - | | $ - | | $ - | 2.66 | $ 990 | 1.19 | $ 443 | | $ - | | $ 12,695 |
| | Fly out boulders support crew to landing area (112 + 10%) | 124 | ea | 37.25 | $ 4,619 | | $ - | | $ - | | $ - | 2.66 | $ 330 | | $ - | | $ - | | $ 4,948 |
| | Load boulders into trucks | 187 | cy | 5.11 | $ 956 | | $ - | | $ - | | $ - | 0.74 | $ 138 | 6.36 | $ 1,189 | | $ - | | $ 2,283 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Upper Barrier Site (UBS):** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Scaffold up + down for Worker Safety | 40 | hr | 406.91 | $ 16,276 | | $ - | | $ - | | $ - | 26.60 | $ 1,064 | | $ - | | $ - | | $ 17,340 |
| | Drill & Split Large Rock into approx. 1.5 CY boulders | 9,672 | drill-ft | 28.44 | $ 275,050 | | $ - | | $ - | | $ - | 1.48 | $ 14,293 | 1.32 | $ 12,789 | | $ - | | $ 302,132 |
| | Drill & Install boulder lifting pins (Assume 3 per boulder) | 1,710 | ea | 30.28 | $ 51,770 | | $ - | | $ - | | $ - | 2.66 | $ 4,549 | 1.19 | $ 2,035 | | $ - | | $ 58,354 |
| | Fly out boulders support crew to landing area (518 + 10%) | 570 | ea | 37.25 | $ 21,230 | | $ - | | $ - | | $ - | 2.66 | $ 1,516 | | $ - | | $ - | | $ 22,746 |
| | Load boulders into trucks | 716 | cy | 5.11 | $ 3,661 | | $ - | | $ - | | $ - | 0.74 | $ 529 | 6.36 | $ 4,552 | | $ - | | $ 8,742 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Materials / M&S:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Fire Tools | 3 | sets | | $ - | | $ - | 700 | $ 2,258 | | $ - | | $ - | | $ - | | $ - | | $ 2,258 |
| | Secondary Containment for Generators, Compressors, etc | 4 | ea | | $ - | | $ - | 450 | $ 1,935 | | $ - | | $ - | | $ - | | $ - | | $ 1,935 |
| | SWPP/BMP Mat'ls | 3,500 | lf | | $ - | | $ - | 4.00 | $ 15,050 | | $ - | | $ - | | $ - | | $ - | | $ 15,050 |
| | Exclusionary Fencing | 3,500 | lf | | $ - | | $ - | 1.00 | $ 3,763 | | $ - | | $ - | | $ - | | $ - | | $ 3,763 |
| | Buy / Haul AB for Access Roads | 5,070 | tn | | $ - | 25.00 | $ 136,256 | | $ - | | $ - | | $ - | | $ - | | $ - | | $ 136,256 |
| | Work Platforms Mat'ls | 2 | ea | | $ - | | $ - | 2,500 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | Scaffold Mat'ls | 1 | ls | | $ - | | $ - | 5,000 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | Rock Drills | 6 | ea | | $ - | | $ - | 2,000 | $ 12,900 | | $ - | | $ - | | $ - | | $ - | | $ 12,900 |
| | Drill Steel | 24 | ea | | $ - | | $ - | 150 | $ 3,870 | | $ - | | $ - | | $ - | | $ - | | $ 3,870 |
| | Drill Bits | 100 | ea | | $ - | | $ - | 25 | $ 2,688 | | $ - | | $ - | | $ - | | $ - | | $ 2,688 |
| | Darta Rock Splitters | 6 | ea | | $ - | | $ - | 20,000 | $ 129,000 | | $ - | | $ - | | $ - | | $ - | | $ 129,000 |
| | Rock lifting pins | 2,100 | ea | | $ - | | $ - | 20 | $ 45,150 | | $ - | | $ - | | $ - | | $ - | | $ 45,150 |
| | Misc Rigging | 1 | ls | | $ - | | $ - | 10,000 | $ 10,750 | | $ - | | $ - | | $ - | | $ - | | $ 10,750 |
| | Rock Fall Mitigation | 1 | ls | | $ - | | $ - | 5,000 | $ 5,375 | | $ - | | $ - | | $ - | | $ - | | $ 5,375 |
| | M&S @ 5% of Labor | 1 | ls | | $ - | | $ - | $ 33,535 | $ 36,050 | | $ - | | $ - | | $ - | | $ - | | $ 36,050 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subcontractor / Other Costs:** | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Surveying | 10 | day | | $ - | | $ - | | $ - | 2,500 | $ 25,000 | | $ - | | $ - | | $ - | | $ 25,000 |
| | Misc Engineering | 1 | ls | | $ - | | $ - | | $ - | 10,000 | $ 10,000 | | $ - | | $ - | | $ - | | $ 10,000 |
| | Geologist Rock Fall Mitigation Recommendation/Inspection | 1 | ls | | $ - | | $ - | | $ - | 7,500 | $ 7,500 | | $ - | | $ - | | $ - | | $ 7,500 |
| | Develop Water Quality Testing Plan & Final Report | 1 | ls | | $ - | | $ - | | $ - | 5,000 | $ 5,000 | | $ - | | $ - | | $ - | | $ 5,000 |
| | Perform Water Quality Testing | 26 | wks | | $ - | | $ - | | $ - | 3,000 | $ 78,000 | | $ - | | $ - | | $ - | | $ 78,000 |
| | Rock Anchors for Yarder (assume 3 @ Yarder + 2 @ skyline) x 2 | 10 | ea | | $ - | | $ - | | $ - | 5,000.00 | $ 50,000 | | $ - | | $ - | | $ - | | $ 50,000 |
| | Yarder Service: | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Mobe Yarder In + Out | 2 | ea | | $ - | | $ - | | $ - | 15,000.00 | $ 30,000 | | $ - | | $ - | | $ - | | $ 30,000 |
| | Setup Rig Lines and carriage | 4 | ea | | $ - | | $ - | | $ - | 7,500.00 | $ 30,000 | | $ - | | $ - | | $ - | | $ 30,000 |
| | Yarder out Trees/Vegetation | 60 | hr | | $ - | | $ - | | $ - | 287.50 | $ 17,250 | | $ - | | $ - | | $ - | | $ 17,250 |

Page 4 of 5

Green Sheet

**PROJECT NAME:** Eagle Canyon Fish Passage Class 4 Alternative Estimates

| Cost Item No. | Description | Qty | Unit | Labor U.C. | Labor Totals | Materials U.C. | Materials Totals | Constr. Materials M & S U.C. | Constr. Materials M & S Totals | Sub-Contractor U.C. | Sub-Contractor Totals | SRC Equipment U.C. | SRC Equipment Totals | O/S Rental EQ U.C. | O/S Rental EQ Totals | Other / (per diem) U.C. | Other / (per diem) Totals | Total U.C. | Total Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yarder in Scaffold & Work Platform Mat'ls | 2 | hr | | $ - | | $ - | | $ - | 287.50 | $ 575 | | $ - | | $ - | | $ - | | $ 575 |
| | Yarder out Scaffold & Work Platform Mat'ls | 2 | hr | | $ - | | $ - | | $ - | 287.50 | $ 575 | | $ - | | $ - | | $ - | | $ 575 |
| | Yarder out Boulders | 70 | hr | | $ - | | $ - | | $ - | 287.50 | $ 20,125 | | $ - | | $ - | | $ - | | $ 20,125 |
| | Yarder Standby (Assumed at 50% of Oper. Rate) | 85 | day | | $ - | | $ - | | $ - | 1,150.00 | $ 97,750 | | $ - | | $ - | | $ - | | $ 97,750 |
| | Chip Trees / Vegetation | 1 | ls | | $ - | | $ - | | $ - | 30,000 | $ 30,000 | | $ - | | $ - | | $ - | | $ 30,000 |
| | Trucking to Dispose Boulders (Assume 1-hr roundtrip) | 2,044 | tn | | $ - | | $ - | | $ - | 7.00 | $ 14,308 | | $ - | | $ - | | $ - | | $ 14,308 |
| | Hydroseed | 2 | ac | | $ - | | $ - | | $ - | 4,000 | $ 8,000 | | $ - | | $ - | | $ - | | $ 8,000 |
| | Miscellaneous Debris Dumpster Loads | 6 | ea | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | 1,000 | $ 6,000 | | $ 6,000 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subtotal Bid Item Lump Sum** | | | $ 670,693 | | $ 136,256 | | $ 279,537 | | $ 424,083 | | $ 41,895 | | $ 101,504 | | $ 6,000 | | $ 1,659,969 | |
| | **Mark-up** | | | **15%** | **100,604** | **10%** | **13,626** | **10%** | **27,954** | **10%** | **42,408** | **10%** | **4,189** | **10%** | **10,150** | **10%** | **600** | **12.0%** | $ 199,532 |
| | **Item Totals** | | | | **771,297** | | **149,882** | | **307,491** | | **466,491** | | **46,084** | | **111,654** | | **6,600** | | **1,859,500** |
| **4** | **Add-on for Cofferdams and Streamflow Bypasses** | **1** | **LS** | | | | | | | | | | | | | | | | |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | Battle Creek & Eagle Canyon Stream Flow Bypass | 1 | ls | 300,000 | $ 300,000 | | $ - | 245,000 | $ 263,375 | 20,000 | $ 20,000 | 2,900 | $ 2,900 | 110,000 | $ 110,000 | | $ - | | $ 696,275 |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | | | | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | | $ - |
| | **Subtotal Bid Item Lump Sum** | | | $ 300,000 | | $ - | | $ 263,375 | | $ 20,000 | | $ 2,900 | | $ 110,000 | | $ - | | $ 696,275 | |
| | **Mark-up** | | | **15%** | **45,000** | **10%** | | **10%** | **26,338** | **10%** | **2,000** | **10%** | **290** | **10%** | **11,000** | **10%** | | **12.2%** | $ 84,628 |
| | **Item Totals** | | | | **345,000** | | **-** | | **289,713** | | **22,000** | | **3,190** | | **121,000** | | **-** | | **780,903** |

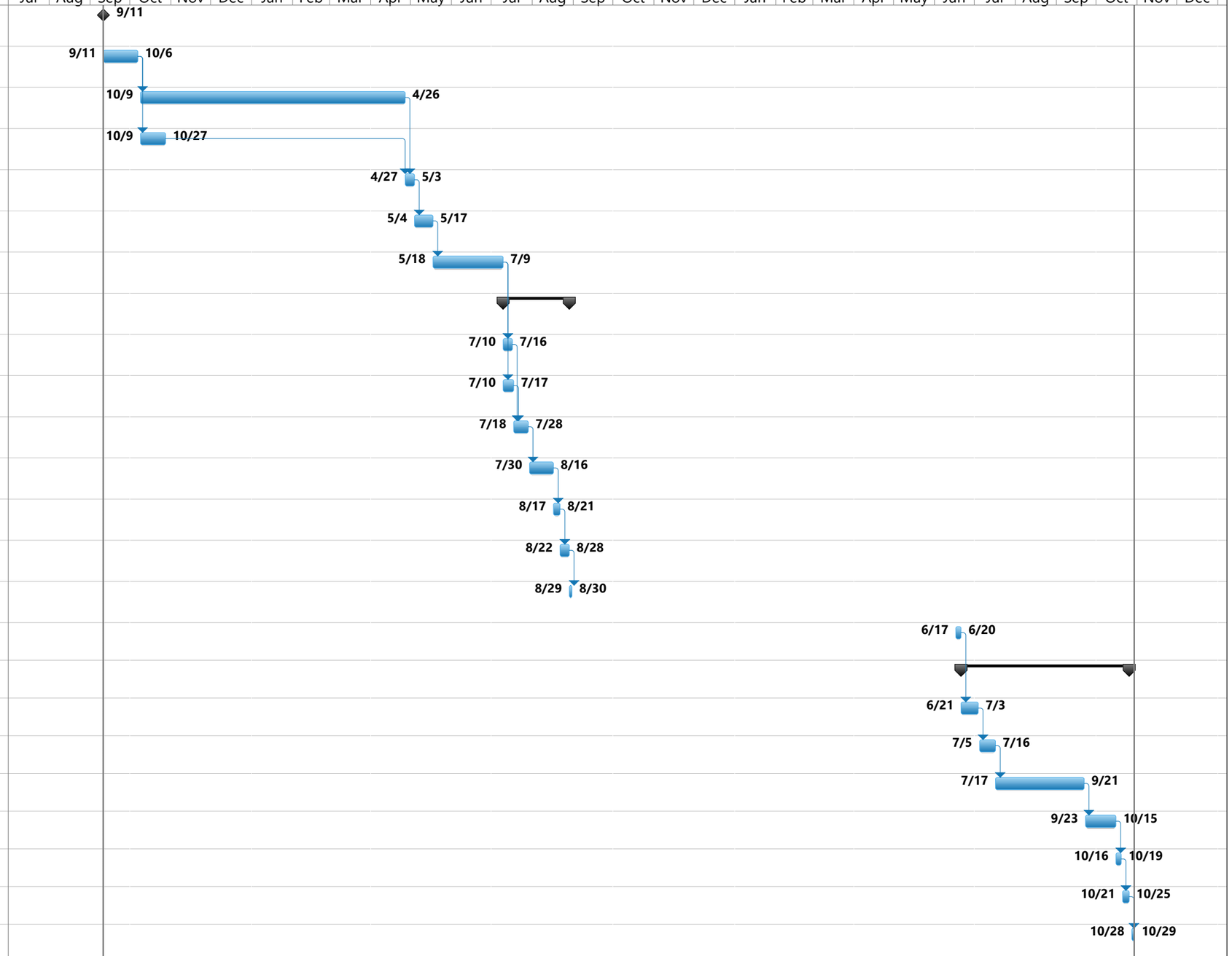
# Attachment 5

*Eagle Canyon Fish Passage Improvement Project*
*Construction Schedule*

**(Page intentionally left blank)**

# Seasons 1 & 2

| ID | Task Name | Start | Finish |
|---|---|---|---|
| 1 | Estimated NTP | Mon 9/11/17 | Mon 9/11/17 |
| 2 | Tree Removal Submittals | Mon 9/11/17 | Fri 10/6/17 |
| 3 | Submittals / Planning / Procurement | Mon 10/9/17 | Thu 4/26/18 |
| 4 | Tree / Vegetation Removal | Mon 10/9/17 | Fri 10/27/17 |
| 5 | Season 1 Mobilization | Fri 4/27/18 | Thu 5/3/18 |
| 6 | Crane Pads / Rock Access Roads | Fri 5/4/18 | Thu 5/17/18 |
| 7 | Rock Fall Mitigation | Fri 5/18/18 | Mon 7/9/18 |
| 8 | **Lower Barrier Site (LBS)** | **Tue 7/10/18** | **Tue 8/28/18** |
| 9 | Foot Access from Flume to Ground | Tue 7/10/18 | Mon 7/16/18 |
| 10 | Improve Foot Access/Build Work Deck | Tue 7/10/18 | Tue 7/17/18 |
| 11 | Install Clear Water Diversion | Wed 7/18/18 | Sat 7/28/18 |
| 12 | Boulder Removal | Mon 7/30/18 | Thu 8/16/18 |
| 13 | Remove Clear Water Diversion | Fri 8/17/18 | Tue 8/21/18 |
| 14 | Site Restoration | Wed 8/22/18 | Tue 8/28/18 |
| 15 | **Season 1 Demobilization** | **Wed 8/29/18** | **Thu 8/30/18** |
| 16 | **Season 2 Mobilization** | **Mon 6/17/19** | **Thu 6/20/19** |
| 17 | **Upper Barrier Site (UBS)** | **Fri 6/21/19** | **Fri 10/25/19** |
| 18 | Improve Foot Access/Build Work Deck | Fri 6/21/19 | Wed 7/3/19 |
| 19 | Install Clear Water Diversion | Fri 7/5/19 | Tue 7/16/19 |
| 20 | Boulder Removal | Wed 7/17/19 | Sat 9/21/19 |
| 21 | Regrade Channel | Mon 9/23/19 | Tue 10/15/19 |
| 22 | Remove Clear Water Diversion | Wed 10/16/19 | Sat 10/19/19 |
| 23 | Site Restoration | Mon 10/21/19 | Fri 10/25/19 |
| 24 | **Season 2 Demobilization** | **Mon 10/28/19** | **Tue 10/29/19** |




Project: Eagle Canyon Fish Passage Improvement Project
Date: Fri 2/17/17

Task Milestone Summary