PERMANENTE CREEK RESTORATION PLAN

90% LEVEL SUBMITTAL

DESIGN BASIS TECHNICAL MEMORANDUM

prepared for

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prepared by

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November 15, 2018

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1.0 INTRODUCTION

1.1 OBJECTIVES OF THIS MEMORANDUM

This technical memorandum has been prepared to describe stream restoration features presented in the "Permanente Creek Restoration Plan Preliminary Grading Plan - 90% Design, Santa Clara County Grading Permit Submittal" ("90% Designs"), dated November 15, 2018, and to document important design criteria, assumptions, and site constraints that have influenced their development. Sheet C2 of the 90% Designs provides an overview for locating project areas discussed in this memorandum.

The Designs have been prepared, in part, to fulfill the requirements set forth in an Amended Consent Decree (Decree) between the Sierra Club and Lehigh Southwest Cement Company and Hanson Permanente Cement, Inc., lodged February 22, 2016. The 90% Designs specifically address the Decree requirements under Section VI. "Creek Restoration". This memorandum and the 90% Designs comprise the "Complete 90 Percent Level Restoration Plan".

1.2 PROJECT GOALS AND OBJECTIVES

The primary objectives of the work, as set forth in the Decree, include the following:

- Increase quantity and quality of resident rainbow trout habitat through creation of pools, increased channel complexity and cover, and by fish passage through and between reaches consistent with a geomorphically stable, self-sustaining channel unless DFW Restoration Manual hydraulic design criteria cannot be met due to (1) the gradient of the reach, or (2) bedrock grade controls confirmed by an independent geologist;
- Improve riparian habitat, including improvement to channel and stream bank stability and ecological/geomorphic function;
- Remove mining-related fill and sediments in the bed, banks and adjacent slopes;
- Remove or alter man-made structures so as to improve riparian habitat;
- Layback creek banks and adjacent hill slopes to provide stable slopes sufficient to prevent fill from entering the creek;
- Require restoration that is no less stringent than any restoration that is approved or required by any agency, including but not limited to the Santa Clara County Planning Department, the DFW, and the Regional Water Board, and that is to be performed in a period of time no greater than any restoration that is approved or required by any agency, including but not limited to the Santa Clara County Planning Department, the DFW, and the Regional Water Board.

The 90% Designs address these broad objectives and comply with the more detailed reach-specific direction provided within paragraphs 34 through 42 of the Decree. Where feasible, the designs follow fish passage design approaches for resident rainbow trout, consistent with the California Department of Fish & Wildlife's "California Salmonid Stream Habitat Restoration Manual, 4th Edition (Vols. I-II, 2010)" ("DFW Restoration Manual").

It should be noted that the Restoration Plan has evolved considerably as designs have progressed beyond initial concepts. For example, a primary objective of the Restoration Plan as recently as 2014 was to modify Permanente Creek within the quarry property to allow the passage of anadromous salmonids. Following subsequent detailed analysis of existing and historic site constraints and consultation with resource agencies, anadromous fish passage has been removed as a design objective.

1.2.1 Introduction to Project Area & Types of Work

Sheets C2 and C4 of the 90% Designs provide an overview of the proposed work area in both plan and profile. For continuity and ease of comparison, we have retained the original reach designations provided in the URS Permanente Creek Long-Term Restoration Plan (URS 2011). However, the project area overview stream stationing has been revised to reflect the results of a more accurate stream centerline survey performed in the summer of 2013.[1] The work is presented in the drawings proceeding from the downstream to upstream limits. There are generally five major component project areas, as shown on Sheet C2, which include:

- Concrete Channel
- Channel Widening Area
- Rock Pile Area (which is included in the Channel Widening Area)
- "Old Crusher Foundation"
- Material Removal Area

Restoration work proposed at each area includes the following design elements and objectives:

Concrete Channel (Sheet L1)

- Encourage development of mature riparian canopy along the southern bank to shade the concrete channel to reduce solar heat gain on instream flow and discourage the establishment of tules;
- Preservation of existing native vegetation;
- Removal of non-native species and suppression of weeds around existing native seedlings and smaller native plants to encourage their establishment; and
- Installation of native vegetation.

Channel Widening Area (Sheets C11-C18)

- Removal of concrete road segments;
- Construction of floodplain bench areas with habitat elements and reduction of access road width;
- Removal of 260 linear feet of culverts, including a road crossing, and daylighting the creek to improve fish passage conditions and ecological complexity;
- Removal of old tractor tires along streambanks at a culvert removal site;
- Removal of imported sediment from the bed and banks of a tributary reach;
- Select removal of rock slope protection (RSP) and concrete rubble bank protection at an area that now has adequate mature riparian vegetation that is providing root reinforcement to bank soils;
- Removal of the retired Rock Plant conveyor system and associated infrastructure; and
- Installation of native vegetation.

[1] Note: Design alignments and stationing at individual project sites differ from the 2013 stream centerline survey because the design alignments have been oriented to the proposed features shown on the drawings.

Rock Pile Area (Sheets C19-C21)

- Removal of concrete road segments and road-related fill material;
- Removal of 930 linear feet of culverts and daylighting of the creek that will help improve fish passage conditions and ecological complexity;
- Construction of a new channel with floodplain bench areas with habitat elements that will help improve fish passage conditions and ecological complexity;
- Removal of Rock Pile, retired Rock Plant conveyor system and associated infrastructure;
- Removal of Pond 13 dam infrastructure; and
- Installation of native vegetation.

"Old Crusher Foundation" (Sheet C22)

- Cutting back the concrete block that is projecting into the channel to better conform to the natural creek bank.

Material Removal Area (Sheets C23-C26)

- Removal of overburden/fill and a relic concrete structure, and moving the north toe of slope northward 25 feet along the majority of the project area, except near Pond 4A where it will move northward 16 feet, in accordance with the Decree, to retain Pond 4A in its current location,
- Construction of a new channel with floodplain bench areas with habitat elements that will help improve fish passage conditions and ecological complexity, and
- Installation of native vegetation.

2.0 BASIS OF DESIGN

There are numerous considerations that contribute to the design of a successful stream restoration project. Initial design efforts typically include researching features of the project setting such as site geology, regional climate, basin hydrology, topographic features, and vegetation. These features and others are considered in light of project goals and objectives to develop opportunities and constraints and design alternatives. As design alternatives gel into a preferred project, calculations begin to inform the project details. The following sections provide an overview of important site features and design criteria that have shaped the project and describe the calculations that have been used to design specific project elements.

2.1 HYDROLOGY

2.1.1 Peak Flow Hydrology

The determination of design peak flow values is critical to the process of analyzing erosive forces on proposed bed and bank stabilization elements, understanding sediment transport and scour potential, and assisting with the specification of appropriate channel geometry.

Design flows were derived from a hydrologic analysis prepared by the Santa Clara Valley Water District (SCVWD) and presented in a report titled "Santa Clara Valley Water District Stevens and Permanente Creeks Hydrology Report" (Wang et al, 2007). Peak flow values published by the SCVWD for Permanente Creek were developed using a rainfall-runoff model. Rainfall data used in the model were derived from a weighted average of precipitation data collected at gaging stations throughout the area. Other model parameters included loss rates, time of concentration estimates, and routing coefficients.

Design flows were calculated for the four drainage areas at the site (Figure 1) by normalizing SCVWD's published values for Upper Permanente Creek (drainage area = 4.01 sq.mi.) upstream of the confluence with the West Branch Permanente Creek. Normalization was performed using a ration of the project site's drainage area compared to the total area above the confluence (4.01 sq. mi.) and then relating to the SCVWD's published peak flow values (Table 1). The 1.5-year flow event was calculated by extrapolating values using a log-normal trend-line plotted through the data.

Table 1. Summary of Peak Flows (cfs)					
Recurrence Interval	**Santa Clara Valley Water District Upper Permanente Creek Peak Flow Rates (Drainage Area = 4.01 sq. mi.)**	**Project Site (Drainage Area A = 3.5 sq.mi.)**	**Project Site (Drainage Area B = 3.01 sq.mi.)**	**Project Site (Drainage Area C = 2.7 sq.mi.)**	**Project Site (Drainage Area D = 2.02 sq.mi.)**
1.5-year	N.A.	284	244	219	164
2.33-year	450	393	338	303	227
5-year	730	637	548	492	368
10-year	970	847	728	653	489
25-year	1,300	1,135	976	875	656
50-year	1,500	1,309	1,126	1,010	757
100-year	1,700	1,484	1,276	1,145	858
Applicable Stream Reaches	**Not Applicable**	**R1-R6[1]**	**R6-R8[2]**	**R9-R15**	**R16-18**

[1]The drainage area extends into a portion of Reach 6, ending at the Concrete Channel downstream of Culvert #2.
[2]The drainage area includes a portion of Reach 6, beginning at Culvert #2.

2.1.2 Fish Passage Hydrology

The California Department of Fish and Wildlife (CDFW) prescribe upper and lower fish passage "design flows" for juvenile and adult rainbow trout. The design flows represent flow rates at which certain hydraulic parameters (*e.g.*, depth, velocity) must be met to consider a reach "passable" by fish. Where flow duration data is available or can be modeled, the upper fish passage design flow is equal to the 5% annual exceedance flow for adult rainbow trout (*i.e.,* adult non-anadromous salmonids) and the 10% annual exceedance for all juvenile salmonids. These flows represent the mean daily flow that is likely to be exceeded 5% or 10% of the time, respectively, in an average year. Similarly, the lower fish passage design flow for adult rainbow trout is equal to the greater of either the 90% annual exceedance or 2 cfs. For juveniles, it is the greater of either the 95% annual exceedance or 1 cfs (CDFW 2003).

Flow duration data for the project were developed from mean daily flows recorded at USGS gaging station 11166000 (Matadero Creek at Palo Alto). This gage is located seven miles north of the project site in a watershed with similar topography and average annual precipitation. We evaluated approximately 65 years of mean daily flow data, from October 1952 to August 2017. Exceedance flows calculated for the gage site were normalized by drainage area to estimate the fish passage flows at the project sites (Table 2). Detailed fish passage design flow calculations are included in Appendix A.

Table 2. Summary of Fish Passage Flows (cfs)

Design Flow / Species and Life Stage	Percent Exceedance	USGS Gage (11166000) Drainage Area =7.26 sq.mi.	Project Site Drainage Area A = 3.5 sq.mi.	Project Site Drainage Area B = 3.01 sq.mi.	Project Site Drainage Area C = 2.7 sq.mi.	Project Site Drainage Area D= 2.02 sq.mi.
Low Flow Juvenile Salmonids	95%	0	1*	1*	1*	1*
Low Flow Adult Non-Anadromous Salmonids	90%	0	2*	2*	2*	2*
High Flow Juvenile Salmonids	10%	3.5	1.7	1.5	1.3	1
High Flow Adult Non-Anadromous Salmonids	5%	9.9	4.8	4.1	3.7	2.8
Corresponding Stream Reaches	--	**Not Applicable**	**R1-R6[1]**	**R6-R8[2]**	**R9-R15**	**R16-18**

* The alternative low fish passage design flows of 2 cfs and 1 cfs were adopted for the adult non-anadromous salmonid and juvenile salmonid fish passage analyses, respectively.

[1]The drainage area extends into a portion of Reach 6, ending at the Concrete Channel downstream of Culvert #2.

[2]The drainage area includes a portion of Reach 6, beginning at Culvert #2.

2.2 GEOMORPHIC DESIGN BASIS

Successful channel restoration requires an understanding of suitable channel geometries (*e.g.*, bankfull width and depth), longitudinal gradients, and pool sizes and spacing for a particular geomorphic context and hydraulic regime. Among other things, appropriate channel geometric design helps to ensure sediment transport continuity through constructed reaches and appropriately distributes shear stresses across the channel bed and floodplain areas during floods. It is also important to have a firm understanding of flood hydraulics to size bed and floodplain material appropriately to ensure short-term channel stability while vegetation becomes established, and long-term stability within the active channel where vegetation will be absent.

This project includes the design and reconstruction of the channel bed and banks at multiple locations - Culverts #7 and #8 within the Channel Widening Area, and the Rock Pile and Material Removal Areas. To assist with developing appropriate channel geometry, we evaluated existing datasets for gaged sites located in the Santa Cruz Mountains to help develop relationships for bankfull width and depth as a function of watershed area. We also surveyed and evaluated geometry data from four nearby "reference" channel reaches, where the channel is considered to be "natural". This includes two analog channels (within Swiss Creek and Corte Madera Creek) identified as having watershed and geomorphic characteristics similar to Permanente Creek (URS, 2011) and two channel segments located in the upper Permanente Creek watershed within Reach 20. The channel geometry of the reference reaches was incorporated into the dataset for the regional geometry developed from the gaged sites to refine bankfull channel dimensions for the project area. An overview of how bankfull channel dimensions were developed for the reconstructed channel segments is included in Appendix B, Permanente Creek Restoration – Regional Hydraulic Geometry and Analog Channel Assessment. A summary of the bankfull channel dimensions is included below in Table 3. Minimum and maximum bankfull dimensions are provided for design slope ranges to provide for variability and flexibility during channel construction. The bankfull dimensions have also been included on the appropriate design drawing sheets.

Table 3. Proposed Channel Dimensions for Constructed Reaches

Project Site	Design Slope (%)	Design Slope Range (%)	Proposed Bankfull Width Min (ft)	Proposed Bankfull Width Max (ft)	Proposed Bankfull Depth Min (ft)	Proposed Bankfull Depth Max (ft)	Cross Sectional Area Min (ft^2)	Cross Sectional Area Max (ft^2)
Culvert 7	4.3%	4%-8%	16.5	20.5	2.1	2.5	28.2	34.2
Culvert 8	2.7%	<4%	18.0	22.0	1.9	2.3	28.2	34.2
Rock Pile Area	Varies	<4%	17.5	21.5	1.8	2.2	26.9	32.9
		4%-8%	16.0	20.0	2.0	2.4		
		>8%	15.5	18.5	2.4	2.8		
Overburden Removal Area	Varies	<4%	16.0	20.0	1.7	2.1	22.5	28.5
		4%-8%	14.5	18.5	1.9	2.3		
		>8%	14.0	17.0	2.3	2.7		

An evaluation of pool dimensions and spacing was also conducted. Data from the reference reach channel surveys and the 2013 Permanente Creek channel survey was used to help inform pool design geometry. A summary of the proposed pool dimensions and spacing are included in Table 4. Sheet C34 also includes a table with pool dimensions and spacing for the Rock Pile and Material Removal Areas. The Culvert #7 and #8 removal sites are relatively short and include a single pool each. The dimensions are shown on the respective culvert removal area design profiles (Sheets C11 and C15).

Table 4. Pool Dimensions and Spacing

Average Channel Slope	Pool Length (ft.)	Pool Depth (ft.)	Pool Drop (ft.)	Pool Spacing (ft.)
4% - 8%	8 – 20	0.5 - 2	0.5 – 1	45 – 150
8% - 12%	8 - 15	0.5 – 2	0.5 - 1	25 - 80

2.3 HYDRAULIC ASSESSMENT

2.3.1 Approach to Fish Passage Evaluation

The improvement of passage conditions for resident rainbow trout is a primary goal of the proposed work. Within the various project reaches, we have attempted to meet this goal through a combination of channel and floodplain enhancements. The nature and extent of these enhancements varies by reach, and each location requires a carefully considered approach to the design and analysis of fish passage elements. Our design basis and methodology are outlined below.

CDFW allows for varying approaches to analyzing fish passage within natural or constructed channels. The "Stream Simulation Method" consists of constructing a channel that mimics geomorphically similar adjacent reference reaches. The Stream Simulation Method works on the premise that a constructed channel that mimics adjacent natural reaches will present no more of an obstacle to passage than the adjacent natural channel.

The "Hydraulic Design" approach allows for construction of a channel geometry that has been proven through modeling to meet specific hydraulic design criteria. For channels designed using Hydraulic Design methods, CDFW provides general guidelines prescribing minimum water depths, maximum velocities, and maximum hydraulic drop heights (Table 5). Projects designed using the Hydraulic Design Method must satisfy these criteria throughout the full range of fish passage design flows.

Table 5. Fish Passage Design Criteria

Species and Life stage	Minimum Flow Depth (ft)	Maximum Water Velocity (ft/s)	Maximum Drop (ft)
Adult Non-Anadromous Salmonids	0.67	2 [1]	1
Juvenile Salmonids	0.5	1	0.5

[1] 2 ft/s for culverts or riffles between pools greater than 200 feet long.

Each of these methods has its limitations. For instance, the Hydraulic Design method is not recommended where profile grades exceed approximately 5%. The Stream Simulation Method is not recommended where adjacent reaches are disturbed or where sediment supply or transport has been significantly altered from natural conditions, which is the case throughout the project area. For these reasons and others, the direct application of these methods has proven difficult at many locations throughout the project area.

Our approach has been to use Hydraulic Design methods to analyze fish passage conditions where the profile gradient is relatively low and where hydraulic design standards for fish passage can be achieved within the recommended range of applicable channel profile gradients. These areas include Reaches 8-10.

Where average profile gradient exceeds that recommended for the Hydraulic Design method (Reaches 11-18), we have designed a channel based upon analogs from less-disturbed reaches within and near to the Permanente Creek Watershed. The objective of channel design within these reaches is the creation of a geomorphically appropriate and stable channel that enhances opportunities for fish passage where feasible. However, the presence of bedrock may ultimately dictate channel geometry and dependent fish passage characteristics at many locations. We have evaluated velocity and depth within these steeper reaches to determine if the Hydraulic Design criteria for fish passage are satisfied, as discussed in the following section.

Although the proposed project does not provide optimal passage opportunities along its entire length, resident rainbow trout passage is still a primary objective of the work. Numerous constraints make it difficult to create optimal fish passage conditions within the project area, or even to meet established minimum performance standards. Some of these constraints include:

- Reaches with historically high gradients prior to development of the quarry (>10%);
- The presence of natural bedrock drops exceeding 6 feet in height; and
- Highly unstable reaches with excessive bed load.

Where these constraints exist, we have done our best to optimize passage and habitat benefits, while considering the need to ensure the following:

- Maintenance of channel, bank, and floodplain stability;
- Maintenance of flood conveyance (where infrastructure is present);
- Protection of public safety;
- Preservation and protection of existing critical infrastructure; and
- Preservation of existing mature riparian vegetation, where feasible.

One of the greatest challenges to the development of the Designs has been a lack of knowledge of the extent to which past anthropogenic disturbances at the site may have altered the original channel geometry, and as a result, fish passage conditions. Within Reaches 11-12 and 17-18, it appears that the channel profile has been altered through the placement of fill. The designs lower the profile in these reaches to remove culverts and/or fill material to establish a profile grade more closely following what existed prior to disturbance, a portion of which will likely follow bedrock. The resulting profile grades are still quite steep, averaging up to 12% in portions of Reach 11 and up to 22.7% in portions of Reach 17.

The design profiles at these locations are based on a best fit to subsurface bedrock locations that were identified through a seismic refraction study (Appendix C), and later refined at the Rock Pile Area based on exploratory borings. In order to avoid alternating steep chutes or drops and low gradient segments, and optimize fish passage potential, the design attempts to follow an average grade that connects the high points of the bedrock profile rather than following it continuously. It is likely that the original channel would have followed a more irregular profile with exposed bedrock at pinch points and steepened reaches, as seen at other less disturbed reaches within the project area (*e.g.,* reaches 15 and 16). A process has been outlined to further evaluate the geometry of bedrock in the field during construction and make field adjustments allowing the proposed channel to conform to uncovered areas of bedrock. For instance, the minimum design profile grade upstream of bedrock controls will be set to 4% and the maximum constructed profile grade between bedrock outcrops will not exceed 12%. For further details, see the field engineering description included in Appendix D.

Individual project components or areas are discussed in detail within Section 0. Within each section, we have provided a summary of the ability of the design to meet recommended fish passage criteria.

2.3.1.1 *Assessment of Fish Passage within Constructed Channel Reaches*

Manning's equation is the primary method we used to determine depths and average velocities within the constructed channel sections under design fish passage flows to evaluate compliance with the fish passage criteria listed in Table 5[2]. Fish passage was evaluated at the following locations where channel bed modifications or reconstruction is proposed:

- Culvert #7;
- Culvert #8;
- Rock Pile Area; and
- Material Removal Area.

Proposed channel gradients are less than 4% at Culverts #7 and #8. Fish passage design criteria were evaluated using the Hydraulic Design Method at these locations.

The maximum average gradient at which a restored channel segment will be constructed at the Rock Pile and Material Removal Areas is 12%. This maximum gradient has been established by the guidelines included in the Field Engineering Notes, Appendix D. As discussed above, 12% is considerably steeper than the 5% maximum profile grade that is recommended for application of the Hydraulic Design method. We evaluated hydraulic parameters of a 12% channel for comparison to fish passage design criteria established under the Hydraulic Design method to determine if the fish passage design criteria would still be met.

Manning's equation is a universally accepted method for determining relationships between depth, velocity, and channel geometry (*e.g.*, shape, size and roughness of the channel) for open channel flow conditions. Calculations were performed using the "Hydraflow Express" extension of AutoCAD Civil 3D. Parameters used in the equation include:

- Discharge;
- Channel bed slope;
- Hydraulic radius; and
- Manning's roughness coefficient.

The roughness coefficients were estimated using depth-based roughness equations applicable to the proposed channels (Mussetter, 1989). Refer to Appendix E for detailed calculations.

Hydraulic calculations for the constructed channel sections are also presented in detail within Appendix E. The modeled cross section geometry incorporates boulders that will protrude above the channel bed to take into account cracks between rocks that fish can use for moving between reaches. Results indicate that depth and velocity criteria would be satisfied over the range of design fish passage flows described in Section 2.1.2 "Fish Passage Hydrology". It should be noted that within steep (>6-8%) portions of the reconstructed channel, it will be impossible to avoid post-construction channel adjustments and associated formation of steps, chutes, and pools, the geometry of which cannot be accurately predicted.

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[2] Design fish passage criteria were evaluated within channel sections where the channel bed and lower banks would be modified. The portions of Permanente Creek where only a floodplain bench would be constructed along the main channel (e.g. Channel Widening Area) were not evaluated.

Further, the channel will likely conform to bedrock outcrops in some locations, which may dictate cross section and profile geometry in ways that we cannot anticipate.

Fish passage flows were also modeled using HEC-RAS to generate water surface profiles and velocity profiles for existing and proposed conditions, as requested by the reviewing agencies. This was completed for the two locations where the channel bed will be reconstructed and the Field Engineering Notes (Appendix D) do not apply - Culvert #7 and Culvert #8 removal areas within the Channel Widening Area. The culverts will be removed and the channel will be reconstructed as shown on the drawings. Reconstruction of the channel at these two locations greatly improves fish passage conditions. See Section 2.3.2.2 below for a summary of model results. Since there is uncertainty regarding the post-project channel profile within the Rock Pile and Material Removal Areas due to the unknown depth to bedrock, it does not seem relevant to present existing versus proposed HEC-RAS results. If bedrock is encountered the constructed profile could be very steep (>12%) and potentially include significant vertical drops of several feet.

Qualitatively, it is apparent that removal of Culverts #10 and #11 at the Rock Pile Area and the construction of an open channel will improve fish passage opportunities within this channel segment. This, of course, assumes that significant drops over bedrock or bedrock chutes are not uncovered once the culvert is removed.[3] Culverts with a low Manning's n value will be replaced with open channels constructed using Engineered Streambed Material (ESM) with increased hydraulic roughness. This changed condition will both reduce flow velocities and increase flow depth, along with providing improved habitat and hydraulic complexity. The coarse-grained ESM will provide areas of velocity shadowing behind large boulders, and cracks between boulders with increased flow depths that will provide more conducive conditions for fish passage under proposed conditions. *See* Section 2.3.2.2 for a discussion of the HEC-RAS model results that predict improved fish passage conditions once Culverts #7 and #8 are removed and the channel bed is reconstructed.

We could not locate a resource that estimates the maximum sustained channel slope that will be a barrier to upstream passage of resident rainbow trout. However, studies show that adult anadromous salmonids can navigate steeper slopes than resident rainbow trout (Coastal Conservancy 2004). Considering this, CDFW has identified a sustained slope of greater than 8% as a barrier to anadromy (CDFW, 2009). Therefore, it is reasonable to assume that sustained slopes of 8% are a barrier to resident rainbow trout passage. The Washington Department of Transportation considers a slope of 12% for >160 meters as the cutoff for anadromous passage. We have provided passage calculations for reaches up to 12% average profile gradient, although extended reaches at this slope are likely too steep for resident rainbow trout to navigate, especially given the likelihood of channel adjustments and bedrock exposures discussed above.

2.3.2 Channel Hydraulics

Having a good understanding of channel hydraulics is important for developing designs that will provide the intended instream habitat complexity while also providing channel stability during the first few years following construction, until vegetation becomes established. Peak flood hydraulic modeling was conducted using HEC-RAS 5.0.4 river analysis software, developed by the United States Army Corps of Engineers (USACE). Modeling results were used to confirm that appropriate bankfull channel

[3] See the Field Engineering Notes in Appendix D for a description of how the channel will be constructed if bedrock is encountered.

dimensions have been incorporated into project designs, to assist with sizing surface treatments (*e.g.*, engineered streambed material) to provide channel stability and erosion protection, and to ensure infrastructure and access roads won't be significantly impacted by the 100-year flood.

2.3.2.1 *Peak Flood Modeling (1D HEC-RAS)*

Two separate HEC-RAS models have been developed for the project. One model was prepared for the Channel Widening and Rock Pile Areas since they are integrally connected, and a separate model was developed for the Material Removal Area because it is located more than 3,000 feet upstream of the Rock Pile Area. The existing conditions models were developed using topography from detailed surveys conducted at both areas by Waterways between 2013 and 2015. Proposed condition channel geometry was developed by importing the design grade topography into the existing conditions model and adding additional sections as necessary to model areas where culverts are proposed for removal. The Channel Widening and Rock Pile Area model extends over approximately 6,500 linear feet of channel, beginning just downstream of Culvert #2, and extending approximately 400 feet upstream of Pond 13. The Material Removal Area model extends over approximately 2,900 feet, beginning over 500 downstream of Pond 4A and extending approximately 400 upstream of the proposed restoration limits. Overview figures have been prepared for each of the models and are included in Appendix F.[4] The first two figures show the locations of the cross sections included in the model for the Channel Widening and Rock Pile Areas. The third figure shows the location of the cross sections included in the model for the Material Removal Area.

Roughness values (Manning's n) were chosen from field-based observation of the channel and floodplains for existing conditions. The United States Geological Survey (USGS) "Roughness Characteristics of Natural Channels" report was used to aid in the selection of roughness values for proposed conditions. The report includes descriptive data and photographs for fifty different stream channels for which roughness coefficients have been determined.

Boundary conditions were set using the normal depth method and are included in Appendix F. The upstream and downstream boundary conditions were set to match the slope of the energy grade line at these respective locations, which roughly matches the channel slope.

1.5-Year Flood Model

The 1.5-year flood was evaluated to confirm that the bankfull geometry for the Rock Pile and Material Removal Areas developed in the "Permanente Creek Restoration – Regional Hydraulic Geometry and Analog Channel Assessment" included in Appendix B, is appropriate for the constructed channel segments. This modeled flow was also used to assist with determining the channel-side design elevation of the floodplain bench along the Channel Widening Area. Graphical outputs of water surface profiles are included in Appendix F. Results for existing and proposed conditions have been included per the request of the reviewing agencies. The profile outputs include a profile of the channel-side design elevation of the floodplain bench to demonstrate that the design elevations of the floodplain benches are near the 1.5-year water surface elevation. Detailed output tables that include

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[4] The HEC-RAS models extend beyond the limits of the proposed work to account for downstream conditions that could affect hydraulics within the proposed restoration areas. Because of this, design stationing does not match stationing used in the HEC-RAS models. To assist with comparison between HEC-RAS and the design drawings, HEC-RAS stationing for the Channel Widening and Rock Pile Area model includes the design stationing plus 100+00. The Material Removal Area model includes the design stationing plus 10+00.

flow depth, velocity, and top width for both existing and proposed conditions have also been included in Appendix F.

10-Year Flood Model

The 10-year flood was evaluated to assist with establishing the upper limits of floodplain armor throughout the project area. Floodplain armor will be placed over constructed benches up to approximately the 10-year water surface elevation to provide erosion protection while vegetation becomes established. Results for existing and proposed conditions have been included per the request of the reviewing agencies. Graphical outputs of 10-year water surface profiles are included in Appendix F. Detailed output tables that include flow depth, velocity, and top width for both existing and proposed conditions have also been included in Appendix F.

100-Year Flood Model

The 100-year flood was evaluated to assist with designing surface treatments to ensure reconstructed channel areas remain stable, and that floodplain benches remain stable while vegetation becomes established. It was also used to evaluate the potential for erosion above the limits of floodplain armor, which has been set to approximately the 10-year water surface elevation, and whether the proposed angular rock vehicle barrier along the Channel Widening Area would remain stable at locations where bank overtopping will occur. See Section 2.4 below for design details related to surface treatments.

Graphical outputs of 100-year water surface profiles under existing and proposed conditions are included in Appendix F. Detailed output tables that include flow depth, velocity, and top width for both existing and proposed conditions have also been included in Appendix F.

Angular Rock Vehicle Barrier Assessment

At locations where bank overtopping flows will run along the rock vehicle barrier, the maximum velocity of the overtopping flow was determined to be 6.3 ft/sec. with a flow depth of approximately 1.2 feet and a maximum shear stress of 3.7 lbs/ft^2. This occurs for approximately 50 linear feet near the upstream end of the Channel Widening Area (HEC-RAS Station 144+50) where the proposed floodplain bench narrows and the height of the bank between the bench and access road is reduced.

Overtopping flow that occurs at discrete locations along the Channel Widening Area has velocities that range from 0.6 – 6.3 ft/sec with an average velocity of 3.1 ft/sec. Six-inch diameter cobbles can resist flow velocities up to 10 ft/sec and shear stresses of 2.5 lbs/ft^2 (Fischenich 2001). The vehicle barrier will be composed of 4 to 8-inch diameter angular rock along most of its length, which is more stable than sub-rounded to rounded cobble. To protect against mobilization at the area of maximum velocity the vehicle barrier will be composed of 10 to 16-inch dimeter angular rock, which can resist flow velocities up to 13 ft/sec and shear stresses of 5.1 lbs/ft^2 (Fischenich 2001). A summary of the overtopping locations, flow depths, and velocities are included in Appendix F.

2.3.2.2 *Fish Passage Hydraulics at the Culvert #7 and #8 Removal Areas*

Fish passage has been assessed at the Culvert #7 and #8 removal areas within the Channel Widening Area where the channel bed and banks will be reconstructed as shown on Sheets C11 and C15. Results of the modeling effort are included Appendix F. Water surface profiles and velocity profiles for adult and juvenile high and low design flows are presented in there as well. As can be seen, flow depths are increased, and velocities are reduced under proposed versus existing conditions along the length of proposed channel reconstruction. The HEC-RAS results document that flow depths and velocities meet fish passage design criteria along the reconstructed channel segments at all locations within the culvert removal areas, except that flow depths are slightly below the design criteria listed in Table 5 for both adult and juvenile low flows at the upstream end of the Culvert #7 removal area. The adult low flow depth is 0.50 ft. versus 0.67 ft. and the juvenile depth is 0.37 ft. versus 0.5 ft. However, unlike the Manning's at a section calculations (Appendix E), the model does not account for cracks within the boulders that will occur within the engineered streambed material. These cracks will provide additional depth for fish to utilize for passage. Fish passage design criteria are not necessarily meet outside the culvert removal areas shown on the profile plots, where active channel geometry reverts to existing conditions.

2.3.2.3 *Sediment Transport*

The project has been designed to help maintain sediment transport continuity while creating depositional zones on the extensive floodplain areas that will be constructed as part of project implementation. As discussed above, proposed bankfull channel dimensions at each of the reconstructed reaches have been informed by a reference reach study and would vary as channel slope changes. Appropriately sized bankfull dimensions that adjust with changes in the channel profile slope will assist with sediment transport continuity through the reconstructed channels. *See* Table 3 for proposed bankfull dimensions based on channel slope. To help maintain sediment transport continuity and channel stability upstream of bedrock controls encountered at the Rock Pile and Material Removal Areas, the minimum design profile grade at these areas will be set to 4 percent, as outlined in the Field Engineering Description (Appendix D).

Constructed floodplain areas will provide depositional zones for fine sediment and smaller coarse material when flood flows occur. Floodplains constructed along the Channel Widening Area will serve as a depositional area for fine sediment that will be mobilized from the Rock Pile and Material Removal Areas during the first couple of years after their construction, as floodplain and riparian vegetation become established.

2.4 SURFACE TREATMENTS

Surface treatments have been included throughout the project area to ensure that newly constructed surfaces remain stable against erosive forces. Surface treatments include:

- Engineered streambed material (ESM) that will be used as channel substrate where the bed is reconstructed.
- Floodplain armor to protect newly constructed floodplain surfaces.
- Vegetated rock slope protection to protect newly constructed streambanks that are steeper than 2H:1V and the area adjacent to the Culvert #6 inlet.
- Vegetation, which includes both container plants and seeding to provide rooting strength to help reinforce substrate along the channel, at floodplain and riparian areas, and on newly, constructed creek banks.
- Erosion control BMPs (e.g. fiber rolls).

2.4.1 Engineered Streambed Material (ESM)

Throughout the Designs, we have specified the placement of engineered streambed material (ESM) within the bed of the reconstructed portions of the channel. ESM is a term derived from the CDFW

Design Guidelines and refers to a well-graded mixture of boulders, cobble, gravel, sand, and fines, proportioned in a way that is stable under design flood flows and still meets habitat enhancement goals. ESM is mixed to the Engineer's gradation requirements for stability for specific locations, containing sufficient amounts of fine material to ensure that vegetation can establish and that flows do not "sub-out" or move beneath the surface of the mix during times of low flow. Properly specified ESM placed in a geomorphically appropriate location should look and behave like a natural streambed.

At the Rock Pile and Material Removal Areas, ESM sizing may vary depending on the location of bedrock exposures and the constructed channel geometry. The Field Engineering Description (Appendix D) will guide channel construction since there is uncertainty regarding the vertical and lateral position of bedrock. ESM sizing will be refined during construction, as needed, to account for conform locations along exposed bedrock where hydraulic forces may be more significant than can be foreseen during the design phase.

Pools will be incorporated into the Rock Pile and Material Removal Areas as shown on the Typical Profile Detail on Sheet C34. For this project, the ESM material has been designed to remain stable during the 100-year recurrence interval flow, with only minor adjustments to channel shape in reaches with bed slopes less than approximately 6-8%. In steeper reaches (>6-8%) post-construction channel adjustments are expected, as described above in Section 2.3.1.1. These adjustments may result in changes to constructed pool geometry and the formation of new pools and steps in response to flood flows. Detailed ESM sizing calculations are included in Appendix G. Resulting ESM gradations are presented on Sheet C37.

2.4.2 Floodplain Armor

Floodplain armor was sized similarly to ESM, using CDFW Design Guidelines for developing a well-graded mixture of boulders, cobble, gravel, sand, and fines. The substrate is proportioned to be stable under design flood flows while providing appropriately sized material to enhance constructed floodplain habitats. Sufficient fine material has been included to ensure that vegetation can establish and the flows do not "sub-out" or move beneath the surface of the mix when floodplains are activated by flood flows. As with the ESM, the floodplain armor has been designed to remain stable during the 100-year recurrence interval flow, with only minor adjustments to floodplain shape in reaches with slopes less than approximately 6-8%. Post-construction floodplain adjustments are anticipated in steeper reaches.

Planting pockets have been incorporated throughout proposed floodplain areas to provide locations for planting during project revegetation. Planting pockets are areas 5 to 8 feet in diameter that will be interspersed within the floodplain and filled with soil mixes designed to support container plants. If erosion of planting pocket soils were to occur, the floodplain armor would adjust to fill and protect eroded areas. Boulder sills have also been periodically incorporated across proposed floodplain areas to provide roughness to help reduce overbank flow velocities and serve as grade control if significant erosion were to occur along floodplain areas. Boulders used in the construction of boulder sills will be equal to the D100 of the respective floodplain armor gradation. The planting pocket and boulder sill details are included on Sheets C36 and C34, respectively.

At the Rock Pile and Material Removal Areas floodplain armor sizing may vary depending on the location of bedrock exposures and the constructed channel geometry. The Field Engineering Description (Appendix D) will guide floodplain construction since there is uncertainty regarding the vertical and lateral position of bedrock. Floodplain armor sizing will be refined, as needed, during construction to conform to exposed bedrock. Detailed floodplain armor calculations are included in Appendix G. Resulting floodplain armor gradations are presented on Sheet C37.

2.4.3 Vegetated Rock Slope Protection (RSP)

Vegetated rock slope protection (RSP) has been proposed at three locations. Vegetated RSP will be constructed using boulders of a specified gradation with live stakes installed throughout the RSP. Live stakes are live plant cuttings capable of regenerating into mature plants. Live stakes are typically taken from willows.

Vegetated RSP will be used to provide channel stability at the Culvert #7 and #9 removal areas, where the right bank (looking downstream) will be left in an over-steepened condition after culvert removal, and where the floodplain bench conforms to the inlet of Culvert #6 at the downstream end of the Channel Widening Area. Culvert #7 is an 11.5-foot diameter culvert that will be removed along with the fill placed over the top of the culvert. After culvert removal the right bank side slope will be 1-1.5H:1V. Although the RSP sizing calculations do not call for very large material at Culvert #7, RSP is required to ensure the over-steepened reconstructed streambank remains stable while vegetation becomes established. Culvert #9 consists of a 60-inch diameter corrugated metal pipe that is perched in the bank above the channel. The culvert appears to be a relic of an historic crossing. The culvert likely became plugged or the entrance obstructed at some time in the past and the channel cut around it. The right bank side slope will be 1-1.5H:1V after culvert removal. Flow velocities are high at this location, as the channel is narrow and relatively steep, requiring large RSP to protect the channel bank. Flow velocities are relatively low at the entrance to Culvert #6. However, vegetated RSP is required to protect the existing over-steepened slope at the floodplain bench conform to the Culvert #6 inlet.

2.4.4 Vegetation

Vegetation will be an essential component of ensuring short and long-term erosion projection and habitat value on excavated slopes, constructed floodplains and the reconstructed channel banks. All areas disturbed during construction will be revegetated with native species appropriate to the setting. Planting will include live staking, container planting and seeding. Sheets L1-L6 show proposed planting areas, tables identifying proposed species, container sizes, on-center spacings, seed quantities, and installation details. Irrigation details have not been included with this submittal. However, an irrigation system will be designed to maintain installed plantings during their establishment period. The irrigation plan will primarily consist of drip emitters at container plants. Overhead sprinklers may be used to irrigate seed during initial establishment only. A detailed plan will be included with the next design submittal.

Sheet L1 includes details for planting that will occur along the concrete channel. Grading is not proposed along the concrete channel. The planting information on Sheet L1 reflects habitat enhancement specifications included in the Decree.

The remaining landscape sheets include planting information for the areas that will be disturbed by grading activities. Planting tables have been included for each work area (e.g. Rock Pile Area) for both floodplain and riparian areas. A seed mix table has also been included. The seed mix will be applied to all disturbed areas as shown on the Drawings. The seed is expected to provide short-term erosion control through dense establishment of a groundcover including grasses and herbaceous species. Woody species and container plantings will contribute to long-term erosion control and habitat value.

Container plants will be installed in planting pockets and live stakes will be installed throughout the floodplain armor and ESM at floodplain and streambank areas at the spacings shown in the planting tables and relevant details. Live stake trench packs and live willow transplants will also be installed throughout floodplain areas. Refer to relevant details on Sheets C34-C36 for trench pack and willow transplant installation and spacing information.

For revegetation purposes, the "riparian" planting zone has been defined as the areas extending 10 vertical feet up the channel bank from the toe of slope at the edge of constructed floodplain benches. Riparian areas will be revegetated with container plants and seed mix. Refer to the planting tables for individual component project areas.

Erosion Protection above the 10-Year Water Surface Elevation

Revegetation will be the primary means of erosion control on slopes above the limits of floodplain armor (i.e. 10-year water surface) Flow velocities along the lateral margin of floodplain areas average less than 3 ft/sec during the 100-year flood. Revegetated soils can resist flow velocities of 4-6 ft/sec (Fischenich 2001). These areas will be seeded and planted. Mulch and/or erosion control fabric will be provided as appropriate pending constructed geometry, with fabric preferred on slopes over 2.5H:1V.

2.4.5 Project Best Management Practices (BMPs)

Project designs typically incorporate BMPs to reduce construction-related impacts during and after construction. BMPs may include structural elements (*e.g.,* dewatering of work areas, installation of silt fence, or revegetation of disturbed areas) and may also include planning measures such as beneficial phasing and scheduling of work or limitations on disturbance areas. Some of these elements are typically shown on the Design Drawings, while others are often presented within a detailed Stormwater Pollution Prevention Plan (SWPPP). A SWPPP is a separate document that provides specifications for implementation as well as monitoring and reporting, and is submitted to the Regional Water Quality Control Board for review. At present, a SWPPP has not been prepared for the project. Given the complexity of the project site and the particular challenges associated with work within the streambed, we anticipate a very detailed SWPPP document will be required to address the phasing of the work and the potential variations on final geometry and surface materials (*e.g*., bedrock vs. alluvium in channel banks).

The primary concerns at this site include limiting disturbance to adjacent riparian areas, avoiding episodic or chronic release of sediments to the creek, and quickly reestablishing a dense riparian canopy within disturbed work areas. Some of the principal BMPs currently included in the design are presented below.

Construction fencing will be installed along limits of disturbance prior to commencement of grading activities. Access to project areas will be along existing quarry access roads, as shown on Sheets C27-C28. Equipment will be staged and refueled within established staging areas. Continuous dust control will be provided throughout construction in accordance with the dust control notes shown on Sheet C27 and project permits.

Dewatering will occur at all sites where surface water is present and grading is proposed along the channel bed, or where access across the channel is required (i.e. Culvert #9 removal area). Diversion plans are included on Sheets C29-C32, with a typical dewatering plan and details shown on Sheet C33. Block nets will be installed upstream/downstream of the area to be dewatered, and fish and other aquatic organisms will be removed and relocated by a qualified biologist, prior to the installation of dewatering facilities. Where removal of seepage water is required within an isolated construction area, the water will be pumped to a depression or temporary basin to either infiltrate or be detained until it is routed through a sediment treatment facility. Turbid waters will not be allowed to discharge into Permanente Creek. At the completion of construction, all accumulated sediment will be removed from the work area and disposed of.

Silt fence will be installed around staging areas and along the creek-side edge of the proposed floodplain bench excavation areas at the Channel Widening Area. Silt fence will be in place to trap mobilized sediment in case there is a rain event during construction. The silt fence will also act as a barrier to any loose material during floodplain bench excavation. Where substrate is too rocky to install silt fence, fiber roles may be used instead.

Constructed channel areas and bank slopes will be protected from erosion using the specified rock mixtures and/or vegetation as shown on the drawings. Erosion control fabric will be utilized if needed. Fiber rolls will be installed across excavated slopes as shown on Sheets C29 to C32. Prior to revegetating slopes, these areas will be track-walked to ensure drainage in the intended direction and provide smooth transitions to undisturbed sloped. Fiber rolls and container plants will be installed, where specified, and the slopes will be hydroseeded with the seed mix shown on the drawings. The hydroseed mixture will include hydromulch, amendment/fertilizer, and tackifier, to assist with erosion control and seed establishment[5]. Constructed channel and floodplain areas will receive ESM, floodplain armor, and vegetation as discussed above.

All constructed slopes that are steeper than 2H:1V will be evaluated by the Geotechnical Engineer or Project Geologist, and recommendations will be provided, as needed, to ensure geotechnical stability.

2.5 FLOODPLAIN LOGS AND HABITAT LOG INSTALLATIONS

Floodplain Logs

Floodplain logs have been proposed throughout the project. Floodplain logs will consist of both “live logs” and “roughness logs”, as described on Sheet C34. All floodplain logs will be salvaged with rootwads left intact. Live logs will consist of willows that will be removed during project grading. These trees will have all limbs removed to increase the likelihood they will survive and regrow, and they will be partially buried on floodplain areas with the expectation that the majority of them will re-sprout. Roughness logs will consist of all other tree species impacted by project grading. These trees will be partially buried like the live logs, but some limbs will be left intact to add additional roughness and complexity to the floodplain. Calculations have been completed to determine ballasting requirements, and the floodplain logs will be properly ballasted so they will not be moved by flood flows. Ballast calculations are included in Appendix H. Calculations will be adjusted, as necessary, during project implementation to ensure appropriate ballasting for trees of varying dimensions.

Habitat Logs

Habitat log installations are a requirement of the Decree and are proposed in Reaches 14-16 and Reaches 19-21. Habitat logs will be placed within the channel to enhance the complexity of existing pools lacking large wood, or installed at geomorphically appropriate locations in an attempt to

[5] Hydroseeding specifications will be included in the next design submittal.

encourage pool development. In order to meet this requirement and limit construction related impacts, only hand tools and locally available logs will be used. Both fallen and standing trees may be used. Confers will be used if available, but it is expected that most habitat logs would consist of native hard woods readily available adjacent to the creek throughout the specified Reaches. Habitat logs will be secured together using threaded rebar with bolts and positioned (wedged) between existing trees to prevent transport. The habitat logs, either as a group or individually, will be secured to existing trees that are a minimum of 14-inches in diameter at breast height (DBH) using rebar to provide resistance to mobilization during flood events. See the Habitat Log Plan on Sheet C37 for further details.

Pools formed by the installation of habitat logs are expected to evolve in response to periodic large floods and mobilized bed sediment loads. There are already numerous pools within these reaches. They are typically related to forcing features such as bedrock drops, woody debris, or large bed load deposits. Most pools appear to be transitory, changing location in response to episodic flood events and the movements of these forcing features. The channel and floodplain are very active, with mobile deposits of coarse sediment four feet thick at many locations, indicating that existing or newly constructed pools could easily be buried or undercut in even a modest flood event. Though this dynamism presents difficulty in trying to create discrete pools that will persist, we are confident that the addition of roughness through the introduction of large wood will ultimately result in a reach scale increase in pool development and channel complexity.

2.6 GEOTECHNICAL CONSIDERATIONS

Golder Associates (Golder), the project Geotechnical Engineer and Geologist, has been involved in the project since the initial concept designs were prepared in 2014. Golder reviewed the 90% Designs and prepared a review letter, which is included in Appendix I. Design slopes shown on the drawings meet Golder's recommendations included in their previous review letters.

In addition to their work developing an estimated bedrock profile beneath the Rock Pile and Material Removal Areas, the geotechnical analysis has focused primarily on evaluating the stability of the final valley slopes within restored reaches. Golder has provided recommendations on allowable slope angles for the different material types that may be encountered within excavations and they will be integrally involved with construction at the Rock Pile and Material Removal Areas to inspect excavated areas and provide recommendations, as necessary, to ensure finished slopes meet geotechnical criteria for stability. At both the Rock Pile and Material Removal Areas, excavations on the southern side of Permanente Creek are expected to follow similar slope angles as the existing exposed slope, likely uncovering areas of bedrock. The 90% Designs show a 1.5H:1V side slope at these locations for the two sites. The northern bank of the creek will be initially excavated into fill material and may potentially exposing underlying bedrock depending on the depth of excavation. Default design side slopes on the north bank are 2H:1V or flatter. The northern banks may be constructed at a steeper slope if bedrock is uncovered. Golder will inspect the slope below the Rock Pile once it is removed and evaluate the nature and stability of the exposed material. Recommendations will be developed, as necessary, to ensure the slope is geotechnically stable.

2.7 DESCRIPTION OF INDIVIDUAL PROJECT COMPONENTS

The individual project components are briefly described below, introduced from the downstream to the upstream limits of the proposed work.

2.7.1 Concrete Channel (Reach 6, Sheet L1)

Native riparian plantings will be installed along the southern bank of the concrete channel, from the edge of concrete to the top of bank. Installed plantings will infill areas outside of existing mature tree canopy. Existing oak seedlings will be preserved and a 3-foot radius around each seedling will be hand-weeded to reduce competition. The goal of the work is to expand the riparian corridor and increase canopy cover over the channel to lower stream temperature. Shading will also reduce the ability of cattails to established or persist in the channel. Cattails currently block the channel in many locations, thereby reducing sediment transport and flood capacity. They also present a partial barrier to the movement of any fish within the concrete channel.

Fish passage was not evaluated within the concrete channel, as there are not any improvements proposed within the concrete channel.

These proposed improvements meet the conditions outlined in paragraph #40 of the Decree.

2.7.2 Channel Widening Area (Reaches 8-12, Sheets C11-C18)

Within Reaches 8 through 10, the north bank will be excavated to form a bench at the estimated bankfull (1.5-year) water surface elevation. The bench width will be maximized by narrowing the existing roadway. The bench will be constructed to leave a maximum roadway width of 20 feet, as measured to the top of the creekside vehicle barrier. Work generally avoids disturbance to the bed of the channel and the south bank, except where large concrete debris or culverts are proposed for removal. Where existing mature riparian trees are present, the bench excavation has been modified to preserve them, where feasible, in the interest of maintaining shade cover and improved habitat.

The floodplain bench will be over-excavated and then lined with a mixture of coarse alluvial materials sized to resist mobilization during floods. Periodic floodplain roughness elements (e.g., floodplain logs and boulder sills) will be incorporated to minimize channel migration into the benches as vegetation becomes well established.

Fish passage was not evaluated where only the construction of a floodplain bench is proposed because work is not proposed within the active channel bed.

These improvements meet the conditions outlined in paragraphs #38-39 of the Decree.

2.7.3 Culvert 7 (Reach 8, Sheet C11)

Culvert #7 will be completely removed and the area restored with a floodplain bench incorporated along the northern bank. Biomechanical bank stabilization treatments will be required on the outer bend to support the toe of the hillslope where the culvert and associated fill are removed. Expected work includes the installation of vegetated RSP.

Fish passage design criteria for both depth and velocity are met when using the “Hydraulic Design” approach.

These improvements meet the conditions outlined in paragraph #39 of the Decree.

2.7.4 Culvert 8 (Reach 9, Sheets C14-C15)

Culvert #8 will be completely removed and the area restored with a floodplain bench incorporated along the northern bank.

Fish passage design criteria for both depth and velocity are met when using the "Hydraulic Design" approach.

These improvements meet the conditions outlined in paragraph #39 of the Decree, although Culvert #8 is not specifically mentioned.

2.7.5 Sediment Removal Area (Reach 9, Sheets C14 & C16)

Accumulated sediments and fill materials will be removed as necessary to restore pre-disturbance geometry within the tributary channel and adjacent floodplain area. The access road and existing storage area will be revegetated. Final grades will be dependent upon sub-surface conditions (*i.e*., the location of bedrock). All disturbed areas will be revegetated with native riparian species.

These improvements meet the conditions outlined in paragraph #39 of the Decree.

2.7.6 Culvert #9 Removal Area (Reach 10, Sheet C18)

Culvert #9 will be completely removed from its perched location in the channel bank and the bank will be restored in the vicinity of the work. Biomechanical bank stabilization treatments will likely be required to restore the southern streambank unless bedrock is exposed during demolition. Expected work includes the installation of vegetated RSP.

Fish passage was not evaluated because there is not any work proposed within the active channel bed.

These improvements meet the conditions outlined in paragraph #39 of the Decree.

2.7.7 Culverts #10 & #11, Rock Pile, and Pond 13 (Reaches 11-13, Sheets C19-C21)

Extensive channel realignment and reconstruction is proposed throughout this area, including removal of Culverts #10 & #11, rip rap in the vicinity of the Culvert #10 outlet, and the dam at Pond 13.

As discussed above, the channel profile appears to have been significantly modified in this reach, resulting in a flattened profile downstream of Pond 13 at Culvert #11 (half culvert) and a very steep profile through Culvert #10. The design optimizes fish passage conditions by creating a more uniform grade through the reach. Cuts approximating thirty to forty feet of depth are required to accomplish this. The grading plan reflects the Lower Limit of Potential Design Channel Invert. The Upper Limit of Potential Design Channel Invert shown in profile has been established as a best fit to bedrock elevations that were estimated using a seismic refraction analysis and geotechnical borings. The results of this seismic refraction analysis are attached as Appendix D. Since we cannot know the exact location of all bedrock without extensive subsurface exploration, (*e.g*., drilling or trenching) final geometry will likely vary somewhat from that shown on the drawings, as necessary to conform to existing bedrock.

The newly excavated floodplain benches will be lined with a mixture of coarse alluvial materials sized to resist mobilization. Floodplain roughness elements (*e.g*., log structures and/or boulder sills) will be incorporated to minimize channel migration into the benches until vegetation becomes well established.

The dam will be removed at Pond 13 and replaced with a boulder weir grade control structure, if the upper limit of potential design channel invert is constructed. Fine sediment impounded within the pond will be removed so the material is not transported downstream after the restoration project is implemented. The limits and thickness of accumulated sediment have not been surveyed. Accumulated fine sediment occurring below elevation 805.0 will be removed. Removal of fine sediment will occur until alluvial material (*i.e.,* gravel/cobble) or bedrock are encountered. Pond 13 would then be allowed to fill naturally with sediment over time, to allow for improved sediment transport continuity through downstream reaches.

The rock pile and associated infrastructure will be removed to accommodate the lowered and widened channel, as shown on cross sections C and D of Sheet C21. An access road has been incorporated into the design for maintenance of Pond 13B. Newly disturbed upland hillslopes will be vegetated with native species, as will the constructed channel and floodplains. The slope exposed below the Rock Pile will be inspected by the Geotechnical Engineer or Project Geologist to evaluate the nature and stability of the exposed material and provide recommendations, as necessary, to ensure geotechnical stability of the slope and access road.

These improvements meet the conditions outlined in paragraphs #37 & 38 of the Decree.

Fish passage design criteria for both depth and velocity are met when compared to the hydraulic design parameters established under the Hydraulic Design approach, due to the high roughness of the proposed channel substrate. However, it should be noted that the design profile grade of 12% exceeds CDFW's estimated limit to anadromy, which is a sustained slope of over 8%; and studies show that adult anadromous salmonids are able to navigate steeper slopes than resident rainbow trout (Coastal Conservancy 2004). See Section 2.3.1.1 above for a discussion regarding fish passage evaluation in steep reaches.

2.7.8 Habitat Logs (Reaches 14-16 and 19-21, Sheet C37)

Woody Debris will be placed within the active channel at select locations in these reaches to provide hydraulic complexity to maintain existing pools or create new pools and provide cover for resident rainbow trout. The exact locations of proposed wood placement will be determined in the field at the time of construction, with the chosen locations based on local geomorphic conditions and the availability of existing pools and/or trees that may serve to anchor installed wood. The 90% Designs recommend the use of locally available species as habitat logs due to the limited site access. However, the source and species of installed wood shall ultimately comply with CDFW and Regional Water Board permits.

We anticipate that the details of habitat log species, size, placement locations and installation criteria will be further refined in coordination with feedback received from the resource agencies in accordance with paragraph #36 of the Decree.

2.7.9 "Old Crusher Foundation" Removal (Reach 17, Sheet C22)

The "old crusher foundation" will be modified to conform to the adjacent banks. The portion of the "old crusher foundation" that is projecting into the creek will be removed. Sheet C22 includes a site plan and cross sections of the proposed work. All work will be completed using hand labor and small equipment with worker safety being the highest priority, given that the foundation is located at the base of a very steep and tall slope. All waste material and spoils will be removed from the creek using hand tools and disposed of. Access is anticipated to be provided by use of a constant rate descender, or similar. Final geometry will be inspected by the Engineer to ensure a smooth hydraulic transition along the portion of the "old crusher foundation" to remain.

These improvements meet the conditions outlined in paragraph #35 of the Decree.

2.7.10 Material Removal Area (Reaches 17 & 18, Sheets C23-C26)

This area has been modified by the placement of material within and adjacent to the channel. The exact extent and depth of material is uncertain at this time, due to limited subsurface data. A seismic refraction analysis has been performed to estimate the depth to bedrock, in an effort to gain a clearer understanding of the pre-disturbance site geometry and allow a more informed evaluation of opportunities and constraints to enhancement. The results of this analysis are attached as Appendix D.

The 90% Designs show the area will be excavated to establish a more uniform profile gradient, as shown on Sheets C23 and C24.[6] The grading plan reflects the Upper Limit of Potential Design Channel Invert and has been established as a best fit to bedrock elevations that were estimated using the seismic refraction analysis. The Lower Limit of Potential Design Channel Invert is shown in profile and represents the lowest grade at which the channel invert would be constructed if bedrock is not encountered. Proposed cuts extend to depths of over thirty feet below existing ground, resulting in profile grades of 7.1% to 22.7%. These grades follow the peaks of the estimated subsurface bedrock profile. Final grades would be determined in the field to best-fit bedrock exposures encountered during excavation. Since we cannot know the exact location of all bedrock without extensive subsurface exploration, (*e.g.*, drilling or trenching) final geometry will likely vary somewhat from that shown on the drawings.

The proposed centerline of the creek was established by extending the existing southern hillside slope down at 1.5H: 1V to meet the new profile grade, and then leaving room for a bench that varies in width at bankfull elevation. The existing toe of the slope on the north side of the creek was relocated northward by twenty-five feet, except near Pond 4 where the bench needed to be narrowed slightly to accommodate the water treatment plant and existing access road. The north bank is sloped at a maximum steepness of 2H:1V. The “relic concrete structures” shown on the Drawings will be removed during site grading. All disturbed areas will be revegetated with native species appropriate to the site.

The newly excavated floodplain benches will be lined with a mixture of coarse alluvial materials sized to resist mobilization. Floodplain roughness elements (*e.g.,* log structures and/or boulder sills) will be incorporated to minimize channel migration into the benches until vegetation becomes well established.

These improvements meet the conditions outlined in paragraph #35 of the Decree. It should be noted, however, that the design profile grade within this reach will likely vary from 7.1% to 22.7% and may have drops over bedrock features. Fish passage will be an objective, but cannot be guaranteed with these site constraints, the majority of which exceed CDFW’s estimated limit to anadromy, which is a sustained slope of over 8%; and studies show that adult anadromous salmonids are able to navigate steeper slopes than resident rainbow trout (Coastal Conservancy 2004). See Section 2.3.1.1 above for a discussion regarding fish passage evaluation in steep reaches.

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[6] An alternative concept design to that shown on Sheets C23 and C24 has been prepared should the regulatory agencies and Lehigh conclude that the Final Treatment System – Upper (“FTS-Upper”) should stay in place to treat water generated from the site. The alternative concept is presented on Figures 4 and 5, which are attached to the Updated Response to March 5, 2018 County of Santa Clara, Department of Planning and Development, Grading Application Incomplete Letter, dated November 15, 2018.

3.0 IMPLEMENTATION

3.1 CONSTRUCTION SEQUENCING

There are many considerations when determining the optimal sequencing of a large stream restoration effort. At Permanente, examples include project area diversion and dewatering requirements, temporary impacts to stream and wetland habitat, post-construction sedimentation, quarry operations, and noise and dust. Permit requirements, including the in-stream work window, will also have bearing on the sequence of construction and the amount of construction that is completed in a given season.

In-stream flows can vary from year to year with surface water present in some portions of Permanente Creek and not in others. Although the presence of surface water will not dictate where work occurs in a given year, it will be considered to help simplify construction and reduce potential water quality impacts. The location and operation of the water treatment plant facilities and associated infrastructure (*e.g.,* Pond 1250) that have been installed to remove selenium from quarry water will also be considered when determining construction sequencing. Work at the Material Removal Area may be sequenced to occur after other portions of the project are constructed if the treatment facilities and Pond 1250 need to remain in place at the start of project implementation.

Ecological impacts from temporary site disturbances are also an important consideration. Of the potential impacts, soil disturbance and riparian vegetation removal are primary concerns. Vegetation removal reduces available cover and habitat for wildlife and shading of Permanente Creek. Soil disturbance associated with channel grading activities will further increase risk of erosion and sedimentation in the short term. Although the constructed features will be designed to ultimately reduce erosion and sedimentation, there will always be some minor erosion that mobilizes fine sediment while vegetation from erosion control seed and installed container plantings are becoming established during the first year following construction. Although the project will ultimately result in a significant expansion of riparian area, the removal of vegetation will temporarily reduce areas of riparian habitat, increase risk of erosion, and reduce shading of the creek until replacement plantings have matured.

In consideration of these short-term impacts, we have planned to stage the work so that the area of impact is limited in any given year, and in a manner that will allow newly constructed floodplains at the downstream limit of the work to treat runoff from the upstream end of the project area that would be disturbed in subsequent years.

We recommend that the initial stream restoration work occur along the Channel Widening Area, extending upstream to the end of Reach 10, where floodplain benches will be created. The benching will provide opportunities for sediment deposition to occur if material is mobilized from the Rock Pile and Material Removal Areas during the initial years after construction. The benches will also provide depositional areas for fine sediment mobilized from the large sediment deposits located within reaches, R14-R16 and R19-R21. In addition to providing this water quality benefit, the Channel Widening Area is also the least complex of the major construction components, allowing the opportunity for the construction team to gain familiarity with the particular challenges of the site (e.g., material processing, dewatering, topsoil salvage, and revegetation) before tackling the upstream reaches where channel grading is more complex.

The second phase of the work is expected to involve the Rock Pile Area. The final stage would include the Material Removal Area.

A final construction schedule will be prepared once all project permits and approvals are received for project construction, in accordance with paragraph #46 of the Decree.

3.2 FIELD ENGINEERING – ROCK PILE (REACHES 11-13) AND MATERIAL REMOVAL AREA (17-18)

The design engineers will be closely involved with construction implementation at the Rock Pile and Material Removal Areas. The drawings for each site present an "Upper Limit of Potential Design Channel Invert" and "Lower Limit of Potential Design Channel Invert". The upper limit represents the design grade based on connecting high points on the bedrock profile that were identified during subsurface investigations. The lower limit represents the maximum extent of excavation at locations where bedrock is not encountered during project construction. The likelihood is that the constructed channel will lie somewhere between these two profiles. Appendix D includes a description of field engineering parameters that will guide determination of the final profile at the Rock Pile and Material Removal Areas. Final slopes steeper than 2H:1V will be evaluated by the Geotechnical Engineer or Project Geologist and recommendations will be provided, as needed, to ensure geotechnical stability.

4.0 ADAPTIVE MANAGEMENT

The project has been designed to restore significant portions of Permanente Creek and greatly expand floodplain and riparian areas along the component project areas. Project designs include elements to provide short-term stability, while also being able to respond to future flooding events and changes in the sediment transport regime. As with most stream restoration projects, it is not possible to predict all future adjustments that may occur, and adaptive management may be required.

The reconstructed channel and floodplains will be protected with engineered streambed material (ESM) and floodplain armor. These substrates have been sized to remain relatively stable while allowing for natural adjustments to flooding events and sediment transport from upstream reaches. Boulder sills have been incorporated throughout the project to reduce the percentage of large boulders used in the ESM and floodplain armor, and to protect against erosion from large flooding events that may occur in the initial years after project construction while vegetation is becoming established. We anticipate that the armoring and sills will perform as designed. However, adjustments or erosion could occur that require attention to ensure the project evolves as intended.

The creation of inset floodplain benches will allow for significant sediment storage within the project reaches, or for the low flow channel to adjust laterally without consequence in most instances. However, sediment mobilized from project areas or from areas outside the influence of project construction may accumulate in undesirable locations within the reconstructed channel segments. Areas of significant aggradation would be evaluated and corrective measures would be proposed. In the initial years after project implementation, it will be important to ensure that sediment/debris does not accumulate at locations that may direct future flood flows in a manner that could affect project stability.

The plants selected for the revegetation effort were chosen based on experience revegetating other areas of the project site. Although a certain percentage of die-off is typical with any native revegetation effort, it is expected that the selected species will do well along the restored project areas. If it is found that the revegetation effort is not meeting project performance standards, the cause will be evaluated and either alternative species will be used, or the species that are performing well be increased to ensure the project meets required performance standards for vegetation establishment.

Each project area should be inspected during the first year after construction after storms delivering 1.5 inches or more of rainfall have occurred. If erosion or sedimentation does occur, the cause of the issue will be evaluated and adaptive management practices will be developed to help stabilize the area. The default approach at areas of erosion will be the installation of additional vegetation where this approach is a viable solution to help halt erosion. If the area of erosion is significant, and the installation of additional vegetation is not a potential solution, an approach will be developed and the resource agencies will be engaged if heavy equipment is involved.

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