

Bonde Weir Fish Passage and Channel Stabilization Project Project Description

San Francisquito Creek Palo Alto & Menlo Park, CA

August 2013



Summary: The *Bonde Weir Fish Passage and Channel Stabilization Project* (or project) is located in San Francisquito Creek in the cities of Palo Alto and Menlo Park. The project site occupies a portion of the border between Menlo Park and Palo Alto about 1.7 miles southwest of U.S. Highway 101 near El Camino Real Bridge (Appendix A). The project proposes to remove a bank-to-bank concrete sill, known as the Bonde Weir, that acts as a barrier to fish passage under current conditions and replace it with a re-graded and "roughened" channel. This channel type uses engineered streambed materials to maintain and improve stability over a wide range of streamflows while providing vastly improved conditions for fish migration and movement. In particular, the project is intended to benefit steelhead trout (*Oncorhynchus mykiss*), as the San Francisquito Creek watershed provides habitat for this species. The watershed is part of the Central California Coast steelhead Evolutionarily Significant Unit in which steelhead are considered "threatened" under the federal Endangered Species Act. The project also will improve channel stability over existing conditions.

Need for the project: The Bonde Weir has been recognized by local biologists and state and federal resource agencies as an impediment to steelhead passage for at least ten years. The deteriorating condition of the weir may also pose a risk to channel stability. Under low flow conditions, stream flow pools upstream from the weir resulting in a lack of flow over the weir or

in sheet flow unfavorable to migrating fish due to inadequate water depth. Under higher flow conditions, water velocity may further limit migration opportunities. The majority of the watershed's spawning and rearing habitat occurs in San Francisquito Creek and its tributaries upstream from the weir, suggesting that limits to in-migrating steelhead have substantial effects on the steelhead population. Further, under low flow conditions, fish may be prevented or delayed from moving downstream to favorable habitats or to out-migrate, possibly resulting in mortality. The project will greatly improve passage conditions and opportunities to successfully complete the steelhead life history.

The remainder of this project description includes sections that characterize existing conditions at the project site, elements of the project, sequence and schedule of proposed activities, staging areas and access, related permits and measures to avoid impacts. The description has been prepared by the San Mateo County Resource Conservation District (RCD) on behalf of the several organizations partnering to implement the project to provide information to reviewing agencies and the interested public. Funding for this project has been provided by the NOAA Restoration Center, the EPA San Francisco Bay Water Quality Improvement Fund, and the State Coastal Conservancy. Questions or comments on any aspect of the project are welcomed and may be addressed to the RCD staff listed at the end of this document.

Existing site conditions: The Bonde Weir is located in San Francisquito Creek where the creek passes through El Palo Alto Park. The weir is about 15 feet downstream from the pedestrian bridge crossing and approximately 80 feet downstream from the bridge over which the Caltrain tracks cross the creek. It consists of an 11 foot long and 45 foot wide concrete sill.

The weir is located near the midpoint of a right trending bend (looking downstream) in the creek. The creek upstream of the weir has trapezoidal shape with a bed width of about 20 feet, a right bank (looking downstream) side slope of about 0.6 feet horizontal to 1 foot vertical (0.6:1), and a left bank side slope of 0.8:1. The creek bed is about 20 to 25 feet below the adjacent top of banks. A concrete wall along the right bank (looking downstream) extends from 3 feet downstream of the weir to about 150 feet upstream. The left bank is composed of native material. Sheet C2 from the design plans (Appendix B) shows the site topography and planimetric features. A view of the creek looking upstream of the pedestrian bridge is shown in Figure [1].



Figure 1: Looking Upstream from Bonde Weir.

The sill slopes downstream at 4.8 feet horizontal to 1 foot vertical (4.8:1, or about 20 percent). The low point along the weir crest is at elevation 46.6 feet (all elevations are relative to USC&GS BM H7) and the downstream end of the weir is at elevation 44.5 feet. Figures [2], [3], and [4] show frontal, side, and top views of the weir, respectively.



Figure 2: Bonde Weir looking from downstream to upstream.

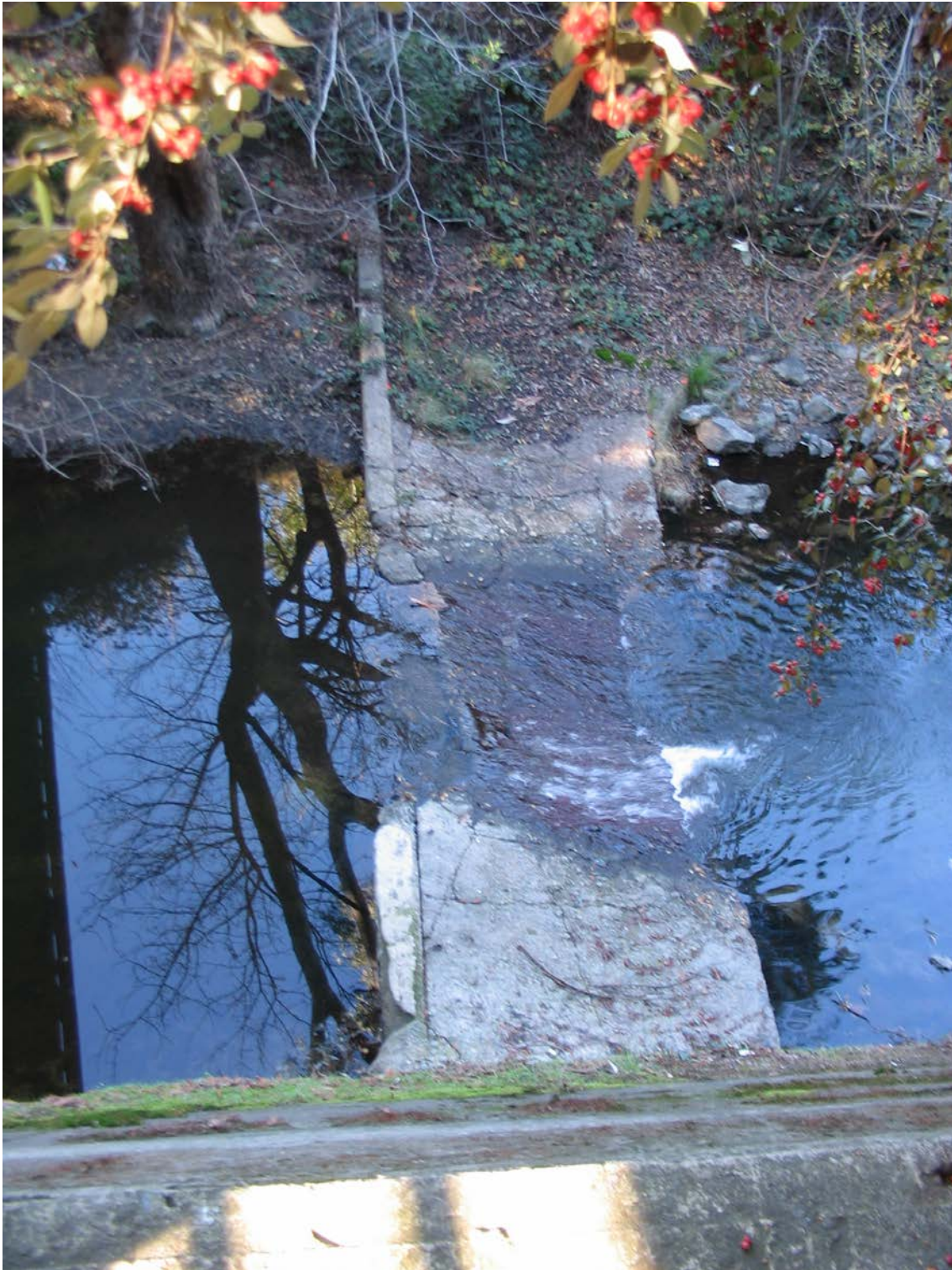


Figure 3: Bonde Weir looking from the right bank above.



Figure 4: Bonde Weir looking from upstream to downstream from the pedestrian bridge above.

A pool forms upstream of the weir during low flows. The pool characteristics are influenced by several factors, including the hydraulic characteristics of stream bends, which typically induce scour along the outside toe of the bend. At the weir, local scour also occurs in the lee of a sackcrete storm drain outlet apron and at the backwater resulting from the weir. Using the weir crest to define the pool surface, the pool extends more than 160 feet upstream of the weir. The deepest part of the pool is along the downstream end of the drainage outlet, where the substrate is about 4 feet below the lowest point of the weir crest. Figure [5] shows the storm drain outlet.



Figure 5: Storm drain outfall on the left bank just upstream from Bonde Weir.

Downstream of the weir, the channel width increases to about 25 feet. The adjacent banks range in slope from 5:1 to 2:1. Toward the top of the adjacent banks, slope ranges from 2:1 to 1:1. Figure [6] shows a view of the creek downstream of the pedestrian bridge.



Figure 6: San Fransquito Creek Channel looking downstream from Bonde Weir.

Concrete rubble and large rock are found in the bed immediately downstream of the weir. The rubble does not appear to be a significant portion of the bed and will have to be removed from the site. The exact volume of rubble to be removed will likely be less than 50 tons. This rubble will be disposed of at an approved waste facility. The large rock will be evaluated by the field engineer to ensure it meets hardness criteria and will likely be included in the proposed channel design.

Project elements and activities: The project will remove the existing weir, add scour protection to the retaining wall at the Caltrain bridge, re-profile the channel using engineered streambed materials, and stabilize and re-vegetate adjacent stream banks. The following describes each of these activities in greater detail. Sheets C2 and C3 in Appendix B provide plan and profile views of each of the project elements.

Remove existing weir: In this part of the project, heavy equipment will be used to demolish the existing weir and remove the associated debris. As-built design drawings of the weir were unattainable and the exact dimensions of the weir are unknown. However, the weir is not believed to be attached to the concrete wall protecting the foot of the pedestrian and Caltrain bridges. Concrete rubble and limited amounts of poor quality rock will be removed from the site

during this phase and disposed of at an approved waste facility. It is expected about 400 cubic yards of material will be removed from the site.

Excavate project site: After the weir has been removed, the channel will be excavated down to 3 feet below the finished grade along the 100 lineal feet of channel where the roughened channel will be located. Excavation will occur between streambanks and will maintain a slope of 1.5H:1V or flatter between excavated surfaces and existing surfaces to be undisturbed. The excavated material will be sorted and stockpiled on-site. This material will be used in creating the engineered streambed material in later construction stages.

Add Caltrain bridge scour protection: Approximately 65 lineal feet of rock riprap will be placed along the left bank of the channel. The rock will be placed along the toe of the concrete wall to protect the wall from erosion, and will extend downstream of the wall about 25 feet. The rock will be placed at a 3 foot thickness and result in about 0.5-1CY of rock per lineal foot of protection.

Re-profile using engineered materials and rock buttresses: The creek channel will be re-profiled between a location about 20 feet upstream of the existing weir's upper extent and a location about 80 feet downstream of the existing weir's lower extent. The roughened channel will be about 100 feet long and will have a slope of about 1 percent.

The roughened channel construction includes importing various sizes of quarried rock, cobble and gravel and mixing these Engineered Streambed Materials (ESM) with fines found on site. The heterogeneous mix of ESM forms a tight structure that minimizes loss of streamflow into the bed and potential for scour during high flow events. Hydraulic modeling completed by Northwest Hydraulic Consultants (2012) indicates that water depths and velocities in the roughened channel will be comparable to those found in proximate riffle sections of the creek. The model results show that flow upstream from the project site will be unaffected by the channel reconfiguration.

After placement of the ESM, the contractor will install buttress/framework material, boulder clusters, and engineered streambed materials per the design, and as directed by the engineer. The field engineer will be onsite to verify the grade of the rock buttress material and the gradation of the ESM to ensure it is placed properly. The contractor will likely set the rock buttresses at the proper grade and fill the ramp between buttresses with 1 foot compacted lifts of ESM. Boulder clusters will be placed as appropriate.

Stabilize and re-vegetate banks: Disturbed areas will be replanted with native plants sourced as much as possible from the San Francisquito Creek watershed. An estimated 2,000 square foot area will be temporarily disturbed and will need to be revegetated. Plantings will be watered and maintained after the construction period to assure their survival. Temporary erosion control measures will be used to maintain soil stability until plantings are established.

Please see the Basis of Design Report (Appendix C) by Northwest Hydraulics for additional detail into the engineers rational for proposed project designs.

Sequence and schedule: Construction is expected to last approximately eight weeks, beginning as early as June 2013 and completed by October 15, 2013. Major tasks are listed below:

Install tree protection measures
Establish staging and access areas
Mobilize equipment
Survey layout
Install temporary erosion control measures (if necessary)
Install traffic control and signage
Establish staging and equipment access areas
Removal and offhaul weir
Excavate channel, and salvage and stockpile bed material
Imported ESM
Construct roughened channel
Restore and revegetate disturbed areas

Staging areas and access: Equipment and material access is shown on sheet G2 of Appendix B. Equipment access will occur via a path between Palo Alto Avenue and the south side of the creek. The access route will follow the route of an existing 8 foot wide bike path and will terminate at the least steep portion of the stream bank. The footprint of the access route has been limited to the fullest extent feasible.

Public Access: All equipment will access the site on designated access routes and will be staged in the designated staging area. Signage and traffic control will be accomplished in accordance with Palo Alto and Menlo Park standards along the bike path and surface streets. Construction will be limited to normal daylight hours. Temporary closure of the bike path will be necessary when equipment is moving in and out of the site. A detour has been established using the Willow Road Pedestrian Bridge just downstream of the El Palo Alto pedestrian bridge.

Permits: The project will require the following permits:

- Clean Water Act, Section 404 Permit, U.S. Army Corps of Engineers
- Clean Water Act, Section 401 Water Quality Certification, San Francisco Regional Water Quality Control Board
- Lake or Streambed Alteration Agreement, California Department of Fish and Wildlife
- Biological Opinion, National Marine Fisheries Service
- Letter of Concurrence, U.S. Fish and Wildlife Service
- Park Improvement Ordinance, Grading Permit, and Encroachment Permit, City of Palo Alto
- Encroachment Permit, City of Menlo Park

Contact Information:

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Resource Conservation District

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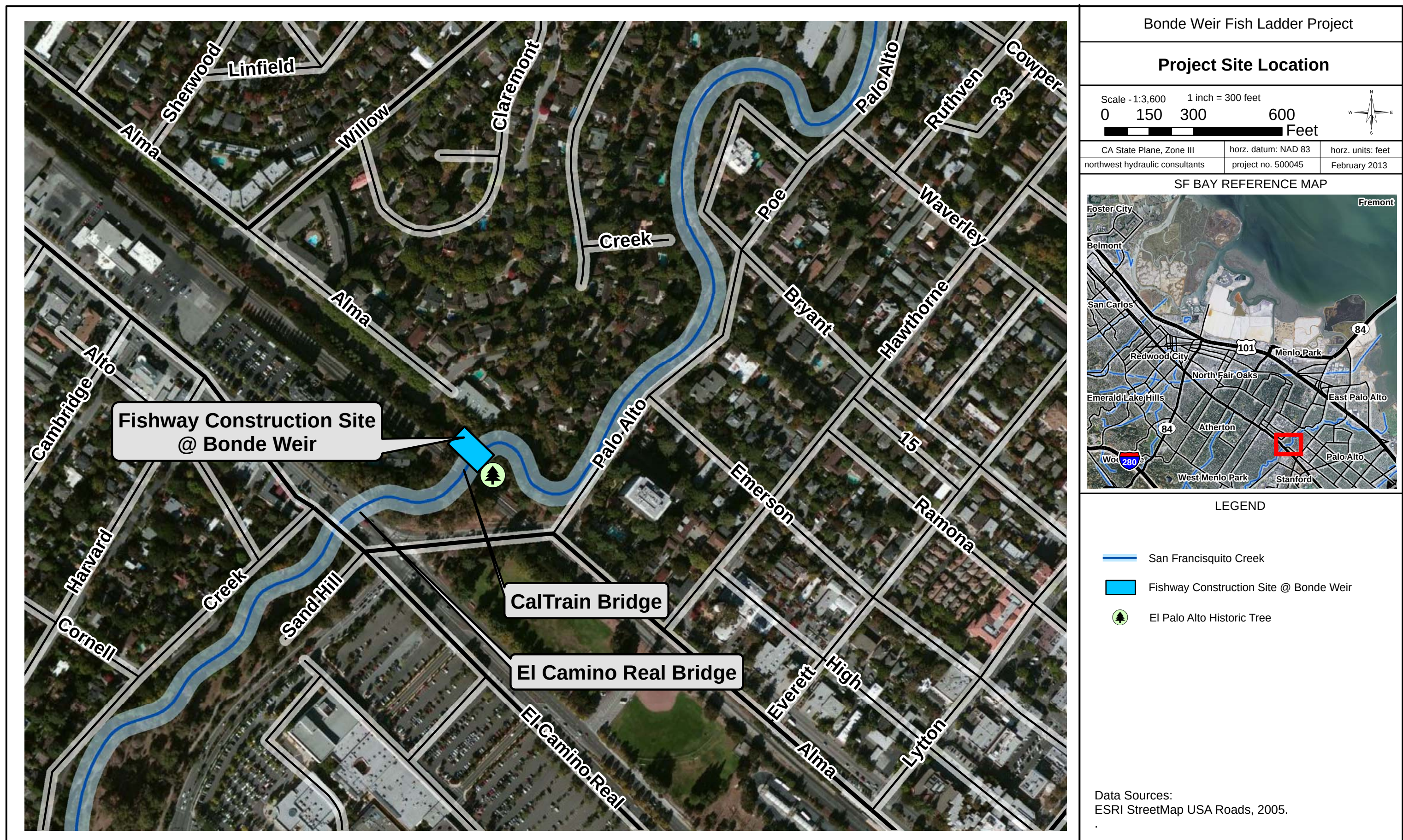


Figure 1: Project Site Location

SHEET INDEX	
COVER SHEET	G1
GENERAL NOTES SHEET	G2
DEMOLITION SHEET	C1
PLAN SHEET	C2
PROFILE & SECTIONS SHEET	C3
DETAILS SHEET	D1

- GENERAL NOTES**
- 1.CONTRACTOR SHALL NOTIFY USA NORTH AT 811 OR 1-800-227-2600 OR WWW.USANDRTH.ORG TO REQUEST IDENTIFICATION AND LOCATION OF EXISTING UNDERGROUND UTILITIES. CONTRACTOR SHALL CONTACT USA NORTH 2 TO 14 DAYS BEFORE PLANNED EXCAVATION DATE.
 - 2.THE CONTRACTOR SHALL BE RESPONSIBLE FOR IDENTIFYING AND AVOIDING DAMAGE TO UNDERGROUND UTILITIES. IF UTILITY CONFLICTS ARE IDENTIFIED, THE CONTRACTOR SHALL HALT ALL WORK IN THE AREA AFFECTED BY THE UTILITY CONFLICT AND SHALL IMMEDIATELY NOTIFY THE PROJECT MANAGER.
 - 3.THIS PROJECT IS SUBJECT TO REQUIREMENTS OF PERMITS ISSUED BY VARIOUS REGULATORY AGENCIES. THE CONTRACTOR IS RESPONSIBLE TO UNDERSTAND AND PERFORM ALL WORK IN ACCORDANCE WITH THE REQUIREMENTS OF THE PERMITS. COPIES OF THE PERMITS HAVE BEEN PROVIDED TO THE CONTRACTOR ALONG WITH THESE PLANS. PRIOR TO COMMENCING WORK THE CONTRACTOR SHALL COORDINATE WITH THE PROJECT MANAGER TO VERIFY THE MOST RECENT COPY OF ALL APPLICABLE PERMITS ARE INCORPORATED INTO THE PROJECT CONSTRUCTION DOCUMENTS.
 - 4.THE CONTRACTOR IS RESPONSIBLE FOR DEVELOPING AN EROSION CONTROL AND POLLUTION PREVENTION PLAN FOR CONSTRUCTION ACTIVITIES. THIS PLAN MUST BE APPROVED BY THE PROJECT MANAGER PRIOR TO CONSTRUCTION ACTIVITIES COMMENCING FOR THIS PROJECT. ELEMENTS OF THE EROSION CONTROL AND POLLUTION PREVENTION ARE SHOWN ON THESE PLANS.
 - 5.ACCESS TO SITE IS THROUGH PUBLIC PROPERTY. CONTRACTOR TO COORDINATE ACCESS, WORK HOURS, AND WORK DATES IN ADVANCE WITH THE SAN MATEO RESOURCE CONSERVATION DISTRICT.
 - 6.WHEN CONDITIONS IN THE FIELD DO NOT CONFORM WITH INFORMATION IN THESE PLANS AND/OR WHEN UNUSUAL CIRCUMSTANCES ARISE DURING CONSTRUCTION, THE CONTRACTOR SHALL IMMEDIATELY CONTACT THE PROJECT MANAGER.
 - 7.IN THE EVENT THAT ANY ARCHEOLOGICAL ARTIFACTS ARE UNCOVERED DURING CONSTRUCTION ACTIVITIES, THE CONTRACTOR SHALL STOP ALL WORK IMMEDIATELY IN THE AREA AND CONTACT THE PROJECT MANAGER. WORK IN THE AREA SHALL NOT RESUME UNTIL APPROVED BY THE PROJECT MANAGER.
 - 8.DURING CONSTRUCTION THE PROJECT MANAGER OR DESIGNATED REPRESENTATIVE MAY MAKE ADJUSTMENTS TO THE DESIGN TO ACCOMMODATE CONDITIONS ENCOUNTERED AT THE SITE.
 - 9.CONSTRUCTION SHALL BE IN ACCORDANCE TO THE FOLLOWING SPECIFICATIONS AND PROVISIONS:
 - PROJECT SPECIFICATIONS
 - CALTRANS STANDARD SPECIFICATIONS 2010

LEGEND

EXISTING TREES	
EXISTING TREES TO PRESERVE	
EXISTING RAILROAD TRACKS	
EXISTING PAVED ROAD	
EXISTING GRAVEL ROAD	
EXISTING CONTOURS (MAJOR)	
EXISTING CONTOURS (MINOR)	
EXISTING FENCE	
EXISTING EDGE OF WATER (04/15/05)	
EXISTING BUILDINGS & STRUCTURES	
PROPOSED EARTHWORK	
CONSTRUCTION BASELINE	
FENCE WITH FIBER ROLL SILT BARRIER	
SILT PRESERVATION FENCE	

San Mateo County Resource Conservation District

CONSTRUCTION PLANS FOR

SAN FRANCISQUITO CREEK

BONDE WEIR FISH PASSAGE IMPROVEMENT

AUGUST 2012

Kellyx Nelson—Project Manager
SAN MATEO RESOURCE CONSERVATION DISTRICT

APPROVED BY:

Virginia Parks— City of Menlo Park (date)

Daren Anderson— City of Palo Alto (date)



Vicinity Map

San Mateo County Resource Conservation District

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Leonard J. Howard

California Registered Professional Engineer No. # C53319
northwest hydraulic consultants

APRIL 19, 2013

(date)



Project Location Map

Drawing Name BONDE WEIR BASEMAP.dwg			Date 19 April 2013	
Drawing Status 100% SUBMITTAL	Designer tvs	Drafter tvs	Checked j/h	Job Number 500045
				Sheet Number

Sheet 1 of 6

G1



- ACCESS NOTES
1. EQUIPMENT WILL BE BROUGHT ONSITE USING APPROXIMATE ACCESS ROUTE SHOWN ON PLAN. SMCRCD WILL MARK PROPOSED ROUTE PRIOR TO THE COMMENCEMENT OF CONSTRUCTION. CONSTRUCTION EQUIPMENT MUST BE ABLE TO ACCESS SITE ALONG 11 FOOT WIDE ROUTE AND BE NO TALLER THAN 8 FEET HIGH.
 2. WHERE THE ACCESS ROUTE IS NOT ALREADY PAVED, THE CONTRACTOR SHALL PLACE A 10" THICK MULCH COVERING WITH CONSTRUCTION MATS PLACED ON TOP TO PROTECT THE EXISTING GROUND.
 3. TREES LOCATED WITHIN 6 FEET OF THE ACCESS ROUTE WILL REQUIRE TYPE 1 TREE PROTECTION. THIS PROTECTION WILL CONSIST OF WOOD FENCING AND PLYWOOD COVERING THE TREE TRUNK.
 4. EQUIPMENT WILL NOT BE ALLOWED TO BE PARKED ALONG THE ACCESS ROUTE OR AT ANY LOCATION WITHIN THE EL PALO ALTO PARK AREA.
 5. TRAFFIC SIGNAGE AND TRAFFIC CONTROL SHALL BE IN ACCORDANCE WITH CITY OF PALO ALTO AND CITY OF MENLO PARK STANDARDS. SIGNAGE SHOWN ON THIS PLANE SHEET WILL BE USED AT MINIMUM. FLAGMEN WILL BE PRESENT WHEN THE ACCESS ROUTE IS IN USE. THE CONTRACTOR SHALL REFER TO PERMIT CONDITIONS FOR CITY OF PALO ALTO AND CITY OF MENLO PARK FOR TRAFFIC CONTROL REQUIREMENTS.
 6. THE BIKE PATH SHALL REMAIN OPEN TO PEDESTRIAN AND BIKE TRAFFIC DURING CONSTRUCTION.
 7. ALL MATERIALS WILL BE BROUGHT ONSITE FROM THE NORTH ACCESS. CITY OF MENLO PARK OFFICIALS WILL MARK PROPOSED MATERIAL ACCESS ROUTE PRIOR TO COMMENCEMENT OF CONSTRUCTION.
 8. CONTRACTOR SHALL DELIVER ROCK AND ENGINEERED STREAMBED MATERIAL TO SITE FROM NORTH BANK. CONTRACTOR SHALL PROVIDE TEMPORARY CHUTE TO PROTECT BANK AND DELIVER MATERIAL TO STREAMBED. CONTRACTOR SHALL PROVIDE SHOP DRAWINGS DETAILING CHUTE FOR APPROVAL TO SMCRD. AT THE CONTRACTORS OPTION, CHUTE MAY BE CONSTRUCTED OF METAL PLATE AND I-BEAM SUPPORTS. CHUTE SHALL BE DESIGNED TO SUPPORT WEIGHT OF MATERIAL DELIVERED TO SITE. CONTRACTOR SHALL CONTROL DELIVERY OF MATERIAL. CONTRACTOR SHALL TAKE MEASURES TO ENSURE CONSTRUCTION MATERIALS DO NOT COME IN CONTACT WITH CONCRETE WALL ON SOUTH BANK AND ENSURE THAT MATERIALS ARE DELIVERED IN GOOD CONDITION TO THE SITE. SMCRD MAY REJECT MATERIALS DELIVERED TO THE SITE THAT DO NOT MEET QUALITY STANDARDS.
 9. ACCESS ROUTE TRAVERSES THROUGH EL PALO ALTO PARK. CONTRACTOR SHALL RETURN PARK TO PRE-CONSTRUCTION CONDITION FOLLOWING COMPLETION OF INSTREAM WORK.
 10. CONTRACTOR SHALL REMOVE RUBBLE AND DEBRIS FROM SITE ALONG MATERIAL CHUTE ACCESS. RUBBLE AND DEBRIS SHALL BE DISPOSED OF AT AN APPROVED LANDFILL OR ALTERNATE SITE APPROVED BY SMCRD.
 11. STAGING AREA BOUNDARIES SHOWN ON PLANS ARE APPROXIMATE. FINAL AREA TO BE STAKED BY SMCRCD IN THE FIELD AT PRE-BID MEETING
 12. THE CONTRACTOR SHALL FOLLOW APPLICABLE SPECIFICATIONS FOR GENERAL TREE PROTECTION AS OUTLINED IN THE ATTACHED STANDARDS, TREE TECHNICAL MANUAL FOR DURING CONSTRUCTION.

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Revisions			Drawing Information	
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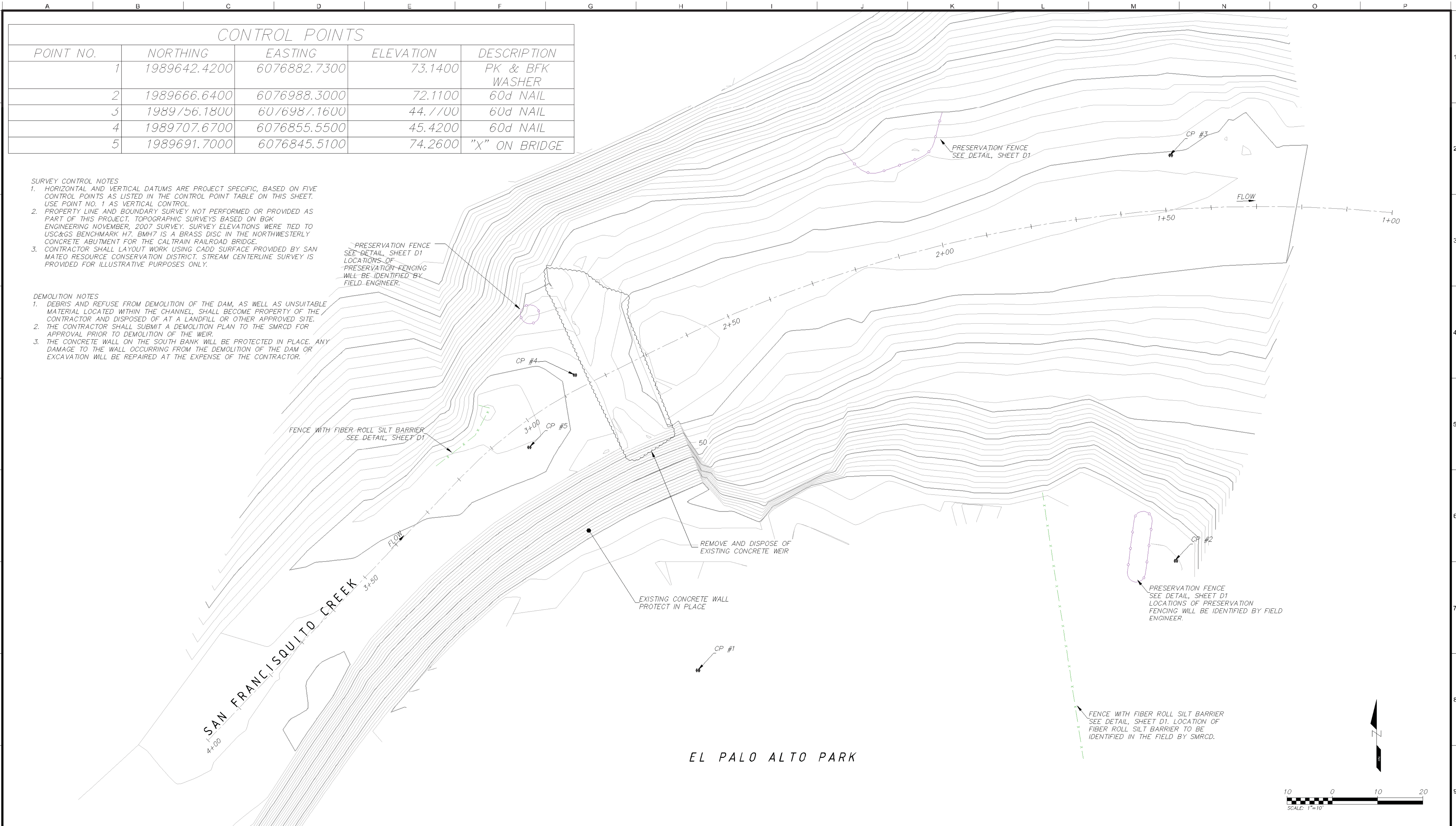
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IMPROVEMENT
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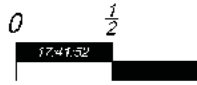
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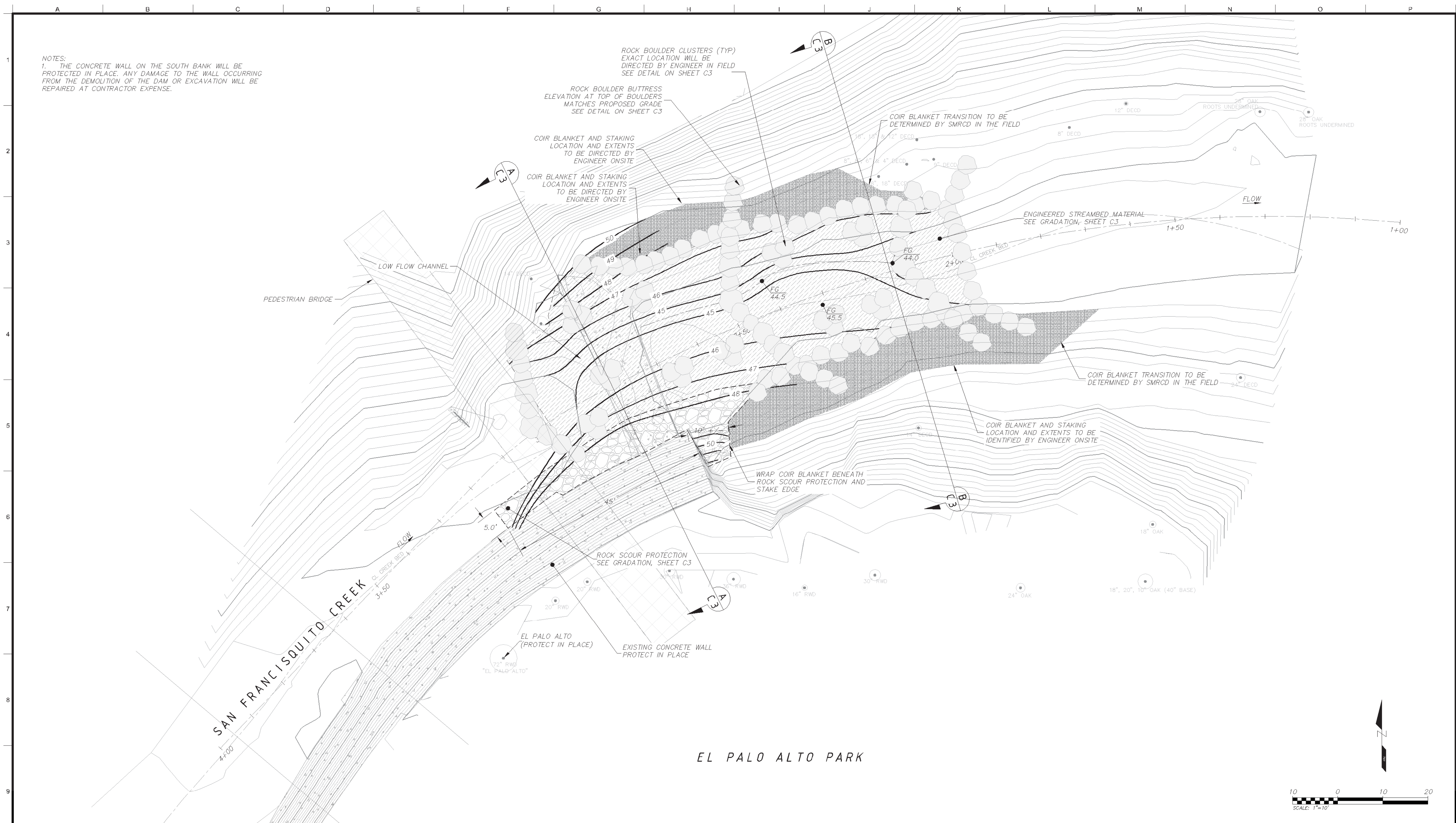
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G2

Sheet 2 of 6



San Mateo County Resource Conservation District 625 Miramontes Street, Suite 103 Half Moon Bay, California 94019 phone (650) 712-7765 fax (650) 726-0494 www.sanmateorcd.org	nhc northwest hydraulic consultants 3950 industrial boulevard, suite 100c west sacramento, california 95691 phone: (916) 371-7400 fax: (916) 371-7475 www.nhcweb.com		Revisions		Drawing Information		
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SAN FRANCISQUITO CREEK BONDE WEIR FISH PASSAGE IMPROVEMENT Survey Control and Demolition Plan Sheet							Job Number 500045 Sheet Number C1 Sheet 3 of 6



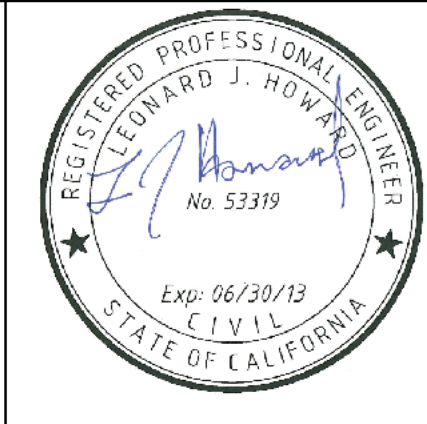
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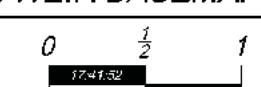
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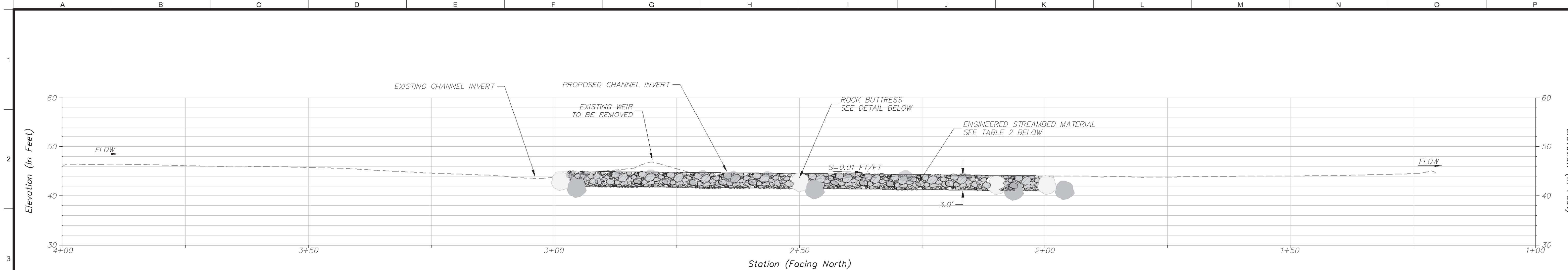
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BONDE WEIR FISH PASSAGE
IMPROVEMENT
Plan Sheet**

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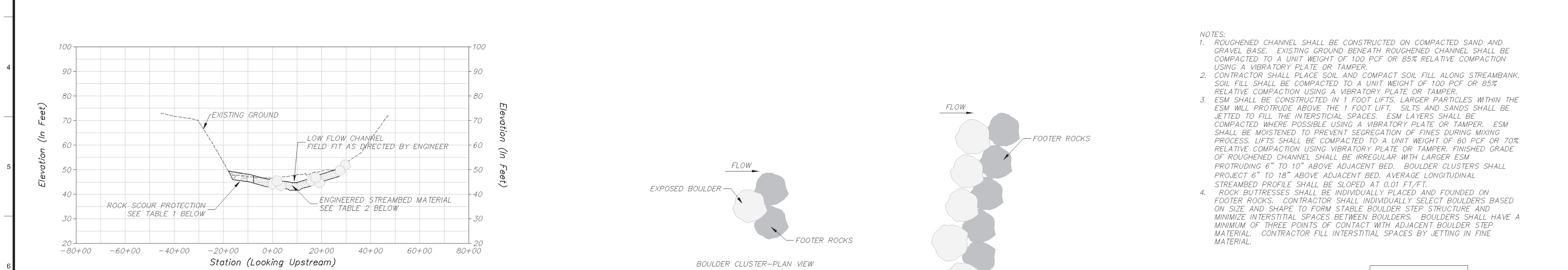
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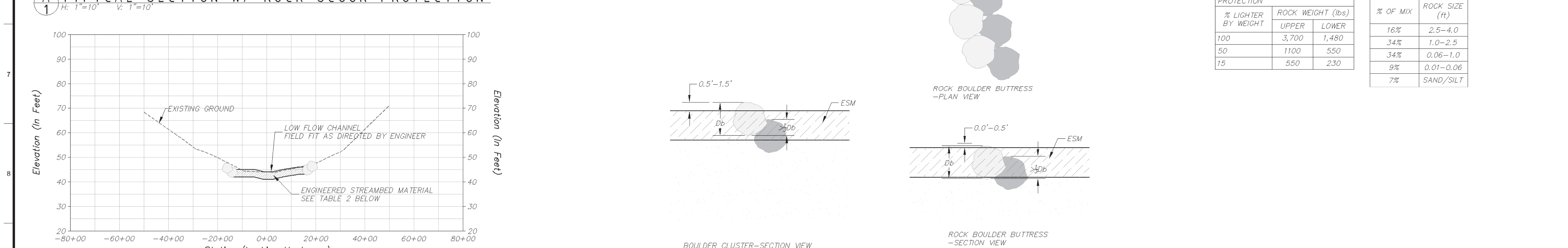
Sheet 4 of 6



CHANNEL PROFILE



A TYPICAL SECTION W/ ROCK SCOUR PROTECTION



B TYPICAL SECTION

NOTES:

- ROUGHENED CHANNEL SHALL BE CONSTRUCTED ON COMPACTED SAND AND GRAVEL BASE. EXISTING GROUND BENEATH ROUGHENED CHANNEL SHALL BE COMPACTED TO A UNIT WEIGHT OF 100 PCF OR 85% RELATIVE COMPACTION USING A VIBRATORY PLATE OR TAMPER.
- CONTRACTOR SHALL PLACE SOIL AND COMPACT SOIL FILL ALONG STREAMBANK. SOIL FILL SHALL BE COMPACTED TO A UNIT WEIGHT OF 100 PCF OR 85% RELATIVE COMPACTION USING A VIBRATORY PLATE OR TAMPER.
- ESM SHALL BE CONSTRUCTED IN 1 FOOT LIFTS. LARGER PARTICLES WITHIN THE ESM WILL PROTRUDE ABOVE THE 1 FOOT LIFT. SILTS AND SANDS SHALL BE JETTED TO FILL THE INTERSTITIAL SPACES. ESM LAYERS SHALL BE COMPACTED WHERE POSSIBLE USING A VIBRATORY PLATE OR TAMPER. ESM SHALL BE MOISTENED TO PREVENT SEGREGATION OF FINES DURING MIXING PROCESS. LIFTS SHALL BE COMPACTED TO A UNIT WEIGHT OF 80 PCF OR 70% RELATIVE COMPACTION USING VIBRATORY PLATE OR TAMPER. FINISHED GRADE OF ROUGHENED CHANNEL SHALL BE IRREGULAR WITH LARGER ESM PROTRUDING 6" TO 10" ABOVE ADJACENT BED. AVERAGE LONGITUDINAL STREAMBED PROFILE SHALL BE SLOPED AT 0.01 FT/FT.
- ROCK BUTTRESSES SHALL BE INDIVIDUALLY PLACED AND FOUNDED ON FOOTER ROCKS. CONTRACTOR SHALL INDIVIDUALLY SELECT BOULDERS BASED ON SIZE AND SHAPE TO FORM STABLE BOULDER STEP STRUCTURE AND MINIMIZE INTERSTITIAL SPACES BETWEEN BOULDERS. BOULDERS SHALL HAVE A MINIMUM OF THREE POINTS OF CONTACT WITH ADJACENT BOULDER STEP MATERIAL. CONTRACTOR FILL INTERSTITIAL SPACES BY JETTING IN FINE MATERIAL.

BOULDER CLUSTER-PLAN VIEW

ROCK BOULDER BUTTRESS-PLAN VIEW

BOULDER CLUSTER-SECTION VIEW

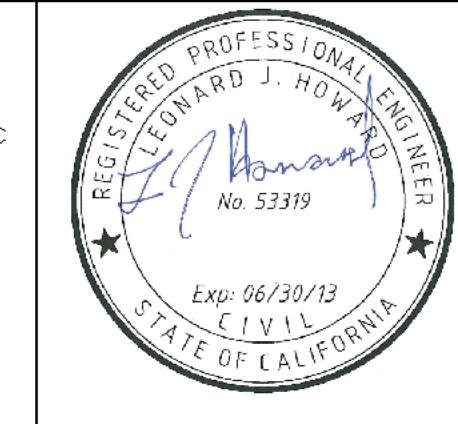
ROCK BOULDER BUTTRESS-SECTION VIEW

TABLE 1: ROCK SCOUR PROTECTION		
% LIGHTER BY WEIGHT	ROCK WEIGHT (lbs)	
	UPPER	LOWER
100	3,700	1,480
50	1100	550
15	550	230

TABLE 2: ENGINEERED STREAMBED MATERIAL	
% OF MIX	ROCK SIZE (ft)
16%	2.5-4.0
34%	1.0-2.5
34%	0.06-1.0
9%	0.01-0.06
7%	SAND/SILT

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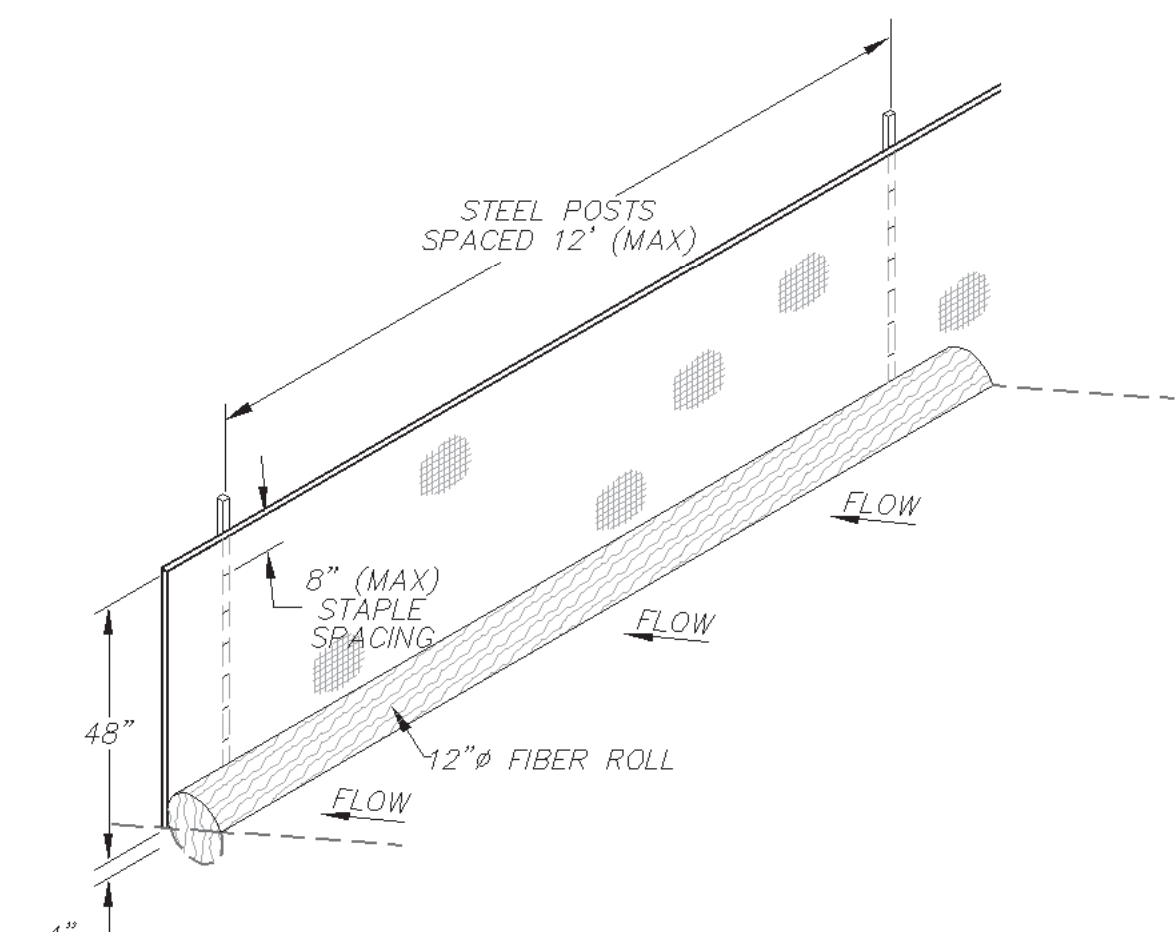
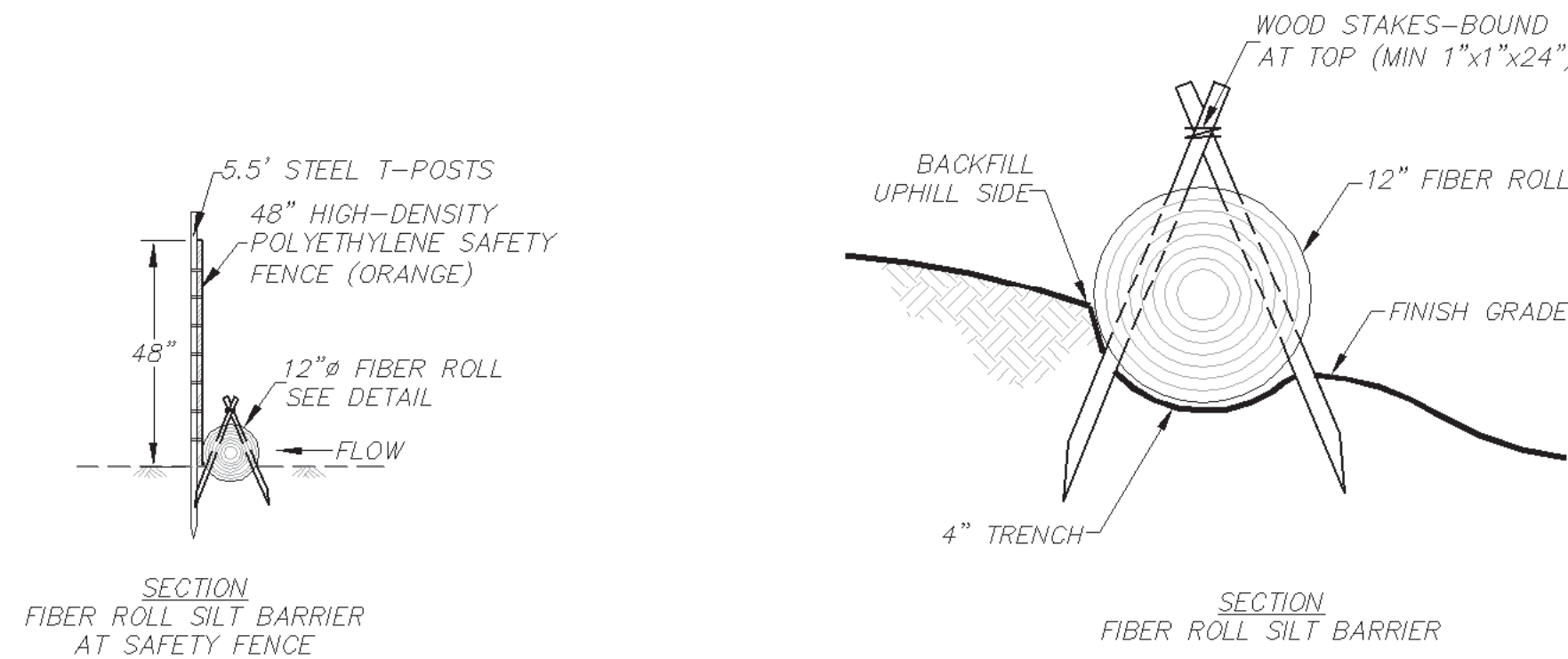
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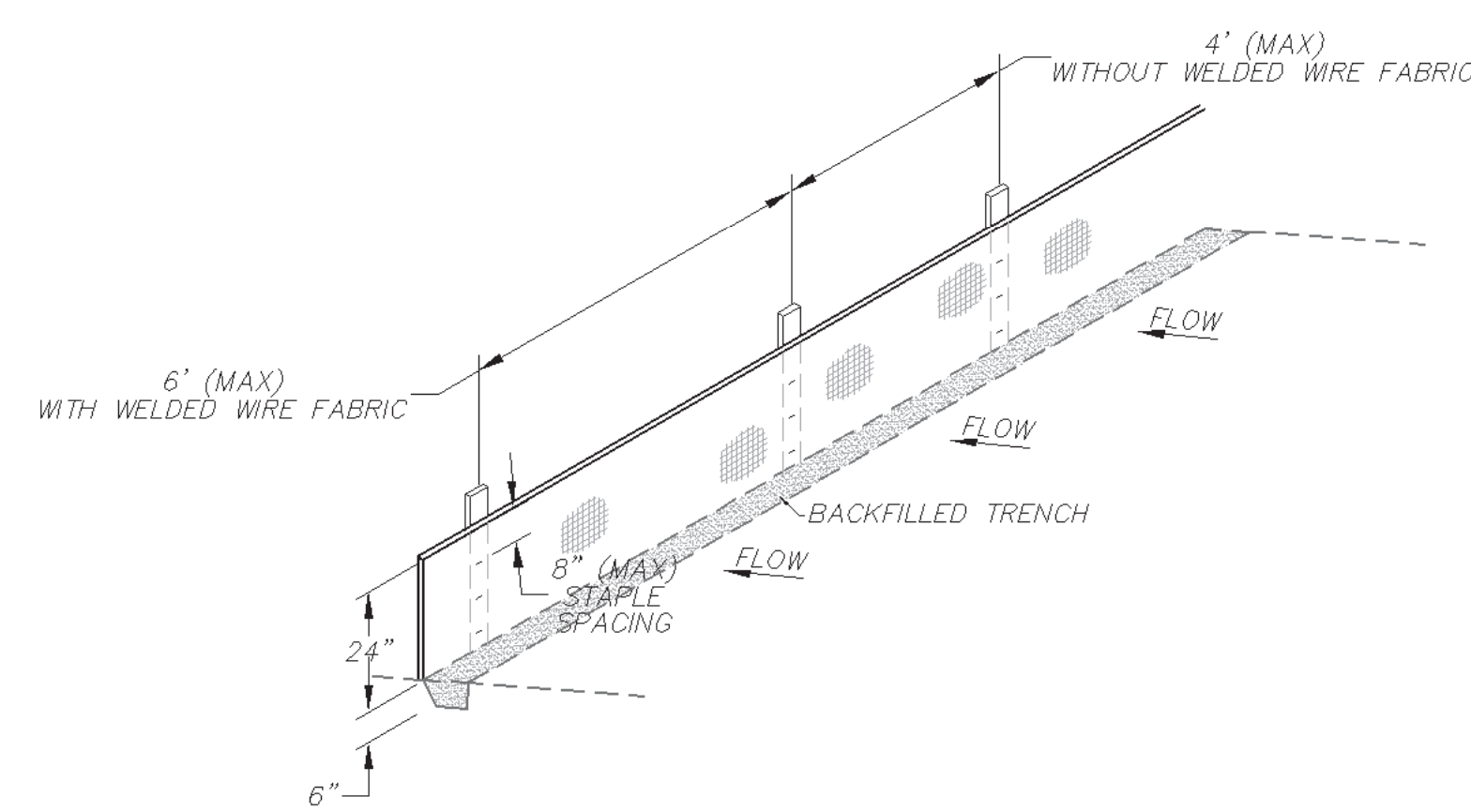
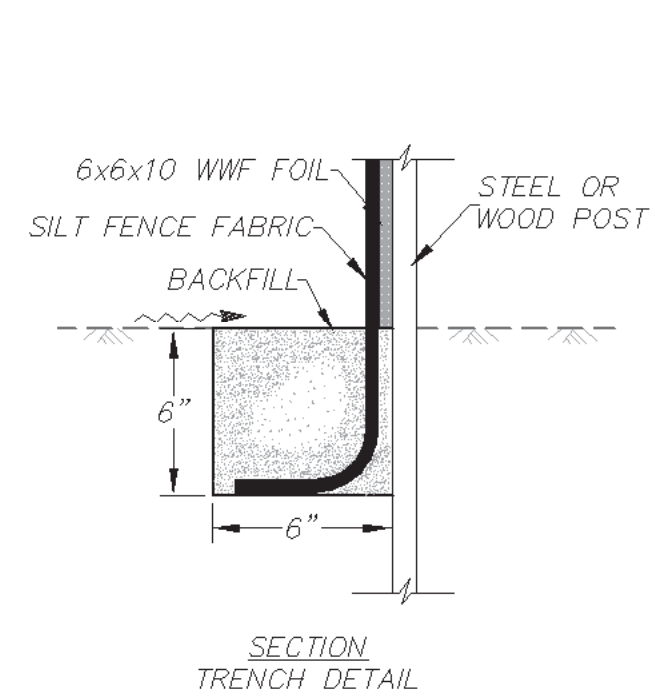
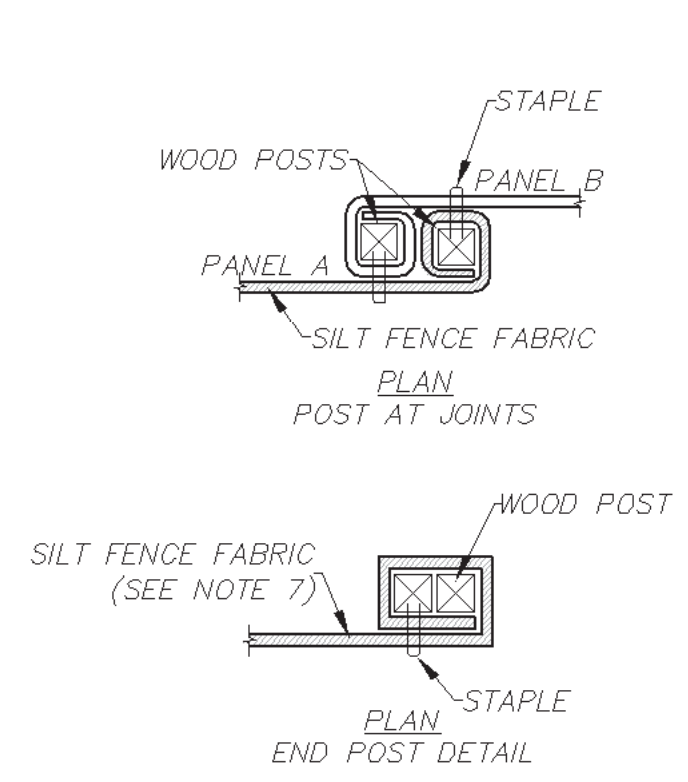
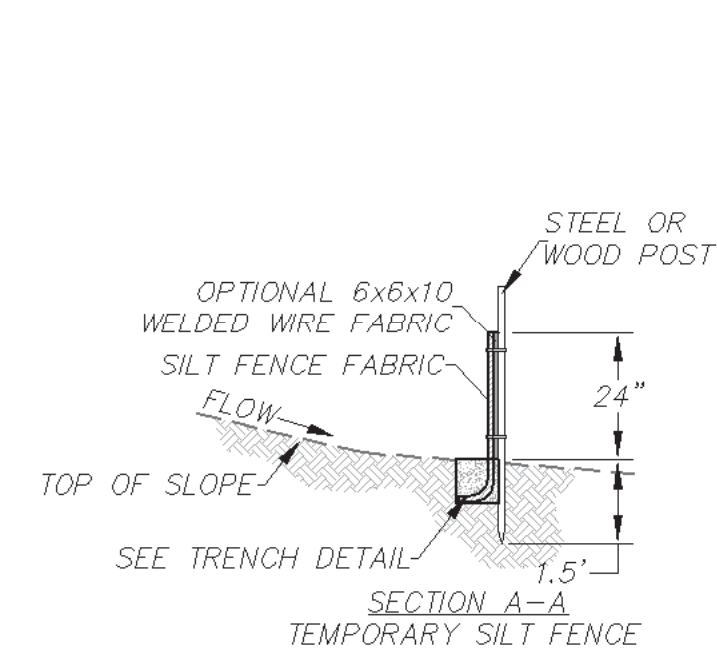
SAN FRANCISQUITO CREEK
BONDE WEIR FISH PASSAGE
IMPROVEMENT
Profile & Sections Sheet

Job Number
500045
Sheet Number
C3
Sheet 5 of 6



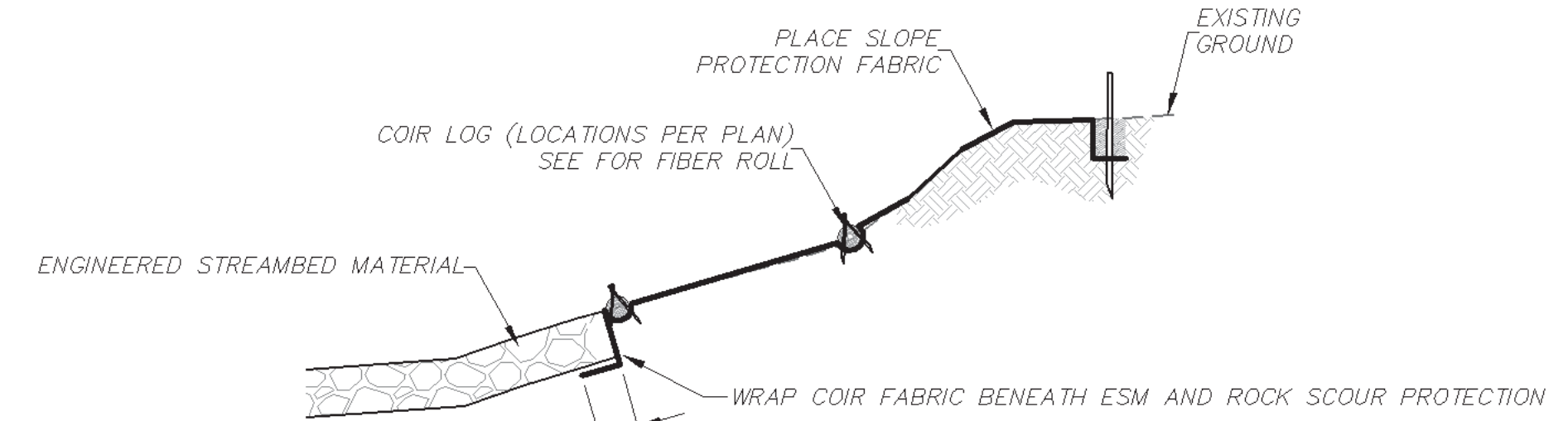
FENCE WITH FIBER ROLL SILT BARRIER
Not to Scale

- NOTES:
1. FIBER ROLL SHALL BE MADE FROM 100% MATTRESS GRADE COCONUT FIBER AND BOUND BY HIGH STRENGTH COIR NETTING, AND HAVE A MINIMUM WEIGHT OF 5 LBS PER LINEAL FOOT.
 2. ORANGE SAFETY FENCE SHALL BE HIGH DENSITY POLYETHYLENE WITH A MESH OPENING OF APPROXIMATELY 1"x4" AND A MINIMUM HEIGHT OF 4'.
 3. FIBER ROLL SILT BARRIER SHALL BE INSTALLED ALONG CONTOUR AND ON SLOPES 5H:1V OR FLATTER UNLESS OTHERWISE APPROVED.
 4. THE INSTALLATION CONFIGURATION SHALL PREVENT RUNOFF FROM LEAVING THE SITE OR ENTERING A WATERCOURSE WITHOUT PASSING THROUGH A SILT BARRIER.
 5. THE MAXIMUM LENGTH OF SLOPE DRAINING TO THE SILT BARRIER SHALL BE 100'.
 6. FIBER ROLL SHALL BE INSTALLED BY SHAPING A 4" DEEP FURROW TO MATCH THE SHAPE OF THE LOG, SECURING IN FURROW WITH WOOD STAKES, AND TAMPING THE GROUND AROUND THE FIBER ROLL TO FILL VOIDS BETWEEN THE LOG AND THE GROUND.



SILT PRESERVATION FENCE
Not to Scale

- NOTES:
1. SILT FENCE FABRIC SHALL BE WOVEN POLYPROPYLENE WITH A MINIMUM GRAB BREAKING LOAD (ASTM D4632) OF 120 LB.
 2. A MINIMUM OF 4 STAPLES ARE REQUIRED PER POST.
 3. SILT FENCE SHALL BE INSTALLED ALONG CONTOUR AND ON SLOPES 3H:1V OR FLATTER UNLESS OTHERWISE APPROVED BY SMRCD.
 4. THE INSTALLATION CONFIGURATION SHALL PREVENT RUNOFF FROM LEAVING THE SITE OR ENTERING A WATERCOURSE WITHOUT PASSING THROUGH A SILT FENCE.
 5. THE MAXIMUM LENGTH OF SLOPE DRAINING TO THE SILT FENCE SHALL BE 100 FEET FOR SLOPES 10% OR GREATER AND 200 FEET FOR SLOPES FLATTER THAN 10%.
 6. DOUBLED POSTS AT JOINTS AND SHALL BE SECURED TO EACH OTHER.
 7. WELDED WIRE FABRIC SHALL BE 6x6x10 MINIMUM (6"x6" OPENINGS WITH 10 GAGE WIRE).



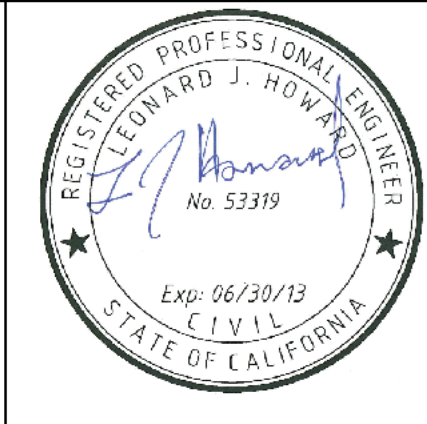
SLOPE STABILIZATION
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			Status	100% SUBMITTAL
			Designer	bw, ljh
			Drafter	tvs
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			Plotted Scale	0 1/2 1

SAN FRANCISQUITO CREEK
BONDE WEIR FISH PASSAGE
IMPROVEMENT
Details Sheet

Job Number
500045
Sheet Number
D1
Sheet 6 of 6

Bonde Weir Fish Passage: Basis of Design Report

San Mateo Resource Conservation District

September 7, 2012



Bonde Weir Fish Passage: Basis of Design Report

September 7, 2012

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TABLE OF CONTENTS

1.0	Introduction	1
2.0	Project Description.....	1
2.1	Project Objective.....	1
2.2	Existing Conditions	1
2.3	Project Conditions.....	7
3.0	Topographic Survey and Datums	7
4.0	Hydrologic Analysis	7
4.1	Flow Frequency Analysis	7
4.2	Fish Passage Flows	8
5.0	Hydraulic Analyses	9
5.1	Existing Conditions Model	9
5.2	Project Conditions Model	10
5.3	Extreme Flows.....	10
5.4	Fish Migration Flows	10
6.0	Engineered Streambed Material.....	14
7.0	Implementation considerations.....	14
8.0	References	15
	Appendix A: Hydrology	17
	Appendix B: HEC-RAS Model Results	18
	Appendix C: Rock Sizing Calculations.....	31
	Appendix D: 30% Design Drawings	33

LIST OF FIGURES

Figure 2-1: Site Map	3
Figure 2-2: San Francisquito Creek Upstream of the Alma St Pedestrian Bridge	4
Figure 2-3: Bonde Weir viewed from downstream	4
Figure 2-4: Bonde Weir Crest.....	5
Figure 2-5: Bonde Weir	5
Figure 2-6: Bonde Weir and Storm Drain Outlet	6
Figure 2-7: San Francisquito Creek downstream of the Alma St Pedestrian bridge.....	6
Figure 5-1: 100 Year Flood Profiles for Existing and Project Conditions.....	10
Figure 5-2: HEC-RAS Computer Velocities	12
Figure 5-3: HEC-RAS Computer Depths.....	13

LIST OF TABLES

Table 4-1: USGS Gage Stations in the San Francisquito Creek Drainage Basin.....	8
Table 4-2: Flow Summary Table near the Bonde Weir	8

Table 4-3: Fish Passage Flow Criteria	9
Table 5-1: Minimum Required Flow Depth.....	11
Table 5-2: Maximum Permissible Velocity (CDFG, 1998)	11
Table 5-3: Recommended Maximum Energy Dissipation Factors (CDFG, 2009)	11
Table 5-4: Design Comparison with Criteria	14
Table 6-1: Engineered Streambed Material Design Gradation.....	14

BONDE WEIR FISH PASSAGE PROJECT: BASIS OF DESIGN REPORT

1.0 INTRODUCTION

Northwest Hydraulic Consultants (**nhc**) is preparing the design for a fish passage improvement project at the Bonde Weir in San Francisquito Creek for the San Mateo County Resource Conservation District (RCD). This report briefly describes the physical setting, project considerations, and proposed design.

The Bonde Weir was recognized by the San Francisquito Creek Watershed Council – Steelhead Task Force - as a barrier to steelhead (*Oncorhynchus mykiss*) passage. At times, in-migrating adult as well as out-migrating smolt steelhead trout may be delayed or prevented from passing the weir. The San Mateo County RCD, the project sponsor, received a grant from the mitigation funds generated by the Bay Bridge Project and administered by the National Marine Fisheries Service to improve passage at the weir.

2.0 PROJECT DESCRIPTION

2.1 Project Objective

The broad goal for the project is to improve the hydraulic characteristics for fish passage at the existing Bonde Weir site while protecting existing infrastructure.

2.2 Existing Conditions

The Bonde Weir crosses San Francisquito Creek about 15 feet downstream of the Alma Street Bicycle/Pedestrian Bridge and 80 feet downstream of a Caltrain Bridge near El Palo Alto Park. The weir is located near the midpoint of a right trending bend (looking downstream) in the creek. The creek upstream of the weir has a bed width of 20 feet, a right bank side slope of about 0.6 feet horizontal to 1 foot vertical, and a left bank side slope of 0.8 feet horizontal to 1 foot vertical. The creek bed is about 20 to 25 feet below the adjacent ground. A concrete wall along the right bank (looking downstream) extends from 3 feet downstream of the weir upstream about 150 feet. The left bank is composed of native material. Figure 2-1 shows the site topography and planimetric features. A view of the creek looking upstream of the Alma Street Bicycle/Pedestrian Bridge is shown in Figure 2-2.

The weir consists of an 11 foot long and 45 foot wide concrete sill. The sill slopes downstream at 4.8 feet horizontal to 1 foot vertical (20 percent). The low point along the weir crest is at elevation 46.6 feet (all elevations are relative to USC&GS BM H7- See Section 3.0) and the downstream end of the weir is at elevation 44.5 feet. Figure 2-3, 2-4, and 2-5 show frontal, side, and top views of the weir, respectively.

A pool forms upstream of the weir during low flows. The pool characteristics are influenced by several factors. These factors include the hydraulic characteristics of stream bends, which typically induce scour along the outside toe of the bend, local scour in the lee of a sackcrete storm drain outlet apron, and the backwater resulting from the weir. Using the weir crest to define the pool surface, the pool extends more than 160 feet upstream of the weir. The deepest part of the pool is along the downstream end of the sackcrete drainage outlet structure. The minimum pool elevation surveyed November of 2007 was

at 44.7 feet. This elevation is 4 feet below the low point on the weir crest. Figure 2-6 shows the storm drain outlet and the outlet apron.

Downstream of the weir, the creek is less confined than the upstream reach. The channel width increases from 20 feet to about 25 feet. The channel banks near the bed range in slope from 5 feet horizontal to 1 foot vertical to 2 feet horizontal to 1 foot vertical. The upper portion of the banks range in slope from 2 feet horizontal to 1 foot vertical to 1 foot horizontal to 1 foot vertical. Figure 2-7 shows a view of the creek downstream of the pedestrian bridge.

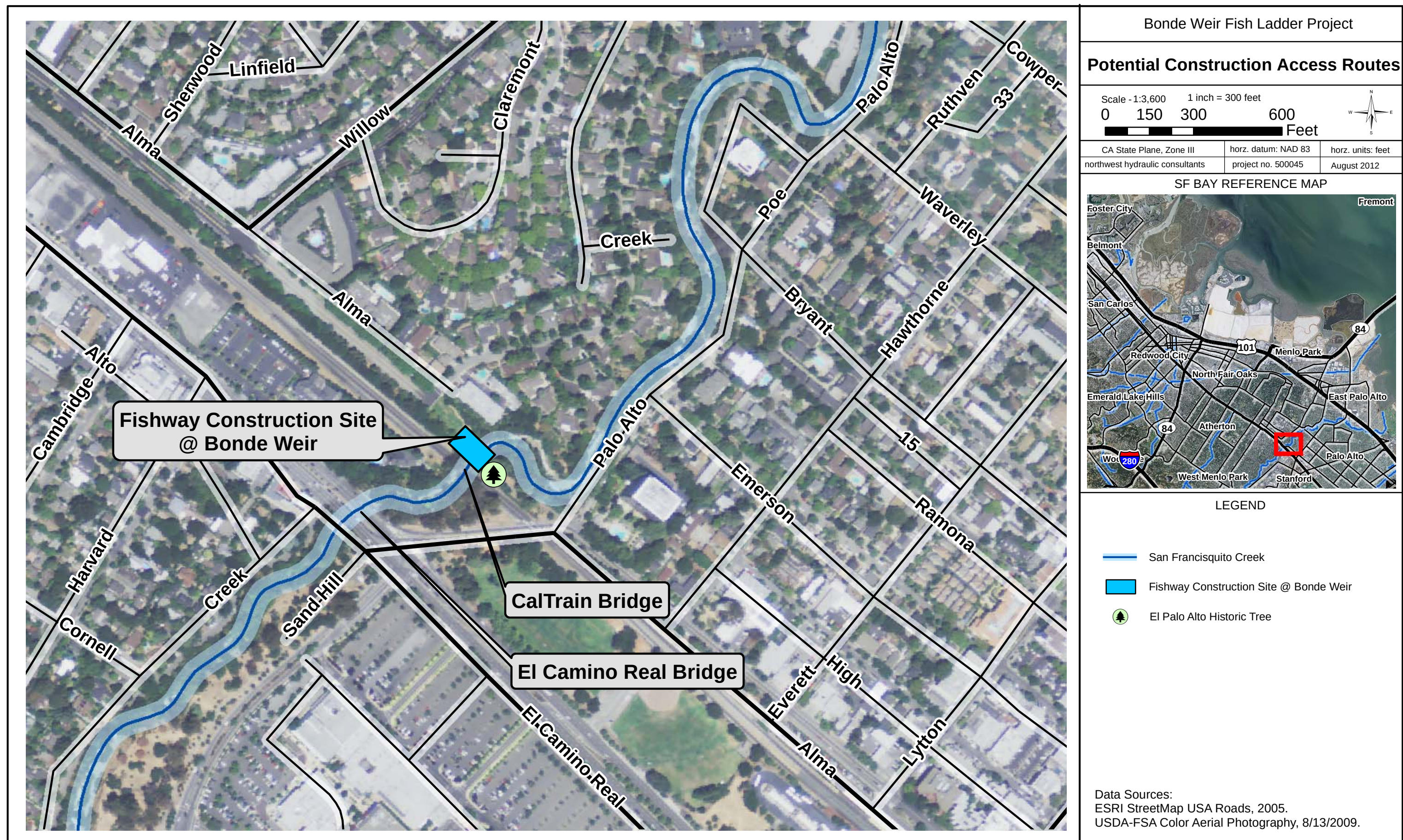


Figure 1: Project Site Location



Figure 2-2: San Francisquito Creek Upstream of the Alma St Pedestrian Bridge



Figure 2-3: Bonde Weir viewed from downstream



Figure 2-4: Bonde Weir Crest



Figure 2-5: Bonde Weir



Figure 2-6: Bonde Weir and Storm Drain Outlet



Figure 2-7: San Francisquito Creek downstream of the Alma St Pedestrian bridge

2.3 Project Conditions

The proposed project would remove the existing weir and reprofile the streambed using a roughened channel (Appendix E). Roughened channels are channels engineered to remain relatively stable using a framework of large boulders with a matrix of heterogeneous mix of cobbles, gravels, sands, and silts. The roughened channel would have a grade of about 1%. The upstream section of the roughened channel would originate about 15 feet upstream of the current location of the weir, and would extend downstream about 70 feet past the current location of the weir. The roughened channel would be composed of engineered streambed material (Section 6). Angular rock riprap would be placed along the toe of the existing wall to prevent toe scour.

The roughened channel is designed to replace the existing weir by acting as a grade control structure preventing undermining of the concrete wall and preventing channel incision from migrating upstream. The reprofiling of the channel helps reduce the abrupt hydraulic disruption and potential local scour caused by this disruption. Appendix E provides 30% conceptual design drawings of the proposed project design.

3.0 TOPOGRAPHIC SURVEY AND DATUMS

BGK Engineering under contract with NHC conducted a topographic survey of the site (including the creek, the adjacent area, and the weir) in November, 2007. The survey extended about 150 feet downstream of the weir and about 50 feet upstream of the weir from top of left bank to top of right bank. Survey elevations were tied into USC&GS benchmark H7 (BM H7). BM H7 is a brass disc in the Northwesterly concrete abutment for the Caltrain Railroad bridge over the San Francisquito Creek located just upstream of the site. The BM is stamped with an elevation of 72.123 feet. All elevations reported within this document are based on this elevation.

4.0 HYDROLOGIC ANALYSIS

To develop design parameters for the fish passage improvement project, NHC estimated peak flood flows and flow durations. The results are described in the following.

4.1 Flow Frequency Analysis

Flow frequency analyses and flow duration analyses were conducted using data collected at the U.S. Geological Survey (USGS) gage on San Francisquito Creek at Stanford University (Gage 1116400). This gage, located on the Stanford Golf Course upstream of Junipero Serra Boulevard, provides the best long-term record of flow in San Francisquito Creek with measurements from 1931 to 1941 and from 1951 to present. The gage has a tributary area of 37.5 square miles composed of areas within the Santa Cruz Mountains and Bay Foothills. .

Stream gages that have been operated on San Francisquito Creek and its tributaries by the USGS are summarized in Table 4-1.

Table 4-1: USGS Gage Stations in the San Francisquito Creek Drainage Basin

<i>Gage Name</i>	<i>Gage Number</i>	<i>Period of Record</i>	<i>Area (mi²)</i>	<i>River Mile ¹</i>
At Searsville Dam (staff gage on spillway crest)	None	1892-1913	—	12.7
At Stanford University	11164500	1931-41; 1950 to present	37.5	7.6
At Menlo Park	11165000	1931-1941	38.3	5.4
At Palo Alto	11165500	1934-36	38.4	4.6
Los Trancos Ck near Stanford University	11163000	1930-41	—	—
Los Trancos Tributary near Stanford University	11163200	1958-66	0.42	—
Los Trancos Ck at Stanford University	11163500	1930-41	7.46	—

Peak flows were calculated from an analysis of annual maxima at the USGS Gage Number 1116400. Flood frequency statistics were calculated for the gage using the procedures recommended by the USGS and described in Bulletin 17B (IACWD, 1982). A flood frequency plot for this gage is included in Appendix A.

Peak flows expected to occur at 2-, 10-, 25-, 50-, and 100-year return periods were calculated at USGS Gage were used to estimate the flows at the Bonde Weir and are listed in Table 4-2. The effective 100-year peak flood flow calculated in this analysis is essentially the same as the flow listed in the Flood Insurance Study (FIS) for Menlo Park at San Francisquito Creek at El Camino Real (FEMA, 1999). The effective FIS cites a flow of 8,280 cubic feet per second (cfs) for a drainage area of 40.6 square miles at El Camino Real.

Table 4-2: Flow Summary Table near the Bonde Weir

Characteristic	San Francisquito Crk at Stanford University (11164500)
Drainage Basin Area	37.5 mi ²
100-year peak flow	8,272 cfs
25-year peak flow	6,157 cfs
10-year peak flow	4,595 cfs
2-year peak flow	1,576 cfs

4.2 Fish Passage Flows

The California Salmonid Stream Habitat Restoration Manual (CDFG, 1998) identifies the 1% and 95% exceedance flows, based on a duration analysis of mean daily flows, as the upper and lower bounds for

fish passage analyses for the target fish species and life stages. The fish migration flows at the Bonde Weir were calculated from USGS gage Number 1116400. Exceedance flows are summarized in Table 4-3. As noted in Table 4-3, we suggest adopting an alternative minimum flow of 1 cfs and 3 cfs, respectively, for the juvenile and adult fish migration analysis. The data and program output for the fish migration flows are included in Appendix A.

Table 4-3: Fish Passage Flow Criteria

Description	Flow rate (cfs)
1% exceedance flow <i>High Flow Adult Salmonid</i>	470
10% exceedance flow <i>High Flow for Juvenile Salmonid</i>	40
50% exceedance flow <i>Low Flow Adult Salmonid</i> (3 cfs alt min flow)	0.8
95% exceedance flow <i>Low Flow Juvenile Salmonids</i> (1 cfs alt min flow)	<0.1

5.0 HYDRAULIC ANALYSES

NHC conducted hydraulic analyses using HEC-RAS version 4.1.0 (USACE, 2010) to characterize existing and project hydraulic conditions. HEC-RAS is a one-dimensional model that is capable of computing average channel velocities and water surface profiles. HEC-RAS is useful in estimating hydraulic characteristics and water surface profiles during moderate to high flows. It can also be used to estimate hydraulic characteristics during low flow, but is not capable of simulating microhydraulics in roughened channels. Sections 5.1 and 5.2 describe the existing and project conditions model development. Section 5.3 describes the model results for extreme flows, while Section 5.4 describes model results for fish passage flows. Results from HEC-RAS analysis are included in Appendix B.

5.1 Existing Conditions Model

The downstream boundary of the HEC-RAS model is about 130 feet downstream of the weir the model extends about 50 feet upstream of the weir. The basic features of the model include:

- Through this reach, the channel section and slope provide the downstream hydraulic control for stream flow. At low flows the riffle crest 50 feet downstream of the weir serves as a control that causes flow to backup to the base of the weir. Under the existing condition, the steep smooth weir surface efficiently conveys flows over the weir. These flows are characterized by high velocities and are supercritical.
- The downstream boundary condition is computed as a normal depth with friction slope of 0.002.
- The concrete weir was simulated in the model geometry within HEC-RAS. Model cross section spacing ranges from 5 to 50 feet with a narrower spacing near the weir.
- The roughness coefficient ("Manning's n") across the existing concrete weir was estimated to be 0.025 under the existing conditions. Manning's n in the channel for the existing was estimated to be 0.035. The overbank Manning's n was estimated to be 0.05.

- Model runs were performed using a subcritical flow regime to identify peak water surface levels. Application of the subcritical flow regime to calculate water surface profiles is consistent with FEMA flood hazard modeling guidelines to determine flood profiles (FEMA, 2003).
- Profiles and hydraulic calculations for flood flows were compiled for the 10-, 25- and 100-year flood events.

5.2 Project Conditions Model

The project conditions HEC-RAS model used the same model extents, cross-section locations, and boundary conditions as the existing condition model. Modifications to the project conditions model included:

- Adjustment of the cross-section geometry to create a channel approximately 40 feet wide with invert elevations producing a 1% slope through the area of the proposed roughened channel.
- Increasing the Manning's n value of the cross-sections within the roughened channel to 0.05.

5.3 Extreme Flows

The project's influence on peak water surface elevation (i.e., stage) during a 100-year flood event was estimated using HEC-RAS. Water surface profiles for existing conditions and with the project in place were calculated and compared. The 100-year peak flow water surface profiles for the existing and proposed conditions are shown in Figure 5-1. The project shows water surface elevations downstream and upstream of the project area are likely to be unaffected. Water surface elevations may vary between existing and project conditions within the project reach as a result of a hydraulic jump, which currently exists at the weir, moving downstream about 30 feet.

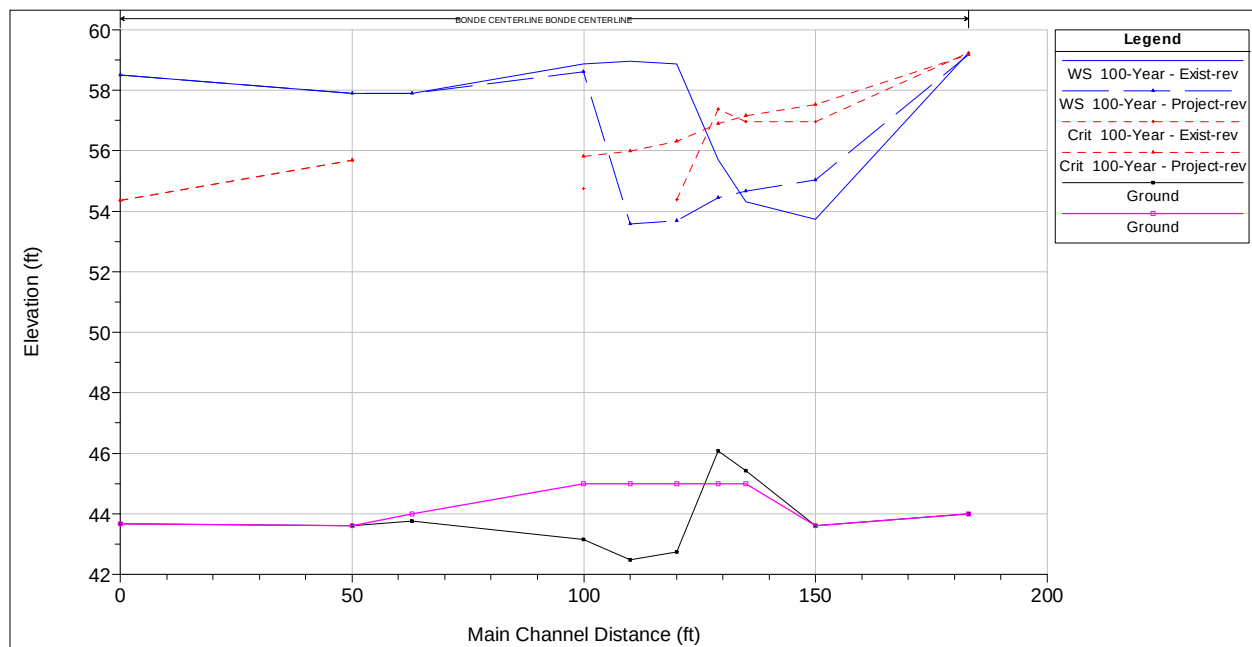


Figure 5-1: 100 Year Flood Profiles for Existing and Project Conditions

5.4 Fish Migration Flows

Adult steelhead typically migrate to spawn between late fall and early spring, with a peak between January and March. Downstream migration of juveniles usually occurs between about February and April. The roughened channel was designed to simulate adjacent stream and hydraulic conditions and

reprofile the reach where the Bonde Weir currently occurs, without affecting the upstream or downstream bed profile. The following design parameters were used to determine if the project would provide fish passage: maximum average velocity, minimum flow depth, maximum hydraulic drop height, and maximum turbulence. These design parameters are further segregated by life stage and species. Minimum flow depth is primarily a function of body size, which is characterized by life stage and species. Table 5-1 shows the minimum flow depths.

Table 5-1: Minimum Required Flow Depth

Species/Lifestage	Minimum flow depth, ft
Adult Anadromous Salmonid	1.0
Adult Non-Anadromous Salmonid	0.67
Juvenile Salmonid	0.5

Design criteria for maximum average velocities are categorized first by life stage and by the distance that the average velocity occurs. The distances are intended to match the swimming characteristics of adult fishes where maximum swim speeds for adult salmonids and non-salmonids are generally characterized into three groups: burst, prolonged, and sustained. Burst speeds generally occur for less than 20 seconds, prolonged speeds generally range from about 20 seconds to about 200 minutes, and sustained speeds may occur for an indefinite period that exceeds 200 minutes. The maximum average water velocity for juveniles is 1 foot per second (fps). Table 5-2 shows design criteria for adults.

Table 5-2: Maximum Permissible Velocity (CDFG, 1998)

Passage Distance (Culvert Length) Ft	Adult Non-Anadromous Salmonids, fps	Adult Anadromous Salmonids, fps
< 60	4	6
60 – 100	4	5
100 – 200	3	4
200 – 300	2	3
> 300	2	2

Turbulence, defined herein as irregular and random fluctuations in local velocity and pressure, can impair fishes' ability to move upstream. Turbulent flow may disorient fish or reduce leaping abilities by aerating the flow and reducing stream flow density. The California Department of Fish and Game (DFG) and the National Marine Fisheries Service (NMFS) use the energy dissipation factor (EDF) to characterize turbulence. Maximum permissible EDFs vary with the type of flow conditions. Table 5-3:

Recommended Maximum Energy Dissipation Factors (CDFG, 2009)

lists EDF equations for sloping channels and the maximum permissible EDF for adult steelhead and resident trout.

Table 5-3: Recommended Maximum Energy Dissipation Factors (CDFG, 2009)

Flow Condition	EDF Eqn.	Max EDF Adult Steelhead	Max EDF Adult Resident Trout

		ft-lbs/s/ft ³	ft-lbs/s/ft ³
Sloping Channel	$\gamma V S$	6.0	4.5

Hydraulic characteristics for fish passage were assessed for flows ranging from 1 cfs up to 470 cfs (Table 4-3). Figure 5-2 shows modeled in-channel velocities. The reprofiled channel reach starts near distance 60 and ends near distance 140 in the figures below. Modeled cross section average velocities are less than 6 fps through the project the entire range of modeled flows. Since HEC-RAS cannot account for the presence of in-channel features such as boulder clusters or variation in velocity across a section over various depths, there are likely to be pockets and areas of slightly lesser and greater velocities as those shown in Figure 5-2.

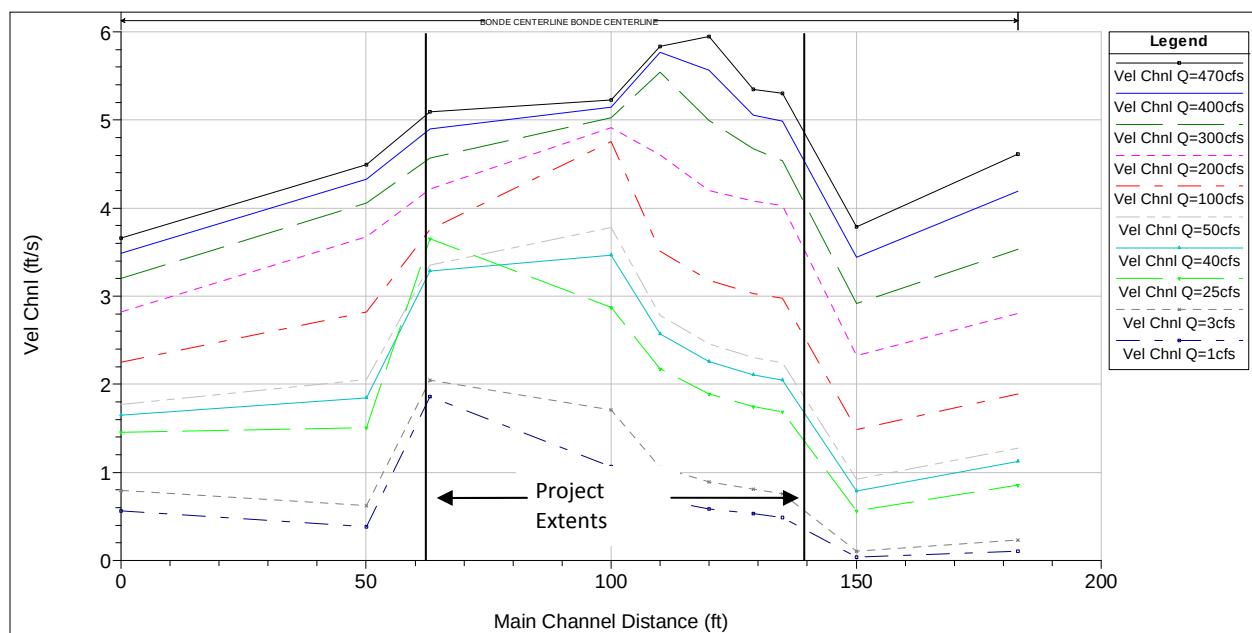


Figure 5-2: HEC-RAS Computer Velocities

Modeled flow depths were the lowest at the minimum modeled flow of 1 cfs. Flow depths were about 1 foot or greater at flows of 25 cfs and greater. It should be noted that channel geometry simulated in the model is simplified and represents the roughened channel as a level bed. Actual conditions on the roughened channel will be complex, allowing for smaller pockets of increased depth to exist.

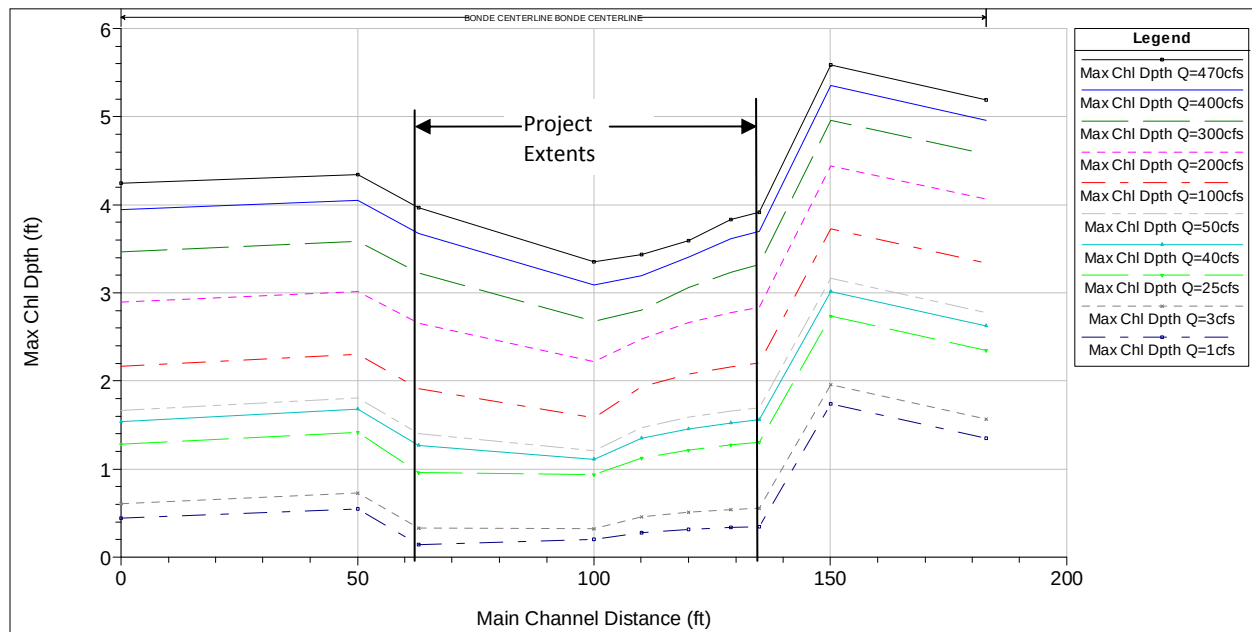


Figure 5-3: HEC-RAS Computer Depths

Fish passage performance along the project reach was compared with DFG and NMFS stream simulation and hydraulic criteria. A summary of DFG and NMFS fish passage criteria are listed in Table 5-4. This comparison shows that computed design velocities meet criteria to allow both juvenile and adult fish passage. Flow depth criterion is met for the adult fish when the flow exceeds 25 cfs, but do not meet criteria down to the 3 cfs minimum design flow. Similarly, the flow depth criterion is not met for juvenile for flow rates between 1-3 cfs, but is met for flows above 3 cfs. The energy dissipation factor is met for both juvenile and adult passage. It is important to note that due to the lack of a defined low flow channel that depths in sections of downstream reaches are unlikely to meet fish passage criteria at flows less than about 25 cfs.

Table 5-4: Design Comparison with Criteria

Design Condition	Calculated	Comparison with Criteria
Velocity (Adult Anadromous Salmonid)	<6fps	Within Criteria
Velocity (Juvenile Anadromous Salmonid)	<3.5 fps	Estimated to be within Criteria along channel margins and near boundary layer
Flow Depth (Adult Anadromous Salmonid)	1ft-4 ft (Q>25 cfs) <1ft (Q<25 cfs)	Not Within Criteria
Flow Depth (Juvenile Anadromous Salmonid)	>0.5 ft when Q≥3cfs 0.3 ft @ 1cfs	Not Within Criteria
EDF	<4lb/ft ² /s	Within Criteria

6.0 ENGINEERED STREAMBED MATERIAL

The roughened channel will be constructed using engineered streambed materials (ESM). ESM will include a heterogeneous mix of material that is intended to form a tight structure that will minimize subsurface flow, prevent loss of smaller particles within the matrix, and remain relatively stable during extreme flood events. Inspection of native streambed material near the project site suggests that sediment supply into this reach ranges from fine wash load to small boulders (less than about 8 inches).

Estimates for ESM were made using California Department of Fish and Game procedures. Calculations are provided in Appendix C. NHC proposes to use the ESM gradation shown in Table 6-1

Table 6-1: Engineered Streambed Material Design Gradation

PERCENT OF MIX	ROCK SIZE, ft	
	min	max
16%	2.5	4.0
34%	1.0	2.5
34%	0.06	1.0
9%	0.01	0.06
7%	SAND/SILT	

7.0 IMPLEMENTATION CONSIDERATIONS

The proposed fish passage structure is not anticipated to induce morphologic change that will negatively affect the stream banks, profile, adjacent properties, or infrastructure. The project is not expected to produce excessive degradation (i.e., downcutting by erosion) or aggradation upstream or downstream of the project area. Flow downstream of the project area is subcritical (downstream dependent) and should not be affected by the upstream changes. The results of the HEC-RAS modeling show flow at

comparable depths and velocities under both existing and project conditions. The 0.01 ft/ft (1%) slope of the project is fairly representative of local bed slopes in riffle sections of the stream. The upstream edge of the project was found to be under critical flow conditions for both the existing and project conditions. This indicates that flow upstream of the project site will be unaffected by changing hydraulics through the project reach.

8.0 CONSTRUCTION ACTIVITIES

Construction of the proposed roughened channel will involve mobilizing construction equipment to the work area, removing the existing Bonde Weir, delivering materials to the work area, constructing reprofiled channel, installing scour protection, demobilizing, and installing erosion control measures along the edges of the work area and access route.

Temporary construction access to the site will be coordinated with Cities of Palo Alto and Menlo Park. Access through El Palo Alto Park from Palo Alto Avenue would likely require fewer disturbances to the stream banks and be less costly than access from the green space at the southerly end of Alma Street. An access ramp from Creek Drive to the streambed exists about 0.25 miles upstream of the project site. Construction access from this point requires traversing about a quarter mile of the streambed upstream of the project site and disturbing existing vegetation within the streambed. During earlier design phases, the resource agencies considered the disturbance to the streambed and vegetation to be too great to consider access from Creek Drive as a viable option. As noted above, the project will restore the access route to pre-project conditions.

NHC anticipates that the project will be constructed between June and mid-October when San Francisquito Creek is not conveying water and the streambed is dry and groundwater levels are relatively deep below the streambed. Rainfall events are relatively rare during this time of year and generally do not produce significant flow. Based on the historic conditions, NHC believes construction will not include dewatering and fish rescue and relocation. Excavation within the streambed will be relatively shallow and is unlikely to intercept groundwater, which will limit the need to control water.

Dam removal will involve demolishing the existing dam while protecting the existing concrete slope protection and removing and disposing of debris from the project site. Construction equipment will likely include a small excavator with a hydraulic breaker attachment to demolish the dam and excavator to load trucks. Debris will be disposed at a landfill or other approved site.

Preliminary material estimates indicate that about 400 cubic yards of material will excavated from the site and about 180 cubic yards of the excavated sand and gravel will be stockpiled and mixed with imported engineered streambed material to construct the roughened channel. About 600 cubic yards of material will be imported.

Construction will likely occur over a period of about 6 weeks and will be scheduled to end prior to October 15th.

9.0 REFERENCES

California Department of Fish and Game. 1998. California Salmonid Stream Habitat Restoration Manual. <http://www.dfg.ca.gov/nafwb/manual.html>

CalTrans. Standard Specifications, State of California Business, Transportation and Housing Agency Department of Transportation. May 2006. <http://www.dot.ca.gov/hq/esc/oe/conststand.html>. 543 pp.

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APPENDIX A: HYDROLOGY

APPENDIX A: HYDROLOGY

Contents:

- PeakFQ Flow Frequency Output
- Flow Frequency Plot
- Flow Duration Plot

1
Program PeakFq U. S. GEOLOGICAL SURVEY Seq.000.000
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date /
Time
05/06/2005 following Bulletin 17-B Guidelines 07/02/2007
17:04

--- PROCESSING OPTIONS ---

Plot option = Graphics & Printer
Basin char output = None
Print option = Yes
Debug print = No
Input peaks listing = Long
Input peaks format = WATSTORE peak file

Input files used:

peaks (ascii) -
P:\50454\HYDROLOGY\FLOWFREQ\PKS06WS.TXT
specifications - PKFQWPSF.TMP
Output file(s):
main - P:\50454\HYDROLOGY\FLOWFREQ\PKS06WS.PRT

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.001
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date /
Time
05/06/2005 following Bulletin 17-B Guidelines 07/02/2007
17:04

Station - 11164500 SAN FRANCISQUITO C A STANFORD UNIVERSITY CA

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	67
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	67
Historic peaks in analysis	=	0
Years of historic record	=	0
Generalized skew	=	-0.300
Standard error	=	0.550
Mean Square error	=	0.303
Skew option	=	WEIGHTED
Gage base discharge	=	0.0
User supplied high outlier threshold	=	--
User supplied low outlier criterion	=	--
Plotting position parameter	=	0.00

***** NOTICE -- Preliminary machine computations. *****
***** User responsible for assessment and interpretation. *****

WCF133I-SYSTEMATIC PEAKS BELOW GAGE BASE WERE NOTED. 1 0.0
WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED. 1 49.9
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE. 24700.8

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date /
Time
05/06/2005 following Bulletin 17-B Guidelines 07/02/2007
17:04

Station - 11164500 SAN FRANCISQUITO C A STANFORD UNIVERSITY CA

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	EXCEEDANCE		MEAN	STANDARD	SKEW
	DISCHARGE	PROBABILITY		DEVIATION	
SYSTEMATIC RECORD	0.0	0.9851	3.1164	0.5084	-1.652
BULL.17B ESTIMATE	49.9	0.9701	3.1386	0.4490	-0.797

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL		'EXPECTED 95-PCT CONFIDENCE			
LIMITS					
EXCEEDANCE	BULL.17B	SYSTEMATIC	PROBABILITY'	FOR BULL. 17B	
ESTIMATES					
PROBABILITY	ESTIMATE	RECORD	ESTIMATE	LOWER	UPPER
0.9500	205.6	130.6	194.8	139.5	279.9
0.9000	345.6	276.7	334.9	250.9	449.3
0.8000	614.1	598.7	605.3	474.6	768.3
0.6667	997.7	1082.0	992.5	799.2	1229.0
0.5000	1576.0	1776.0	1576.0	1280.0	1952.0
0.4292	1877.0	2106.0	1880.0	1524.0	2341.0
0.2000	3334.0	3386.0	3365.0	2654.0	4347.0
0.1000	4595.0	4125.0	4666.0	3582.0	6199.0
0.0400	6157.0	4708.0	6302.0	4691.0	8606.0
0.0200	7253.0	4965.0	7466.0	5447.0	10350.0
0.0100	8272.0	5125.0	8559.0	6138.0	12020.0
0.0050	9215.0	5226.0	9579.0	6768.0	13590.0
0.0020	10350.0	5304.0	10810.0	7515.0	15500.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date /
Time
05/06/2005 following Bulletin 17-B Guidelines 07/02/2007
17:04

Station - 11164500 SAN FRANCISQUITO C A STANFORD UNIVERSITY CA

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1931	0.0		1974	3410.0	
1932	1160.0		1975	2190.0	
1933	730.0		1976	82.0	
1934	670.0		1977	82.0	
1935	1560.0		1978	2470.0	
1936	1660.0		1979	1330.0	
1937	2620.0		1980	3300.0	
1938	1330.0		1981	626.0	
1939	120.0		1982	5220.0	
1940	3100.0		1983	3420.0	
1941	2410.0		1984	1700.0	
1951	3650.0		1985	2270.0	
1952	2320.0		1986	3480.0	
1953	1950.0		1987	1540.0	
1954	332.0		1988	712.0	
1955	797.0		1989	394.0	
1956	5560.0		1990	460.0	
1957	125.0		1991	626.0	
1958	4460.0		1992	2580.0	
1959	868.0		1993	3010.0	
1960	1020.0		1994	824.0	
1961	12.0		1995	3320.0	
1962	996.0		1996	1520.0	
1963	3270.0		1997	3250.0	
1964	948.0		1998	7200.0	
1965	1120.0		1999	2640.0	
1966	880.0		2000	3930.0	
1967	4000.0		2001	621.0	
1968	1130.0		2002	1060.0	
1969	2300.0		2003	3730.0	
1970	3110.0		2004	1980.0	
1971	1000.0		2005	940.0	
1972	700.0		2006	4840.0	
1973	3390.0				

Explanation of peak discharge qualification codes

PEAKFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
-8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.0 Beta 8 Annual peak flow frequency analysis Run Date /
Time
05/06/2005 following Bulletin 17-B Guidelines 07/02/2007
17:04

Station - 11164500 SAN FRANCISQUITO C A STANFORD UNIVERSITY CA

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1998	7200.0	0.0147	0.0147
1956	5560.0	0.0294	0.0294
1982	5220.0	0.0441	0.0441
2006	4840.0	0.0588	0.0588
1958	4460.0	0.0735	0.0735
1967	4000.0	0.0882	0.0882
2000	3930.0	0.1029	0.1029
2003	3730.0	0.1176	0.1176
1951	3650.0	0.1324	0.1324
1986	3480.0	0.1471	0.1471
1983	3420.0	0.1618	0.1618
1974	3410.0	0.1765	0.1765
1973	3390.0	0.1912	0.1912
1995	3320.0	0.2059	0.2059
1980	3300.0	0.2206	0.2206
1963	3270.0	0.2353	0.2353
1997	3250.0	0.2500	0.2500
1970	3110.0	0.2647	0.2647
1940	3100.0	0.2794	0.2794
1993	3010.0	0.2941	0.2941
1999	2640.0	0.3088	0.3088
1937	2620.0	0.3235	0.3235
1992	2580.0	0.3382	0.3382
1978	2470.0	0.3529	0.3529
1941	2410.0	0.3676	0.3676
1952	2320.0	0.3824	0.3824
1969	2300.0	0.3971	0.3971
1985	2270.0	0.4118	0.4118
1975	2190.0	0.4265	0.4265
2004	1980.0	0.4412	0.4412
1953	1950.0	0.4559	0.4559
1984	1700.0	0.4706	0.4706
1936	1660.0	0.4853	0.4853
1935	1560.0	0.5000	0.5000

1987	1540.0	0.5147	0.5147
1996	1520.0	0.5294	0.5294
1938	1330.0	0.5441	0.5441
1979	1330.0	0.5588	0.5588
1932	1160.0	0.5735	0.5735
1968	1130.0	0.5882	0.5882
1965	1120.0	0.6029	0.6029
2002	1060.0	0.6176	0.6176
1960	1020.0	0.6324	0.6324
1971	1000.0	0.6471	0.6471
1962	996.0	0.6618	0.6618
1964	948.0	0.6765	0.6765
2005	940.0	0.6912	0.6912
1966	880.0	0.7059	0.7059
1959	868.0	0.7206	0.7206
1994	824.0	0.7353	0.7353
1955	797.0	0.7500	0.7500
1933	730.0	0.7647	0.7647
1988	712.0	0.7794	0.7794
1972	700.0	0.7941	0.7941
1934	670.0	0.8088	0.8088
1981	626.0	0.8235	0.8235
1991	626.0	0.8382	0.8382
2001	621.0	0.8529	0.8529
1990	460.0	0.8676	0.8676
1989	394.0	0.8824	0.8824
1954	332.0	0.8971	0.8971
1957	125.0	0.9118	0.9118
1939	120.0	0.9265	0.9265
1976	82.0	0.9412	0.9412
1977	82.0	0.9559	0.9559
1961	12.0	0.9706	0.9706
1931	0.0	--	--

1

	Program PeakFq	U. S. GEOLOGICAL SURVEY
Seq.001.005	Ver. 5.0 Beta 8	Annual peak flow frequency
analysis	Run Date / Time	following Bulletin 17-B
	05/06/2005	
Guidelines	07/02/2007 17:04	

End PEAKFQ analysis.

Stations processed :	1
Number of errors :	0
Stations skipped :	0
Station years :	67

Data records may have been ignored for the stations listed below.
 (Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
 (2, 4, and * records are ignored.)

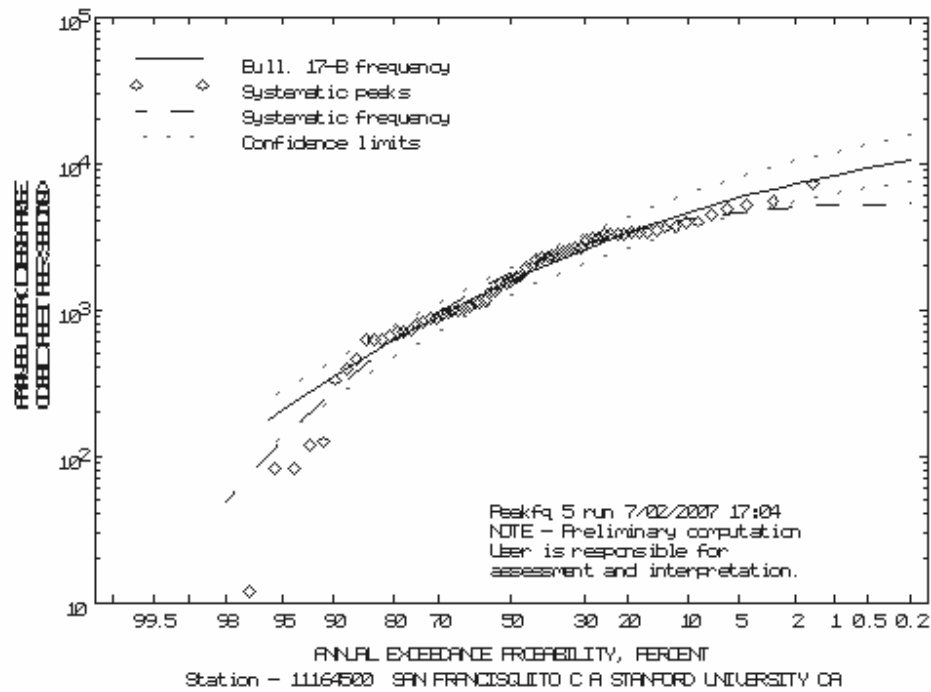
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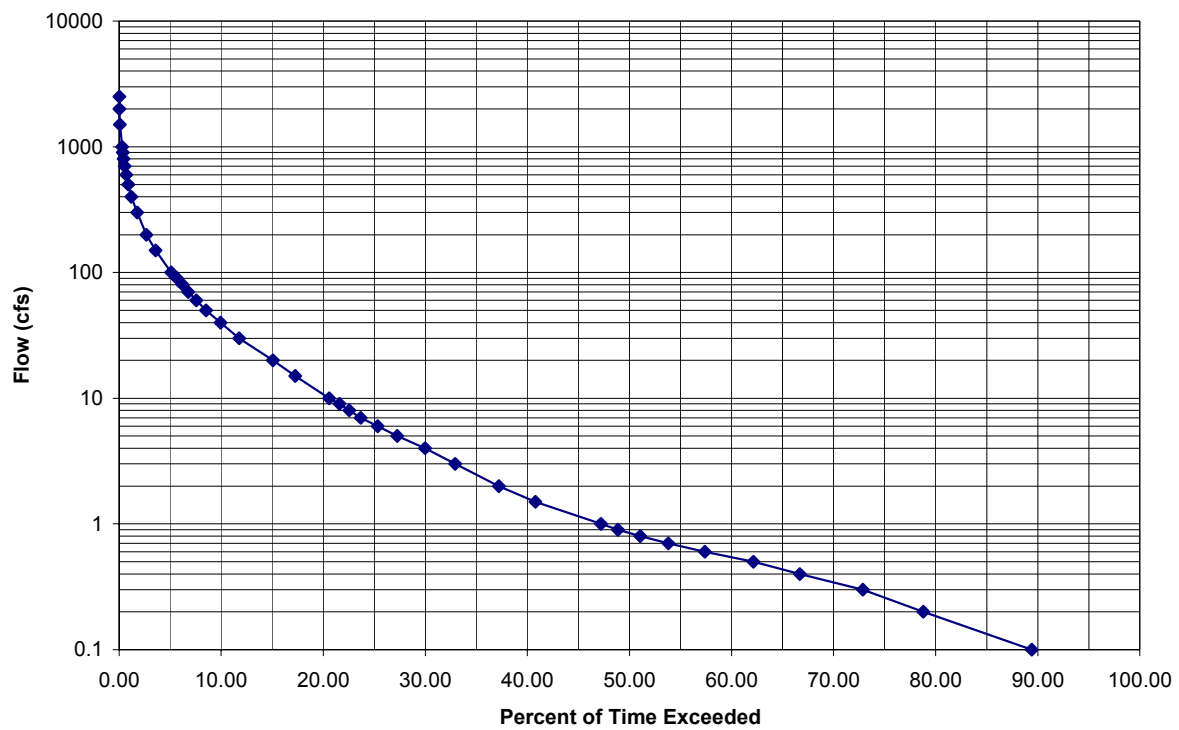
FINISHED PROCESSING STATION: 11164500
STANFORD

USGS SAN FRANCISQUITO C A

For the station below, the following records were ignored:

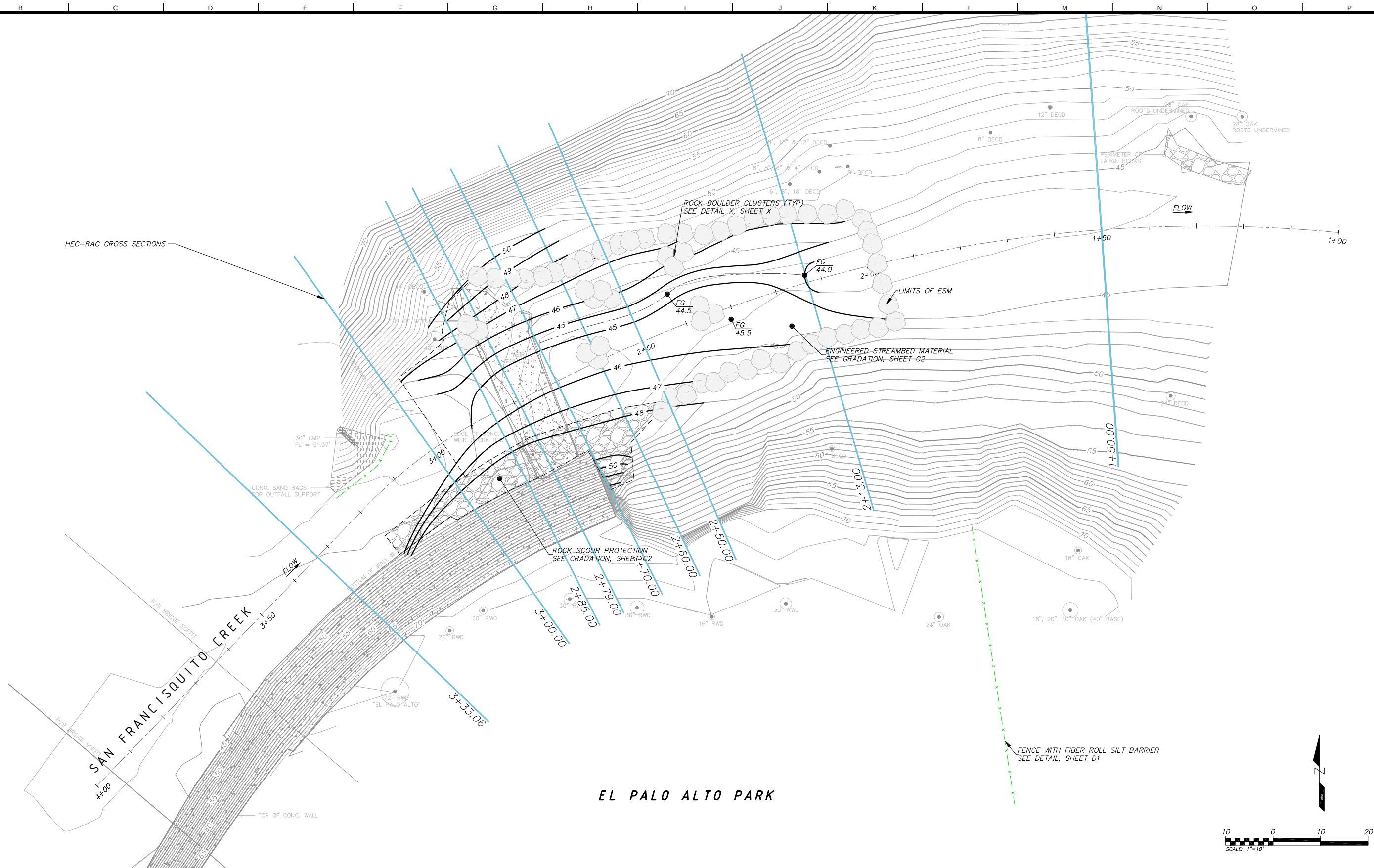
FINISHED PROCESSING STATION:





San Francisquito Creek at Stanford University Flow Duration Curve for the period between 10/1/1963 to 10/9/1998

APPENDIX B: HEC-RAS MODEL RESULTS



San Mateo County Resource
Conservation District
625 Miramontes Street, Suite 103
Half Moon Bay, California 94019
phone (650) 712-7765
fax (650) 726-0494
www.sanmateorcd.org

nhc
northwest
hydraulic
consultants

3950 industrial boulevard, suite 100c
west sacramento, california 95691
phone: (916) 371-7400
fax: (916) 371-7475
www.nhcweb.com

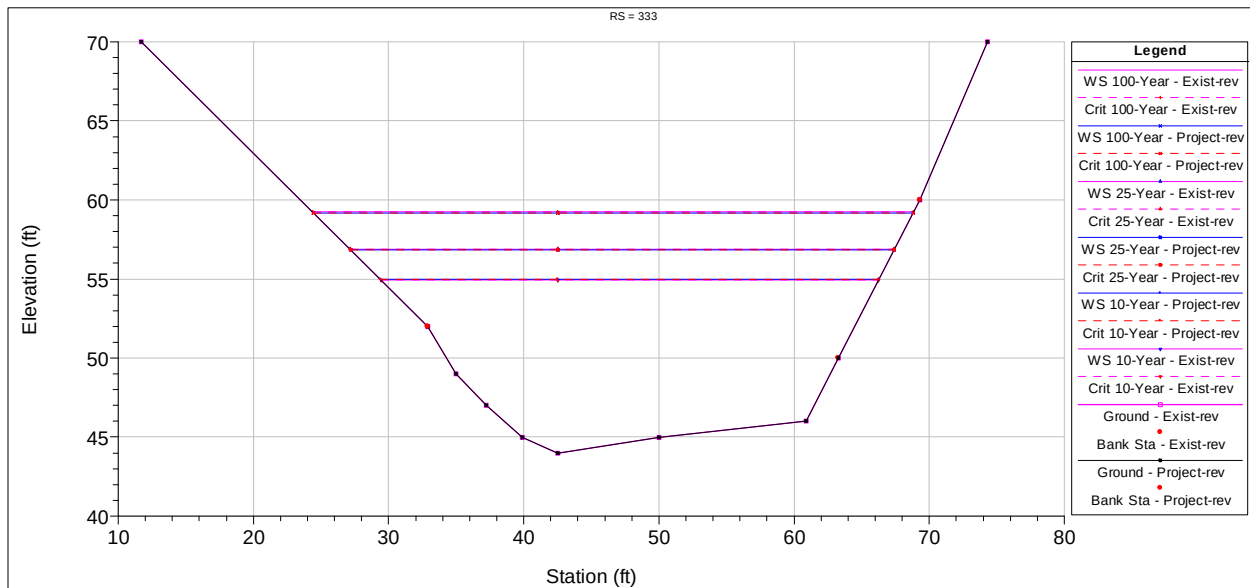
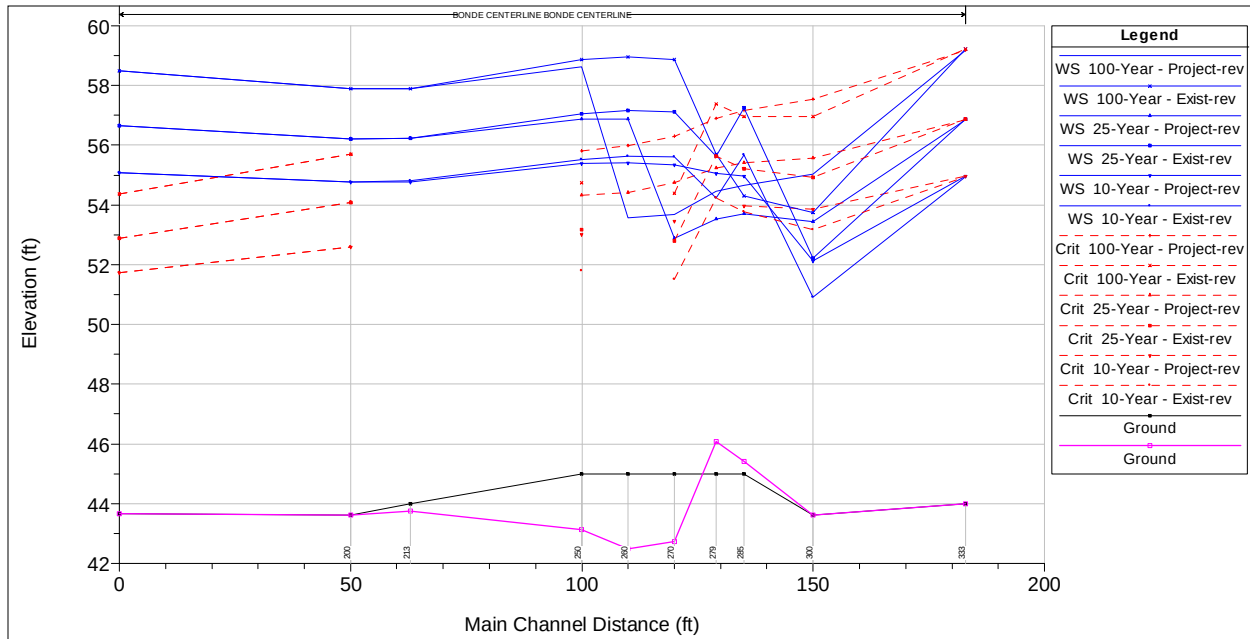
PRELIMINARY
NOT FOR CONSTRUCTION

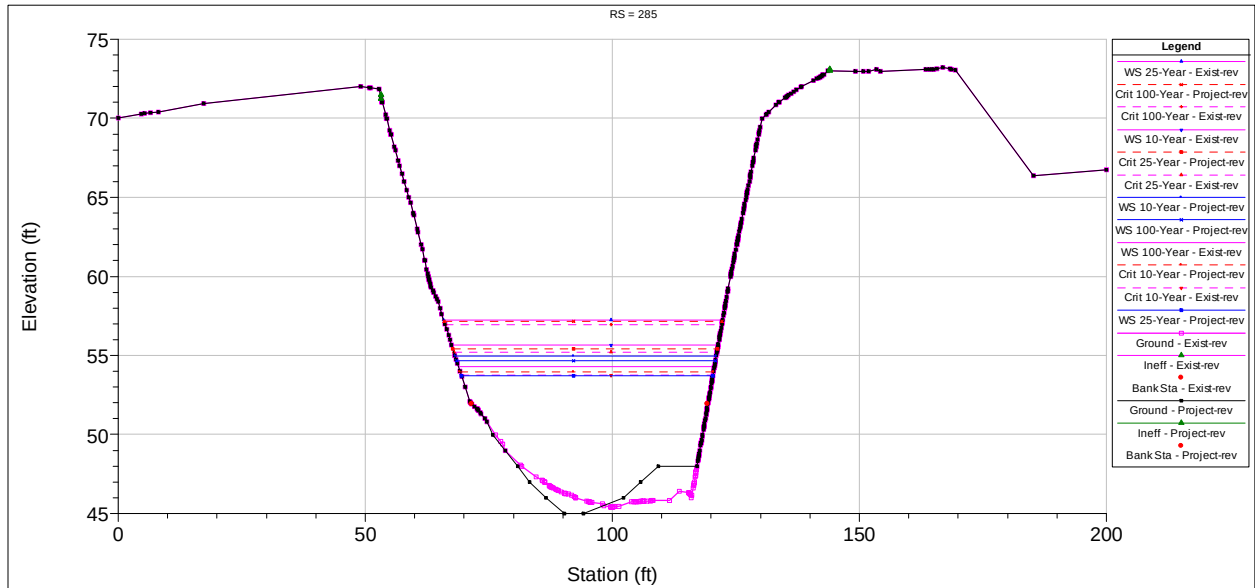
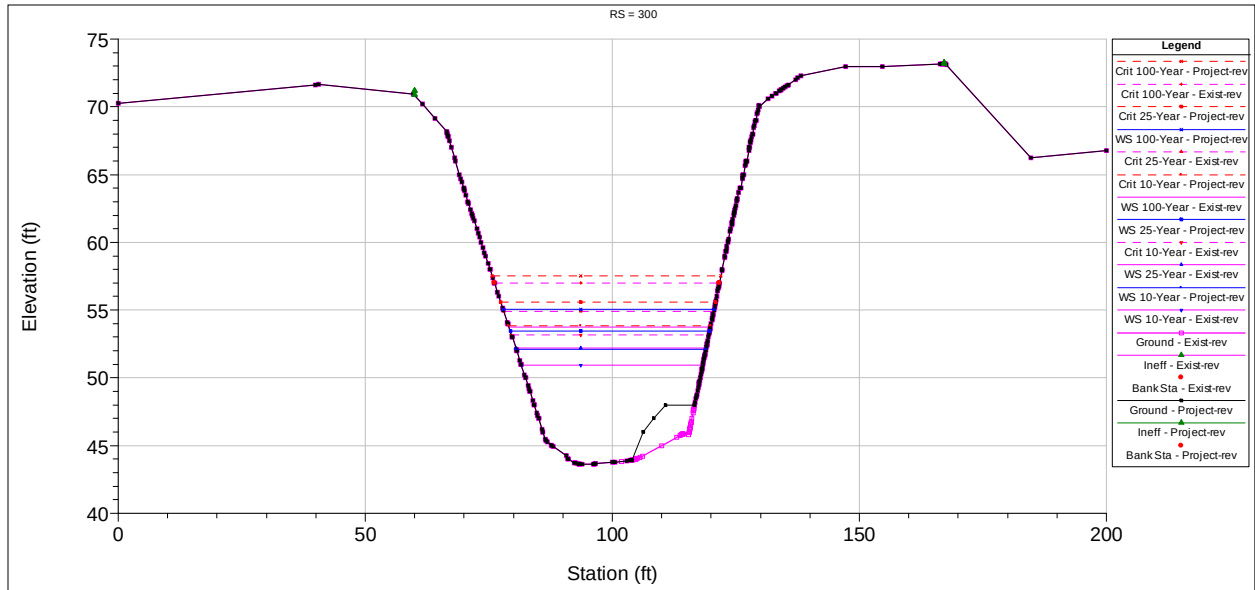
Revisions			Drawing Information	
No.	Date	Description	Date	27 July 2012
			Status	
			Designer	bgw
			Drafter	bgw
			Checked	ljh
			File Name	BGW_RAS_SECTIONS.dwg
			Plotted Scale	

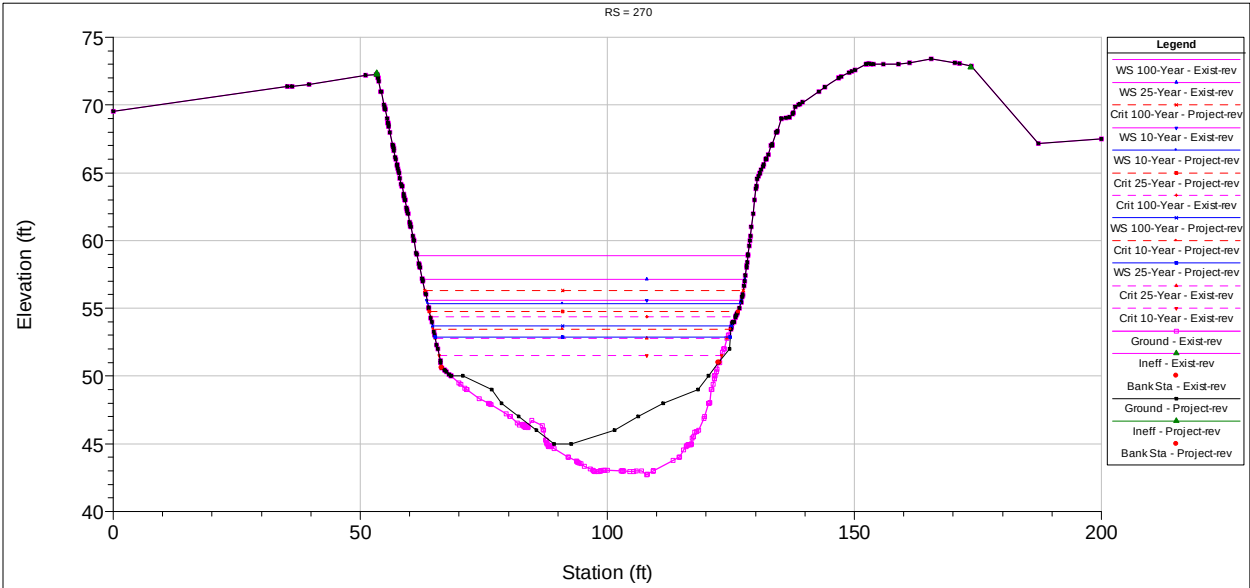
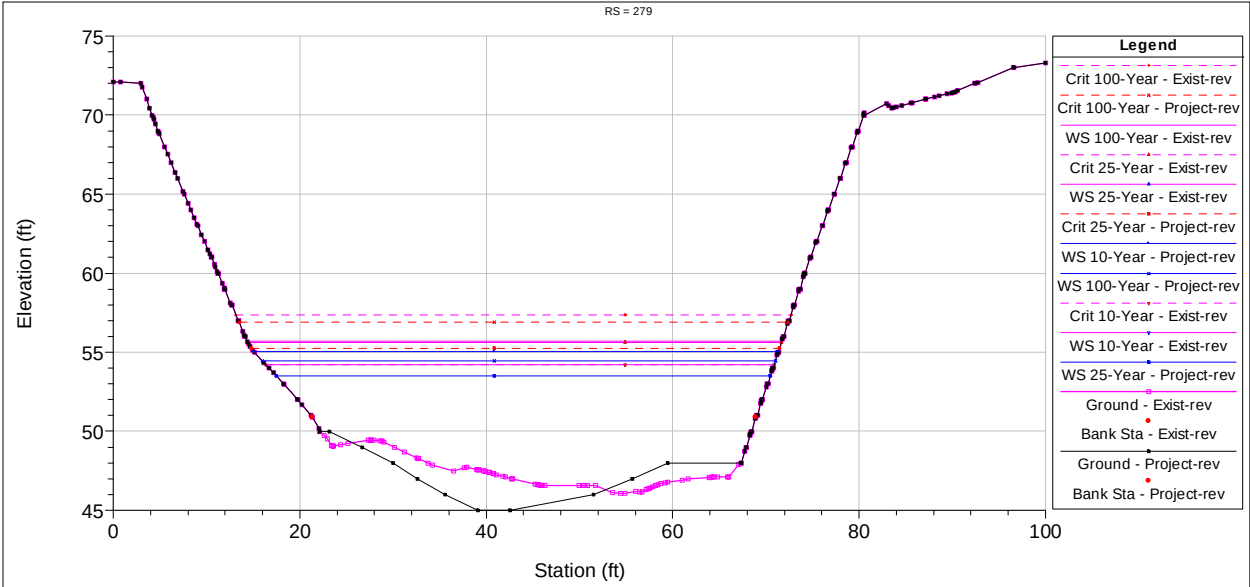
**SAN FRANCISQUITO CREEK BONDE
WEIR FISH PASSAGE IMPROVEMENT**
HEC-RAS Cross Section Locations

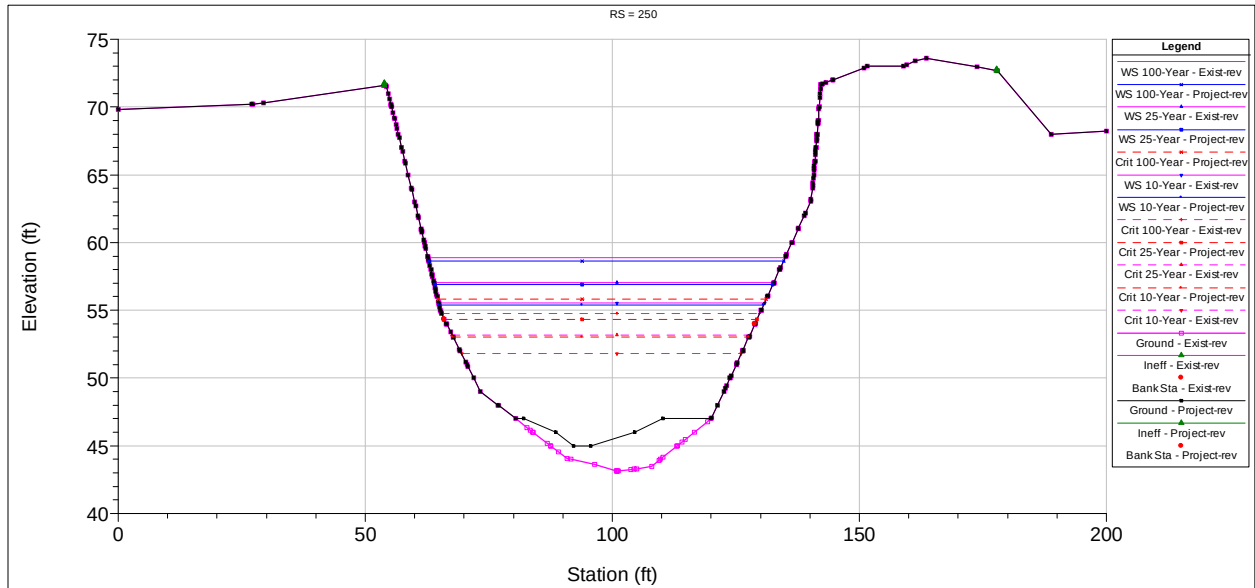
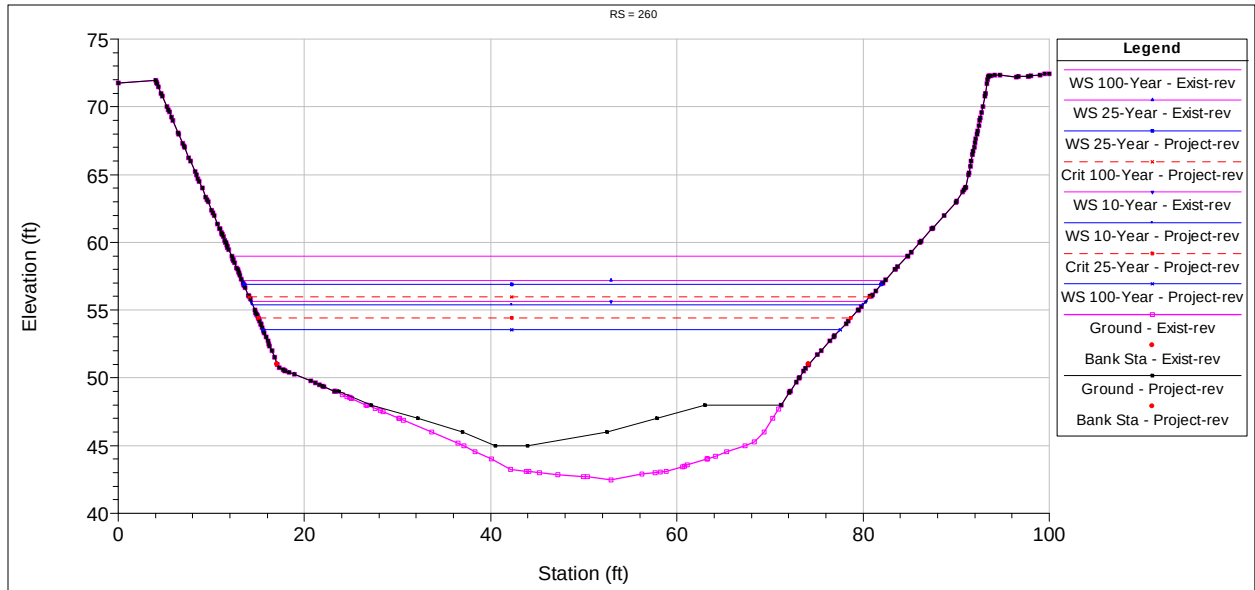
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500045
Sheet Number

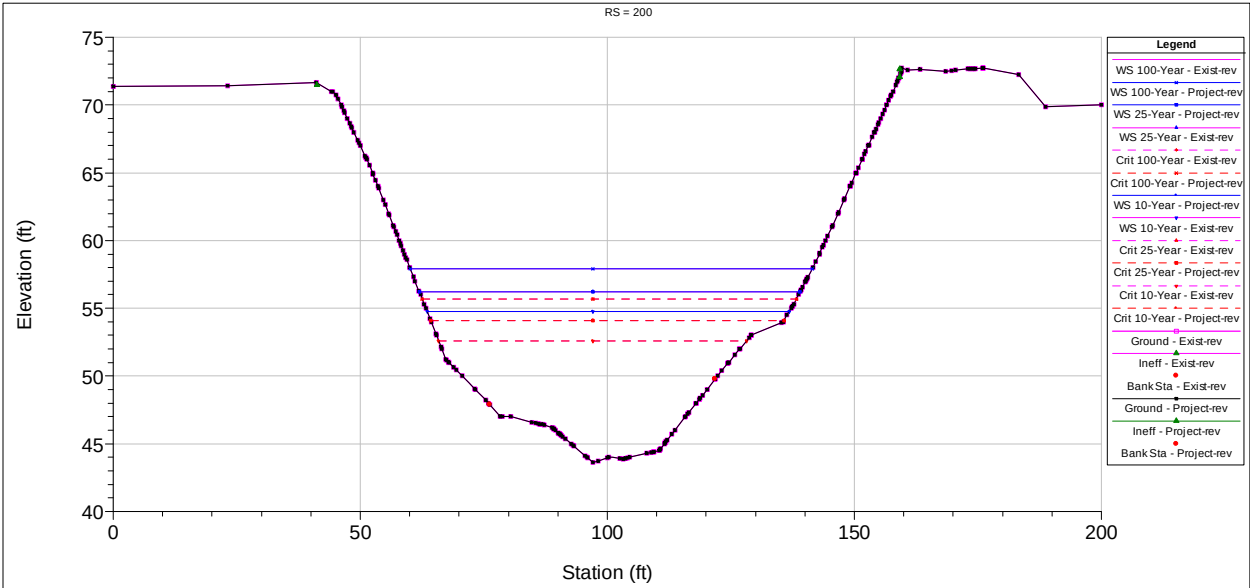
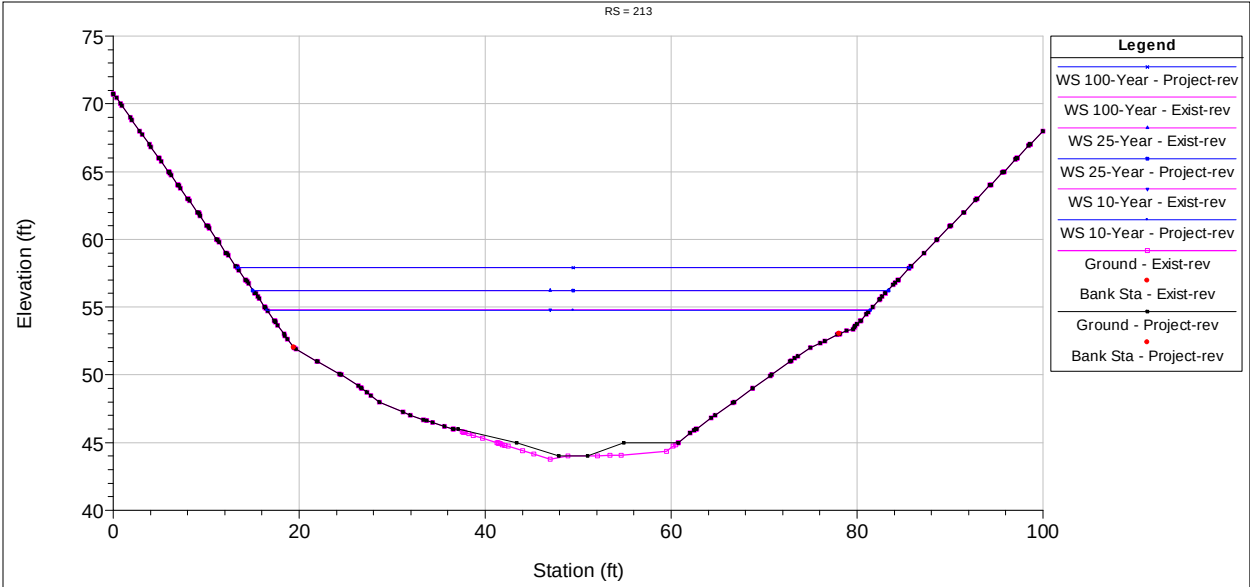
APPENDIX B: HYDRAULIC MODEL RESULTS

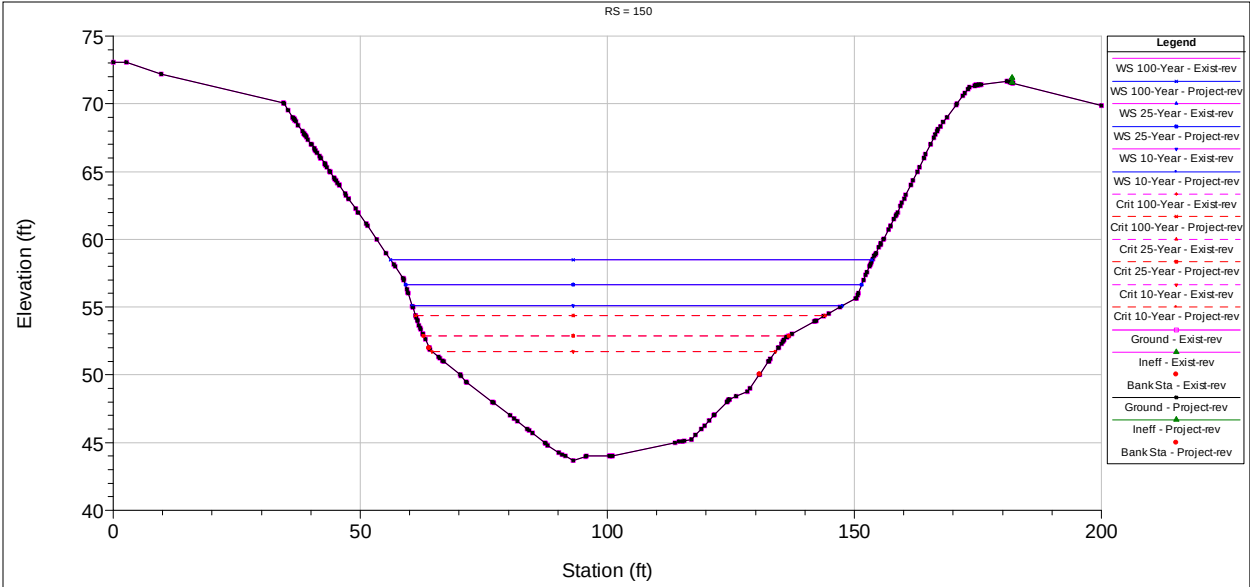












Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BONDE CENTERLINE	333	100-Year	Project-rev	8272.00	44.00	59.17	59.17	64.63	0.010354	18.92	458.01	44.35	0.97
BONDE CENTERLINE	333	100-Year	Exist-rev	8272.00	44.00	59.23	59.23	65.09	0.008584	19.74	460.64	44.46	0.95
BONDE CENTERLINE	333	25-Year	Project-rev	6157.00	44.00	56.84	56.84	61.62	0.011018	17.63	359.44	40.21	0.98
BONDE CENTERLINE	333	25-Year	Exist-rev	6157.00	44.00	56.88	56.88	61.90	0.009391	18.14	361.07	40.28	0.97
BONDE CENTERLINE	333	10-Year	Project-rev	4595.00	44.00	54.96	54.96	59.04	0.011481	16.25	286.90	36.86	0.99
BONDE CENTERLINE	333	10-Year	Exist-rev	4595.00	44.00	54.94	54.94	59.20	0.010264	16.64	285.99	36.82	0.98
BONDE CENTERLINE	300	100-Year	Project-rev	8272.00	43.61	55.04	57.54	63.79	0.025268	23.74	348.48	42.66	1.46
BONDE CENTERLINE	300	100-Year	Exist-rev	8272.00	43.61	53.74	56.97	64.14	0.031182	25.88	319.63	40.78	1.63
BONDE CENTERLINE	300	25-Year	Project-rev	6157.00	43.61	53.44	55.57	60.83	0.025456	21.81	282.27	40.36	1.45
BONDE CENTERLINE	300	25-Year	Exist-rev	6157.00	43.61	52.21	54.92	61.00	0.031413	23.79	258.76	38.58	1.62
BONDE CENTERLINE	300	10-Year	Project-rev	4595.00	43.61	52.12	53.87	58.30	0.025433	19.95	230.37	38.46	1.44
BONDE CENTERLINE	300	10-Year	Exist-rev	4595.00	43.61	50.92	53.18	58.33	0.031648	21.85	210.33	36.67	1.61
BONDE CENTERLINE	285	100-Year	Project-rev	8272.00	45.00	54.66	57.17	63.20	0.048942	23.51	356.68	52.39	1.53
BONDE CENTERLINE	285	100-Year	Exist-rev	8272.00	45.42	54.31	56.96	63.29	0.026359	24.07	347.82	51.84	1.58

BONDE CENTERLINE	285	25-Year	Project-rev	6157.00	45.00	53.71	55.42	60.02	0.043432	20.17	307.41	50.86	1.41
BONDE CENTERLINE	285	25-Year	Exist-rev	6157.00	45.42	57.25	55.20	59.69	0.004565	12.59	506.96	56.47	0.70
BONDE CENTERLINE	285	10-Year	Project-rev	4595.00	45.00	54.96	53.97	57.39	0.013200	12.53	372.30	52.87	0.80
BONDE CENTERLINE	285	10-Year	Exist-rev	4595.00	45.42	55.67	53.77	57.61	0.004528	11.20	419.73	53.98	0.68
BONDE CENTERLINE	279	100-Year	Project-rev	8272.00	45.00	54.45	56.89	62.87	0.047661	23.41	362.16	55.01	1.52
BONDE CENTERLINE	279	100-Year	Exist-rev	8272.00	46.08	55.70	57.38	62.58	0.008536	21.18	409.94	57.33	1.31
BONDE CENTERLINE	279	25-Year	Project-rev	6157.00	45.00	53.53	55.24	59.72	0.041794	20.04	312.27	53.02	1.39
BONDE CENTERLINE	279	25-Year	Exist-rev	6157.00	46.08	55.63	55.63	59.51	0.004862	15.90	406.16	57.25	0.99
BONDE CENTERLINE	279	10-Year	Project-rev	4595.00	45.00	55.05		57.24	0.011233	11.97	395.45	56.33	0.75
BONDE CENTERLINE	279	10-Year	Exist-rev	4595.00	46.08	54.23	54.23	57.45	0.005184	14.45	327.59	54.56	0.99
BONDE CENTERLINE	270	100-Year	Project-rev	8272.00	45.00	53.69	56.31	62.38	0.058426	23.73	354.06	60.55	1.68
BONDE CENTERLINE	270	100-Year	Exist-rev	8272.00	42.73	58.87	54.39	60.72	0.001230	10.96	794.01	66.93	0.53
BONDE CENTERLINE	270	25-Year	Project-rev	6157.00	45.00	52.89	54.74	59.29	0.051643	20.34	306.02	59.77	1.55
BONDE CENTERLINE	270	25-Year	Exist-rev	6157.00	42.73	57.12	52.80	58.49	0.001099	9.43	678.27	65.24	0.49
BONDE CENTERLINE	270	10-Year	Project-rev	4595.00	45.00	55.35	53.46	56.99	0.008030	10.32	457.40	63.38	0.65
BONDE	270	10-Year	Exist-	4595.00	42.73	55.60	51.52	56.62	0.000984	8.12	580.67	63.68	0.45

CENTERLINE			rev										
BONDE CENTERLINE	260	100- Year	Project- rev	8272.00	45.00	53.58	55.98	61.63	0.053290	22.82	367.13	62.05	1.60
BONDE CENTERLINE	260	100- Year	Exist- rev	8272.00	42.48	58.96		60.65	0.002095	10.53	831.17	72.48	0.51
BONDE CENTERLINE	260	25-Year	Project- rev	6157.00	45.00	56.88	54.42	58.71	0.007032	10.97	582.47	68.44	0.62
BONDE CENTERLINE	260	25-Year	Exist- rev	6157.00	42.48	57.17		58.44	0.001893	9.10	704.50	69.07	0.47
BONDE CENTERLINE	260	10-Year	Project- rev	4595.00	45.00	55.40		56.86	0.006945	9.75	483.48	65.58	0.60
BONDE CENTERLINE	260	10-Year	Exist- rev	4595.00	42.48	55.64		56.59	0.001702	7.86	600.86	66.04	0.43
BONDE CENTERLINE	250	100- Year	Project- rev	8272.00	45.00	58.62	55.81	60.79	0.007231	11.87	711.17	71.79	0.63
BONDE CENTERLINE	250	100- Year	Exist- rev	8272.00	43.14	58.87	54.75	60.62	0.002500	10.67	793.59	72.21	0.54
BONDE CENTERLINE	250	25-Year	Project- rev	6157.00	45.00	56.88	54.32	58.61	0.007195	10.56	589.24	68.43	0.61
BONDE CENTERLINE	250	25-Year	Exist- rev	6157.00	43.14	57.06	53.17	58.41	0.002374	9.34	666.32	68.89	0.51
BONDE CENTERLINE	250	10-Year	Project- rev	4595.00	45.00	55.39	53.02	56.77	0.007263	9.43	488.91	65.69	0.60
BONDE CENTERLINE	250	10-Year	Exist- rev	4595.00	43.14	55.52	51.80	56.56	0.002260	8.20	562.44	65.93	0.48
BONDE CENTERLINE	213	100- Year	Project- rev	8272.00	44.00	57.90		60.46	0.008720	12.96	663.08	72.28	0.70
BONDE CENTERLINE	213	100- Year	Exist- rev	8272.00	43.76	57.90		60.43	0.004132	12.85	672.42	72.27	0.69
BONDE	213	25-Year	Project-	6157.00	44.00	56.22		58.28	0.008750	11.57	544.92	68.34	0.68

CENTERLINE			rev										
BONDE CENTERLINE	213	25-Year	Exist- rev	6157.00	43.76	56.24		58.24	0.004048	11.38	555.77	68.38	0.66
BONDE CENTERLINE	213	10-Year	Project- rev	4595.00	44.00	54.78		56.44	0.008872	10.37	448.85	64.84	0.67
BONDE CENTERLINE	213	10-Year	Exist- rev	4595.00	43.76	54.81		56.40	0.004004	10.11	460.77	64.93	0.64
BONDE CENTERLINE	200	100- Year	Project- rev	8272.00	43.61	57.89	55.69	60.36	0.003685	13.27	739.41	81.30	0.67
BONDE CENTERLINE	200	100- Year	Exist- rev	8272.00	43.61	57.89	55.69	60.36	0.003685	13.27	739.41	81.30	0.67
BONDE CENTERLINE	200	25-Year	Project- rev	6157.00	43.61	56.21	54.08	58.19	0.003532	11.76	606.02	77.06	0.64
BONDE CENTERLINE	200	25-Year	Exist- rev	6157.00	43.61	56.20	54.08	58.19	0.003535	11.76	605.84	77.05	0.64
BONDE CENTERLINE	200	10-Year	Project- rev	4595.00	43.61	54.76	52.59	56.35	0.003383	10.42	497.40	73.30	0.61
BONDE CENTERLINE	200	10-Year	Exist- rev	4595.00	43.61	54.76	52.59	56.35	0.003385	10.43	497.30	73.30	0.61
BONDE CENTERLINE	150	100- Year	Project- rev	8272.00	43.66	58.49	54.36	59.91	0.002001	9.77	931.83	97.49	0.50
BONDE CENTERLINE	150	100- Year	Exist- rev	8272.00	43.66	58.49	54.36	59.91	0.002001	9.77	931.83	97.49	0.50
BONDE CENTERLINE	150	25-Year	Project- rev	6157.00	43.66	56.65	52.88	57.81	0.002000	8.74	757.46	92.39	0.48
BONDE CENTERLINE	150	25-Year	Exist- rev	6157.00	43.66	56.65	52.88	57.81	0.002000	8.74	757.46	92.39	0.48
BONDE CENTERLINE	150	10-Year	Project- rev	4595.00	43.66	55.09	51.73	56.03	0.002003	7.83	615.99	87.03	0.47
BONDE CENTERLINE	150	10-Year	Exist- rev	4595.00	43.66	55.09	51.73	56.03	0.002003	7.83	615.99	87.03	0.47

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BONDE CENTERLINE	333	100-Year	Project-rev	8272.00	44.00	59.17	59.17	64.63	0.010354	18.92	458.01	44.35	0.97
BONDE CENTERLINE	333	100-Year	Exist-rev	8272.00	44.00	59.23	59.23	65.09	0.008584	19.74	460.64	44.46	0.95
BONDE CENTERLINE	333	25-Year	Project-rev	6157.00	44.00	56.84	56.84	61.62	0.011018	17.63	359.44	40.21	0.98
BONDE CENTERLINE	333	25-Year	Exist-rev	6157.00	44.00	56.88	56.88	61.90	0.009391	18.14	361.07	40.28	0.97
BONDE CENTERLINE	333	10-Year	Project-rev	4595.00	44.00	54.96	54.96	59.04	0.011481	16.25	286.90	36.86	0.99

APPENDIX C: ROCK SIZING CALCULATIONS

Bonde Weir Fish Passage Project

Rock Scour Protection Analysis

Date: 7/5/2012

By: jh, bw

PERCENT OF MIX	ROCK SIZE, ft	
	min	max
16%	2.5	4.0
34%	1.0	2.5
34%	0.06	1.0
9%	0.01	0.06
7%	SAND/SILT	

Hydraulic Characteristics

$q_f = 165.4 \text{ ft}^3/\text{s}/\text{ft}$ Unit discharge in Main Channel
 $Q_{100} = 8270 \text{ ft}^3/\text{s}$ 1pct AEP (100-year peak flow)
 $W = 50 \text{ ft}$ Main channel width
 $S_o = 0.01 \text{ ft}/\text{ft}$ Channel slope = 0.01 ft/ft,

USACE (1991) Channel Bed Rock Sizing

$S_o = 0.01 \text{ ft}/\text{ft}$ Channel slope
 $q^*1 = 165.4 \text{ ft}^3/\text{s}/\text{ft}$ Unit discharge
 $g = 32.2 \text{ ft}/\text{s}^2$ gravitational acceleration
 $sf = 1$ factor of safety
 $D_{30} = 1.66 \text{ ft}$

Abt and Johnson (1990)

$S_o = 0.01 \text{ ft}/\text{ft}$ channel slope
 $q = 165.4 \text{ ft}^2/\text{s}$ design unit discharge
 $f_{q \text{ sizing factor}} = 1.35$ - sizing factor
 $q_{\text{sizing}} = 223 \text{ ft}^2/\text{s}$ unit discharge for sizing
 $\phi_e = 1.2$ - coefficient for the empirical envelope on the regression
 $\phi_c = 1.2$ - coefficient for flow concentration assuming sheet flow
 $a = 1$ - Shape factor
 $D_{30} = 1.43 \text{ ft}$
 $D_{50} = 1.79 \text{ ft}$

USACE (1991) Channel Bed Rock Sizing

$S_o =$	0.01	ft/ft
$q =$	165.4	ft ² /s
$g =$	32.2	lbm*ft/s ²
$n_{sed} =$	0.40	-
$D_{30-CORPS} =$	1.66	ft

DFG Engineered Bed Material Size

$D_{8-ESM} =$	0.010	ft
$D_{16-ESM} =$	0.06	ft
$D_{50-ESM} =$	1.0	ft
$D_{84-ESM} =$	2.5	ft
$D_{100-ESM} (calc) =$	6.24	ft

APPENDIX D: 30% DESIGN DRAWINGS

APPENDIX D: 30% DESIGN DRAWINGS