APPENDIX F-1

CHELSEA WETLAND RESTORATION PROJECT RISK AND UNCERTAINTY ANALYSIS (QUESTA, 2013)

Chelsea Wetland Restoration Project
Risk and Uncertainty Analysis

Prepared for:

Ducks Unlimited Inc.
3074 Gold Canal Drive
Rancho Cordova, CA 95670

Submitted by:

Questa Engineering Corporation
1220 Brickyard Cove Road, Suite 206
P. O. Box 70356
Point Richmond, California 94807
(510) 236-6114

November 27, 2013

November 27, 2013

Contra Costa County Flood Control
& Water Conservation District
255 Glacier Drive
Martinez, CA 94553-487

Subject: Proposed Chelsea Wetland Restoration Project Risk and Uncertainty Analysis

To Contra Costa County Flood Control & Water Conservation District:

I hereby state that all work completed in the attached Risk and Uncertainty Analysis for the Chelsea Wetland Restoration Project follows accepted engineering practice and was completed under my direction. The project is intended to restore tidal marsh, provide flood storage benefits, and provide habitat used by numerous wildlife species, including special-status species. This Risk and Uncertainty Report demonstrates that the proposed project will not compromise protection against flooding and will meet the original 1960's project design standard, as implemented by the U.S. Army Corps of Engineers.

Sydney Temple, P.E. Date
Principal/Senior Hydrologist
Questa Engineering Corp.

Contents

List of Tables

List of Figures

Appendices

1.0 INTRODUCTION

The Chelsea Wetland Restoration Project proposes to restore tidal marsh habitat on a vacant nine-acre parcel adjacent to Pinole Creek in the City of Hercules, Contra Costa County, California (see project location on **Sheet 1, Appendix A**). The tidal marsh restoration will be accomplished by connecting the project area to Pinole Creek utilizing a new arch culvert. The project will increase Pinole Creek's floodplain through excavation of fill previously deposited on the site. Conceptual Plans for the project are included in **Appendix A**.

1960's Corps Project

The U.S. Army Corps of Engineers (Corps) implemented a flood protection project on lower Pinole Creek in the mid 1960's. The Contra Costa County Flood Control and Water Conservation District (FC District) is the local sponsor that owns and maintains these flood protection improvements. The Chelsea Wetland Restoration Project will modify the Corps and FC District facility, and therefore must be analyzed to determine its flood control performance on a risk and uncertainty (RU) basis. The goal of a RU analysis is to determine the minimum levee/floodwall elevation required for the proposed project that will provide the same protection as the 1960's project.

2010 Demonstration Project

In 2010, the Lower Pinole Creek Demonstration Project was completed along the downstream 3000 feet of Pinole Creek, including the reach adjacent to the Chelsea Wetland. The project included the following components:

- Channel excavation to create low floodplain terraces
- Construction of approximately 2,400 linear feet of floodwalls
- Construction of a new pedestrian bridge
- Construction of 1200 linear feet of trail
- Restoration of 2.55 acres of marsh plain and adjacent upland habitat
- Vegetation and landscape management
- Pathway lighting
- Interpretive signs and benches

In 2009 as a requirement for the Demonstration Project, the FC District prepared the *Lower Pinole Creek Demonstration Project Risk and Uncertainty Analysis* (2009 RU Report). The 2009 RU Report compared the original 1965 As-Built channel geometry and hydraulic performance to the channel geometry and hydraulic performance of the proposed Demonstration Project to determine the minimum levee/floodwall heights required for the Demonstration Project. The results of the 2009 RU Report prescribed an elevation of 14 feet (NAVD88) for the top of the levees/floodwalls for the channel reach adjacent to the Chelsea Wetland.

However, floodwall construction during the Demonstration Project ended at the upstream extent of Chelsea Wetland (as shown in **Photo 1)**, leaving the adjacent communities on the north side of Pinole Creek susceptible to flooding during a 100-year storm event.

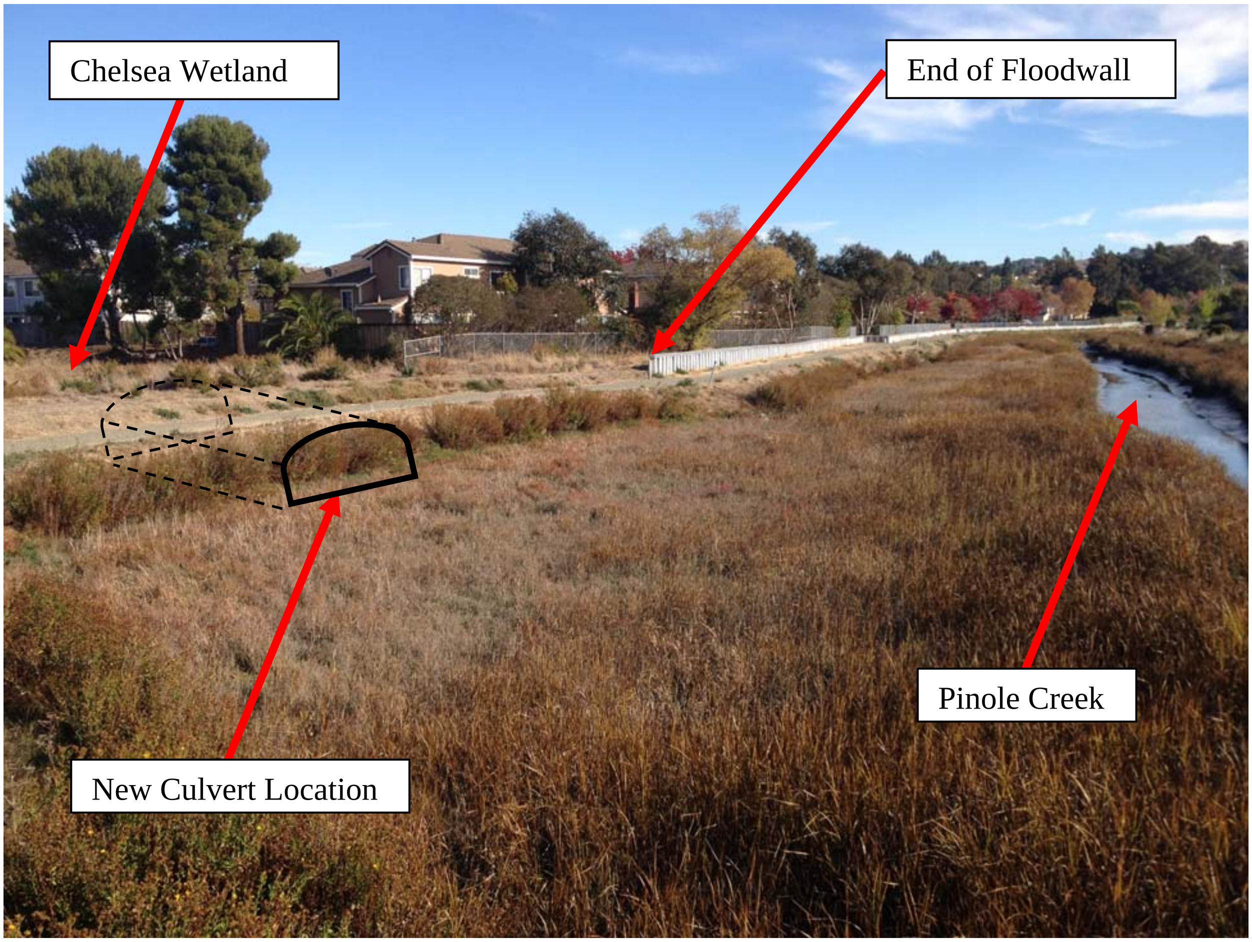


Photo 1. Floodwall along the northern bank of Pinole Creek ending at Chelsea Wetland; photo taken from new pedestrian bridge looking upstream to the east.

Proposed Chelsea Wetland Restoration Project

The proposed Chelsea Wetland Restoration Project will implement the final phase of flood control for this reach of Pinole Creek – as prescribed in the 2009 RU Report – by constructing a connecting floodwall with a top height of 14 feet around the Chelsea Wetland as shown on the Conceptual Plans in **Appendix A**. In addition, a new culvert will be installed through the Pinole Creek channel bank that will improve connectivity to the Chelsea Wetland.

The project is not proposing significant changes to the Pinole Creek channel geometry or hydraulic function. The proposed culvert installation and fill removal within the Chelsea Wetland will create additional floodplain storage for Pinole Creek. The culvert will be located at Station 19+50, with the specific design details shown on the Conceptual Plans. As Pinole Creek water surface elevations rise during large storm events, flood water will flow through the new culvert into the proposed wetlands. Currently, large magnitude flows in excess of the 25-year event overtop the Pinole Creek's northern bank and become directly connected with the Chelsea Wetland. The installation of the new culvert will allow Pinole Creek access to that floodplain during all storm events. Velocities are low in the project area and the site is considered to be non-effective flow and floodplain storage.

The effects of this proposed project will not produce any significant changes to water surface elevations during storm events. Considering that no significant modifications to channel geometry are proposed and that the project will result in a reduction of water surface elevations, the 2009 RU Report, included as **Appendix B**, provides much of the information necessary to assess the risk and uncertainty of the proposed Chelsea Wetland Restoration Project. The following analysis summarizes the 2009 RU Report and its relevance to the proposed project as well as providing a discussion of new Pinole Creek cross section survey data.

2.0 HYDROLOGIC ANALYSIS

The Pinole Creek watershed covers approximately fifteen square miles draining into the San Pablo Bay north of Point Pinole. The flood discharge rates used in the 2009 RU Report for eight design storms are listed in **Table 1**. These flows are based on the hydrology of the original project from the 1962 Report[1]. No additional hydrologic analysis was needed based on the definition of an RU analysis.

Table 1. Pinole Creek Flows for the Risk and Uncertainty Analysis

Annual Exceedance Probability	**Flow Rate** (cubic feet per second)	**Return Frequency** (yrs)
50%	570	2
20%	1,300	5
10%	1,650	10
4%	2,200	25
2%	2,600	50
1%	3,000	100
0.5%	3,400	200
0.2%	4,100	500

3.0 HYDRAULIC ANALYSIS

The 2009 RU Report completed hydraulic analyses for both the 1965 As-Built channel and the

1 "Detailed Project Report, Local Flood Protection Project, Point Pinole Creek," Contra Costa County, California; U.S. Army Corps of Engineers District, San Francisco, CA; November 1962 (1962 Report).

proposed Demonstration Project. The vertical datum from the 1960's As-Built channel was adjusted up by 2.66 feet to match the current NAVD88 datum.

In order to determine the "uncertainty" portion of the RU analysis, three different scenarios were analyzed with HEC-RAS for the 1965 and 2009 conditions respectively.

- Design condition geometries
- Best conditions geometries
- Worst conditions geometries

The differences between these three scenarios were assumed to be:

- Downstream boundary conditions
- Manning's n-value or channel roughness
- Sediment accumulation

The specific channel geometries for each scenario are discussed in the following sections of this analysis.

Downstream Boundary Condition - Tidal Water Surface Elevation

Based on discussions between Corps staff and the FC District in 2008, it was determined that the beginning water surface used in 1962, without a predicted sea level rise, should be used for the RU analysis[2]. However, to account for the uncertainty in the tidal elevation, a differential of 0.3 feet between the design conditions and best- and worst-conditions models were used. The beginning tidal elevations used as the downstream boundary condition for the HEC-RAS models are summarized in **Table 2**.

Table 2. Tidal Elevations

Design Value	NAVD88
Mean Higher High Water Beginning water surface elevation : **best condition** (design condition -0.3 ft)	**5.46 feet**
Mean Higher High Water Beginning water surface elevation : **design conditions**	**5.76 feet**
Mean Higher High Water Beginning water surface elevation : **worst condition** (design condition +0.3 ft)	**6.06 feet**

2 See 2009 RU Report in Appendix B, pages 7 and 8.

Upstream Boundary Condition and Flow Regime

The HEC-RAS models were run with the mixed flow regime and the upstream boundary conditions were set as normal depth with a slope of 0.003 ft/ft, matching the 1965 As-Built plans around Station 39+00.

1965 As-Built Channel Conditions

A description of the HEC-RAS modeling of the As-Build plans based on the 1960's project is included on page 10 of the 2009 RU Report in **Appendix B**. A summary of the Pinole Creek channel conditions adjacent to the Chelsea Wetland Project for the three scenarios is shown on **Table 3**.

Table 3. As-Built Channel Roughness

Design Value	Channel Bottom "n-value"	Right Bank "n-value"	Left Bank "n-value"
Best Condition (lowest roughness)	0.025	0.03	0.03
Design Condition	0.03	0.03	0.03
Worst Condition* (highest roughness)	0.05	0.05	0.05

*Worst conditions also included 1 foot layer of sediment deposition on the bottom of the channel

Proposed Demonstration Project

A description of the HEC-RAS modeling for the Demonstration Project is included on page 12 of the 2009 RU Report in **Appendix B**. A summary of the Pinole Creek channel conditions adjacent to the Chelsea Wetland Project for the three scenarios is shown on **Table 4**.

Table 4. Demonstration Project Channel Roughness

Design Value	Low Flow Channel "n-value"	Low Terrace "n-value"	Channel bank "n-value"	Top of right bank "n-value"	Top of left bank "n-value"
Best Condition (lowest roughness)	0.025	0.03	0.03	0.03	0.035
Design Condition	0.03	0.035	0.04	0.03	0.035
Worst Condition (highest roughness)	0.035	0.05	0.05	0.03	0.035

Existing Pinole Creek Cross Sections

To insure relevance of the 2009 RU Report for the Chelsea Wetland Project, channel cross sections taken from a 2012 field survey were compared to the cross sections used for the 2009 Demonstration Project and re-modeled in applicable HEC-RAS models. The five cross sections located at Stations 1876.5, 1926.5, 1976.5, 2026.5, and 2076.5 as shown on **Figure 1,** were updated based on existing topography from the 2012 survey. Comparisons between 2012 cross sections and those modeled for the 2009 Proposed Demonstration Project and 1965 As-Built channel are shown on **Figures 2** to **6**.

Figure 1. Plan View of HEC-RAS Cross Section Location

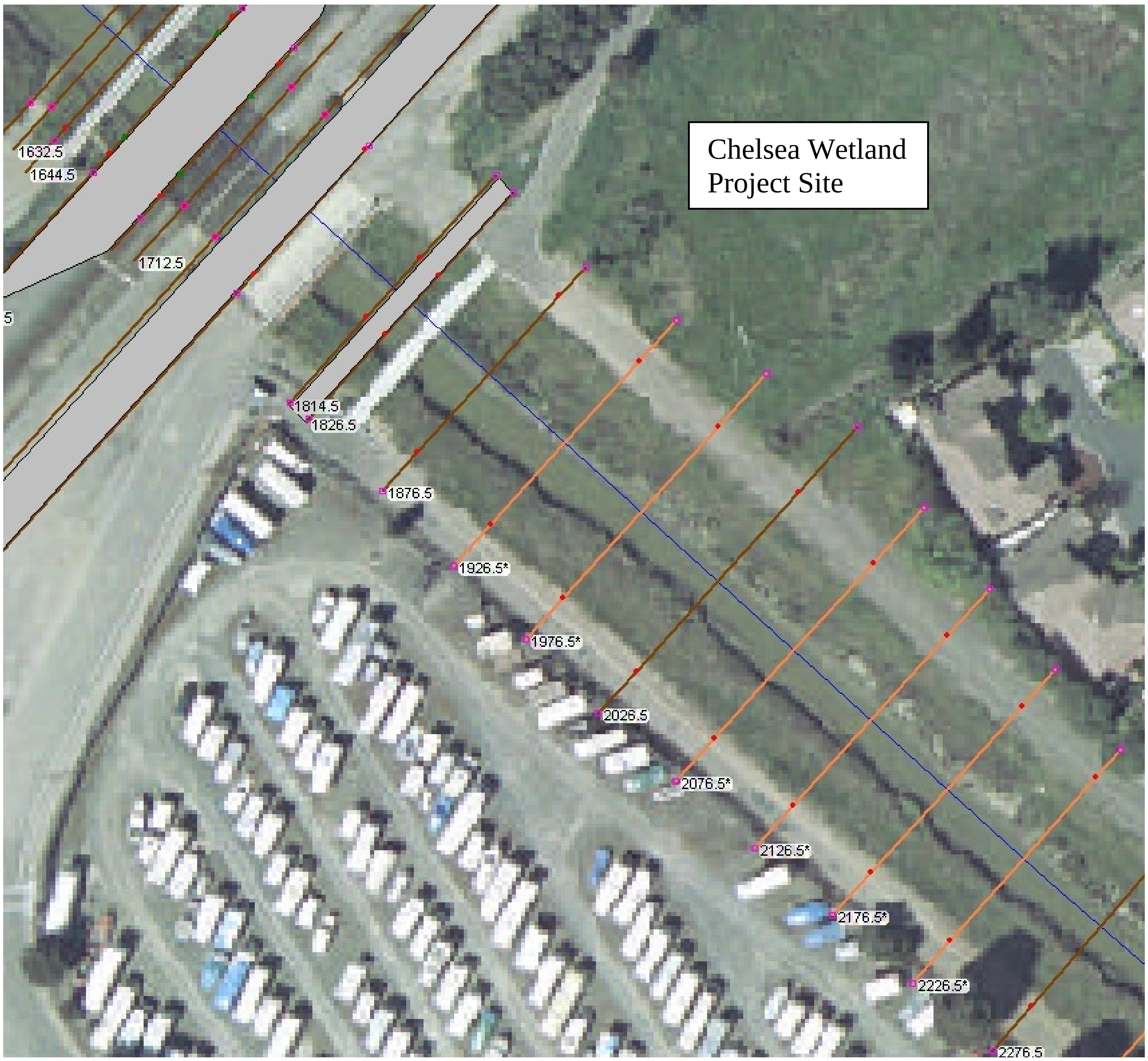


Figure 2. Channel Cross Section Comparison Station 1876.5

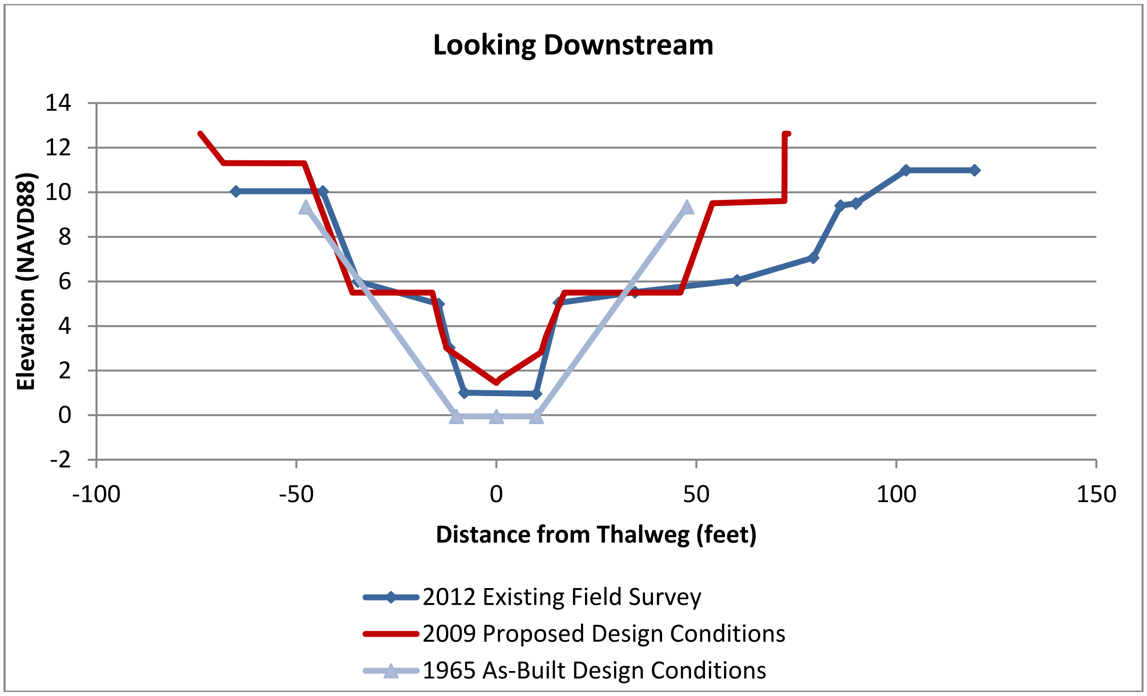


Figure 3. Channel Cross Section Comparison Station 1926.5

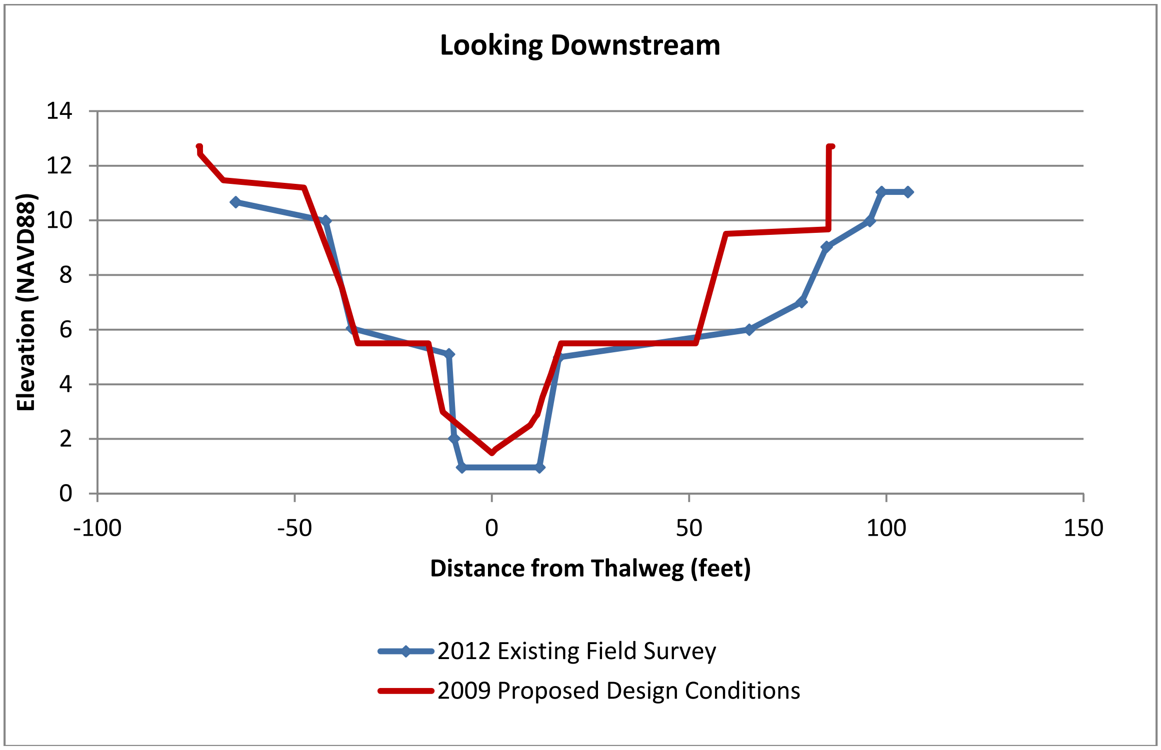


Figure 4. Channel Cross Section Comparison Station 1976.5

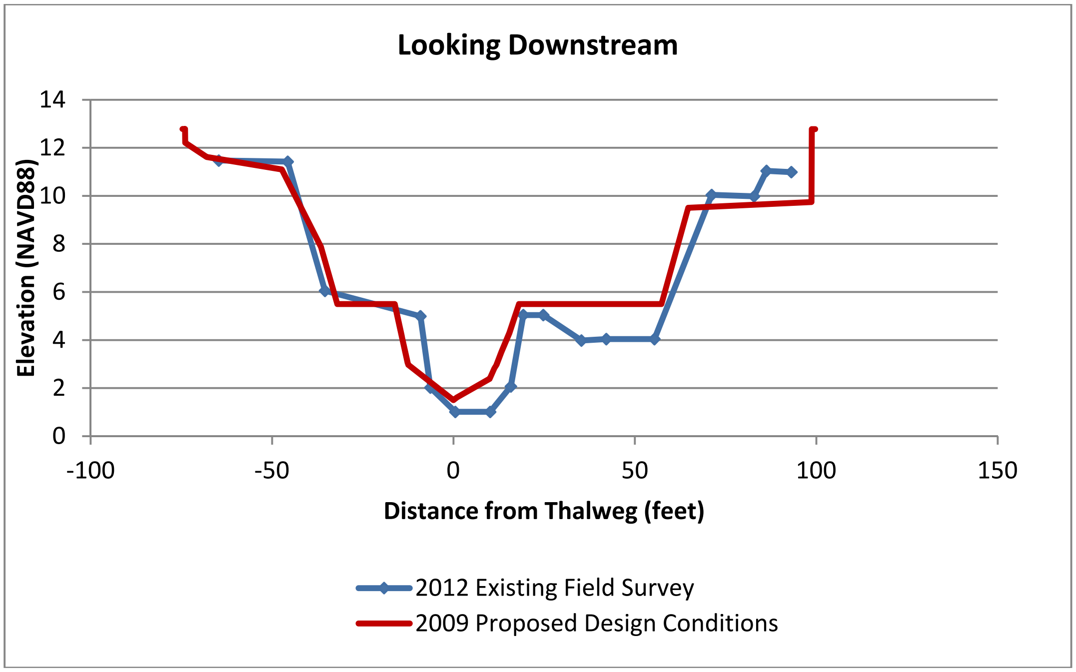


Figure 5. Channel Cross Section Comparison Station 2026.5

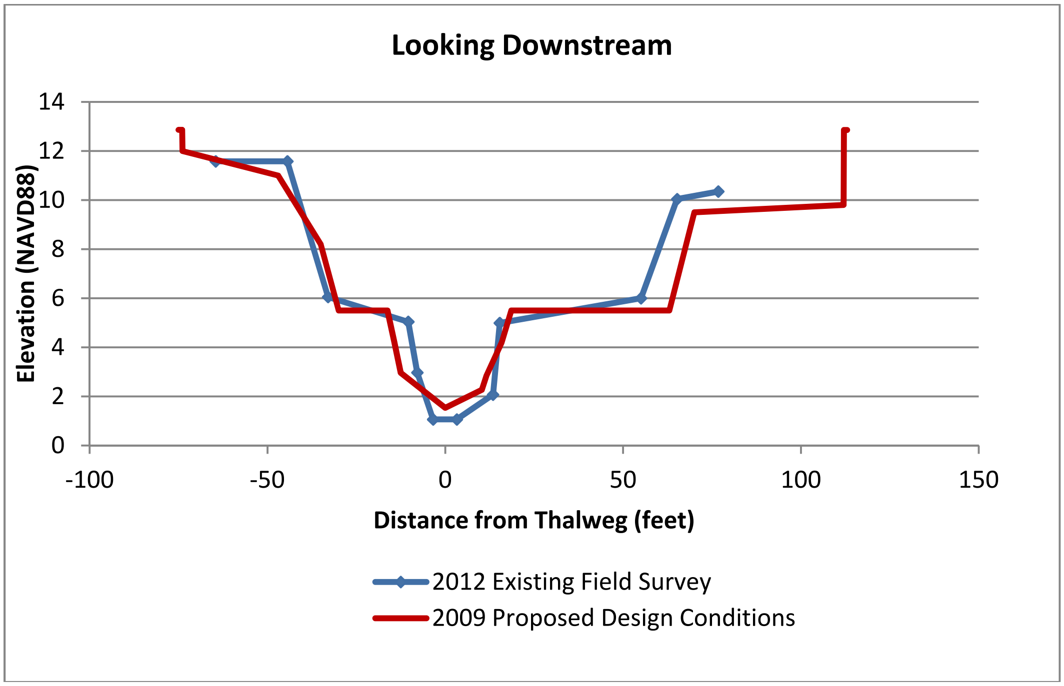
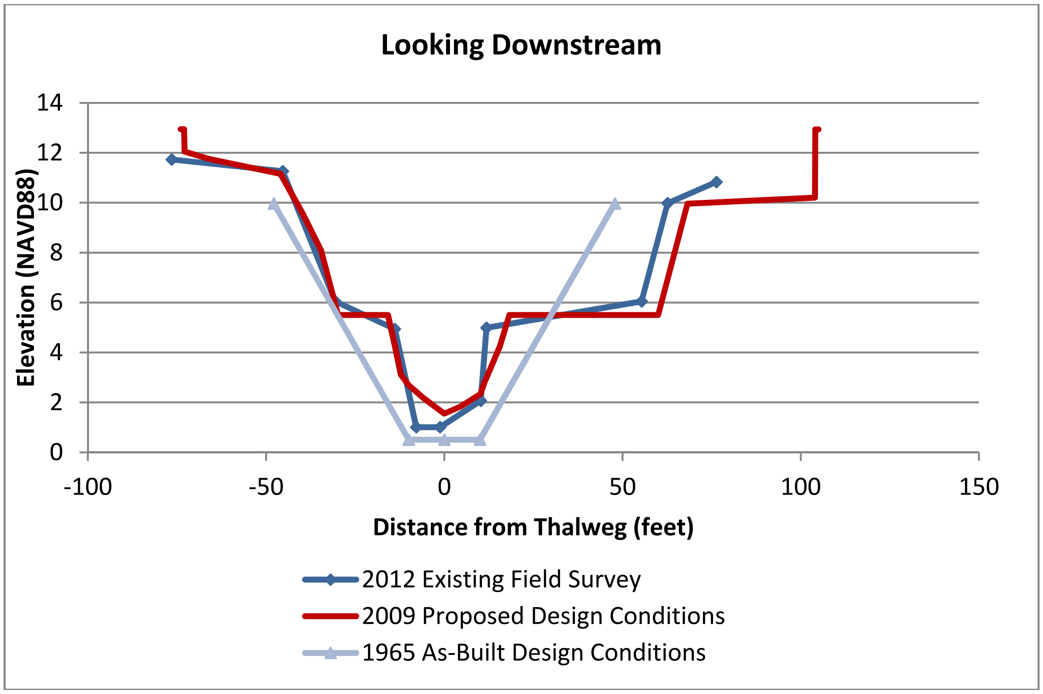


Figure 6. Channel Cross Section Comparison Station 2076.5



Overall, the 2009 Proposed Demonstration Project cross sections and 2012 Existing channel cross sections have very similar geometries. In addition, HEC-RAS outputs from a new model that incorporates the five updated channel cross sections resulted in 100-year water surface elevations that were within 0.07 feet of the water surface elevations predicted during the 2009. The results from this comparison are summarized in **Table 5**. In the 2012 model, the two upstream cross sections have a slight increase in water surface elevation and the two downstream cross sections have a slight decrease in water surface elevations as compared to the 2009 model. No additional upstream effects greater than 0.01 feet are predicted by the 2012 model. Considering these minor difference between the 2009 and 2012 HEC-RAS model results, the HEC-FDA analysis presented in the 2009 RU Report is relevant and adequate for determining the floodwall heights for the proposed Chelsea Wetland Project.

Table 5. HEC-RAS Output Comparisons of 2009 and 2012 Water Surface Elevations

Cross Section Station	100-yr Water Surface Elevation based on 2009 Design (ft NAVD88)	100-yr Water Surface Elevation based on 2012 Survey (ft NAVD88)	Change in 100-yr Water Surface Elevation from 2009 to 2012 (ft)
1876.5	13.78	13.85	-0.07
1926.5	13.82	13.85	-0.03
1976.5	13.85	13.85	0
2026.5	13.87	13.84	0.03
2076.5	13.88	13.86	0.02

4.0 HEC-FDA ANALYSIS

The Corps Hydraulic Engineering Center (HEC) in Davis, California developed a program named "Flood Damage Analysis (HEC-FDA). HEC-FDA was used by the FC District to perform the RU analysis on the 1965 As-Built project to determine the target conditional non-exceedance probability (CNP). The FC District also used HEC-FDA to perform the RU analysis on the channel modifications proposed by the Demonstration Project to establish the levee/floodwall heights required to meet or exceed the 1965 As-Built performance.

A description of the HEC-FDA modeling is included on page 14 of the 2009 RU Report in **Appendix B**. As defined in the 2009 RU Report, the proposed Chelsea Wetland Restoration Project is located within the following Damage Reach:

- Damage Reach Station: 19+00
- Beginning Station (downstream): 17+42
- Ending Station (upstream): 21+26.5
- Actual Modeled Damage Reach Station: 18+76.5
- Range Represented: RR Bridge to Upstream of Chelsea Marsh

For Damage Reach 19+00, the HEC-FDA final outputs are shown in **Tables 5** and **6**, using a 1965 As-Built levee elevation of 9.35 feet and a 2009 Proposed floodwall top height of 13.78 feet.

Table 6. HEC-FDA Results – Target Stage Annual Exceedance Probability and Long Term Risk

Plan and Stream Name	Damage Reach	Target Stage Annual Exceedance Probability		Long-Term Risk (years)		
		Median	Expected	10	25	50
Pinole Creek 1965 As-Built	19+00	0.0090	0.0180	0.1685	0.3696	0.6026
Pinole Creek with Proposed Demonstration Project	19+00	0.0100	0.0170	0.1581	0.3496	0.5770

Table 7. HEC-FDA Results – Conditional Non-Exceedance Probability

Plan and Stream Name	Damage Reach	Conditional Non-Exceedance Probability by Events					
		10%	4%	2%	1%	0.4%	0.2%
Pinole Creek 1965 As-Built	19+00	0.9947	0.8839	0.6733	0.4320	0.1943	0.0942
Pinole Creek with Proposed Demonstration Project	19+00	0.9970	0.9017	0.6966	0.4499	0.2006	0.0958

5.0 CONCLUSION

The results from the 2009 RU Report for Damage Reach 19+00 can be used for the Chelsea Wetland Restoration Project considering that no significant changes to the Pinole Creek channel cross section geometries are proposed under this project and that recent field survey data and HEC-RAS modeling results are closely aligned with the 2009 analysis.

The 2009 RU Report was completed using the 1965 As-Built plans and design flows to determine target conditional non-exceedance probabilities which were then used to determine appropriate levee/floodwall heights along Pinole Creek for the Demonstration Project. The Chelsea Wetland Restoration Project incorporates new floodwalls with top elevations of 14 feet (NAVD88) that will tie into an existing floodwall along the north bank of Pinole Creek. This is higher than the elevation of 13.78 feet as recommended in the 2009 RU Report for Damage Reach 19+00 and therefore will have a conditional non-exceedance probability equal to or greater than the original 1960's Corps project.

Appendix A

DUCKS UNLIMITED

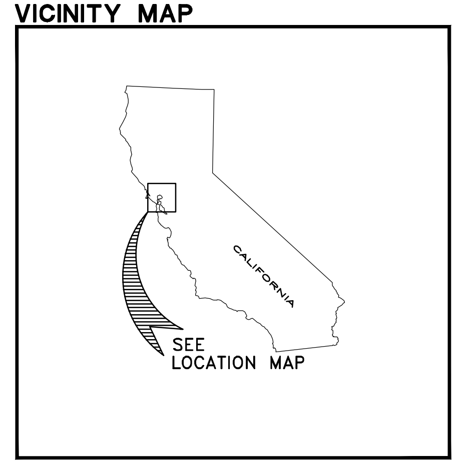
US-CA-517-1
CHELSEA WETLAND RESTORATION PROJECT

DUCKS UNLIMITED, INC.
WESTERN REGIONAL OFFICE
3074 GOLD CANAL DRIVE
RANCHO CORDOVA, CA. 95670-6116
PH. (916) 852-2000

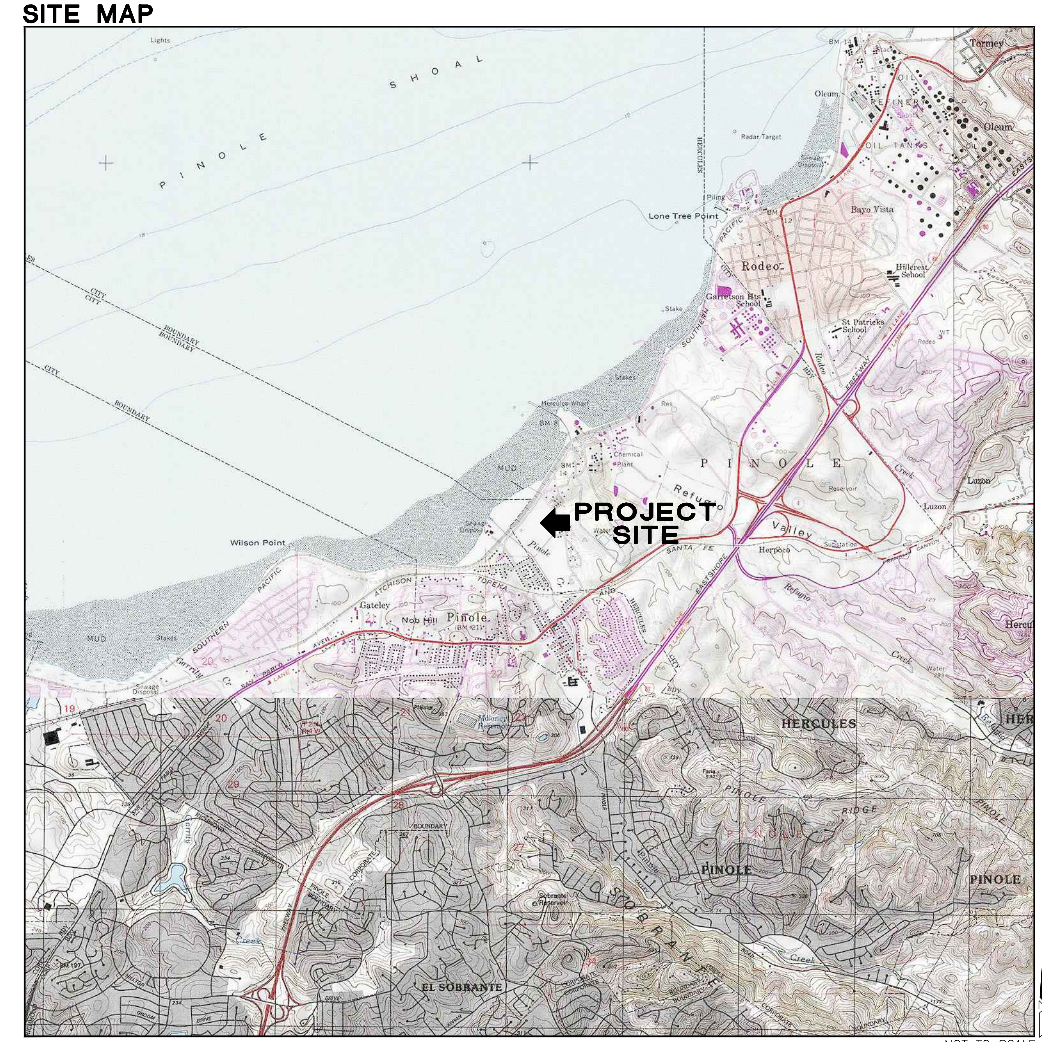
LOCATION MAP

NOT TO SCALE

VICINITY MAP



SITE MAP



NOT TO SCALE

SHEET INDEX

PRELIMINARY
NOT FOR CONSTRUCTION

Utility Notification Center
CALL BEFORE YOU DIG

SURVEY DATUM

The horizontal datum for this survey is the California Coordinate System of 1983, Zone 3 (0403), NAD 83 (2011), Epoch Date 2010.00 in U.S. Survey Feet. The vertical datum for this survey is the North American Vertical Datum of 1988 (NAVD88) computed using GEOID12. Both datums were derived from Static GPS observations corrected using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) program. Static GPS observations were collected on May 7, 2013. The NGS OPUS Solution Report is on file at the WRO engineering department in Rancho Cordova, California.

CONTOUR INTERVAL: 1 FOOT

REVISIONS

REV. NO.	DESCRIPTION	DATE	APPROVED
5			
4			
3			
2			
1			

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

PROJECT NO. US-CA-517-1			DESIGNED BY: BW
CHELSEA WETLAND RESTORATION PROJECT COVER SHEET			DRAWN BY: DW
			SURVEYED BY: JM
			CHECKED BY: VT
APPROVED BY:	APPROVED BY:	DATE: 10/10/2013	SHEET NO. 1 of 6

GENERAL NOTES:

1. DUCKS UNLIMITED MAKES NO REPRESENTATIONS AS TO THE EXISTENCE OR NONEXISTENCE OF UTILITIES. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO COMPLY WITH THE PROVISIONS OF ALL APPLICABLE UTILITY NOTIFICATION REGULATIONS. THE CONTRACTOR IS RESPONSIBLE FOR LOCATING UTILITIES PRIOR TO THE START OF CONSTRUCTION. THE CONTRACTOR WILL BE LIABLE FOR ANY DAMAGE TO UTILITIES CAUSED BY CONSTRUCTION ACTIVITIES.
2. IN ACCORDANCE WITH GENERALLY ACCEPTED CONSTRUCTION PRACTICES THE CONTRACTOR WILL BE SOLELY AND COMPLETELY RESPONSIBLE FOR THE CONDITIONS OF THE JOB SITE INCLUDING SAFETY OF ALL PERSONS AND PROPERTY DURING PERFORMANCE OF THE WORK. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN AND CONSTRUCTION OF PROPER SHORING OF TRENCHES IN ACCORDANCE WITH OCCUPATIONAL SAFETY LAWS. THE DUTIES OF THE PROJECT ENGINEER DO NOT INCLUDE REVIEW OF THE ADEQUACY OF THE CONTRACTORS SAFETY IN, ON, OR NEAR THE JOB SITE.
3. SHOULD THE CONTRACTOR FIND ANY DISCREPANCIES BETWEEN THE CONDITIONS EXISTING IN THE FIELD AND THE INFORMATION SHOWN ON THE DRAWINGS, HE SHALL NOTIFY THE ENGINEER BEFORE PROCEEDING WITH CONSTRUCTION.
4. SHOULD IT APPEAR THAT THE WORK TO BE DONE, OR ANY MATTER RELATIVE THERETO, IS NOT SUFFICIENTLY DETAILED OR EXPLAINED ON THESE PLANS OR IN THE SPECIFICATIONS, THE CONTRACTOR SHALL CONTACT THE PROJECT ENGINEER FOR SUCH FURTHER EXPLANATIONS AS MAY BE NECESSARY.
5. CONTRACTOR TO CONTACT UNDERGROUND SERVICE ALERT (U.S.A.) 48 HOURS MINIMUM PRIOR COMMENCING ONSITE ACTIVITIES FOR UTILITY SERVICE LOCATIONS PHONE = 1-800-227-2600 -OR- 1-800-642-2444

SURVEY POINT DESCRIPTORS

CTBM	Bench Mark (permanent)	TFTR	Tree
CTBT	Bench Mark (temporary)	TFVP	Vernal Pool Edge
CTCP	Survey Control Point (permanent)	ELBX	Electric, Box or Pullbox
CTCT	Survey Control Point (temporary)	ELGY	Electric, Guy Wire to Pole
DIFL	Ditch Flowline	ELOH	Electric, Overhead
DIGB	Ditch Grade Break	ELMT	Electric, Meter
DITO	Ditch Toe	ELPP	Electric, Power Pole
DITP	Ditch Top	ELSN	Electric, Warning Sign
SWFL	Swale Flowline	ELTR	Electric, Transformer
SWGB	Swale Grade Break	ELTW	Electric, Tower
SWTO	Swale Toe	ELUG	Electric, Underground
SWTP	Swale Top	ELVT	Electric, Vault
IRCO	Irrigation Concrete Pad	NGMT	Natural Gas, Meter
IRCP	Irrigation Control Panel	NGPI	Natural Gas, Pipe
IRPI	Irrigation Pipe Invert	NGSN	Natural Gas, Warning Sign
IRPM	Irrigation Pump	NGVL	Natural Gas, Valve
IRPT	Irrigation Pipe Top	SDMH	Storm Drain, Manhole
IRVL	Irrigation Valve	SDPI	Storm Drain, Pipe Invert
IRWL	Irrigation Well	SDPT	Storm Drain, Pipe Top
FNAP	Fence Angle Point	SSCO	Sanitary Sewer, Cleanout
FNCR	Fence Corner	SSMH	Sanitary Sewer, Manhole
FNGT	Fence Gate	SSPI	Sanitary Sewer, Pipe Invert
FNLN	Fence Line	SSSV	Sanitary Sewer, Service
LVCL	Levee Centerline	TEGY	Telephone, Guy Wire to Pole
LVGB	Levee Grade Break	TEOH	Telephone, Overhead
LVTO	Levee Toe of Slope	TERI	Telephone, Riser
LVTP	Levee Top of Slope	TESN	Telephone, Warning Sign
RDCL	Road, Centerline	TETP	Telephone, Pole
RDED	Road, Edge of Dirt Road	TEUG	Telephone, Underground
RDEG	Road, Edge of Gravel Road	WTFH	Water Fire Hydrant
RDEP	Road, Edge of Paved Road	WTHW	Water High Water
RDFC	Road, Face of Curb	WTMT	Water Meter
RDFL	Road, Gutter Flowline	WTPI	Water Pipe
RDGB	Road Grade Break	WTPM	Water Pump
RDSH	Road Shoulder	WTVL	Water Valve
RDSN	Road Sign	WTWL	Water Well
RDST	Road, Painted Stripe	WAEW	Edge of Water
RDTC	Road, Top Back of Curb	WAHW	High Water Mark
RDTO	Road, Toe of Slope	WAUW	Under Water Ground Shot
RDTP	Road, Top of Slope	WAWS	Water Surface
RDTW	Road, Top Back of Walk	WCFL	Water Control Structure, Flowline/Invert at Structure
TFBL	Building	WCHW	Water Control Structure, Headwall
TFBR	Brush	WCPI	Water Control Structure, Pipe Invert at Outlet
TFCO	Concrete (pad, slab, etc.)	WCPT	Water Control Structure, Pipe Top at Outlet
TFGB	Grade Break	WCST	Water Control Structure, Top of Structure
TFGS	Ground Shot	WCWW	Water Control Structure, Wing Wall
TFRK	Rock Or Rocky Area Boundary		
TFTO	Grade Break at Toe		
TFTP	Grade Break at Top		
TFTL	Tree line		

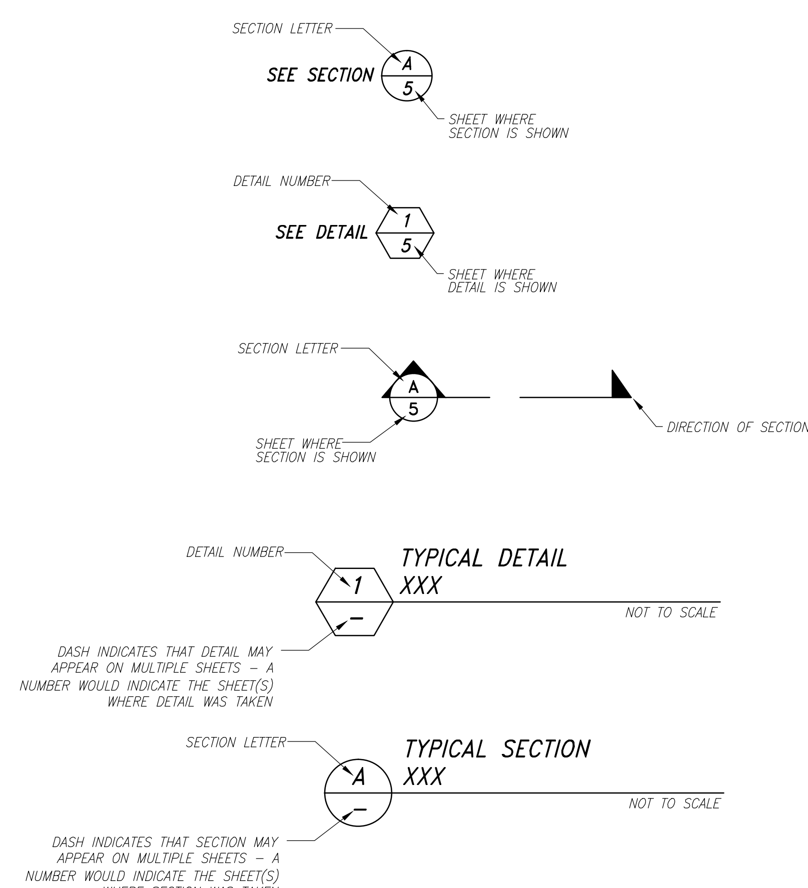
UNAUTHORIZED CHANGES & USES

THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR, UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

ABBREVIATIONS

A.B.	AGGREGATE BASE	MISC	MISCELLANEOUS
AC	ACRE	N	NORTH
CAP	CORRUGATED ALUMINUM PIPE	NTS	NOT TO SCALE
CC	CENTER TO CENTER	OC	ON CENTER
CL	CENTERLINE	OD	OUTSIDE DIAMETER
CMP	CORRUGATED METAL PIPE	PP	POWER POLE
CMPA	CORRUGATED METAL ARCH PIPE	PSI	POUNDS PER SQUARE INCH
CONC	CONCRETE	PVC	POLYVINYL CHLORIDE
DIA	DIAMETER	R	RIGHT
Dp	PIPE DIAMETER	RCB	REINFORCED CONCRETE BOX
Dr	RISER DIAMETER	RD	ROAD
DU	DUCKS UNLIMITED, INC.	REF	REFERENCE DIMENSION
E	EAST	REQD	REQUIRED
EG	EXISTING GROUND	S	SOUTH
EL	ELEVATION	SCH	SCHEDULE
EX	EXISTING	SF	SQUARE FEET
FB	FLASHBOARD	SP	SPECIAL
FG	FINISH GRADE	SY	SQUARE YARD
FL	FLOWLINE	STA	STATION
FT	FOOT, FEET	TBD	TO BE DETERMINED BY ENGINEER
FTG	FITTING, FOOTING	TE	TOP ELEVATION
GA	GAUGE	TOL	TOP OF LEVEE
H	HEIGHT	TOB	TOP OF BERM
HDPE	HIGH-DENSITY POLYETHYLENE	TYP	TYPICAL
ID	INSIDE DIAMETER	USA	UNDERGROUND SERVICE ALERT
IE	INVERT ELEVATION	VLV	VALVE
IN	INCH, INCHES	W	WIDTH
L	LENGTH, LEFT	W	WEST (WHERE APPLICABLE)
LBF	POUNDS-FORCE	W/	WITH
LF	LINEAR FEET	WCS	WATER CONTROL STRUCTURE
MAX	MAXIMUM	WS	WATER SURFACE
MIN	MINIMUM	WSEL	WATER SURFACE ELEVATION
		WWF	WELDED WIRE FABRIC

DETAILING CONVENTIONS



LEGEND & STANDARD SYMBOLS

NEW	EXISTING
TULES	EX BLIND
NEW SLOPE SYMBOL	EX SLOPE SYMBOL
NEW LEVEE SECTION OR ELEVATION CHANGE POINT	EX LEVEE SECTION OR ELEVATION CHANGE POINT
NEW ELECTRIC SIGN	EX ELECTRIC SIGN
NEW ELECTRIC GUY WIRE	EX ELECTRIC GUY WIRE
NEW ELECTRIC METER	EX ELECTRIC METER
NEW ELECTRIC/TELEPHONE POLE	EX ELECTRIC/TELEPHONE POLE
NEW ELECTRIC TRANSFORMER	EX ELECTRIC TRANSFORMER
NEW ELECTRIC TOWER	EX ELECTRIC TOWER
NEW ELECTRIC VAULT	EX ELECTRIC VAULT
NEW GATE VALVE	EX GATE VALVE
NEW PRESSURE REDUCTION VALVE	EX PRESSURE REDUCTION VALVE
NEW AIR RELIEF VALVE	EX AIR RELIEF VALVE
NEW BACKFLOW PREVENTER	EX BACKFLOW PREVENTER
NEW IRRIGATION WELL	EX IRRIGATION WELL
NEW IRRIGATION PUMP	EX IRRIGATION PUMP
	EX WATER METER
	EX FIRE HYDRANT
	EX MANHOLE
	EX DRAIN INLET
	EX SEWER CLEANOUT
NEW PIPE WITH CANAL GATE	EX PIPE WITH CANAL GATE
NEW FULL ROUND RISER	EX FULL ROUND RISER
NEW HALF ROUND RISER	EX HALF ROUND RISER
NEW PRECAST CONCRETE RISER	EX PRECAST CONCRETE RISER
NEW WATER CONTROL FLARED END SECTION	EX WATER CONTROL FLARED END SECTION
NEW WATER CONTROL OUTLET STRUCTURE	EX WATER CONTROL OUTLET STRUCTURE
NEW NATURAL GAS VALVE	EX NATURAL GAS VALVE
	EX NATURAL GAS METER
	EX NATURAL GAS SIGN
NEW BENCHMARK	EX BENCHMARK
NEW TEMPORARY BENCHMARK	EX TEMPORARY BENCHMARK
NEW CONTROL POINT	EX CONTROL POINT
NEW CONTROL POINT	EX CONTROL POINT
NEW SECTION CORNER	EX SECTION CORNER

Line	Description
X	EX FENCE LINE
OH	POWER/TELEPHONE OVERHEAD LINES
G	UNDERGROUND GAS LINE
SS	EXISTING SEWER MAIN
SD	EXISTING STORM DRAIN
FM	EXISTING SEWER FORCE MAIN
TOP / TOE / TOE / TOP	DITCH TOP / TOE EX DITCH FLOWLINE DITCH TOP / TOE
TOE / TOP / TOP / TOE	LEVEE TOP / TOE EX LEVEE CENTERLINE LEVEE TOP / TOE
EDGE / EDGE	ROAD EDGE EX ROAD CENTERLINE ROAD EDGE
	EX SWALE FLOWLINE
	NEW SWALE
	NEW LEVEE
	IMPROVED LEVEE
	REMOVE EX LEVEE
	NEW VINYL SHEETPILE FLOODWALL

REVISION NUMBER IDENTIFIER

EX TREES TO BE REMOVED

PRELIMINARY

SURVEY DATUM

The horizontal datum for this survey is the California Coordinate System of 1983, Zone 3 (0403), NAD 83 (2011), Epoch Date 2010.00 in U.S. Survey Feet. The vertical datum for this survey is the North American Vertical Datum of 1988 (NAVD88) computed using GEOID12. Both datums were derived from Static GPS observations corrected using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) program. Static GPS observations were collected on May 7, 2013. The NGS OPUS Solution Report is on file at the WRO engineering department in Rancho Cordova, California.

CONTOUR INTERVAL: 1 FOOT

REVISIONS

REV. NO.	DESCRIPTION	DATE	APPROVED
1			
2			
3			
4			
5			

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

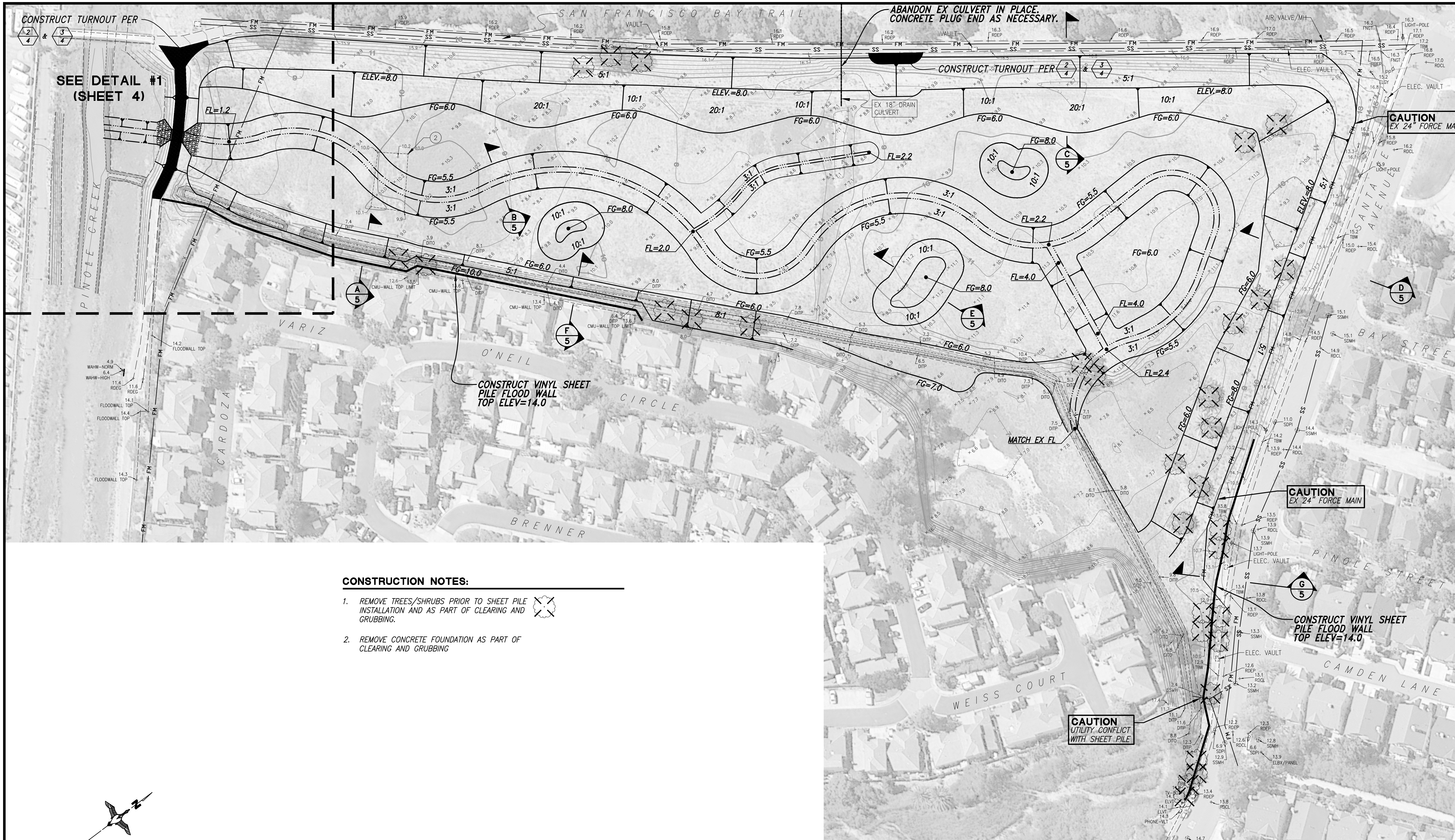
DATE: 10/10/2013

PROJECT NO. US-CA-517-1

CHELSEA WETLAND RESTORATION PROJECT

DEFINITIONS, ABBREVIATIONS & LEGEND

DESIGNED BY: BW
DRAWN BY: DW
SURVEYED BY: JM
CHECKED BY: VT



CONSTRUCTION NOTES:

1. REMOVE TREES/SHRUBS PRIOR TO SHEET PILE INSTALLATION AND AS PART OF CLEARING AND GRUBBING.
2. REMOVE CONCRETE FOUNDATION AS PART OF CLEARING AND GRUBBING.

BAR SCALE
0 50 100 150

UNAUTHORIZED CHANGES & USES

THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR, UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

PRELIMINARY

SURVEY DATUM

The horizontal datum for this survey is the California Coordinate System of 1983, Zone 3 (0403), NAD 83 (2011), Epoch Date 2010.00 in U.S. Survey Feet. The vertical datum for this survey is the North American Vertical Datum of 1988 (NAVD88) computed using GEOID12. Both datums were derived from Static GPS observations corrected using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) program. Static GPS observations were collected on May 7, 2013. The NGS OPUS Solution Report is on file at the WRO engineering department in Rancho Cordova, California.

CONTOUR INTERVAL: 1 FOOT

REVISIONS

REV. NO.	DESCRIPTION	DATE	APPROVED
5			
4			
3			
2			
1			

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

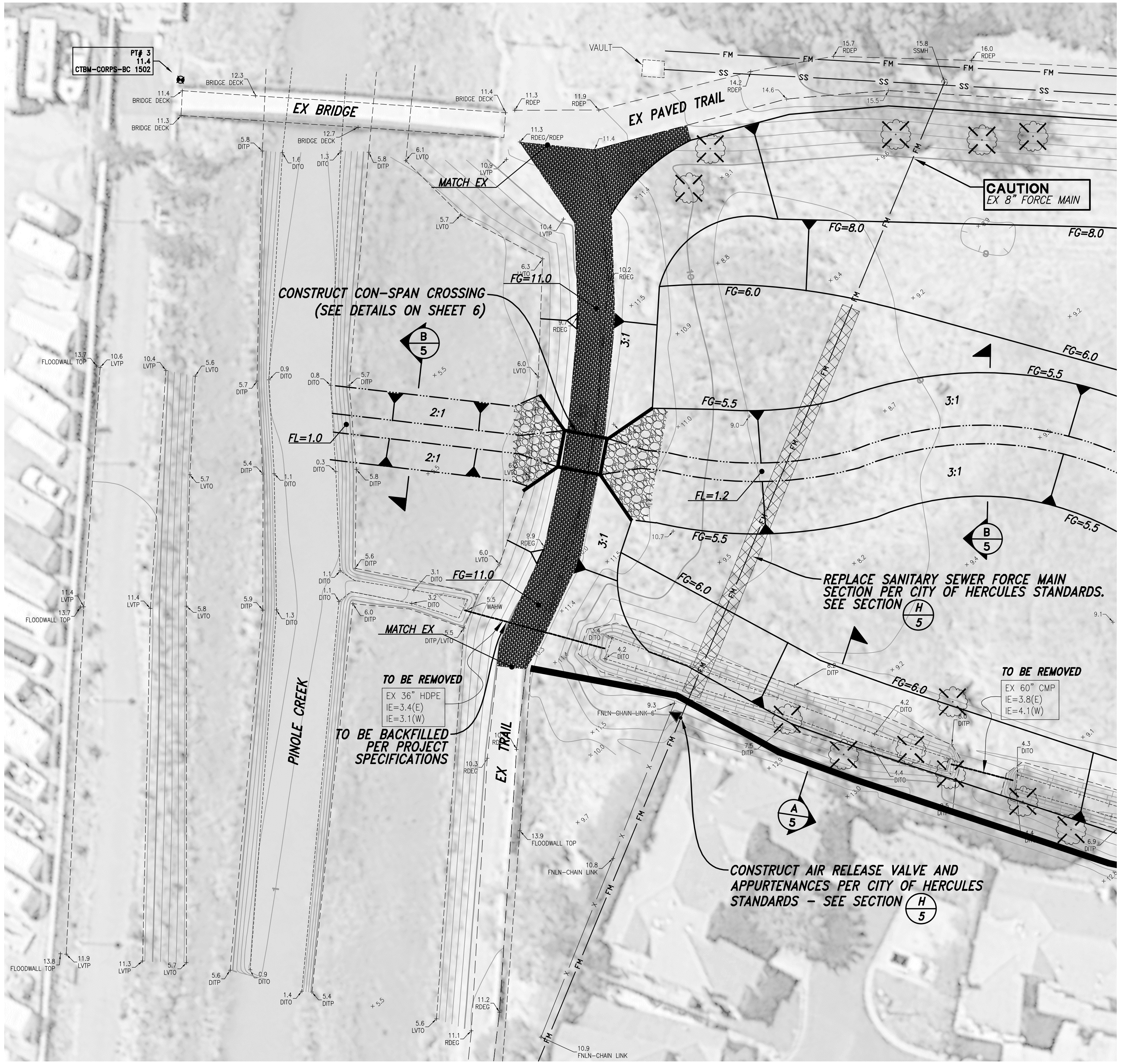
DATE: 10/10/2013

PROJECT NO. US-CA-517-1

CHELSEA WETLAND RESTORATION PROJECT

PLAN SHEET

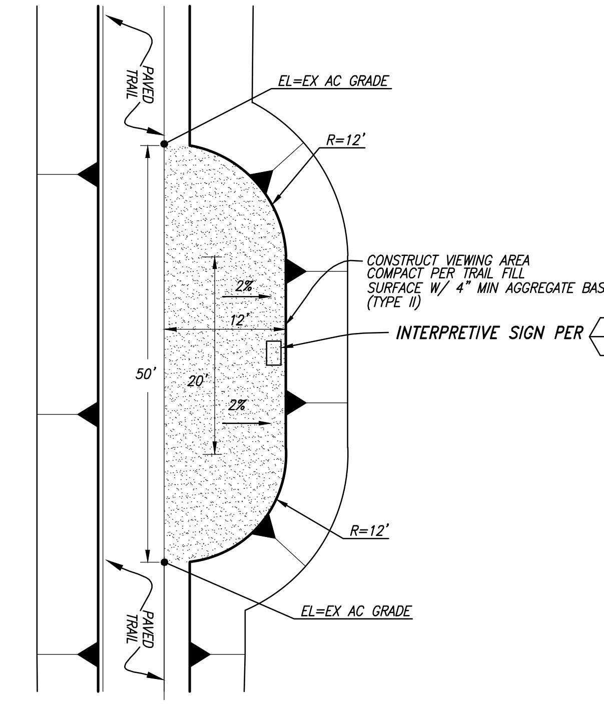
DESIGNED BY:	BW
DRAWN BY:	DW
SURVEYED BY:	JM
CHECKED BY:	VT
SHEET NO.	3 of 6



1 DETAIL – GRADING & CON-SPAN CULVERT

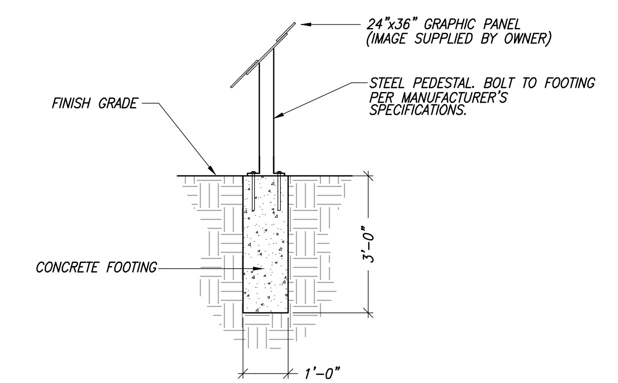
CONSTRUCTION NOTES:

1. REMOVE TREES/SHRUBS PRIOR TO SHEET PILE INSTALLATION AND AS PART OF CLEARING AND GRUBBING.
2. REMOVE CONCRETE FOUNDATION AS PART OF CLEARING AND GRUBBING.



2 TYPICAL DETAIL – BAY TRAIL TURNOUT

NOT TO SCALE



1. DISPLAY PANEL SHALL BE ½" DIGITAL HIGH PRESSURE LAMINATE, PANNIER GRAPHICS, 1-800-544-8428 OR APPROVED EQUAL.
2. STEEL PEDESTAL SHALL BE A3 PEDESTAL, AS MANUFACTURED BY HOPEWELL MANUFACTURING INC., 301-582-2342 OR APPROVED EQUAL.
3. DISPLAY PANEL SHALL BE MOUNTED TO THE PEDESTAL WITH STAINLESS STEEL THREADED INSERTS AND VANDAL RESISTANT SCREWS INSTALLED IN THE BACK OF THE PANELS

3 TYPICAL DETAIL – INTERPRETIVE SIGN

NOT TO SCALE

BAR SCALE

0 20 40 60

UNAUTHORIZED CHANGES & USES

THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR, UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

SURVEY DATUM

The horizontal datum for this survey is the California Coordinate System of 1983, Zone 3 (0403), NAD 83 (2011), Epoch Date 2010.00 in U.S. Survey Feet. The vertical datum for this survey is the North American Vertical Datum of 1988 (NAVD88) computed using GEOID12. Both datums were derived from Static GPS observations corrected using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) program. Static GPS observations were collected on May 7, 2013. The NGS OPUS Solution Report is on file at the WRO engineering department in Rancho Cordova, California.

CONTOUR INTERVAL: 1 FOOT

REVISIONS			
REV. NO.	DESCRIPTION	DATE	APPROVED
5			
4			
3			
2			
1			

PRELIMINARY

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

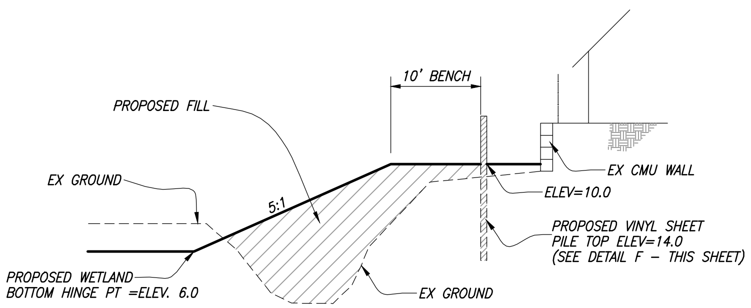
DATE: 10/10/2013

PROJECT NO. US-CA-517-1

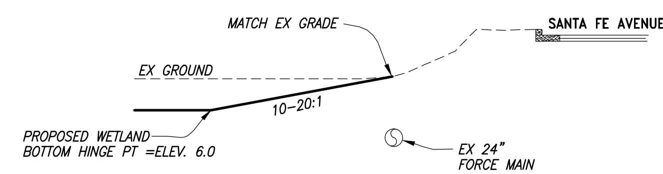
CHELSEA WETLAND RESTORATION PROJECT

DETAILS

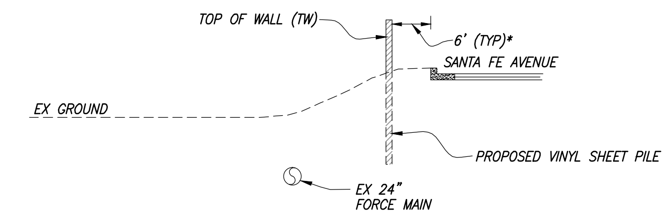
DESIGNED BY:	BW
DRAWN BY:	DW
SURVEYED BY:	JM
CHECKED BY:	VT
SHEET NO.	4 of 6



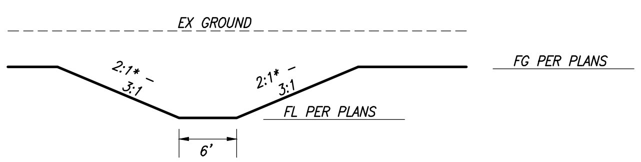
A – TYPICAL SECTION – DITCH GRADING
NOT TO SCALE



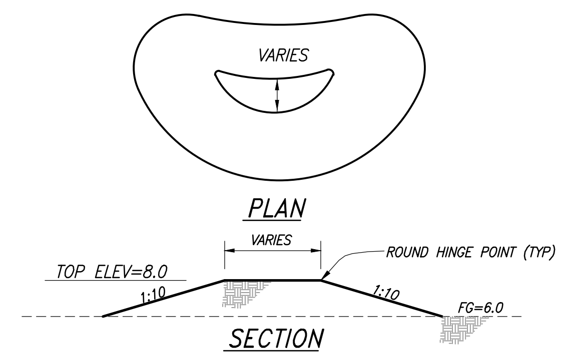
D – SANTA FE ROAD SECTION
NOT TO SCALE



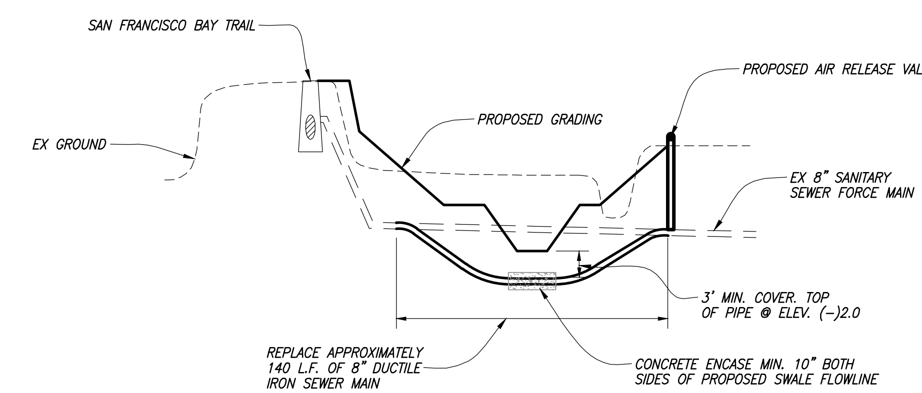
G – SANTA FE ROAD SECTION WITH SHEET PILE
NOT TO SCALE
*DISTANCE VARIES DUE TO CONFLICTS WITH UTILITIES



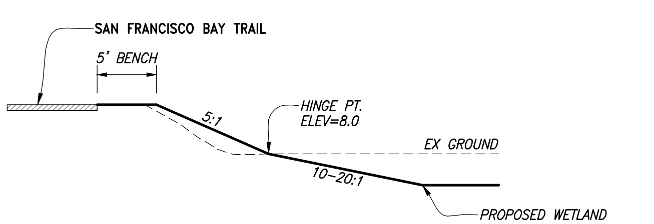
B – TYPICAL SECTION – SWALE
NOT TO SCALE
*SIDE SLOPES AS SHOWN ON PLANS



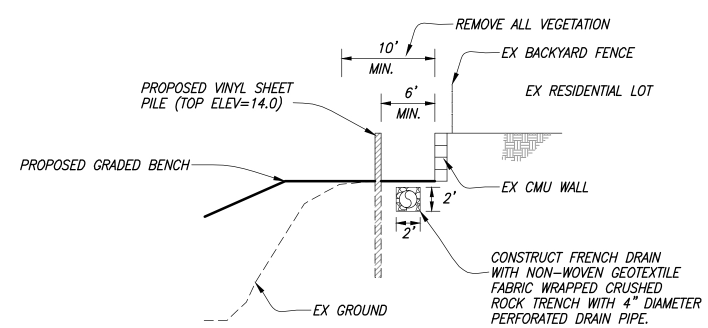
E – WETLAND MOUND DETAIL
NOT TO SCALE



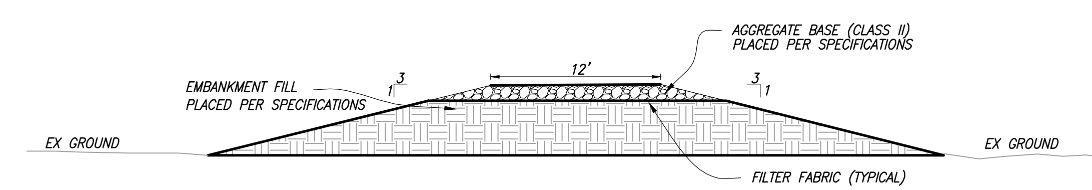
H – REPLACEMENT OF FORCE MAIN
NOT TO SCALE



C – SAN FRANCISCO BAY TRAIL SECTION
NOT TO SCALE



F – TYPICAL SECTION – FRENCH DRAIN
NOT TO SCALE



I – PINOLE CREEK LEVEE ACCESS
NOT TO SCALE

PRELIMINARY

UNAUTHORIZED CHANGES & USES
THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR, UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

SURVEY DATUM
The horizontal datum for this survey is the California Coordinate System of 1983, Zone 3 (0403), NAD 83 (2011), Epoch Date 2010.00 in U.S. Survey Feet. The vertical datum for this survey is the North American Vertical Datum of 1988 (NAVD88) computed using GEOID12. Both datums were derived from Static GPS observations corrected using the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) program. Static GPS observations were collected on May 7, 2013. The NGS OPUS Solution Report is on file at the WRO engineering department in Rancho Cordova, California.
CONTOUR INTERVAL: 1 FOOT

REVISIONS

REV. NO.	DESCRIPTION	DATE	APPROVED
5			
4			
3			
2			
1			

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE
DATE: 10/10/2013

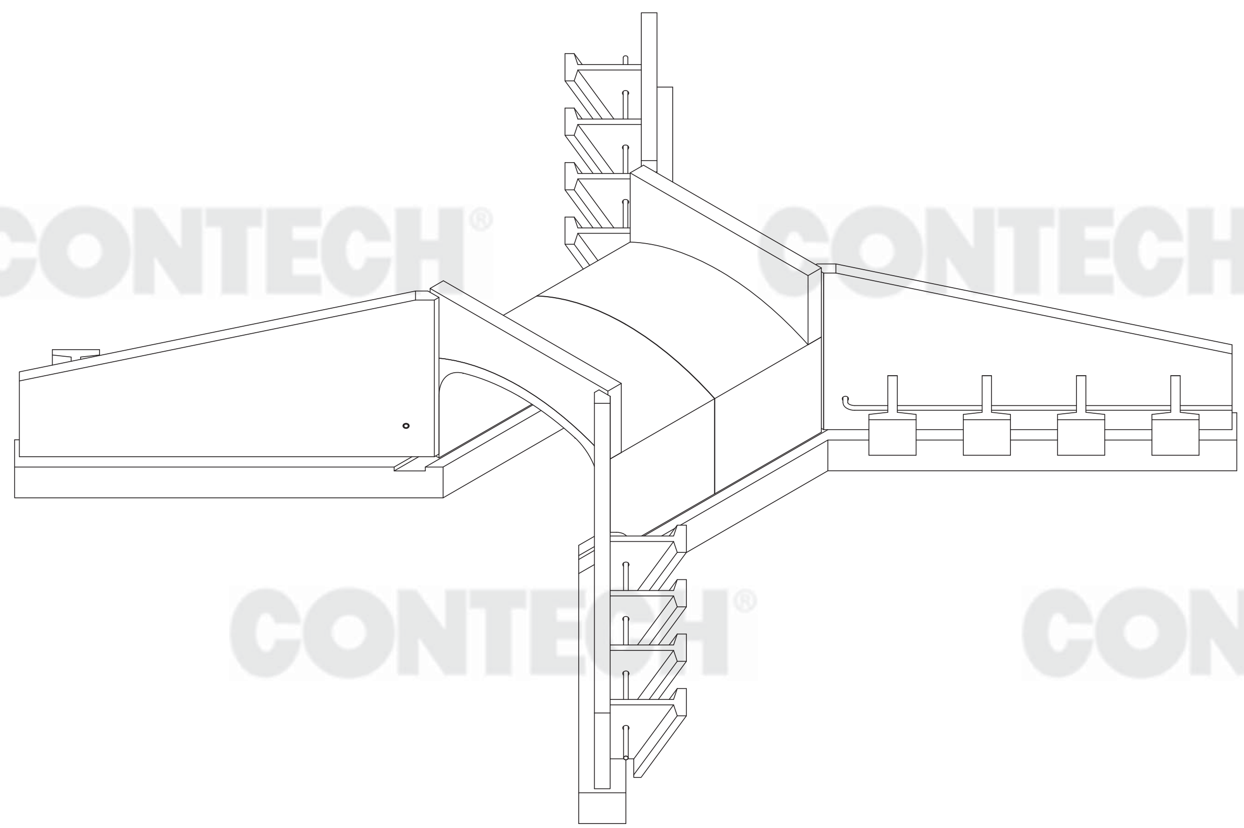
PROJECT NO. US–CA–517–1
CHELSEA WETLAND RESTORATION PROJECT
DETAIL SHEET

DESIGNED BY: BW
DRAWN BY: DW
SURVEYED BY: JM
CHECKED BY: VT
SHEET NO. 5 of 6

BRIDGE SUMMARY

1 cell of CON/SPAN® Bridge System 12' Span x 6'-10" Rise
Length: 16'
Downstream Headwall: Height= 3' from arch crown.
Upstream Headwall: Height= 3' from arch crown.
Wingwall 1: Length= 22' - Angle= 45° - End Height= 4'-11"
Wingwall 2: Length= 22' - Angle= 45° - End Height= 4'-11"
Wingwall 3: Length= 22' - Angle= 45° - End Height= 4'-11"
Wingwall 4: Length= 22' - Angle= 45° - End Height= 4'-11"

Upstream



Downstream

ISOMETRIC VIEW

CONTECH® CONSTRUCTION PRODUCTS INC.
www.contech-cpi.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

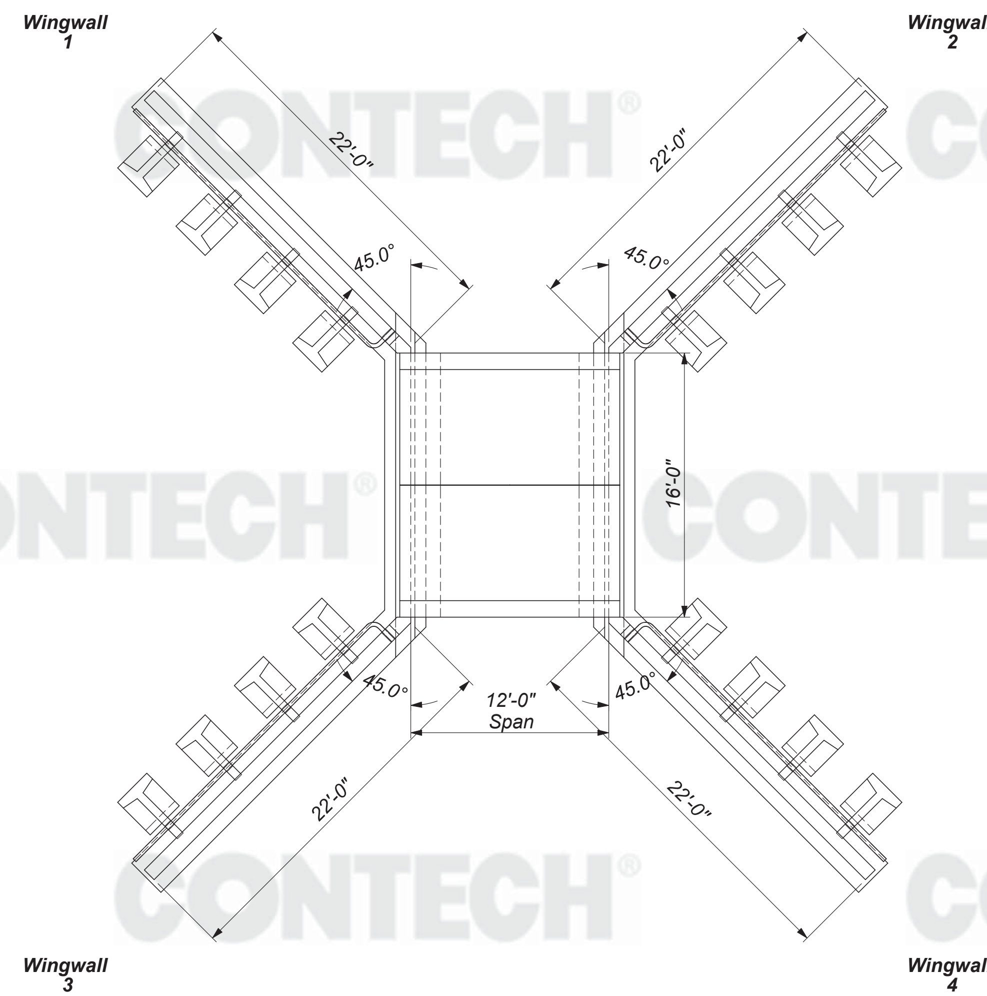
CON/SPAN® BRIDGE SYSTEMS
CONTECH DYOB DRAWING

Chelsea Wetlands

Herculies, CA

PROJECT NUMBER: 139137	DATE: 11/04/13
DESIGNED: DYOB	DRAWN: DYOB
CHECKED:	APPROVED:
SHEET NO.: 1 OF 3	

Upstream



Downstream

BRIDGE PLAN

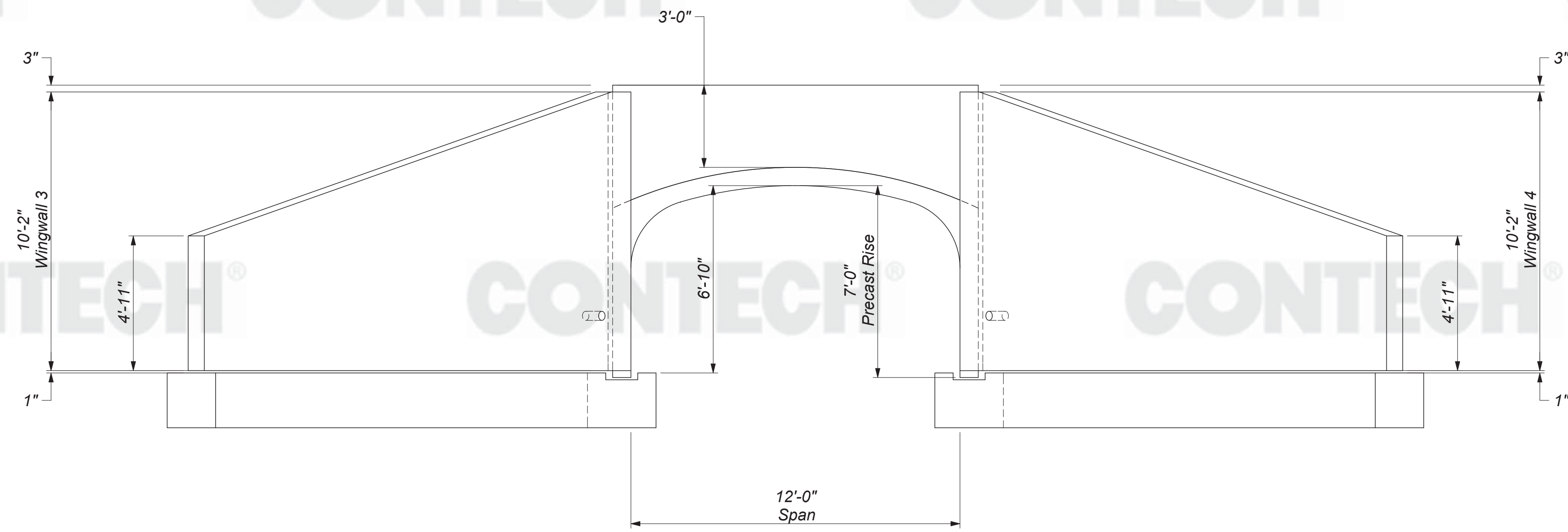
CONTECH®
CONSTRUCTION PRODUCTS INC.
www.contech-cpi.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

CON/SPAN® BRIDGE SYSTEMS
CONTECH DYOB DRAWING

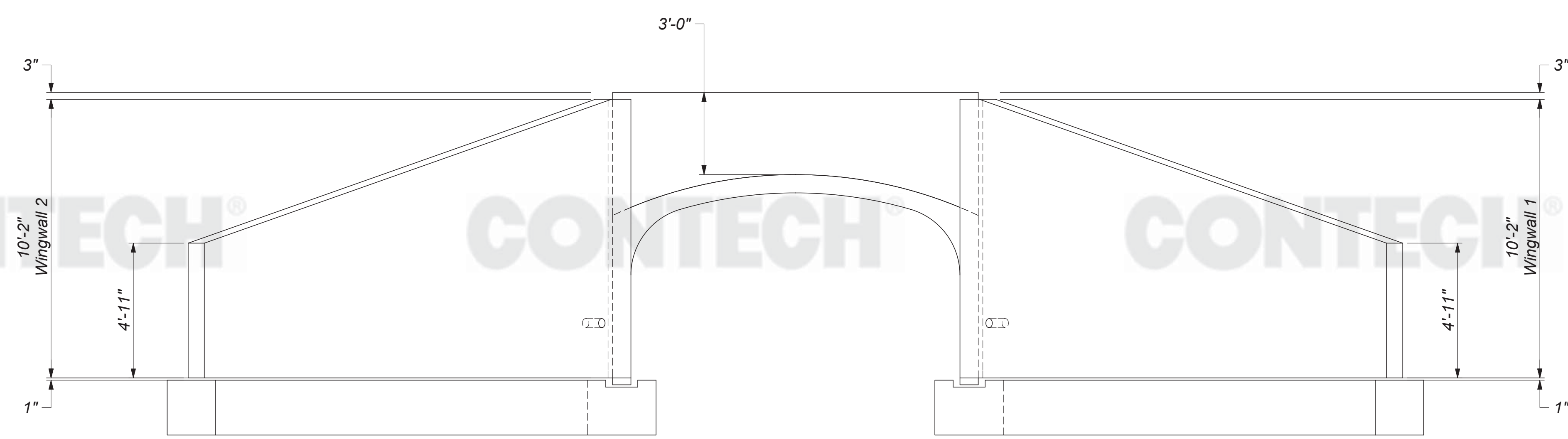
Chelsea Wetlands

Herculies, CA

PROJECT NUMBER: 139137	DATE: 11/04/13
DESIGNED: DYOB	DRAWN: DYOB
CHECKED:	APPROVED:
SHEET NO.: 2 OF 3	



DOWNSTREAM END ELEVATION



UPSTREAM END ELEVATION

CONTECH®
CONSTRUCTION PRODUCTS INC.
www.contech-cpi.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

CON/SPAN® BRIDGE SYSTEMS
CONTECH DYOB DRAWING

Chelsea Wetlands

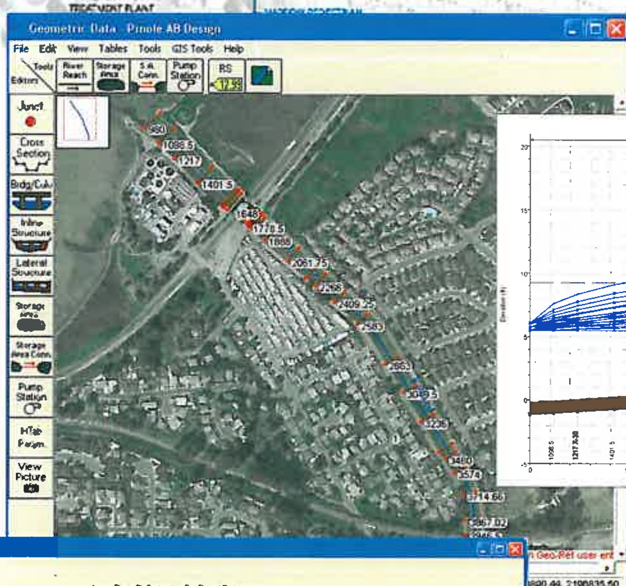
Herculies, CA

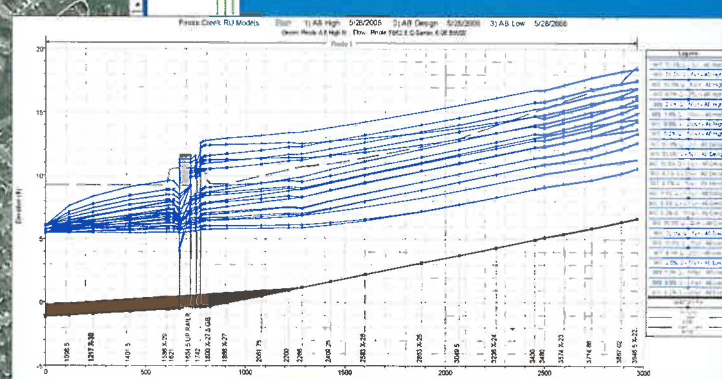
PROJECT NUMBER: 139137	DATE: 11/04/13
DESIGNED: DYOB	DRAWN: DYOB
CHECKED:	APPROVED:
SHEET NO.: 3 OF 3	

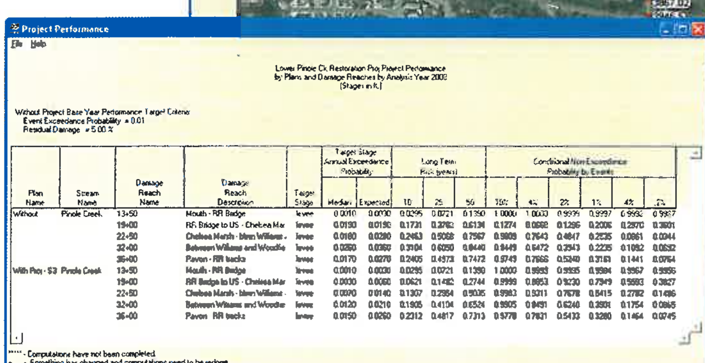
Appendix B

Contra Costa County
Flood Control
& Water Conservation District

Lower Pinole Creek Demonstration Project Risk and Uncertainty Analysis






Project Performance

File Help

Lower Pinole Ck Restoration Proj Project Performance
by Plans and Damage Reaches by Analysis Year 2008
[Stages in ft.]

Without Project Base Year Performance Target Criteria
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long Term Risk (years)			Conditional Non Exceedance Probability by Events					
					Median	Expected	10	25	50	10%	4%	2%	1%	.4%	.2%
Without	Pinole Creek	13+50	Mouth - RR Bridge	levee	0.0010	0.0030	0.0295	0.0721	0.1350	1.0000	1.0000	0.9999	0.9997	0.9992	0.9987
		19+00	RR Bridge to US - Chelsea Mar	levee	0.0130	0.0190	0.1731	0.2782	0.6134	0.1274	0.0662	0.1296	0.2006	0.2970	0.3601
		22+50	Chelsea Marsh - btwn Williams -	levee	0.0180	0.0280	0.2463	0.5068	0.7567	0.9809	0.7643	0.4847	0.2535	0.0861	0.0344
		32+00	Between Williams and Woodfie	levee	0.0260	0.0360	0.3104	0.6050	0.8440	0.9449	0.6472	0.3343	0.2235	0.1092	0.0632
		36+00	Pavon - RR tracks	levee	0.0170	0.0270	0.2405	0.4973	0.7472	0.9749	0.7666	0.5240	0.3163	0.1441	0.0764
With Proj - S3	Pinole Creek	13+50	Mouth - RR Bridge	levee	0.0010	0.0030	0.0295	0.0721	0.1350	1.0000	0.9993	0.9995	0.9984	0.9967	0.9956
		19+00	RR Bridge to US - Chelsea Mar	levee	0.0030	0.0060	0.0621	0.1482	0.2744	0.9999	0.8853	0.9230	0.7949	0.5593	0.3827
		22+50	Chelsea Marsh - btwn Williams -	levee	0.0070	0.0140	0.1307	0.2954	0.5035	0.9983	0.9311	0.7678	0.5415	0.2782	0.1486
		32+00	Between Williams and Woodfie	levee	0.0120	0.0210	0.1905	0.4104	0.6524	0.9905	0.8491	0.6240	0.3901	0.1754	0.0865
		36+00	Pavon - RR tracks	levee	0.0150	0.0260	0.2312	0.4817	0.7313	0.9778	0.7831	0.5433	0.3280	0.1464	0.0745

***** - Computations have not been completed
* - Something has changed and computations need to be redone

February 18, 2009

Blank Page

This report was prepared by or under the supervision of the Registered Professional Engineer indicated below:

REGISTERED PROFESSIONAL ENGINEER
MARK E. BOUCHER
No. 45516
EXP. 12/31/10
CIVIL
STATE OF CALIF

Mark E. Boucher, PE C 45516 Date: 2/18/09

Acknowledgements
Other contributors and reviewers of this report:

Alex Rivas, Civil Engineer
Carl Roner, Associate Civil Engineer
Paul Detjens, Senior Civil Engineer
Greg Connaughton, Supervising Civil Engineer

Table of Contents

List of Figures

List of Tables

ABBREVIATIONS

cfs	cubic feet per second
CNP	Conditional Non-Exceedance Probability
Corps	U.S. Army Corps of Engineers
FC District	Contra Costa County Flood Control and Water Conservation District
Elev.	Elevation
FDA	HEC-FDA computer program used for RU analysis
ft	Feet
HEC	Hydrologic Engineering Center, US Army Corps of Engineers[1]
LOB	Left overbank (a HEC-RAS term)
NAVD 88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
RAS	HEC-RAS computer program used for open channel flow analysis
RDG	Restoration Design Group
ROB	Right overbank (a HEC-RAS term)
RU	Risk and Uncertainty

[1] http://www.hec.usace.army.mil/

Blank Page

Lower Pinole Creek Demonstration Project Risk and Uncertainty Analysis

February 18, 2009

INTRODUCTION

The Pinole Creek watershed covers approximately fifteen square miles of west Contra Costa County's Briones Hills that drain into San Pablo Bay north of Point Pinole. The general plan for the watershed is comprised of approximately 80% open space, park, agricultural, and watershed land uses. The remaining area is a mixture of residential, transportation, commercial, and industrial uses.

The watershed can be divided into three general zones, each with distinct physical characteristics and geomorphologic processes.

- The upper portion of the watershed is known as the headwaters and has channels that are rocky and steep. It is primarily owned and managed by the East Bay Municipal Utility District (EBMUD). This area is an erosional zone supplying sediment to the downstream channel.

- The middle portion of the watershed is a transition zone because sediment from the hills is being transferred to the lower portions of the creek. The channel slope is moderate in between the steep headwater channels and the low meandering downstream channels.

- The lower reaches of the creek, which pass through the cities of Pinole and Hercules, meander through a broad alluvial floodplain representing the accumulation of sediment. Occasionally, the high flows overtop the banks and flood the lower watershed areas.

The US Army Corps of Engineers (Corps) constructed a flood protection project on lower Pinole Creek in the mid 1960's. The Contra Costa County Flood Control and Water Conservation District (FC District) is the local sponsor that owns and maintains the flood protection improvements.

The City of Pinole and The Friends of Pinole Creek have a vision to enhance Pinole Creek and make it an amenity to the community. They produced a vision plan [2] that includes the following objectives:

- Improved flood capacity and protection.

- Enhanced recreational amenities and improvements to Pinole Creek (the Pinole Creek Greenway) and the Bay Trail.

---

[2] "Pinole Vision Watershed Vision Plan," Urban Creeks Council of California & Restoration Design Group, LLC, 2005. (http://www.urbancreeks.org/Current_Projects.html#Pinole)

- Preservation and restoration of natural habitats.
- Provision of public educational opportunities.
- Creation of opportunities for future restoration projects.

To this end, the proposed **Pinole Creek Restoration Greenway Project** (Project) would remove sediment and native soils, modifying levees and channel banks in some areas along the creek to create new areas of marshplain and floodplain to improve overall flood stage capacity. The project would restore marshplain and floodplain areas along the creek to more natural conditions to create new and enhanced wildlife habitat.

The ultimate project would also include new bridge crossings, trails, a boardwalk on the north side of the creek near the Bay shoreline, and other recreational amenities to improve the creek's recreational value. The new bridges would replace existing bridges that currently impede flows. The proposed project is described in two segments: work located bayward of the Union Pacific Railroad (UPRR Bridge), and work under and upstream of the UPRR Bridge.

The City of Pinole with assistance from their consultant Restoration Design Group, LLC (RDG)[3], was awarded a California Proposition 50 River Parkways Grant to construct a demonstration project. The demonstration project is intended to show the community the potential for transforming Pinole Creek into an environmental and recreational amenity if the full Project is implemented and to generate support for the Vision Plan.

Purpose and Overview

The purpose of this report is to explain the assumptions, data sources, and procedures used to analyze the proposed Project performance on a risk and uncertainty (RU) basis. Future phases of the Project will require separate analyses.

This report presents the hydraulic and RU analyses performed by the FC District. The Corps required this analysis because the original improvements were accomplished using federal funding and the Corps has begun to use RU analysis on all of its projects. The Corps San Francisco office was instrumental in guiding the FC District through this analysis.

Risk and Uncertainty Analysis Overview

The goal of the RU analyses was to determine the minimum levee elevation required for the proposed project. The proposed levee elevations are to provide the same protection as the original 1960's project provided. The level of protection or "performance" of the proposed project was characterized using the conditional non-exceedance probability (CNP); CNP is an output of the RU analysis.

CNP is, fundamentally, the probability that the water surface will not exceed a certain elevation (e.g., levee top) during statistically based storm runoff events. That is, if the CNP is calculated to be 0.90 at a certain analytical cross section, we are 90% sure that the levee will not be overtopped at that location. The RU analysis is a complex analysis that attempts to factor in as

---

[3] Restoration Design Group, LLC, 2560 Ninth Street, Suite 216 / Berkeley, California 94710, tel. (510) 644-2798, www.restorationdesigngroup.com

many uncertainties as possible. For this analysis, we specifically tried to account for the following uncertainties:

- Statistical variability in flow rates.
- The range of possible channel roughness conditions due to vegetation (Manning's n-values).
- Uncertainty in design tide (for beginning water surface elevation in channel models).
- Possibility of sedimentation (accumulation or removal of sediment).

Target Conditional Non-Exceedance Probability

The Corps designed the original 1965 project for the 2% annual exceedance probability (2% AEP[4]) flow of 2,600 cfs. Per a 1962 Report[5], this reach of the project did not have a freeboard requirement, but was only required to contain the design storm flows. However, RU analysis replaces the simple application of a uniform freeboard depth above a design water surface elevation to establish levee elevations with a statistical based determination of levee elevation.

The current written standards for RU analysis have been developed mostly from the perspective of providing adequate flood protection performance based on Federal Emergency Management Agency (FEMA) levee certification requirements. For example, the current FEMA levee certification requires 3.0 feet of freeboard above the base flood (100-year or 1% AEP) water surface elevation and a CNP of at least 0.90. The freeboard can be reduced to 2.0 feet if the CNP is at 0.95.

This Project does not fit the mold of the FEMA levee certification requirements. It was originally designed for the 1965 2% AEP flows and is not being modified with the intent to provide 1% AEP FEMA level protection. After clarifying discussions with the Corps, we selected the CNP of the original project to be the target CNP for the proposed Project. That is, the proposed project must meet or exceed the CNP of the original project. Therefore, the As-Built conditions needed to be analyzed to determine the target CNP first, and then the proposed conditions needed to be analyzed and iteratively designed to meet the target CNP.

Procedure Overview

The Corps Hydraulic Engineering Center (HEC) in Davis, California developed a program named "Flood Damage Analysis" (HEC-FDA). This program greatly simplifies the calculations required for performing the RU analysis. The FC District used HEC-FDA to perform the RU analysis on the As-Built project to determine the target CNP.

Data and tools used for the As-Built condition HEC-FDA runs were:

- Flows from the discharge frequency curve from the 1962 Report.
- HEC-RAS (open channel) model based on the As-Built plans of the 1965 project.

---

[4] Historically the 2% AEP storm is referred to as the 50-year flow.

[5] "Detailed Project Report, Local Flood Protection Project, Pinole Creek," Contra Costa County, California; U.S. Army Engineer District, San Francisco, CA; November1962 (1962 Report).

- The top of bank or levee elevations from the As-Built plans.

RDG, the City of Pinole's consutant for the Project, designed the proposed creek modifications and provided the HEC-RAS model for the proposed conditions. The FC District verified the model and performed the RU analysis on the proposed modifications and established the levee heights required to meet or exceed the As-Built performance.

Data and tools used for the proposed condition HEC-FDA runs were:

- Flows from the discharge frequency curve from the 1962 Report.
- HEC-RAS model prepared by RDG for the proposed conditions and modified by the FC District to adjust n-values for varying conditions.
- The top of bank or floodwall elevations from initial HEC-RAS runs for the proposed creek modifications model. The FC District iteratively revised the proposed levee elevations in HEC-FDA to achieve the target CNP.

The FC District understands this analysis of Pinole Creek to be the first RU analysis performed in Contra Costa County for a flood control project. This type of comparison between the As-Built and proposed projects using the RU analysis is also a new process to the Corps.

Model and Plan Terms

This document contains reference to several different combinations of conditions (As-Built, proposed, worst, best, design, etc.) and to reduce the confusion of terms, they are outlined below and used consistently within this document.

Design Condition: The term "design condition" refers to the HEC-RAS model and outputs used in HEC-FDA that reflect the specific design shown in the construction plans and the design report(s) that supported those respective designs. This can refer to either record or proposed plans and reports.

Worst Conditions: The term "worst conditions" refers to a modification of the Design Condition that tries to account for differences in the design parameters that affect the results by making the water surface profiles **higher** in elevation.

Best Conditions: The term "best conditions" refers to a modification of the Design Condition that tries to account for differences in the design parameters that affect the results by making the water surface profiles **lower** in elevation.

As-Built: The term "As-Built" refers to the 1965 As-Built construction drawings in general. It includes the design, worst, and best conditions of the original design.

Proposed: The term "proposed" refers to the soon to be created construction drawings in general. It includes the design, worst, and best conditions of the original design.

As-Built Plan: The term "As-Built Plan" refers to the HEC-FDA analysis plan that includes information from the As-Built design condition, worst condition, and best condition.

Proposed Plan: The "Proposed Plan" refers to the HEC-FDA analysis plan that includes information from the proposed design condition, worst condition, and best condition.

HYDROLOGY

The HEC-RAS modeling and RU analysis were performed using the hydrology of the original project in the 1962 Report. No additional hydrology analysis was needed based on the goals of the project.

The 1962 Report discussed stream flow records from a gauge operated by the East Bay Municipal Utility District with 20 years of data (1939-1959). The 1962 Report discussed major storm events, unit hydrograph derivation, and standard project storm flood. The original designers used a design discharge of 2,600 cfs for this project. At that time, that flow rate was equivalent to the 2% AEP storm or 50-year storm.

EIGHT FLOOD SERIES

The flow rates for the eight flood series are needed for the RU analysis in HEC-FDA. The eight flow rates were taken from **Appendix A** of the 1962 Report. A table on page A-6 of that report contained five of the flows. The rest of the flows were taken from Plate A-3 of the 1962 Report. The eight flood series used is shown in **Table 1**. A copy of Plate A-3 with the flow rates identified is shown in **Figure 1**. The 0.2% AEP was estimated by using a line to extend the flow frequency curve slightly past the limits of the chart.

Table 1 — Eight Flood Series for the Risk and Uncertainty Analysis

Annual Exceedance Probability (AEP)	**Flow Rate** (cubic feet per second)	**Return Period** (Return Frequency) (Years)
50%	570 cfs	2
20%	1,300 cfs	5
10%	1,650 cfs	10
4%	2,200 cfs	25
2%	2,600 cfs	50
1%	3,000 cfs	100
0.5%	3,400 cfs	200
0.2%	4,100 cfs	500

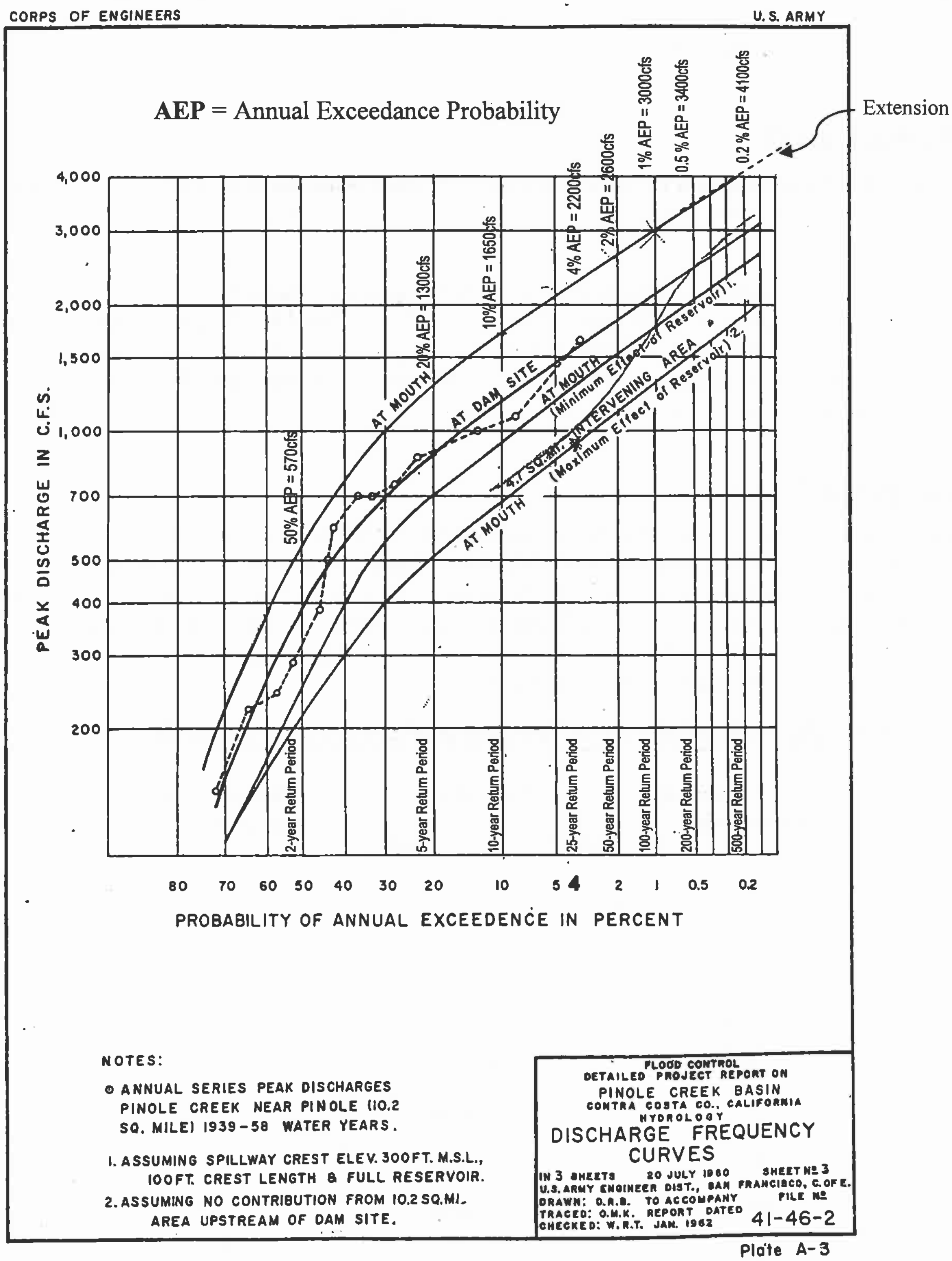


Figure 1 — Plate A-3 from the 1962 Report.

HYDRAULIC MODELING

The following is a discussion of the HEC-RAS modeling performed for the RU analysis. For each scenario (or "Plan" as HEC-FDA calls them), three HEC-RAS geometries (and, therefore, hydraulic conditions) were needed for the RU analysis:

- Design condition geometries.
- Best condition geometries.
- Worst condition geometries.

The difference between the three geometries was generally the assumed Manning's n-value (channel roughness factors), sediment accumulation, and beginning water surface elevation.

BEGINNING WATER SURFACE ELEVATIONS

Datum Adjustment

The datum used for the original project (As-Builts) was the National Geodetic Vertical Datum of 1929 (NGVD29). The proposed project uses the North American Vertical Datum of 1988 (NAVD88). The datum shift varies between 2.35 feet and 2.80 feet depending on the location in Contra Costa County. At the project location, the datum adjustment from NGVD29 and NAVD88 is 2.66 feet.

The As-Built geometry was created in the HEC-RAS model at its original datum, and then the entire geometry was adjusted up 2.66 feet to match the NAVD88 datum using a HEC-RAS function. This allows a better comparison of the As-Built and proposed models. All results in this report are in NAVD88.

Tides

The beginning water surface elevation for the as-built design conditions from Plate 3 of the 1962 Report is the Mean Higher High Water tide elevation (MHHW) of 3.1 feet NGVD29 or **5.76** feet NAVD88.

At an April 30, 2008 meeting, the Corps staff made reference to a more recent standard for the MHHW and Highest Estimated Tide (HET). They later provided a copy of the October 1984 "San Francisco Bay Tidal Stage vs. Frequency Study" (1984 Tide Study). The October 1984 Tide Study elevations were based on "NGVD," which we assume is the same as NGVD29. Based on the adopted 100-year tide elevation contours on Plate 11 of that study, the mouth of Pinole would have a 100-year tide of 6.42 feet NGVD29 or **9.08** feet NAVD88.

In the April 30 meeting, Corps staff also mentioned an estimated sea level rise of 2 mm per year, which would be 48 mm or 0.16 feet in sea level rise since 1984. Section 7 of the 1984 Study provides a table that shows an estimate of sea level rise. **Figure 2** presents the estimated sea level rise from 1984 to 2008 to be around 0.59 feet. This Equals 179.8 mm since 1984 or 7.49 mm/year rise. [6]

[6] [179.8/(2008-1984)] = 7.49

After some discussion with Corps staff, we agreed that, like the flow rates, the beginning water surface used in 1962, without a predicted sea level rise, should be used for our RU analysis.

To account for the uncertainty in the tide elevations, we used a differential of 0.3 feet between the design conditions models and the best and worst conditions models. **Table** 2 presents the beginning water surface elevations used in the HEC-RAS model for the design, best, and worst conditions. To that end, we used the bolded values in **Table** 2 for the As-Built design condition model and the proposed conditions (Project) design condition model.

The 1962 report states that the "highest estimated tide with low discharge in the creek" controlled the design from the mouth to station 9+50 (*approximately station19+49 on the As-Built plans*). Also, the "project design discharges coincident with the mean higher high tidal stage at the mouth of the creek"[7] controlled upstream of station 9+50. Plate 3 of the 1962 Report shows the HET to be 5.6 feet. Converting that HET to today's datum makes it 8.26 feet. For comparison, the top of the service road in the 1965 plans from San Pablo Bay to near the first railroad bridge was one foot (1 ft.) above the HET of 5.60 NGVD feet. Therefore, the minimum proposed levee height should be 9.26 NAVD88 feet. This is also shown in **Table** *2.* We recommend that all the levee elevations be at least 1.0 foot above the HET.

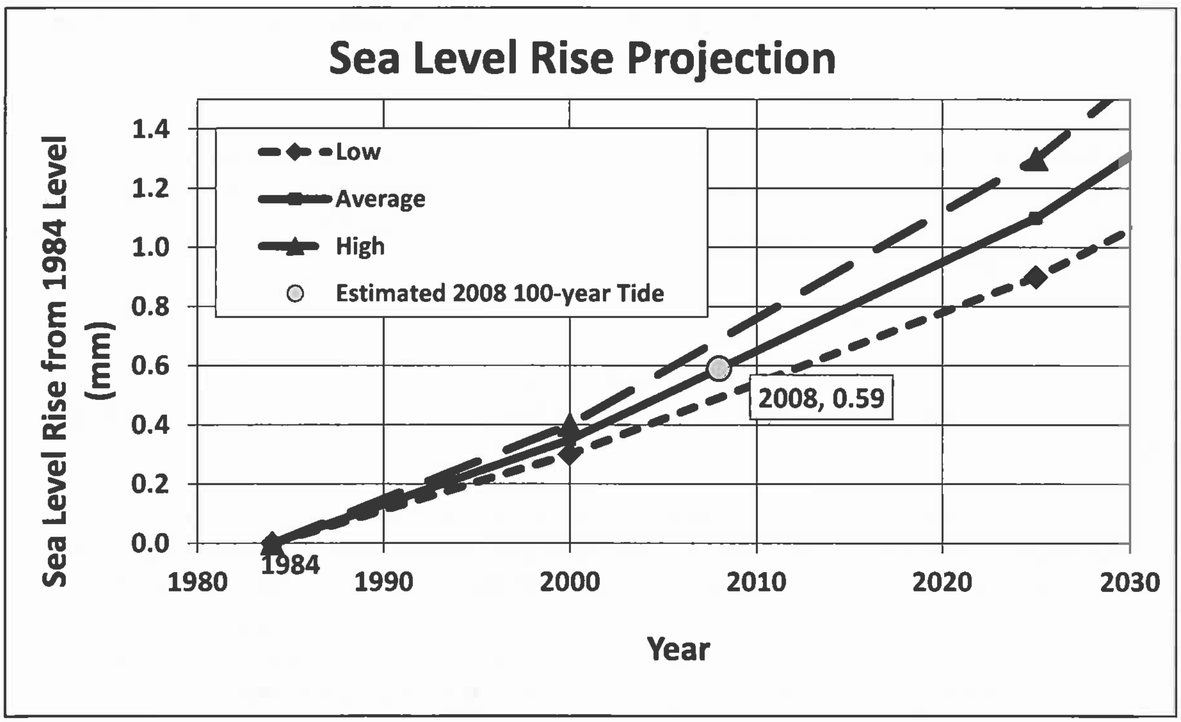


Figure 2 — Estimated Future Sea Level Rise based on table in Section 7 of the October 1984 "San Francisco Bay Tidal Stage vs. Frequency Study."

[7] From the 1962 Report

Table 2 — Tide Elevations Table

Design Value	NGVD29 [8]	NAVD88 (NGVD29 + 2.66 feet datum adjustment)	NAVD88 (adjusted for 0.59 ft sea level rise since 1984 – approximate)
Highest Estimated Tide	5.6 feet	8.26 feet	8.85 feet
Mean Higher High Water Beginning water surface elevation: **best condition** (design condition -0.3 ft)	n/a	Used **5.46 feet**	6.05 feet
Mean Higher High Water Beginning water surface elevation **design condition**	3.1 feet	Used **5.76 feet**	6.35 feet
Mean Higher High Water Beginning water surface elevation: **worst condition** (design condition +0.3 ft)	n/a	Used **6.06 feet**	6.65 feet

[8] From Plate 3 of the 1962 Report

As-Built Plan

A HEC-RAS model was created based on the "As-Built" plans entitled "Pinole Creek Channel Improvements." These plans were signed as "Approved" on April 26, 1965, and "As Constructed" June 10, 1966. Copies of these plans can be found in the FC District office. For the RU analysis, three "As-Built" models: design condition, best condition, and worst condition models were created. The best condition and worst condition models were copies of the design condition model with modifications as discussed below. The HEC-RAS models are on the CD in the back of this report.

Hydraulic Design Values (Manning's n-values)

The 1962 Report states that the design Manning's n-value ("n") for the earth channel was 0.03 with n=0.04 used in areas where riprap was used in short reaches. We used these values for both the "design" and the "best" condition models. Our reasoning is that the 1962 n-values are as low as the FC District would be comfortable using. The FC District's standard practice is to use n-values no lower than 0.035 for earth channels.

Having said that, in this study, we used n=0.025 in the Proposed Plan model in areas where the tides influence the vegetation, the saltwater keeping the vegetative growth at a minimum. Therefore, for the As-Built best conditions model, we used an n-value of 0.025 for the creek bottom in the tidal zone. In a memo by Mr. Roger Leventhal, Principal Engineer of FarWest Restoration Engineering[9] (FarWest), the tidal zone is described as approximately up to station 21+76. Therefore, from the mouth to station 20+61.75, we set the bottom of the As-Built channel n-value to be 0.025.

For the worst conditions As-Built model, we assumed the n-values could go as high as 0.05 for all cross sections. We used n=0.04 where riprap was used in short reaches.

Sedimentation Estimate

In its current condition, lower Pinole Creek has aggradated sediment and the FC District has not had the funds to remove it. In 1978, California Proposition 13 was passed and it "froze" property tax rates. At that time, the Drainage Zone Board for the Pinole Creek watershed maintenance entity (Flood Control Zone 9) had set the tax rate to 0% because there was extra money in the maintenance account. After Proposition 13 passed, there was no more revenue for maintenance. State Special District Augmentation Funds were a source of funding for a time; however, a governor later eliminated them during a state budget crisis, and they have not been replaced. The FC District has not been financially able to keep up with the special maintenance required to remove sediment.

The Operation and Maintenance (O&M) Manual calls for inspections every 90 days and that the inspection is to report any "shoals" (sediment bars) that form. It appears that the authors of the O&M manual assumed that funding would be available to remove shoals that formed.

We approached the sedimentation estimate for the As-Built worst conditions geometry by asking the questions: "What level of maintenance did the original designers expect?" and "What level of risk can we assume the original engineers accepted?" After consultation with Corps staff, we

---

[9] FarWest Restoration Engineering, 11 Camelot Court, Kensington, CA 94707, (510) 522-7200

decided to assume only one foot of sediment would have built-up before the FC District would have removed sediment.

Therefore, in the worst conditions geometry for the As-Built plan, we assumed one foot (1ft) of sediment on top of the As-Built channel bottom from the mouth up. We used the "Fixed Sediment Elevation" tool in HEC-RAS to fill the channel from the mouth upstream with one foot of sediment at the slope of the lower reach (0.001 ft/ft) and let that sediment intersect the channel after the grade break at station 18+00 where the slope changes to 0.00324 ft/ft upstream of station 22+00. **Figure 3** shows the depth and limits of this sediment accumulation as the shaded area in the lower part of the creek (left side of the profile).

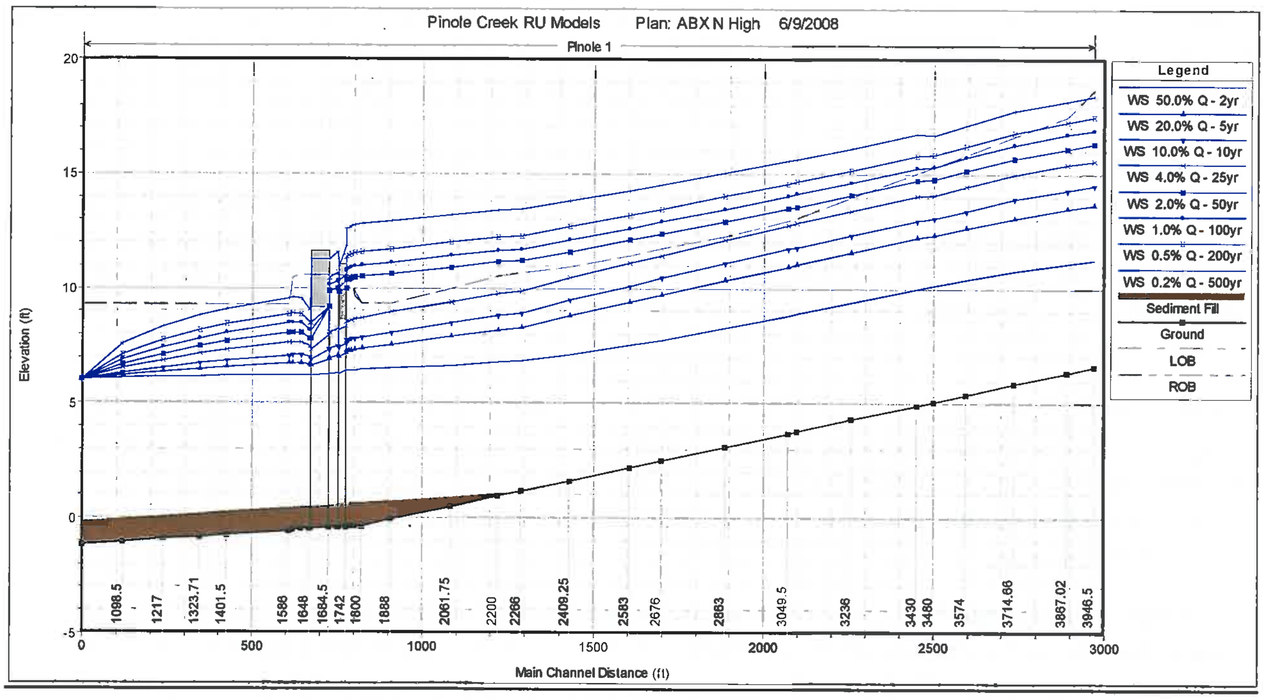


Figure 3 — HEC-RAS plot of the As-Built plan worst conditions profile showing the sedimentation assumptions.

As-Built Model Levees

In HEC-RAS, when the modeled water surface goes higher than the left or right cross section data, the model assumes there is a "glass wall" at the cross section limits of the cross section. The Corps recommended that we use this glass wall at the top of bank of the As-Built cross sections to simulate a levee. Then in HEC-FDA, we set the top of bank as the "levee" height to calculate the CNP.

Proposed Plan

FarWest created a HEC-RAS model for the Proposed Plan, following the creek geometry proposed by RDG. The Proposed Plan geometry, in general, reflects the current silted condition of Pinole Creek with modifications to the banks and service road and with the addition of floodwalls.

The intent of the Proposed Plan is to leave the silt in the lower elevations of the cross sections in place and expand the higher elevations of the cross sections to increase capacity. Raised service roads (levees) and floodwalls are proposed to provide the necessary flow containment and freeboard. The final height and configuration of the levees and floodwalls are dependent on the results of this RU analysis.

There is an 8-inch curb on the Railroad Avenue Bridge. The assumption is that this curb will be removed as part of the project to provide slightly more capacity over that bridge. The Proposed Plan HEC-RAS model can be found on the CD in the back of this report.

Interpolation

Proposed levees are on the outside limit of the cross section for station 2276.5 and the levees are on the top of bank (or creek side of the trail) for cross section 2576.5. Between these two cross sections, the trail ramps up in the upstream direction. The proposed levy is planned to continue on the outside of the cross sections until the trail ramps up to meet the top of the levee at cross section 2576.5.

Between modeled cross sections 2276.5 and 2576.5, interpolated cross sections were created using the HEC-RAS interpolation tool. The interpolation tool interpolates the levees as well as the cross section data to create new cross sections. The default result between these cross sections is an inaccurate representation of the levees because when they are interpolated, the levees cross the path.

To fix this, we adjusted the levee locations in the interpolated cross sections manually to put the modeled levee on the outside of the interpolated cross sections. Then these cross sections were renamed to remove the "*" from their names and make them non-interpolated cross sections and preserve the levee location.[10]

Hydraulic Design Values (Manning's n-values)

FarWest provided the HEC-RAS model and n-values for the Proposed Plan design geometry. We reviewed them and used our engineering judgment to evaluate and revise the n-values for the three models needed in the RU analysis.

After reviewing the HEC-RAS model provided for the Proposed Plan design conditions, we created the exhibits in **Appendix A** to keep track of and suggest revisions to the proposed n-values in the FarWest model.

---

[10] The HEC-RAS interpolation function inserts an "*" at the end of the interpolated cross section names and uses that for identification and other functional purposes. Renaming the cross section to remove the "*" removes the indicator, and afterwards HEC-RAS treats the cross sections as if they were not interpolated.

The cross sections in **Appendix A** display the design, best, and worst conditions n-values used for the three different zones assuming a restoration project from the mouth to the second set of railroad tracks. The station ranges for these zones are:

Zone	Stations
Tidal Zone	below 21+76
Transition Zone	21+76 to 26+00
Fluvial Zone	26+00 and above

The design n-values for the three models for the proposed conditions were set as follows:

Design Conditions Model:

- Follow the exhibits in **Appendix A**

Best Conditions Model:

- 16+68.5 and downstream — subtract 0.005 from all n-values in the Design Condition Model.
- 17+00.5 to 28+26.5 — manually adjusted to match figures in **Appendix A.**
- 28+26.5 and upstream — subtract 0.005 from all n-values in the Design Condition Model.

Worst Conditions Model

- 16+68.5 and downstream — add 0.005 to all n-values and in the Design Condition Model, and then adjust center of channel n-values to 0.040.
- 17+00.5 to 28+26.5 — manually adjusted to match figures in **Appendix A.**
- 28+26.5 and upstream — add 0.005 to all n-values in the Design Condition Model, and then adjust center of channel n-values to 0.040.

Sedimentation Estimate

As previously mentioned, in its current condition, lower Pinole Creek has aggraded sediment over the years and the design concept is to leave that sediment in place. We assume that after more than 30-years, the bed of the creek is in equilibrium with the sediment load of the watershed.

Modeled Levee Heights

The levees for the proposed project HEC-RAS model were set high enough to contain the floodwaters for all of eight flood series' flows. We did this per the recommendation of the Corps staff. We discuss this in more detail later in this report.

Model Runs

Each of the six (6) HEC-RAS geometries was paired up with a steady flow data scenario that included the flows from the eight flood series in **Table 1** and the appropriate beginning water surface elevation (boundary condition) presented in **Table 2.** The models were run with the mixed flow option to check the subcritical and supercritical flow regimes. The upstream boundary condition was set as normal depth with a slope of 0.003 ft/ft matching the As-Built drawings around station 39+00. The results of the HEC-RAS runs are included with the models on the CD in the back of this report.

HEC-FDA ANALYSIS

As mentioned above, the FC District used HEC-FDA to perform the RU analysis on the As-Built project to determine the target CNP. This section explains the inputs, iterations, and results of the HEC-FDA analysis. The FDA model is on the CD in the back of this report.

HEC-FDA MODEL INPUTS

Input into the HEC-FDA model is relatively easy, but complicated to explain. Below, we explain the data inputs that are of relative importance to this analysis in the logical order of the HEC-FDA program menus.

Damage Reaches

A "damage reach" is an element used in HEC-FDA to identify creek reaches that are associated with specific flooding and flood damages. A HEC-FDA model was created to analyze six (6) damage reaches that were judged to provide representative conditions for the project. The locations of the damage reaches are listed in **Table 3** and shown on a HEC-RAS screen shot in **Figure 4**. Please note that the cross section locations shown in the HEC-RAS screen shot are only approximate relative to the areal image.

Table 4 presents the top of bank elevations that are either the top of bank from the As-Builts Plan or the top of levee for the Proposed Plan. These elevations were input as the "Top of levee stage" in the Levee Features dialogue window in HEC-FDA.

Analysis Years

Analysis Years were created as: Base Year = 1995 and Most Likely Future = 2008. Attempts to revise the 1995 year to 1965 in the program failed. This number is not critical to the results we were looking for in the model.

Study Plan Definitions

Two study plan definitions were created: one entitled "Without" and the other entitled "With Project." These titles are reflected in **Table 4.**

Table 3 — Damage Reaches Definition for the HEC-FDA Model

Damage Reach Station	Beginning Station (downstream)	Ending Station (upstream)	Damage Reach Index Station(1)	Range Represented
13+50	9+80	16+23.0	13+23.5	Mouth — RR Bridge
19+00	17+42	21+26.5	18+76.5	RR Bridge to US — Chelsea Marsh
22+50	21+26.5	24+76.5	22+76.5	Chelsea Marsh — Fawcett
26+50	24+76.5	28+76.5	26+76.5	Fawcett— Woodfield
31+00	28+76.5	33+76.5	30+76.5	Woodfield — Pavon
36+00	33+76.5	38+76.5	35+76.5	Pavon — RR tracks

(1) These are actual modeled sections in the Proposed Plan models.

Table 4 — Damage Reach Stations and Levees Elevations for the HEC-FDA Model

Damage Reach Station	As-Built (Without) Plan Index Station	Levee Elev. Used(1)	Proposed (With Project) Plan Index Station	Levee Elev. Used(2)
13+50(3)	13+23.71	9.26	13+23.5	11.00(3)
19+00	18+88	9.35	18+76.5	13.78
22+50	22+66	10.69	22+76.5	14.23
26+50	26+76	11.72	26+76.5	14.48
31+00	30+76.42	13.09	30+76.5	15.10
36+00	35+74	15.85	35+76.5	17.10

(1) The levee used for the As-Built Plan is the lowest top of bank for the cross section.
(2) The levee used for the Proposed Plan is the lowest levee elevation that would cause the Proposed Plan to have the same or higher CNP by events as the same damage reach in the As-Built Plan.
(3) For this Damage Reach, the CNP of the As-Built Plan could not be met. This is due to several factors as described in the text.

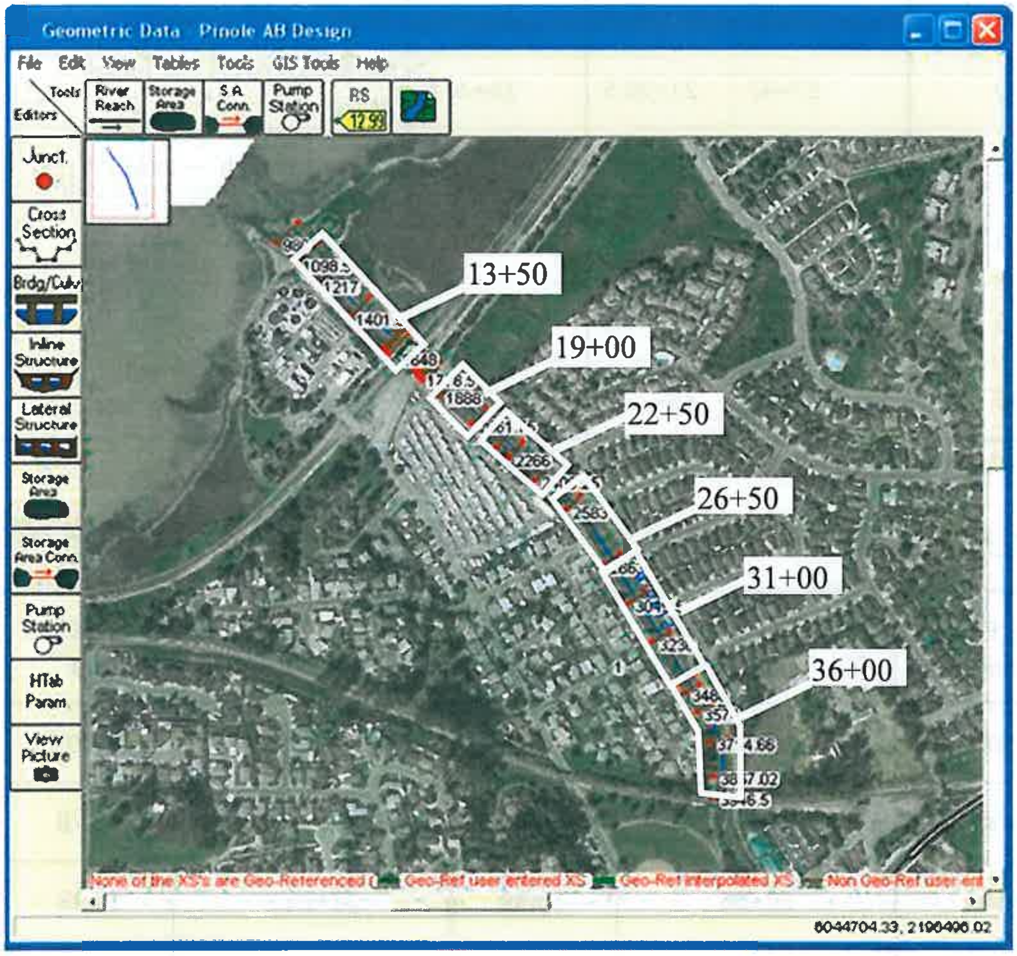


Figure 4 — HEC-RAS Geometry View with Damage Reaches Identified.

Study Water Surface Elevations

The study water surface elevations for the design conditions for both the As-Built and Proposed plans were exported from HEC-RAS to *.wsp files and imported into HEC-FDA as the "As-Built" and "Proposed" for the "Without" and "With Project" FDA plans.

Exceedance probability function with uncertainty

The "Analytical-Exceedance Probability Method" was chosen for the "Exceedance Probability Function with Uncertainty" option. The 0.5, 0.1, and 0.01 AEP flow rates from **Table 1** were input into the analytical option dialogue window shown in **Figure 5**. The equivalent Record Length was set at 20 years per Table 4-5 of EM 1110-2-1616[11], because the rainfall-runoff-routing model in the 1962 Report was calibrated to several events recorded at a short-interval event gauge in the watershed. The "Exceedance Probability Function" plot from HEC-FDA is also shown in **Figure 5**.

Stage Discharge Function with Uncertainty

In FDA, each Damage Reach for each Analysis Year and each Plan (Without and With Project) requires input of the water surface elevations (stages) and standard deviation of error. The stages can be brought in from the *.wsp data imported during the "Study Water Surface Elevations" step above. For each damage reach, these water surface profiles must be brought in first before inputting the Standard Deviation of Error values since the import process erases the Standard Deviation of Error values.

Section 5-7 of EM 1110-2-1619 "Sensitivity Analysis and Professional Judgment" states that professional judgment may be applied to establish the upper and lower bounds on stage for a given discharge. This can be done by estimating the worst and best conditions in the channel calculating the difference between the worst (upper) and best (lower) water surface elevations and dividing the difference by four (4). This resulting number can be used as the estimate of the standard deviation of error in the water surface elevation.

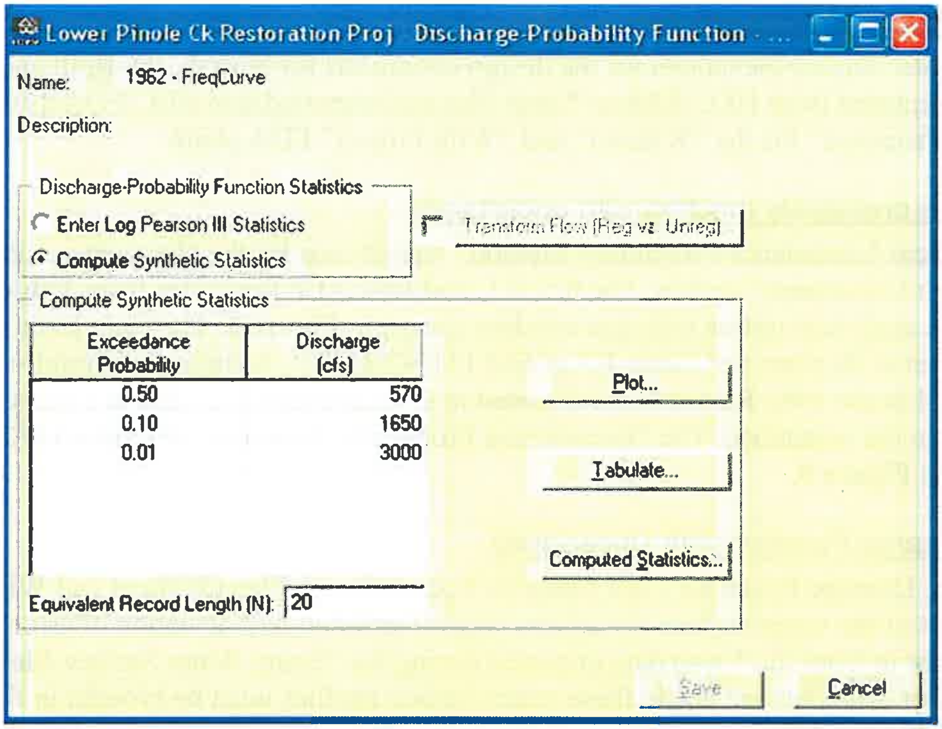
This procedure was accomplished as described above and explained here. For each of the HEC-RAS runs, a HEC-RAS Profile Output Table was used to copy the results to a spreadsheet to allow easy calculation of the difference between worst and best conditions models for the respective As-Built and proposed plans. The spreadsheet was programmed to calculate ¼ of the difference between the water surface elevations for the worst and best condition models as the "estimated standard deviation of error." The spreadsheets used for this project are on the CD in the back of this report. They are also presented in **Table 7** and **Table 8** showing only the data for the six (6) cross sections selected to represent the six damage reaches.

These standard deviation numbers were manually input into the HEC-FDA model under the "Stage Discharge Function with Uncertainty" dialogue window as the standard deviation of error.

The normal distribution type was selected under the "Distribution Type" option and "Enter by Ordinate" was selected under the "Define Uncertainty" option.

---

[11] EM 1110-2-1616, Engineering and Design, Risk-Based Analysis for Flood Damage Reduction Studies, USACOE, 1 August 1969.



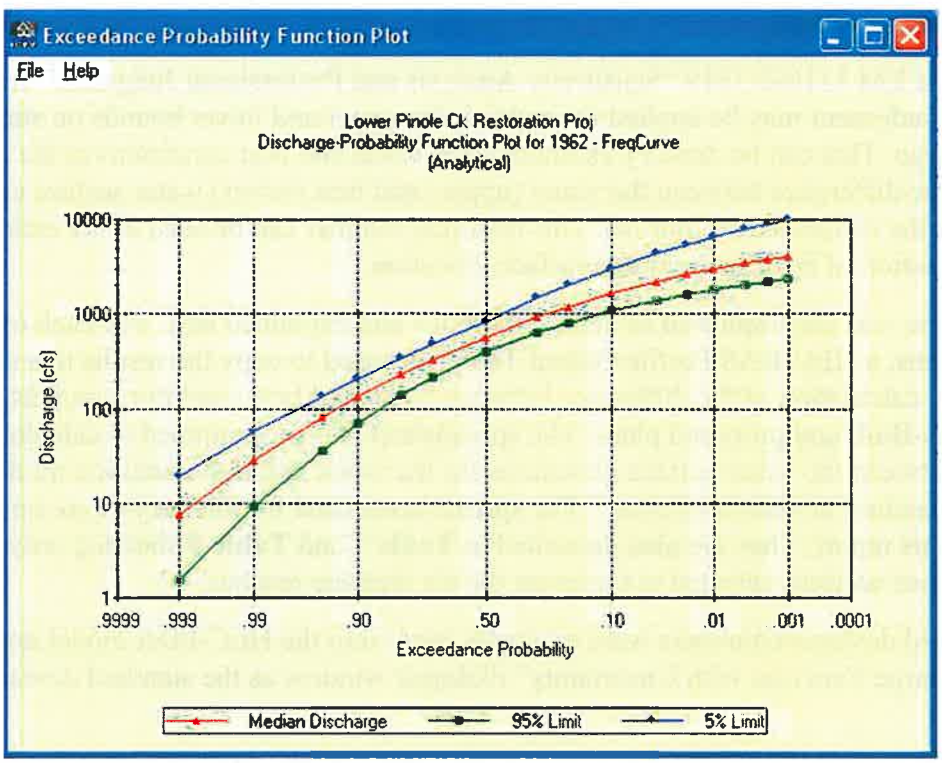


Figure 5 — Exceedance Probability Function with Uncertainty Input and Graph (screen shots from HEC-FDA).

HEC-FDA Levee Features

Table 4 above lists the levee elevations used in the final run in HEC-FDA for each of the damage reaches in each Plan.

HEC-FDA Economic Information

The HEC-FDA model was run to determine the CNP for each case (As-Built and Proposed) not for economics. For this reason, no economic information is needed for the analysis. However, to allow the model to be run, some "dummy" economic information needed to be present.

A default damage category named "Blank" with the default description, "Blank place holder not doing any damage analysis," was input under the Economics\Study Damage Categories menu. Then each plan was run under the Economics\Compute Reach Stage—Damage Function with Uncertainty menu. This allowed the model to run and calculate the CNP.

HEC-FDA Performance Runs

After all the data was input, the model was run to calculate the performance of both the As-Built and the Proposed Plans using the "Evaluation of Plans by Analysis Year" function. Choosing and selecting all of the plans under this option ran the "Monte Carlo" RU analysis and the results were viewed under the "Evaluation\Results\Project Performance" option.

Iterations to Determine Levee Elevations

Through an iterative process, the levee elevations in HEC-FDA for the Proposed Plan were raised and lowered until the analysis showed that the Proposed Plan had slightly better performance (higher CNP) than the As-Built plan. We were able to accomplish this in all damage reaches except for damage reach 13+50. No matter how high we raised the levee, even up to elevation 18.0, which is higher than most elevations in the model, we were unable to meet or exceed the performance of the As-Built model. This is discussed in more detail later in the report.

The final levee elevations for the Proposed Plan are shown in **Table 4** above under the column heading "Levee Elev. Used."

For the iterative process, approach, we ultimately abandoned, was to change the levee heights in the HEC-RAS models as the levee heights were changed in HEC-FDA. There is some good reasoning in this approach. If the levees were lower in the one part of the model and water allowed to spread out, then the water surface would be lower in the upstream part and would not exceed the levee heights as often. Therefore, putting the levee in the model high enough to contain all modeled flows (as mentioned above under **Proposed Plan**) might overestimate the required heights of the levees. However, the number of iterations dramatically increases if we do this. Our approach is conservative, recommended by the Corps, and greatly reduces the modeling effort.

The diagram in **Figure 6** is a general flow chart of the modeling and RU analysis process. It shows that we would have to change three HEC-RAS models to set the levees equal to the levee heights in HEC-FDA every time we iterate the levee height. To do this for each iteration, we would have to:

In HEC-RAS:

- Modify the levee elevations in three HEC-RAS models.
- Run the three HEC-RAS models.
- Export the design water surface profile from HEC-RAS.
- Import the design water surface profile into HEC-FDA.
- Export all three profiles (worst, design, and best) into a spreadsheet to estimate the standard deviation of error.

In HEC-FDA:

- Change the target levee elevations for each damage reach.
- Reset the water surfaces for the eight flood series for each damage reach (data is in HEC-FDA, but needs to be "assigned" to the damage reach).
- Manually enter the estimated standard deviation of error for each damage reach (eight numbers per damage reach).
- Run the HEC-FDA model.

This iterative process becomes unwieldy, and as the number of manual manipulations increases, so does the chance of error. As mentioned above, this approach was abandoned after discussing the procedures with the Corps.

Following the Corps' suggestion to raise the Proposed Plan levees to contain all flows, greatly speeds up the RU analysis by not having to iterate the levee height in the HEC-RAS model. Doing this likely resulted in slightly higher and more conservative levee elevations.

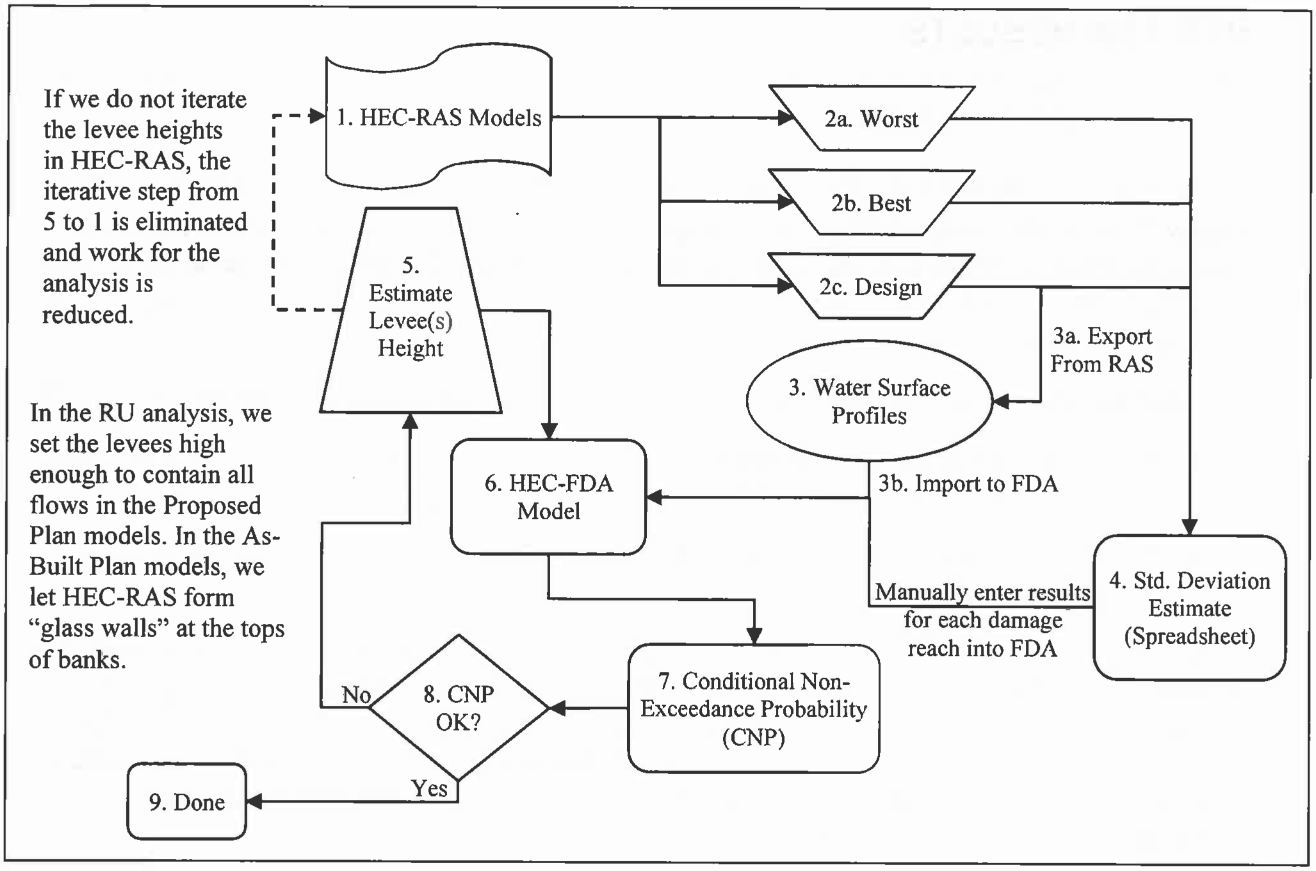


Figure 6 — Risk and Uncertainty Process — The iterative process to determine levee elevations.

HEC-FDA RESULTS

The results of the HEC-FDA RU analysis are included on the CD in the back of this report and provided in **Table 5** and **Table 6**.

Comparison of the As-Built Plan Top of Bank and the Proposed Plan Levee Elevations

Figure 7 shows the As-Built Plan and the eight flood series water surface profiles. **Figure 8** shows the Proposed Plan with the levee elevations from **Table 4** and the eight flood series water surface profiles from the Proposed Plan HEC-RAS models assuming the levees are high enough to contain all flows.

On these figures, we have placed ovals indicating two points of comparison: points "A" and "B."

- Point "A" on both profiles is where the 0.2% and 0.5% AEP flows cross the top of bank in the As-Built Plan model and the top of proposed levee in the Proposed Plan model.
- Point "B" on both profiles is where the 1.0% AEP flow is just below the top of bank or top of proposed levee.

From these profiles, it appears that the levee elevations in **Table 4** could have been estimated or determined graphically instead of using RU analysis. The similar vertical relationship between the various AEP water surface profiles and the top of bank or levee should be expected. This also demonstrates that the proposed levee elevations in **Table 4** are reasonable. That is, assuming the HEC-RAS models are accurate, the proposed levee elevations are adequate to meet the target performance of the proposed project.

As a side note, a graphical solution may be a viable way to estimate or check the results of an RU analysis where the performance target of the proposed project is to meet or exceed the performance of a historic condition. Obviously, we would have to analyze a significant number of diverse plans to be confident enough to replace a complete RU analysis and accept the graphical solution.

CNP for Damage Reach 13+50

In comparing the HEC-RAS profiles at the mouth of the creek in **Figure** 9 and **Figure 10**, we can see the different hydraulic conditions occurring in the two modeled channels. Much of this is due to the existing sediment in the Proposed Plan. The differences are discussed below.

- **Figure 9** shows all eight profiles for the As-Built Plan with the water surface profiles and the critical depths.

  This plot shows that all of these profiles start above critical depth at the boundary conditions water surface elevation. The As-Built Plan water surface profiles do not vary at the most downstream section and the profiles are very close together vertically, even as they diverge going upstream.

- **Figure 10** shows all eight profiles for the Proposed Plan with the water surface profiles and the critical depths.

  This plot shows that most of the design condition profiles start just below critical depth. Only the 50% AEP (2-year storm) profile does not start below critical depth. The Proposed Plan profiles start to spread out vertically and continue to diverge, though the divergence slows more quickly than that of the As-Built Plan profiles. They do not start at the boundary conditions water surface elevation.

We believe that because the Proposed Plan profiles start at very different elevations, the CNP for damage reach 13+50 cannot be met. This means that the RU analysis cannot be used to set the levee height for this damage reach.

The intent of the original As-Built design was to provide protection for flows up to 2,600 cfs without freeboard. Looking at the existing freeboard of the Proposed Plan, the 2% AEP (50-year) storm is almost contained by the left overbank (LOB). The right overbank (ROB) contains up to the 0.5% AEP (200-year) storm. The areas to the north of the creek in damage reach 13+50 are marsh and do not need to be protected due to the negligible risk. To the south, there is a sewage treatment plant that needs to be protected. We proposed that a levee elevation of 11.0 be used for damage reach 13+50. This will exceed the design protection level of the original design (50-year flows with one foot of freeboard per the 1962 Report) and provide more freeboard than the upstream damage reaches.

Before this elevation is selected as the design levee elevation, a review of the sewage treatment plan should be done to see if such a levee would actually trap floodwaters on the sewage treatment plant site. Our modeling shows that flow from the 1% AEP storm comes close to overtopping the railroad tracks. We need to be sure that if water escapes the channel and somehow floods the sewage treatment plant site, that the levee does not prevent the return of over-bank floodwaters to the creek and impound water to a depth that exceeds the flooding depth caused by flooding directly from the adjacent Pinole Creek channel.

Table 5 — HEC-FDA Results – Target Stage Annual Exceedance Probability (AEP) and Long Term Risk

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)		
					Median	Expected	10	25	50
Without	Pinole Creek	13+50	Mouth - RR Bridge	levee	0.0010	0.0030	0.0295	0.0721	0.1390
		19+00	RR Bridge to US - Chelsea Marsh	levee	0.0090	0.0180	0.1685	0.3696	0.6026
		22+50	Chelsea Marsh - Fawcett	levee	0.0060	0.0120	0.1146	0.2623	0.4558
		26+50	Fawcett-Woodfield	levee	0.0050	0.0110	0.1082	0.2489	0.4358
		31+00	Woodfield -Pavon	levee	0.0040	0.0080	0.0803	0.1887	0.3418
		36+00	Pavon – RR Tracks	levee	0.0010	0.0030	0.0302	0.0738	0.1422
With Project	Pinole Creek	13+50	Mouth - RR Bridge	levee	0.0010	0.0030	0.0295	0.0722	0.1393
		19+00	RR Bridge to US - Chelsea Marsh	levee	0.0100	0.0170	0.1581	0.3496	0.5770
		22+50	Chelsea Marsh - Fawcett	levee	0.0060	0.0120	0.1134	0.2599	0.4523
		26+50	Fawcett - Woodfield	levee	0.0050	0.0110	0.1043	0.2408	0.4236
		31+00	Woodfield - Pavon	levee	0.0030	0.0070	0.0645	0.1536	0.2836
		36+00	Pavon –RR Tracks	levee	0.0010	0.0030	0.0298	0.0729	0.1404

Table 6 — HEC-FDA Results – Conditional Non-Exceedance Probability (CNP)

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Conditional Non-Exceedance Probability by Events					
				10%	4%	2%	1%	0.40%	0.2%
Without	Pinole Creek	13+50	Mouth - RR Bridge	1.0000	1.0000	0.9999	0.9997	0.9993	0.9988
		19+00	RR Bridge to US - Chelsea Marsh	0.9947	0.8839	0.6733	0.4320	0.1943	0.0942
		22+50	Chelsea Marsh - Fawcett	0.9991	0.9481	0.8084	0.5950	0.3208	0.1766
		26+50	Fawcett-Woodfield	0.9991	0.9518	0.8230	0.6221	0.3538	0.2062
		31+00	Woodfield -Pavon	0.9995	0.9713	0.8841	0.7334	0.4998	0.3479
		36+00	Pavon – RR Tracks	1.0000	0.9996	0.9977	0.9929	0.9829	0.9743
With Project	Pinole Creek	13+50	Mouth - RR Bridge	1.0000	1.0000	0.9996	0.9987	0.9965	0.9945
		19+00	RR Bridge to US - Chelsea Marsh	0.9970	0.9017	0.6966	0.4499	0.2006	0.0958
		22+50	Chelsea Marsh - Fawcett	0.9992	0.9498	0.8114	0.5974	0.3237	0.1788
		26+50	Fawcett - Woodfield	0.9994	0.9569	0.8324	0.6319	0.3586	0.2071
		31+00	Woodfield - Pavon	0.9999	0.9837	0.9178	0.7854	0.5479	0.3768
		36+00	Pavon –RR Tracks	1.0000	0.9998	0.9986	0.9951	0.9869	0.9797

Summary and Recommendations

An RU analysis for Pinole Creek was completed using the As-Built plans and design flows of the original 1965 project. The results from that As-Built RU analysis served as the target CNPs that used then used to set levee heights for the proposed project. We could not make the lowest damage reach (13+50) meet the CNP target, most likely due to the tidal effects, and recommend a levee height based on reasonable hydraulic assumptions. We also recommend the review of the general flooding potential of the sewage treatment plant on the south side of that damage reach to see if the recommended levee height would trap floodwaters entering the sewage treatment plant property.

The levee elevations for Pinole Creek should be designed and constructed to conform to **Table 4** and **Figure 8** and be at least one (1) foot above the HET. If the project is designed in accordance with these recommendations, it will have a CNP equal to or greater than the original 1960's Corps project.

Table 7 — As-Built Plan: Estimate of the Standard Deviation of Error in the Water Surface Elevation

Reach	River Sta	Profile	Q Total	As-Built Design Stage	As-Built Worst	As-Built Best	Difference	Est. Standard Deviation
1	1323.71	50.0% Q - 2yr	570	5.79	6.15	5.49	0.66	0.165
1	1323.71	20.0% Q - 5yr	1300	5.89	6.48	5.60	0.88	0.220
1	1323.71	10.0% Q - 10yr	1650	5.97	6.71	5.68	1.03	0.258
1	1323.71	4.0% Q - 25yr	2200	6.14	7.13	5.86	1.27	0.318
1	1323.71	2.0% Q - 50yr	2600	6.30	7.46	6.02	1.44	0.360
1	1323.71	1.0% Q - 100yr	3000	6.49	7.81	6.23	1.58	0.395
1	1323.71	0.5% Q - 200yr	3400	6.70	8.17	6.46	1.71	0.428
1	1323.71	0.2% Q - 500yr	4100	7.15	8.80	6.94	1.86	0.465
1	1888	50.0% Q - 2yr	570	6.03	6.50	5.77	0.73	0.183
1	1888	20.0% Q - 5yr	1300	6.72	7.52	6.53	0.99	0.248
1	1888	10.0% Q - 10yr	1650	7.16	8.08	7.01	1.07	0.268
1	1888	4.0% Q - 25yr	2200	7.94	8.95	7.84	1.11	0.278
1	1888	2.0% Q - 50yr	2600	8.54	10.63	8.49	2.14	0.535
1	1888	1.0% Q - 100yr	3000	9.18	11.11	9.19	1.92	0.480
1	1888	0.5% Q - 200yr	3400	11.25	11.69	11.24	0.45	0.113
1	1888	0.2% Q - 500yr	4100	12.43	12.90	12.42	0.48	0.120
1	2266	50.0% Q - 2yr	570	6.13	6.82	5.87	0.95	0.238
1	2266	20.0% Q - 5yr	1300	7.00	8.27	6.83	1.44	0.360
1	2266	10.0% Q - 10yr	1650	7.50	8.93	7.35	1.58	0.395
1	2266	4.0% Q - 25yr	2200	8.30	9.87	8.19	1.68	0.420
1	2266	2.0% Q - 50yr	2600	8.90	11.20	8.83	2.37	0.593
1	2266	1.0% Q - 100yr	3000	9.51	11.71	9.49	2.22	0.555
1	2266	0.5% Q - 200yr	3400	11.38	12.29	11.36	0.93	0.233
1	2266	0.2% Q - 500yr	4100	12.53	13.44	12.52	0.92	0.230
1	2676	50.0% Q - 2yr	570	6.77	7.75	6.66	1.09	0.273
1	2676	20.0% Q - 5yr	1300	8.30	9.70	8.27	1.43	0.358
1	2676	10.0% Q - 10yr	1650	8.92	10.44	8.90	1.54	0.385
1	2676	4.0% Q - 25yr	2200	9.77	11.44	9.75	1.69	0.423
1	2676	2.0% Q - 50yr	2600	10.32	12.36	10.31	2.05	0.513
1	2676	1.0% Q - 100yr	3000	10.85	12.89	10.84	2.05	0.513
1	2676	0.5% Q - 200yr	3400	12.02	13.45	12.01	1.44	0.360
1	2676	0.2% Q - 500yr	4100	13.05	14.50	13.04	1.46	0.365
1	3076.42	50.0% Q - 2yr	570	7.82	8.89	7.80	1.09	0.273
1	3076.42	20.0% Q - 5yr	1300	9.59	11.03	9.58	1.45	0.363
1	3076.42	10.0% Q - 10yr	1650	10.23	11.80	10.23	1.57	0.393
1	3076.42	4.0% Q - 25yr	2200	11.09	12.83	11.09	1.74	0.435
1	3076.42	2.0% Q - 50yr	2600	11.64	13.57	11.64	1.93	0.483
1	3076.42	1.0% Q - 100yr	3000	12.15	14.11	12.15	1.96	0.490
1	3076.42	0.5% Q - 200yr	3400	12.93	14.66	12.93	1.73	0.433
1	3076.42	0.2% Q - 500yr	4100	13.81	15.65	13.80	1.85	0.463
1	3574	50.0% Q - 2yr	570	9.32	10.38	9.32	1.06	0.265
1	3574	20.0% Q - 5yr	1300	11.12	12.62	11.12	1.50	0.375
1	3574	10.0% Q - 10yr	1650	11.77	13.41	11.77	1.64	0.410
1	3574	4.0% Q - 25yr	2200	12.61	14.47	12.61	1.86	0.465
1	3574	2.0% Q - 50yr	2600	13.16	15.15	13.16	1.99	0.498
1	3574	1.0% Q - 100yr	3000	13.65	15.71	13.65	2.06	0.515
1	3574	0.5% Q - 200yr	3400	14.19	16.24	14.19	2.05	0.513
1	3574	0.2% Q - 500yr	4100	14.95	17.14	14.95	2.19	0.548

Table 8 — Proposed Plan: Estimate of the Standard Deviation of Error in the Water Surface Elevation

Reach	River Sta	Profile	Q Total	Proposed Design Stage	Proposed Worst	Proposed Best	Difference	Est. Standard Deviation
1	1323.5	50.0% Q - 2yr	570	6.21	6.57	5.93	0.64	0.160
1	1323.5	20.0% Q - 5yr	1300	7.45	7.8	7.25	0.55	0.138
1	1323.5	10.0% Q - 10yr	1650	7.93	8.31	7.71	0.6	0.150
1	1323.5	4.0% Q - 25yr	2200	8.58	8.98	8.35	0.63	0.158
1	1323.5	2.0% Q - 50yr	2600	8.98	9.39	8.75	0.64	0.160
1	1323.5	1.0% Q - 100yr	3000	9.35	9.77	9.1	0.67	0.168
1	1323.5	0.5% Q - 200yr	3400	9.68	10.13	9.42	0.71	0.178
1	1323.5	0.2% Q - 500yr	4100	10.21	10.7	9.92	0.78	0.195
1	1876.5	50.0% Q - 2yr	570	7.34	7.73	7.07	0.66	0.165
1	1876.5	20.0% Q - 5yr	1300	9.21	9.67	8.98	0.69	0.173
1	1876.5	10.0% Q - 10yr	1650	10.09	10.68	10.01	0.67	0.168
1	1876.5	4.0% Q - 25yr	2200	12.13	12.67	11.74	0.93	0.233
1	1876.5	2.0% Q - 50yr	2600	13.2	13.45	13.09	0.36	0.090
1	1876.5	1.0% Q - 100yr	3000	13.78	14.04	13.65	0.39	0.097
1	1876.5	0.5% Q - 200yr	3400	14.31	14.57	14.17	0.4	0.100
1	1876.5	0.2% Q - 500yr	4100	15.16	15.45	15.01	0.44	0.110
1	2276.5	50.0% Q - 2yr	570	7.59	8.02	7.32	0.7	0.175
1	2276.5	20.0% Q - 5yr	1300	9.48	10.01	9.21	0.8	0.200
1	2276.5	10.0% Q - 10yr	1650	10.33	10.98	10.2	0.78	0.195
1	2276.5	4.0% Q - 25yr	2200	12.26	12.84	11.86	0.98	0.245
1	2276.5	2.0% Q - 50yr	2600	13.31	13.62	13.17	0.45	0.113
1	2276.5	1.0% Q - 100yr	3000	13.9	14.21	13.74	0.47	0.118
1	2276.5	0.5% Q - 200yr	3400	14.43	14.75	14.26	0.49	0.123
1	2276.5	0.2% Q - 500yr	4100	15.28	15.64	15.11	0.53	0.133
1	2676.5*	50.0% Q - 2yr	570	7.91	8.38	7.62	0.76	0.190
1	2676.5*	20.0% Q - 5yr	1300	9.81	10.43	9.48	0.95	0.238
1	2676.5*	10.0% Q - 10yr	1650	10.64	11.37	10.42	0.95	0.238
1	2676.5*	4.0% Q - 25yr	2200	12.47	13.12	12.02	1.1	0.275
1	2676.5*	2.0% Q - 50yr	2600	13.48	13.89	13.28	0.61	0.153
1	2676.5*	1.0% Q - 100yr	3000	14.06	14.48	13.85	0.63	0.158
1	2676.5*	0.5% Q - 200yr	3400	14.6	15.02	14.37	0.65	0.163
1	2676.5*	0.2% Q - 500yr	4100	15.44	15.9	15.21	0.69	0.173
1	3076.5	50.0% Q - 2yr	570	8.33	8.88	7.98	0.9	0.225
1	3076.5	20.0% Q - 5yr	1300	10.37	11.05	9.93	1.12	0.280
1	3076.5	10.0% Q - 10yr	1650	11.15	11.93	10.79	1.14	0.285
1	3076.5	4.0% Q - 25yr	2200	12.72	13.47	12.2	1.27	0.318
1	3076.5	2.0% Q - 50yr	2600	13.65	14.21	13.34	0.87	0.218
1	3076.5	1.0% Q - 100yr	3000	14.24	14.81	13.89	0.92	0.230
1	3076.5	0.5% Q - 200yr	3400	14.78	15.36	14.42	0.94	0.235
1	3076.5	0.2% Q - 500yr	4100	15.65	16.26	15.29	0.97	0.243
1	3576.5	50.0% Q - 2yr	570	10.31	10.7	10.1	0.6	0.150
1	3576.5	20.0% Q - 5yr	1300	12.29	12.95	12.05	0.9	0.225
1	3576.5	10.0% Q - 10yr	1650	13.1	13.76	12.79	0.97	0.243
1	3576.5	4.0% Q - 25yr	2200	14.22	14.94	13.73	1.21	0.303
1	3576.5	2.0% Q - 50yr	2600	14.96	15.6	14.49	1.11	0.278
1	3576.5	1.0% Q - 100yr	3000	15.51	16.08	15.04	1.04	0.260
1	3576.5	0.5% Q - 200yr	3400	15.94	16.52	15.51	1.01	0.253
1	3576.5	0.2% Q - 500yr	4100	16.62	17.28	16.15	1.13	0.283

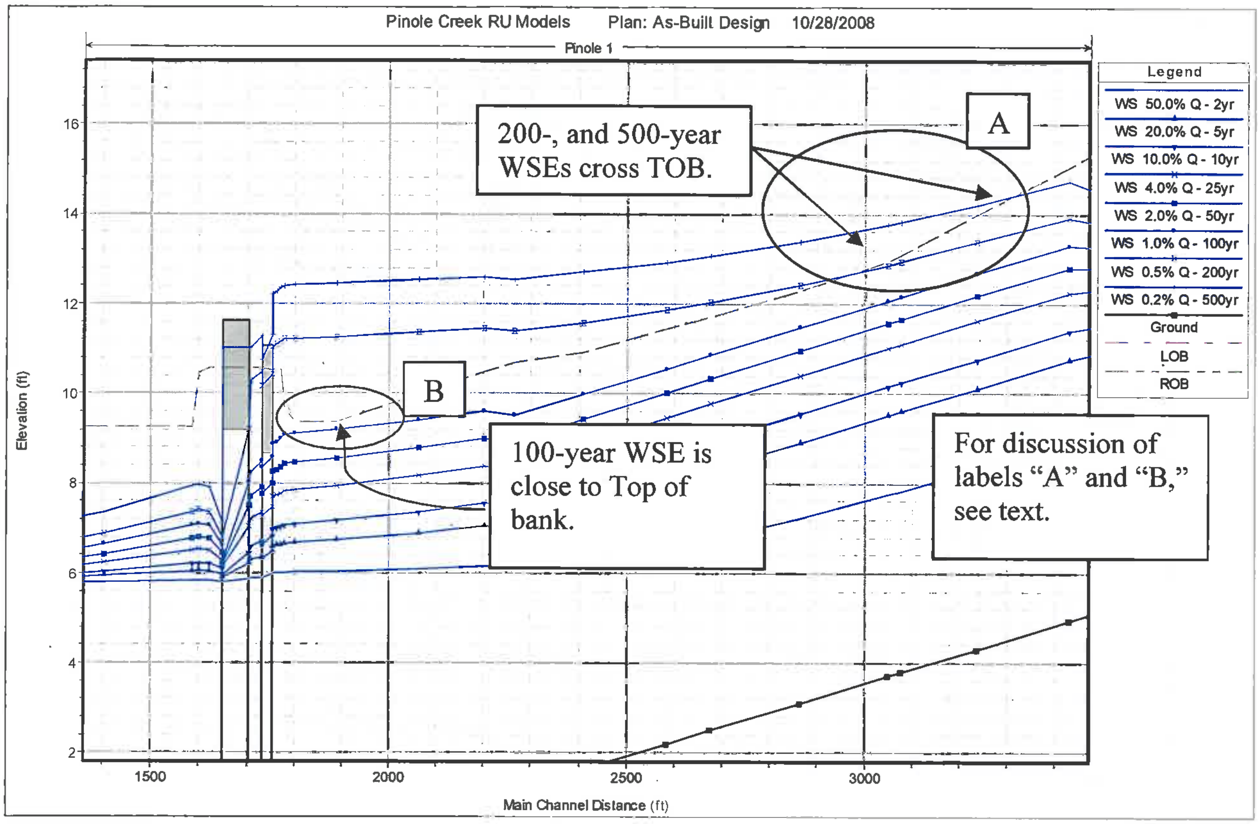


Figure 7 — HEC-RAS Profile of the As-Built Plan Design Conditions with Top of Bank Profile.

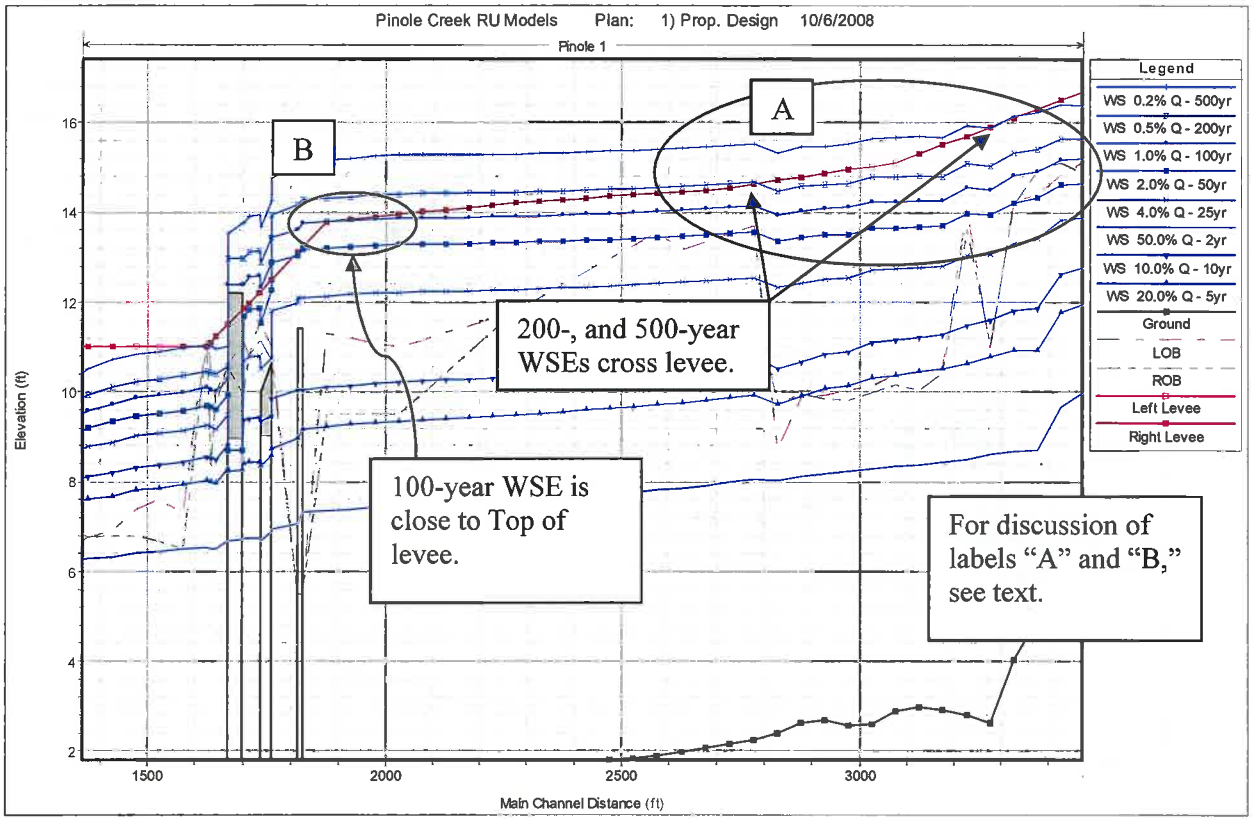


Figure 8 — HEC-RAS Profile of the Proposed Plan Design Conditions with Levees set at Recommended Height.

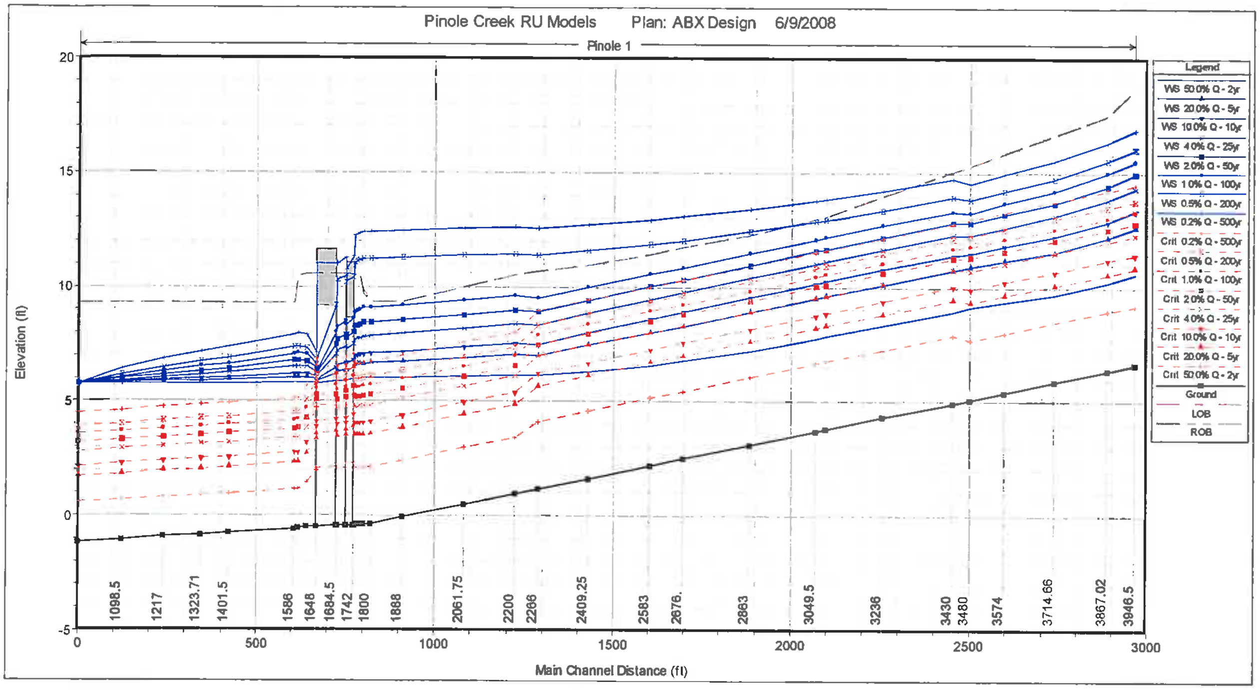


Figure 9 — HEC-RAS Profile of the As-Built Plan Design Conditions.

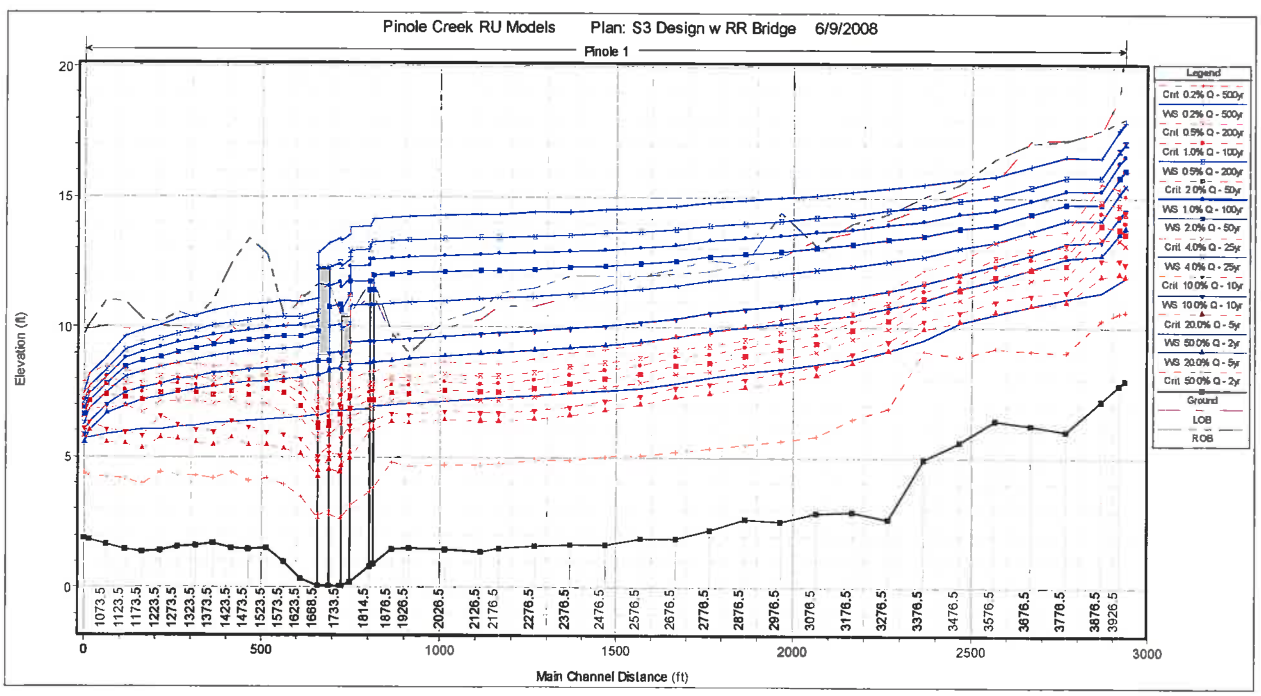


Figure 10 — HEC-RAS Profile of the Proposed Plan Design Conditions.

Blank Page

APPENDIX A — Exhibits

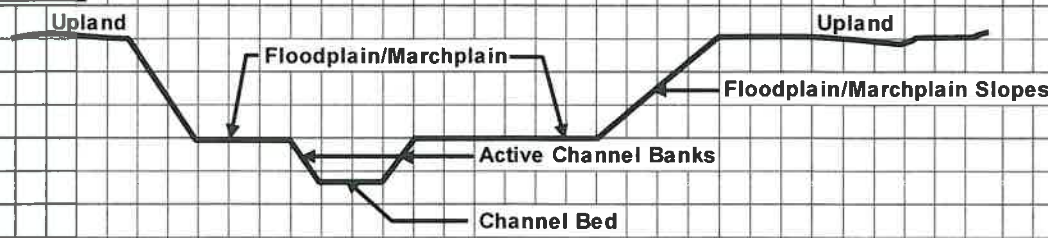
CONTRA COSTA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Computation Sheet

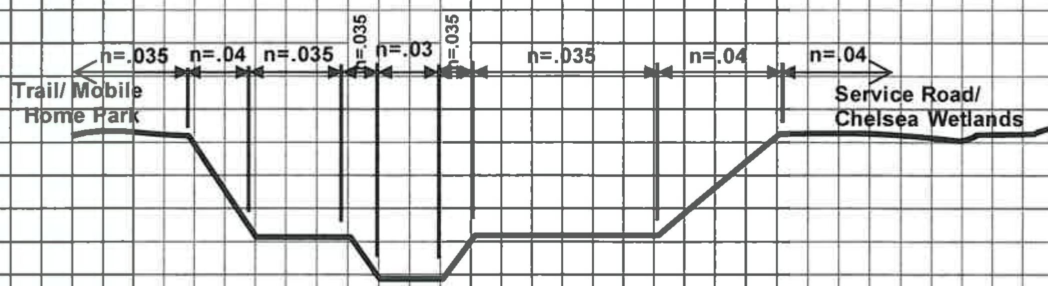
Subject: Manning's N-Values for Pinole Creek Cross Sections Project Number: 6D-8497

By: AR Date: 1/15/2008 Checked by: ____ Date: ____

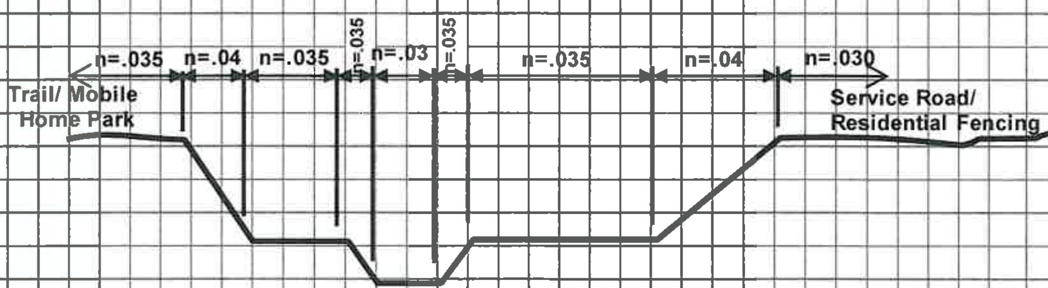
Design Case



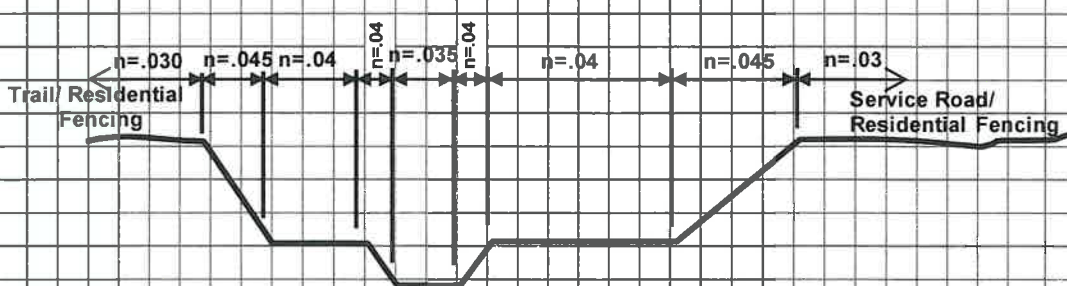
Proposed Pinole Creek Cross Section (TYP)



Proposed Pinole Creek Cross Section at Tidal Zone (TYP)



Proposed Pinole Creek Cross Section at Transition Zone (TYP)



Proposed Pinole Creek Cross Section at Fluvial Zone (TYP)

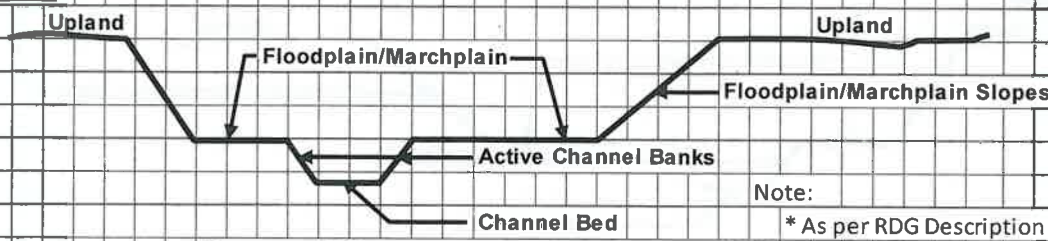
CONTRA COSTA COUNTY FLOOD CONTROL
& WATER CONSERVATION DISTRICT

Computation Sheet

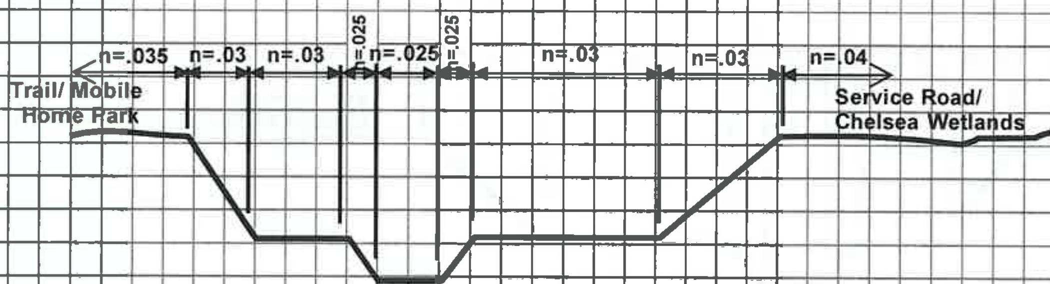
Subject: Manning's N-Values for Pinole Creek Cross Sections Project Number: 6D-8497

By: AR Date: 1/15/2008 Checked by: Date:

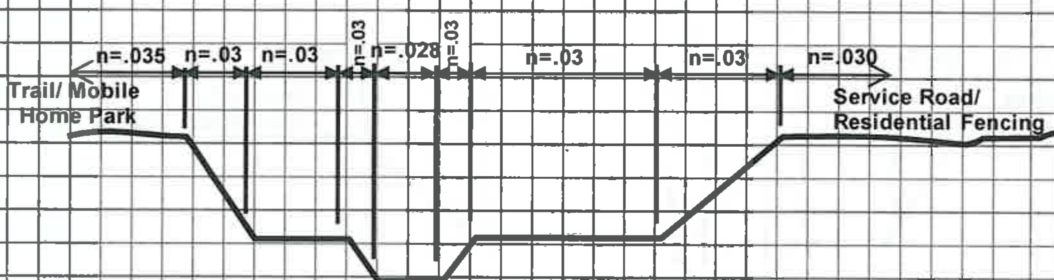
Best Case



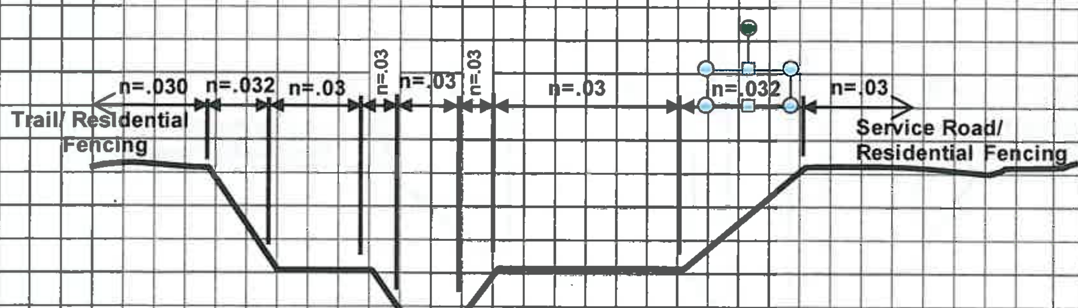
Proposed Pinole Creek Cross Section (TYP)



Proposed Pinole Creek Cross Section at Tidal Zone (TYP)



Proposed Pinole Creek Cross Section at Transition Zone (TYP)



Proposed Pinole Creek Cross Section at Fluvial Zone (TYP)

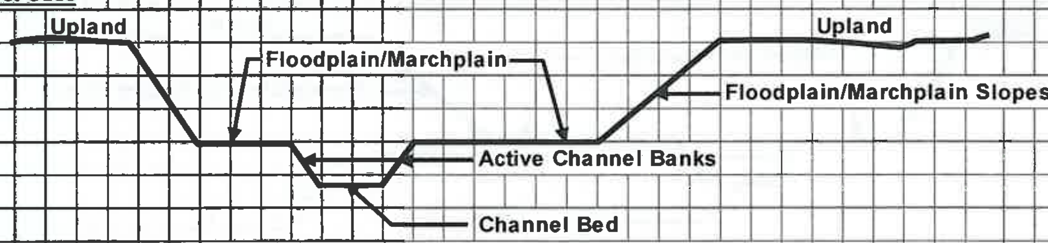
CONTRA COSTA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Computation Sheet

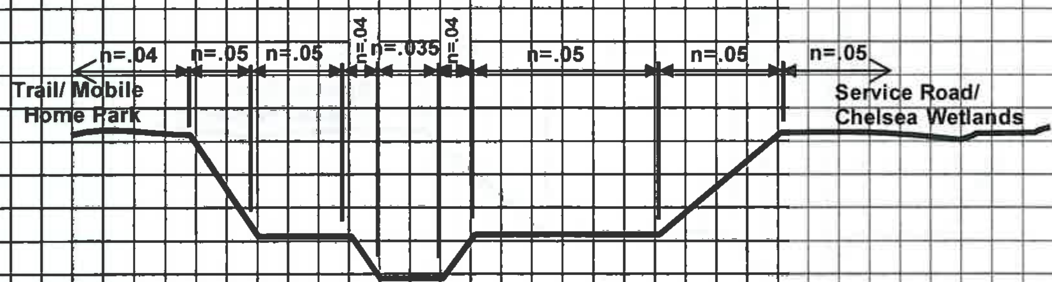
Subject: Manning's N-Values for Pinole Creek Cross Sections   Project Number: 6D-8497

By: AR   Date: 1/15/2008   Checked by: ______   Date: ______

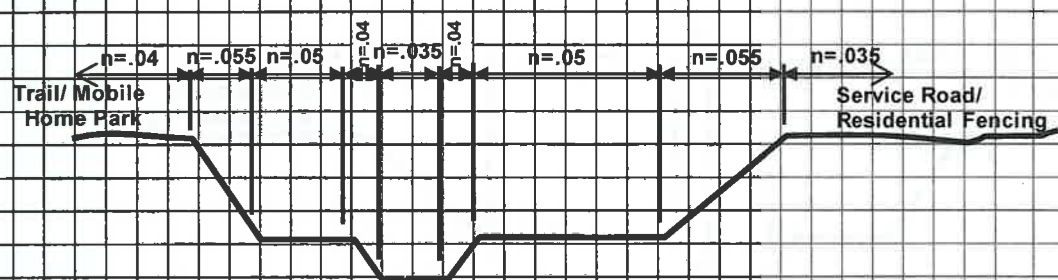
Worst Case



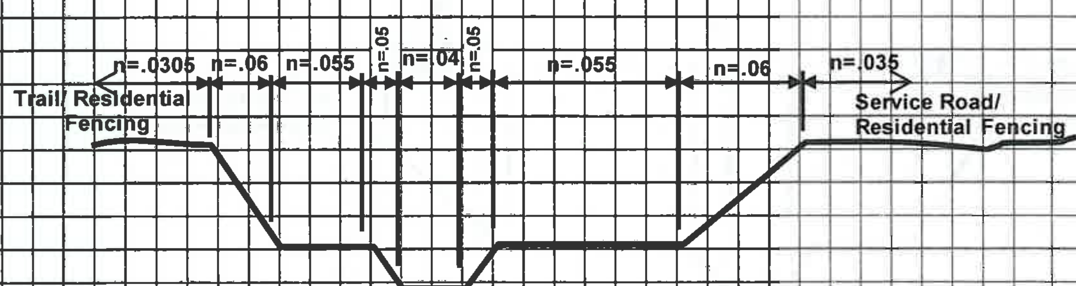
Proposed Pinole Creek Cross Section (TYP)



Proposed Pinole Creek Cross Section at Tidal Zone (TYP)



Proposed Pinole Creek Cross Section at Transition Zone (TYP)



Proposed Pinole Creek Cross Section at Fluvial Zone (TYP)

*Must consider Prop 13 and its effects

APPENDIX B — DATA DISK

Appendix C

HEC-RAS Plan: 2012 Existing River: Pinole Reach: 1 (Continued)

Reach	River Sta	Profile	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)	
1	2376.5*	0.5% Q - 200yr	3400.00	1.71	14.48	8.49	14.68	0.000427	3.62	990.67	143.33	0.22
1	2376.5*	0.2% Q - 500yr	4100.00	1.71	15.33	8.99	15.56	0.000441	3.91	1113.08	143.33	0.22
1	2326.5*	50.0% Q - 2yr	570.00	1.66	7.60	4.93	7.69	0.000681	2.31	247.21	84.52	0.24
1	2326.5*	20.0% Q - 5yr	1300.00	1.66	9.50	6.56	9.65	0.000738	3.13	414.71	92.00	0.26
1	2326.5*	10.0% Q - 10yr	1650.00	1.66	10.36	6.92	10.53	0.000705	3.33	495.36	95.65	0.26
1	2326.5*	4.0% Q - 25yr	2200.00	1.66	12.29	7.43	12.45	0.000475	3.19	697.34	137.84	0.22
1	2326.5*	2.0% Q - 50yr	2600.00	1.66	13.34	7.77	13.49	0.000395	3.20	845.15	143.17	0.20
1	2326.5*	1.0% Q - 100yr	3000.00	1.66	13.92	8.09	14.10	0.000402	3.40	929.11	143.17	0.21
1	2326.5*	0.5% Q - 200yr	3400.00	1.66	14.46	8.40	14.65	0.000409	3.57	1006.11	143.17	0.21
1	2326.5*	0.2% Q - 500yr	4100.00	1.66	15.31	8.90	15.54	0.000424	3.87	1128.31	143.17	0.22
1	2276.5	50.0% Q - 2yr	570.00	1.62	7.57	4.91	7.65	0.000648	2.27	251.51	85.05	0.23
1	2276.5	20.0% Q - 5yr	1300.00	1.62	9.47	6.49	9.62	0.000713	3.10	419.68	92.40	0.26
1	2276.5	10.0% Q - 10yr	1650.00	1.62	10.33	6.85	10.50	0.000683	3.29	500.83	96.10	0.25
1	2276.5	4.0% Q - 25yr	2200.00	1.62	12.27	7.35	12.42	0.000455	3.15	711.58	140.93	0.21
1	2276.5	2.0% Q - 50yr	2600.00	1.62	13.32	7.70	13.47	0.000377	3.16	860.20	143.00	0.20
1	2276.5	1.0% Q - 100yr	3000.00	1.62	13.91	8.02	14.08	0.000385	3.35	944.05	143.00	0.20
1	2276.5	0.5% Q - 200yr	3400.00	1.62	14.44	8.32	14.63	0.000393	3.53	1020.92	143.00	0.21
1	2276.5	0.2% Q - 500yr	4100.00	1.62	15.30	8.82	15.51	0.000408	3.82	1142.90	143.00	0.22
1	2226.5*	50.0% Q - 2yr	570.00	1.60	7.54	4.85	7.62	0.000621	2.21	258.12	88.07	0.23
1	2226.5*	20.0% Q - 5yr	1300.00	1.60	9.44	6.45	9.58	0.000676	3.01	432.39	95.86	0.25
1	2226.5*	10.0% Q - 10yr	1650.00	1.60	10.30	6.79	10.46	0.000645	3.19	516.90	99.83	0.25
1	2226.5*	4.0% Q - 25yr	2200.00	1.60	12.25	7.28	12.40	0.000413	3.03	747.48	149.95	0.20
1	2226.5*	2.0% Q - 50yr	2600.00	1.60	13.31	7.62	13.45	0.000340	3.03	906.47	152.00	0.19
1	2226.5*	1.0% Q - 100yr	3000.00	1.60	13.90	7.93	14.05	0.000345	3.20	995.77	152.00	0.19
1	2226.5*	0.5% Q - 200yr	3400.00	1.60	14.44	8.23	14.61	0.000352	3.37	1077.65	152.00	0.20
1	2226.5*	0.2% Q - 500yr	4100.00	1.60	15.29	8.72	15.49	0.000364	3.64	1207.59	152.00	0.20
1	2176.5*	50.0% Q - 2yr	570.00	1.58	7.51	4.81	7.59	0.000597	2.15	264.50	91.07	0.22
1	2176.5*	20.0% Q - 5yr	1300.00	1.58	9.41	6.41	9.54	0.000643	2.92	444.78	99.30	0.24
1	2176.5*	10.0% Q - 10yr	1650.00	1.58	10.28	6.75	10.43	0.000612	3.10	532.65	103.55	0.24
1	2176.5*	4.0% Q - 25yr	2200.00	1.58	12.24	7.23	12.37	0.000374	2.90	788.12	158.97	0.20
1	2176.5*	2.0% Q - 50yr	2600.00	1.58	13.31	7.55	13.43	0.000305	2.89	957.48	161.00	0.18
1	2176.5*	1.0% Q - 100yr	3000.00	1.58	13.89	7.86	14.03	0.000309	3.05	1052.25	161.00	0.18
1	2176.5*	0.5% Q - 200yr	3400.00	1.58	14.43	8.15	14.58	0.000314	3.21	1139.13	161.00	0.19
1	2176.5*	0.2% Q - 500yr	4100.00	1.58	15.29	8.63	15.46	0.000325	3.46	1277.03	161.00	0.19
1	2126.5*	50.0% Q - 2yr	570.00	1.57	7.49	4.75	7.56	0.000575	2.10	270.85	94.06	0.22
1	2126.5*	20.0% Q - 5yr	1300.00	1.57	9.38	6.37	9.51	0.000614	2.84	457.06	102.75	0.24
1	2126.5*	10.0% Q - 10yr	1650.00	1.57	10.25	6.70	10.39	0.000581	3.01	548.35	107.32	0.23

HEC-RAS Plan: 2012 Existing River: Pinole Reach: 1 (Continued)

Reach	River Sta	Profile	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)	
1	2126.5*	4.0% Q - 25yr	2200.00	1.57	12.23	7.16	12.35	0.000336	2.77	833.86	167.98	0.19
1	2126.5*	2.0% Q - 50yr	2600.00	1.57	13.30	7.48	13.41	0.000272	2.75	1013.53	170.00	0.17
1	2126.5*	1.0% Q - 100yr	3000.00	1.57	13.89	7.78	14.01	0.000275	2.90	1113.75	170.00	0.17
1	2126.5*	0.5% Q - 200yr	3400.00	1.57	14.43	8.07	14.56	0.000280	3.04	1205.67	170.00	0.18
1	2126.5*	0.2% Q - 500yr	4100.00	1.57	15.29	8.54	15.44	0.000288	3.28	1351.51	170.00	0.18
1	2076.5*	50.0% Q - 2yr	570.00	1.01	7.45	4.28	7.53	0.000621	2.15	265.45	92.53	0.22
1	2076.5*	20.0% Q - 5yr	1300.00	1.01	9.35	6.35	9.48	0.000659	2.90	448.94	101.41	0.24
1	2076.5*	10.0% Q - 10yr	1650.00	1.01	10.22	6.69	10.36	0.000613	3.06	539.47	108.89	0.24
1	2076.5*	4.0% Q - 25yr	2200.00	1.01	12.21	7.17	12.33	0.000360	2.86	798.37	152.34	0.19
1	2076.5*	2.0% Q - 50yr	2600.00	1.01	13.27	7.49	13.40	0.000298	2.86	960.87	152.34	0.18
1	2076.5*	1.0% Q - 100yr	3000.00	1.01	13.86	7.80	14.00	0.000305	3.04	1050.14	152.34	0.18
1	2076.5*	0.5% Q - 200yr	3400.00	1.01	14.40	8.08	14.55	0.000314	3.21	1131.97	152.34	0.19
1	2076.5*	0.2% Q - 500yr	4100.00	1.01	15.25	8.57	15.43	0.000328	3.48	1261.71	152.34	0.19
1	2026.5	50.0% Q - 2yr	570.00	1.06	7.42	4.32	7.50	0.000635	2.15	265.63	94.41	0.23
1	2026.5	20.0% Q - 5yr	1300.00	1.06	9.32	6.35	9.44	0.000653	2.87	452.49	103.09	0.24
1	2026.5	10.0% Q - 10yr	1650.00	1.06	10.19	6.69	10.33	0.000604	3.03	544.73	112.31	0.24
1	2026.5	4.0% Q - 25yr	2200.00	1.06	12.19	7.17	12.31	0.000355	2.84	796.18	140.75	0.19
1	2026.5	2.0% Q - 50yr	2600.00	1.06	13.26	7.48	13.38	0.000298	2.86	946.42	140.75	0.18
1	2026.5	1.0% Q - 100yr	3000.00	1.06	13.84	7.78	13.98	0.000308	3.05	1028.57	140.75	0.18
1	2026.5	0.5% Q - 200yr	3400.00	1.06	14.38	8.06	14.53	0.000319	3.23	1103.84	140.75	0.19
1	2026.5	0.2% Q - 500yr	4100.00	1.06	15.22	8.53	15.41	0.000338	3.53	1223.04	140.75	0.20
1	1976.5*	50.0% Q - 2yr	570.00	1.01	7.42	4.35	7.47	0.000319	1.68	338.53	102.32	0.16
1	1976.5*	20.0% Q - 5yr	1300.00	1.01	9.32	5.63	9.41	0.000402	2.40	540.75	110.94	0.19
1	1976.5*	10.0% Q - 10yr	1650.00	1.01	10.19	6.03	10.30	0.000390	2.58	641.88	126.88	0.19
1	1976.5*	4.0% Q - 25yr	2200.00	1.01	12.20	6.49	12.29	0.000244	2.46	926.01	157.75	0.16
1	1976.5*	2.0% Q - 50yr	2600.00	1.01	13.27	6.79	13.36	0.000209	2.49	1094.69	157.75	0.15
1	1976.5*	1.0% Q - 100yr	3000.00	1.01	13.85	7.08	13.96	0.000218	2.66	1187.10	157.75	0.16
1	1976.5*	0.5% Q - 200yr	3400.00	1.01	14.39	7.36	14.51	0.000227	2.82	1271.79	157.75	0.16
1	1976.5*	0.2% Q - 500yr	4100.00	1.01	15.24	7.81	15.38	0.000243	3.09	1406.00	157.75	0.17
1	1926.5*	50.0% Q - 2yr	570.00	0.96	7.39	3.72	7.44	0.000480	1.81	314.97	117.50	0.19
1	1926.5*	20.0% Q - 5yr	1300.00	0.96	9.30	6.14	9.38	0.000464	2.37	547.64	128.92	0.20
1	1926.5*	10.0% Q - 10yr	1650.00	0.96	10.18	6.46	10.27	0.000436	2.48	666.84	145.08	0.20
1	1926.5*	4.0% Q - 25yr	2200.00	0.96	12.19	6.90	12.27	0.000233	2.27	999.65	170.40	0.15
1	1926.5*	2.0% Q - 50yr	2600.00	0.96	13.27	7.18	13.35	0.000193	2.28	1182.26	170.40	0.14
1	1926.5*	1.0% Q - 100yr	3000.00	0.96	13.85	7.44	13.94	0.000199	2.43	1282.25	170.40	0.15
1	1926.5*	0.5% Q - 200yr	3400.00	0.96	14.39	7.68	14.49	0.000206	2.58	1373.91	170.40	0.15
1	1926.5*	0.2% Q - 500yr	4100.00	0.96	15.24	8.09	15.36	0.000218	2.81	1519.17	170.40	0.16

HEC-RAS Plan: 2012 Existing River: Pinole Reach: 1 (Continued)

Reach	River Sta	Profile	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)	
1	1876.5	50.0% Q - 2yr	570.00	0.96	7.36	3.85	7.42	0.000534	1.88	303.63	117.68	0.21
1	1876.5	20.0% Q - 5yr	1300.00	0.96	9.27	6.16	9.36	0.000478	2.42	537.12	127.39	0.21
1	1876.5	10.0% Q - 10yr	1650.00	0.96	10.15	6.51	10.25	0.000456	2.52	657.64	160.42	0.20
1	1876.5	4.0% Q - 25yr	2200.00	0.96	12.18	6.97	12.26	0.000241	2.25	1015.34	184.61	0.16
1	1876.5	2.0% Q - 50yr	2600.00	0.96	13.26	7.26	13.33	0.000195	2.24	1213.81	184.61	0.14
1	1876.5	1.0% Q - 100yr	3000.00	0.96	13.85	7.51	13.93	0.000198	2.38	1322.26	184.61	0.15
1	1876.5	0.5% Q - 200yr	3400.00	0.96	14.39	7.76	14.48	0.000203	2.51	1421.68	184.61	0.15
1	1876.5	0.2% Q - 500yr	4100.00	0.96	15.24	8.16	15.35	0.000212	2.73	1579.26	184.61	0.16
1	1826.5	50.0% Q - 2yr	570.00	0.90	7.30	4.53	7.39	0.000409	2.65	262.11	91.57	0.22
1	1826.5	20.0% Q - 5yr	1300.00	0.90	9.17	6.36	9.33	0.000484	3.65	440.16	99.15	0.26
1	1826.5	10.0% Q - 10yr	1650.00	0.90	10.04	6.77	10.22	0.000457	3.86	528.35	102.70	0.25
1	1826.5	4.0% Q - 25yr	2200.00	0.90	12.09	7.32	12.24	0.000290	3.64	764.56	146.91	0.21
1	1826.5	2.0% Q - 50yr	2600.00	0.90	13.17	7.65	13.32	0.000251	3.64	923.64	147.53	0.20
1	1826.5	1.0% Q - 100yr	3000.00	0.90	13.75	7.98	13.91	0.000263	3.87	1008.91	147.53	0.21
1	1826.5	0.5% Q - 200yr	3400.00	0.90	14.28	8.28	14.46	0.000275	4.08	1087.01	147.53	0.21
1	1826.5	0.2% Q - 500yr	4100.00	0.90	15.11	8.78	15.33	0.000295	4.43	1210.60	147.53	0.22
1	1820		Bridge									
1	1814.5	50.0% Q - 2yr	570.00	0.79	7.05	4.13	7.15	0.000424	2.74	252.55	90.56	0.23
1	1814.5	20.0% Q - 5yr	1300.00	0.79	8.96	6.11	9.13	0.000494	3.72	432.69	98.45	0.26
1	1814.5	10.0% Q - 10yr	1650.00	0.79	10.04	6.58	10.21	0.000416	3.79	541.78	102.93	0.24
1	1814.5	4.0% Q - 25yr	2200.00	0.79	11.96	7.16	12.11	0.000289	3.67	756.57	142.41	0.21
1	1814.5	2.0% Q - 50yr	2600.00	0.79	13.03	7.52	13.18	0.000251	3.67	915.21	148.65	0.20
1	1814.5	1.0% Q - 100yr	3000.00	0.79	13.62	7.85	13.79	0.000263	3.90	1002.52	148.65	0.21
1	1814.5	0.5% Q - 200yr	3400.00	0.79	14.16	8.16	14.34	0.000274	4.10	1082.84	148.65	0.21
1	1814.5	0.2% Q - 500yr	4100.00	0.79	15.01	8.66	15.23	0.000292	4.44	1209.46	148.65	0.22
1	1759.5	50.0% Q - 2yr	570.00	0.77	6.95	4.50	7.11	0.001083	3.26	174.81	54.04	0.32
1	1759.5	20.0% Q - 5yr	1300.00	0.77	8.73	6.27	9.07	0.001552	4.65	279.58	64.05	0.39
1	1759.5	10.0% Q - 10yr	1650.00	0.77	9.82	6.77	10.16	0.001488	4.65	354.86	75.19	0.38
1	1759.5	4.0% Q - 25yr	2200.00	0.77	11.79	7.47	12.08	0.000885	4.29	519.87	96.31	0.30
1	1759.5	2.0% Q - 50yr	2600.00	0.77	12.87	7.96	13.15	0.000718	4.29	623.48	96.31	0.28
1	1759.5	1.0% Q - 100yr	3000.00	0.77	13.43	8.41	13.75	0.000741	4.58	677.73	96.31	0.29
1	1759.5	0.5% Q - 200yr	3400.00	0.77	13.94	8.82	14.30	0.000765	4.85	727.38	96.31	0.29
1	1759.5	0.2% Q - 500yr	4100.00	0.77	14.75	9.56	15.18	0.000812	5.31	805.08	96.31	0.31
1	1746.5		Bridge									
1	1733.5	50.0% Q - 2yr	570.00	1.09	6.74	4.29	6.90	0.000956	3.21	177.51	53.41	0.31
1	1733.5	20.0% Q - 5yr	1300.00	1.09	8.44	5.97	8.77	0.001490	4.63	280.99	65.57	0.39

HEC-RAS Plan: Prop. Design River: Pinole Reach: 1 (Continued) 2009

Reach	River Sta	Profile	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)	
1	2376.5*	0.5% Q - 200yr	3400.00	1.71	14.47	8.49	14.66	0.000429	3.63	989.13	143.33	0.22
1	2376.5*	0.2% Q - 500yr	4100.00	1.71	15.32	8.99	15.55	0.000444	3.92	1110.88	143.33	0.22
1	2326.5*	50.0% Q - 2yr	570.00	1.66	7.62	4.93	7.70	0.000671	2.30	248.32	84.57	0.24
1	2326.5*	20.0% Q - 5yr	1300.00	1.66	9.51	6.56	9.66	0.000732	3.13	415.79	92.05	0.26
1	2326.5*	10.0% Q - 10yr	1650.00	1.66	10.37	6.92	10.54	0.000703	3.33	495.86	95.67	0.26
1	2326.5*	4.0% Q - 25yr	2200.00	1.66	12.28	7.43	12.44	0.000476	3.19	696.87	137.78	0.22
1	2326.5*	2.0% Q - 50yr	2600.00	1.66	13.33	7.77	13.49	0.000396	3.21	844.34	143.17	0.20
1	2326.5*	1.0% Q - 100yr	3000.00	1.66	13.91	8.09	14.09	0.000403	3.40	927.88	143.17	0.21
1	2326.5*	0.5% Q - 200yr	3400.00	1.66	14.45	8.40	14.64	0.000411	3.58	1004.56	143.17	0.21
1	2326.5*	0.2% Q - 500yr	4100.00	1.66	15.30	8.90	15.52	0.000426	3.87	1126.10	143.17	0.22
1	2276.5	50.0% Q - 2yr	570.00	1.62	7.59	4.91	7.66	0.000639	2.26	252.68	85.10	0.23
1	2276.5	20.0% Q - 5yr	1300.00	1.62	9.48	6.49	9.63	0.000707	3.09	420.79	92.45	0.26
1	2276.5	10.0% Q - 10yr	1650.00	1.62	10.33	6.85	10.50	0.000681	3.29	501.34	96.12	0.25
1	2276.5	4.0% Q - 25yr	2200.00	1.62	12.26	7.35	12.42	0.000456	3.15	711.10	140.93	0.21
1	2276.5	2.0% Q - 50yr	2600.00	1.62	13.31	7.70	13.47	0.000378	3.16	859.39	143.00	0.20
1	2276.5	1.0% Q - 100yr	3000.00	1.62	13.90	8.02	14.07	0.000386	3.35	942.81	143.00	0.20
1	2276.5	0.5% Q - 200yr	3400.00	1.62	14.43	8.32	14.62	0.000395	3.53	1019.36	143.00	0.21
1	2276.5	0.2% Q - 500yr	4100.00	1.62	15.28	8.82	15.50	0.000411	3.83	1140.68	143.00	0.22
1	2226.5*	50.0% Q - 2yr	570.00	1.60	7.56	4.85	7.63	0.000612	2.20	259.36	88.12	0.23
1	2226.5*	20.0% Q - 5yr	1300.00	1.60	9.45	6.45	9.59	0.000671	3.00	433.57	95.91	0.25
1	2226.5*	10.0% Q - 10yr	1650.00	1.60	10.31	6.79	10.47	0.000643	3.19	517.44	99.85	0.25
1	2226.5*	4.0% Q - 25yr	2200.00	1.60	12.25	7.28	12.39	0.000413	3.03	746.96	149.95	0.20
1	2226.5*	2.0% Q - 50yr	2600.00	1.60	13.31	7.62	13.44	0.000340	3.03	905.59	152.00	0.19
1	2226.5*	1.0% Q - 100yr	3000.00	1.60	13.89	7.93	14.04	0.000347	3.21	994.44	152.00	0.19
1	2226.5*	0.5% Q - 200yr	3400.00	1.60	14.43	8.23	14.60	0.000354	3.37	1075.99	152.00	0.20
1	2226.5*	0.2% Q - 500yr	4100.00	1.60	15.28	8.72	15.47	0.000367	3.65	1205.22	152.00	0.21
1	2176.5*	50.0% Q - 2yr	570.00	1.58	7.53	4.81	7.60	0.000588	2.14	265.83	91.13	0.22
1	2176.5*	20.0% Q - 5yr	1300.00	1.58	9.42	6.41	9.56	0.000638	2.91	446.02	99.35	0.24
1	2176.5*	10.0% Q - 10yr	1650.00	1.58	10.28	6.75	10.43	0.000610	3.09	533.22	103.58	0.24
1	2176.5*	4.0% Q - 25yr	2200.00	1.58	12.24	7.23	12.37	0.000374	2.91	787.56	158.97	0.20
1	2176.5*	2.0% Q - 50yr	2600.00	1.58	13.30	7.55	13.42	0.000306	2.89	956.55	161.00	0.18
1	2176.5*	1.0% Q - 100yr	3000.00	1.58	13.89	7.86	14.02	0.000310	3.05	1050.84	161.00	0.18
1	2176.5*	0.5% Q - 200yr	3400.00	1.58	14.42	8.15	14.57	0.000316	3.21	1137.37	161.00	0.19
1	2176.5*	0.2% Q - 500yr	4100.00	1.58	15.27	8.63	15.45	0.000327	3.47	1274.52	161.00	0.19
1	2126.5*	50.0% Q - 2yr	570.00	1.57	7.50	4.75	7.57	0.000566	2.09	272.27	94.12	0.22
1	2126.5*	20.0% Q - 5yr	1300.00	1.57	9.40	6.37	9.52	0.000609	2.84	458.38	102.81	0.24
1	2126.5*	10.0% Q - 10yr	1650.00	1.57	10.26	6.70	10.40	0.000580	3.01	548.96	107.35	0.23

HEC-RAS Plan: Prop. Design River: Pinole Reach: 1 (Continued) 2009

Reach	River Sta	Profile	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)	
1	2126.5*	4.0% Q - 25yr	2200.00	1.57	12.23	7.16	12.35	0.000337	2.78	833.27	167.98	0.19
1	2126.5*	2.0% Q - 50yr	2600.00	1.57	13.29	7.48	13.41	0.000273	2.75	1012.55	170.00	0.17
1	2126.5*	1.0% Q - 100yr	3000.00	1.57	13.88	7.78	14.00	0.000277	2.90	1112.26	170.00	0.18
1	2126.5*	0.5% Q - 200yr	3400.00	1.57	14.42	8.07	14.55	0.000281	3.05	1203.77	170.00	0.18
1	2126.5*	0.2% Q - 500yr	4100.00	1.57	15.27	8.54	15.43	0.000290	3.29	1348.85	170.00	0.18
1	2076.5*	50.0% Q - 2yr	570.00	1.55	7.48	4.71	7.54	0.000545	2.05	278.67	97.08	0.21
1	2076.5*	20.0% Q - 5yr	1300.00	1.55	9.37	6.33	9.49	0.000582	2.76	470.57	106.22	0.23
1	2076.5*	10.0% Q - 10yr	1650.00	1.55	10.24	6.65	10.37	0.000547	2.92	570.10	146.41	0.23
1	2076.5*	4.0% Q - 25yr	2200.00	1.55	12.22	7.11	12.33	0.000301	2.64	884.08	176.99	0.18
1	2076.5*	2.0% Q - 50yr	2600.00	1.55	13.29	7.42	13.39	0.000243	2.61	1073.63	179.00	0.16
1	2076.5*	1.0% Q - 100yr	3000.00	1.55	13.88	7.71	13.99	0.000245	2.75	1178.75	179.00	0.17
1	2076.5*	0.5% Q - 200yr	3400.00	1.55	14.42	7.99	14.54	0.000249	2.89	1275.23	179.00	0.17
1	2076.5*	0.2% Q - 500yr	4100.00	1.55	15.27	8.45	15.41	0.000257	3.11	1428.20	179.00	0.17
1	2026.5	50.0% Q - 2yr	570.00	1.53	7.45	4.66	7.51	0.000526	2.00	284.97	100.03	0.21
1	2026.5	20.0% Q - 5yr	1300.00	1.53	9.35	6.30	9.46	0.000558	2.69	482.54	109.65	0.23
1	2026.5	10.0% Q - 10yr	1650.00	1.53	10.22	6.61	10.34	0.000506	2.81	603.66	155.66	0.22
1	2026.5	4.0% Q - 25yr	2200.00	1.53	12.22	7.06	12.31	0.000267	2.50	939.70	186.00	0.17
1	2026.5	2.0% Q - 50yr	2600.00	1.53	13.29	7.35	13.37	0.000215	2.46	1139.46	188.00	0.15
1	2026.5	1.0% Q - 100yr	3000.00	1.53	13.87	7.64	13.97	0.000217	2.60	1249.99	188.00	0.16
1	2026.5	0.5% Q - 200yr	3400.00	1.53	14.41	7.91	14.52	0.000220	2.73	1351.43	188.00	0.16
1	2026.5	0.2% Q - 500yr	4100.00	1.53	15.27	8.37	15.39	0.000227	2.94	1512.28	188.00	0.16
1	1976.5*	50.0% Q - 2yr	570.00	1.50	7.42	4.71	7.49	0.000582	2.09	272.53	96.50	0.22
1	1976.5*	20.0% Q - 5yr	1300.00	1.50	9.31	6.33	9.43	0.000609	2.81	462.97	105.64	0.24
1	1976.5*	10.0% Q - 10yr	1650.00	1.50	10.18	6.65	10.31	0.000549	2.94	575.65	142.93	0.23
1	1976.5*	4.0% Q - 25yr	2200.00	1.50	12.19	7.11	12.29	0.000295	2.63	886.88	172.49	0.18
1	1976.5*	2.0% Q - 50yr	2600.00	1.50	13.26	7.42	13.36	0.000239	2.61	1072.74	174.33	0.16
1	1976.5*	1.0% Q - 100yr	3000.00	1.50	13.85	7.71	13.96	0.000243	2.75	1174.91	174.33	0.17
1	1976.5*	0.5% Q - 200yr	3400.00	1.50	14.39	7.99	14.51	0.000247	2.89	1268.64	174.33	0.17
1	1976.5*	0.2% Q - 500yr	4100.00	1.50	15.24	8.46	15.38	0.000256	3.13	1417.20	174.33	0.17
1	1926.5*	50.0% Q - 2yr	570.00	1.48	7.38		7.46	0.000648	2.19	260.02	92.97	0.23
1	1926.5*	20.0% Q - 5yr	1300.00	1.48	9.26		9.40	0.000668	2.93	442.93	101.42	0.25
1	1926.5*	10.0% Q - 10yr	1650.00	1.48	10.14		10.28	0.000601	3.08	547.04	130.21	0.24
1	1926.5*	4.0% Q - 25yr	2200.00	1.48	12.16		12.28	0.000328	2.78	833.38	157.79	0.19
1	1926.5*	2.0% Q - 50yr	2600.00	1.48	13.24		13.35	0.000268	2.77	1004.98	160.66	0.17
1	1926.5*	1.0% Q - 100yr	3000.00	1.48	13.82		13.94	0.000274	2.93	1098.75	160.66	0.18
1	1926.5*	0.5% Q - 200yr	3400.00	1.48	14.35		14.49	0.000281	3.09	1184.68	160.66	0.18
1	1926.5*	0.2% Q - 500yr	4100.00	1.48	15.20		15.36	0.000293	3.35	1320.87	160.66	0.19

Reach	River Sta	Profile	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)	
1	1876.5	50.0% Q - 2yr	570.00	1.45	7.34	4.79	7.42	0.000726	2.30	247.44	89.47	0.24
1	1876.5	20.0% Q - 5yr	1300.00	1.45	9.21	6.40	9.36	0.000739	3.08	422.45	97.09	0.26
1	1876.5	10.0% Q - 10yr	1650.00	1.45	10.09	6.74	10.25	0.000664	3.23	518.08	117.51	0.25
1	1876.5	4.0% Q - 25yr	2200.00	1.45	12.13	7.22	12.26	0.000369	2.95	779.39	143.88	0.20
1	1876.5	2.0% Q - 50yr	2600.00	1.45	13.20	7.55	13.33	0.000304	2.95	936.51	147.00	0.18
1	1876.5	1.0% Q - 100yr	3000.00	1.45	13.78	7.86	13.93	0.000313	3.13	1021.83	147.00	0.19
1	1876.5	0.5% Q - 200yr	3400.00	1.45	14.31	8.15	14.48	0.000322	3.31	1099.99	147.00	0.19
1	1876.5	0.2% Q - 500yr	4100.00	1.45	15.16	8.64	15.34	0.000339	3.60	1223.69	147.00	0.20
1	1826.5	50.0% Q - 2yr	570.00	0.90	7.30	4.53	7.39	0.000409	2.65	262.11	91.57	0.22
1	1826.5	20.0% Q - 5yr	1300.00	0.90	9.17	6.36	9.33	0.000484	3.65	440.16	99.15	0.26
1	1826.5	10.0% Q - 10yr	1650.00	0.90	10.04	6.77	10.22	0.000457	3.86	528.35	102.70	0.25
1	1826.5	4.0% Q - 25yr	2200.00	0.90	12.09	7.32	12.24	0.000290	3.64	764.56	146.91	0.21
1	1826.5	2.0% Q - 50yr	2600.00	0.90	13.17	7.65	13.32	0.000251	3.64	923.64	147.53	0.20
1	1826.5	1.0% Q - 100yr	3000.00	0.90	13.75	7.98	13.91	0.000263	3.87	1008.91	147.53	0.21
1	1826.5	0.5% Q - 200yr	3400.00	0.90	14.28	8.28	14.46	0.000275	4.08	1087.01	147.53	0.21
1	1826.5	0.2% Q - 500yr	4100.00	0.90	15.11	8.78	15.33	0.000295	4.43	1210.60	147.53	0.22
1	1820		Bridge									
1	1814.5	50.0% Q - 2yr	570.00	0.79	7.05	4.13	7.15	0.000424	2.74	252.55	90.56	0.23
1	1814.5	20.0% Q - 5yr	1300.00	0.79	8.96	6.11	9.13	0.000494	3.72	432.69	98.45	0.26
1	1814.5	10.0% Q - 10yr	1650.00	0.79	10.04	6.58	10.21	0.000416	3.79	541.78	102.93	0.24
1	1814.5	4.0% Q - 25yr	2200.00	0.79	11.96	7.16	12.11	0.000289	3.67	756.57	142.41	0.21
1	1814.5	2.0% Q - 50yr	2600.00	0.79	13.03	7.52	13.18	0.000251	3.67	915.21	148.65	0.20
1	1814.5	1.0% Q - 100yr	3000.00	0.79	13.62	7.85	13.79	0.000263	3.90	1002.52	148.65	0.21
1	1814.5	0.5% Q - 200yr	3400.00	0.79	14.16	8.16	14.34	0.000274	4.10	1082.84	148.65	0.21
1	1814.5	0.2% Q - 500yr	4100.00	0.79	15.01	8.66	15.23	0.000292	4.44	1209.46	148.65	0.22
1	1759.5	50.0% Q - 2yr	570.00	0.77	6.95	4.50	7.11	0.001083	3.26	174.81	54.04	0.32
1	1759.5	20.0% Q - 5yr	1300.00	0.77	8.73	6.27	9.07	0.001552	4.65	279.58	64.05	0.39
1	1759.5	10.0% Q - 10yr	1650.00	0.77	9.82	6.77	10.16	0.001488	4.65	354.86	75.19	0.38
1	1759.5	4.0% Q - 25yr	2200.00	0.77	11.79	7.47	12.08	0.000885	4.29	519.87	96.31	0.30
1	1759.5	2.0% Q - 50yr	2600.00	0.77	12.87	7.96	13.15	0.000718	4.29	623.48	96.31	0.28
1	1759.5	1.0% Q - 100yr	3000.00	0.77	13.43	8.41	13.75	0.000741	4.58	677.73	96.31	0.29
1	1759.5	0.5% Q - 200yr	3400.00	0.77	13.94	8.82	14.30	0.000765	4.85	727.38	96.31	0.29
1	1759.5	0.2% Q - 500yr	4100.00	0.77	14.75	9.56	15.18	0.000812	5.31	805.08	96.31	0.31
1	1746.5		Bridge									
1	1733.5	50.0% Q - 2yr	570.00	1.09	6.74	4.29	6.90	0.000956	3.21	177.51	53.41	0.31
1	1733.5	20.0% Q - 5yr	1300.00	1.09	8.44	5.97	8.77	0.001490	4.63	280.99	65.57	0.39

Reach	River Sta	Profile	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)	
1	2863	4.0% Q - 25yr	2200.00	3.10	10.39	8.92	11.23	0.003267	7.33	300.27	70.33	0.62
1	2863	2.0% Q - 50yr	2600.00	3.10	10.95	9.40	11.85	0.003262	7.64	340.33	74.75	0.63
1	2863	1.0% Q - 100yr	3000.00	3.10	11.45	9.84	12.43	0.003247	7.91	379.31	78.81	0.64
1	2863	0.5% Q - 200yr	3400.00	3.10	12.42	10.25	13.27	0.002476	7.41	458.68	85.41	0.56
1	2863	0.2% Q - 500yr	4100.00	3.10	13.38	10.90	14.27	0.002142	7.58	540.65	85.41	0.53
1	2676.	50.0% Q - 2yr	570.00	2.50	6.77	5.47	7.10	0.002370	4.59	124.08	46.14	0.49
1	2676.	20.0% Q - 5yr	1300.00	2.50	8.30	7.01	8.93	0.003218	6.37	204.13	58.40	0.60
1	2676.	10.0% Q - 10yr	1650.00	2.50	8.92	7.57	9.64	0.003293	6.83	241.66	63.33	0.62
1	2676.	4.0% Q - 25yr	2200.00	2.50	9.77	8.32	10.61	0.003320	7.37	298.52	70.15	0.63
1	2676.	2.0% Q - 50yr	2600.00	2.50	10.32	8.80	11.24	0.003304	7.68	338.74	74.59	0.63
1	2676.	1.0% Q - 100yr	3000.00	2.50	10.84	9.24	11.82	0.003273	7.93	378.23	78.71	0.64
1	2676.	0.5% Q - 200yr	3400.00	2.50	12.02	9.65	12.81	0.002200	7.13	476.71	85.76	0.53
1	2676.	0.2% Q - 500yr	4100.00	2.50	13.05	10.30	13.87	0.001872	7.26	565.07	85.76	0.50
1	2583	50.0% Q - 2yr	570.00	2.20	6.58	5.17	6.88	0.002126	4.41	129.19	47.03	0.47
1	2583	20.0% Q - 5yr	1300.00	2.20	8.00	6.71	8.63	0.003214	6.37	204.24	58.42	0.60
1	2583	10.0% Q - 10yr	1650.00	2.20	8.60	7.27	9.33	0.003320	6.85	240.94	63.25	0.62
1	2583	4.0% Q - 25yr	2200.00	2.20	9.45	8.02	10.30	0.003355	7.40	297.38	70.02	0.63
1	2583	2.0% Q - 50yr	2600.00	2.20	10.01	8.50	10.93	0.003329	7.70	337.79	74.50	0.64
1	2583	1.0% Q - 100yr	3000.00	2.20	10.53	8.94	11.51	0.003285	7.94	377.72	78.67	0.64
1	2583	0.5% Q - 200yr	3400.00	2.20	11.85	9.35	12.61	0.002050	6.97	487.80	85.94	0.52
1	2583	0.2% Q - 500yr	4100.00	2.20	12.91	10.00	13.69	0.001736	7.08	579.14	85.94	0.48
1	2409.25	50.0% Q - 2yr	570.00	1.63	6.30	4.60	6.54	0.001613	3.98	143.04	49.31	0.41
1	2409.25	20.0% Q - 5yr	1300.00	1.63	7.45	6.14	8.07	0.003168	6.33	205.31	58.55	0.60
1	2409.25	10.0% Q - 10yr	1650.00	1.63	8.01	6.70	8.75	0.003379	6.89	239.32	63.02	0.62
1	2409.25	4.0% Q - 25yr	2200.00	1.63	8.84	7.45	9.71	0.003445	7.47	294.41	69.66	0.64
1	2409.25	2.0% Q - 50yr	2600.00	1.63	9.41	7.93	10.35	0.003385	7.75	335.66	74.25	0.64
1	2409.25	1.0% Q - 100yr	3000.00	1.63	9.96	8.37	10.94	0.003299	7.96	377.09	78.58	0.64
1	2409.25	0.5% Q - 200yr	3400.00	1.63	11.57	8.78	12.25	0.001758	6.63	512.80	86.29	0.48
1	2409.25	0.2% Q - 500yr	4100.00	1.63	12.69	9.43	13.39	0.001489	6.73	609.02	86.29	0.45
1	2266	50.0% Q - 2yr	570.00	1.17	6.13	4.14	6.33	0.001240	3.61	157.70	51.64	0.36
1	2266	20.0% Q - 5yr	1300.00	1.17	7.00	5.68	7.62	0.003132	6.30	206.19	58.67	0.59
1	2266	10.0% Q - 10yr	1650.00	1.17	7.50	6.24	8.26	0.003511	6.99	235.96	62.60	0.63
1	2266	4.0% Q - 25yr	2200.00	1.17	8.30	6.99	9.20	0.003625	7.62	288.90	69.04	0.66
1	2266	2.0% Q - 50yr	2600.00	1.17	8.90	7.47	9.85	0.003497	7.84	331.63	73.82	0.65
1	2266	1.0% Q - 100yr	3000.00	1.17	9.48	7.91	10.47	0.003330	7.98	375.79	78.46	0.64
1	2266	0.5% Q - 200yr	3400.00	1.17	11.38	8.32	12.00	0.001547	6.33	537.53	88.14	0.45
1	2266	0.2% Q - 500yr	4100.00	1.17	12.53	8.97	13.17	0.001305	6.41	639.24	88.14	0.42

HEC-RAS Plan: AB Design River: Pinole Reach: 1 (Continued) 1965

Reach	River Sta	Profile	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)	
1	2200	50.0% Q - 2yr	570.00	0.96	6.13	3.42	6.25	0.000594	2.71	210.54	61.40	0.26
1	2200	20.0% Q - 5yr	1300.00	0.96	7.04	4.87	7.40	0.001575	4.82	269.61	68.66	0.43
1	2200	10.0% Q - 10yr	1650.00	0.96	7.55	5.40	8.00	0.001808	5.40	305.39	72.71	0.46
1	2200	4.0% Q - 25yr	2200.00	0.96	8.37	6.12	8.93	0.001942	5.98	367.90	79.30	0.49
1	2200	2.0% Q - 50yr	2600.00	0.96	8.98	6.56	9.58	0.001927	6.23	417.46	84.15	0.49
1	2200	1.0% Q - 100yr	3000.00	0.96	9.56	6.99	10.20	0.001884	6.41	468.09	88.83	0.49
1	2200	0.5% Q - 200yr	3400.00	0.96	11.43	7.38	11.87	0.000950	5.27	644.79	96.25	0.36
1	2200	0.2% Q - 500yr	4100.00	0.96	12.59	8.03	13.05	0.000837	5.42	756.43	96.25	0.34
1	2061.75	50.0% Q - 2yr	570.00	0.51	6.08	2.97	6.17	0.000438	2.42	235.48	64.57	0.22
1	2061.75	20.0% Q - 5yr	1300.00	0.51	6.88	4.42	7.19	0.001296	4.49	289.62	70.96	0.39
1	2061.75	10.0% Q - 10yr	1650.00	0.51	7.35	4.95	7.76	0.001537	5.09	324.24	74.76	0.43
1	2061.75	4.0% Q - 25yr	2200.00	0.51	8.16	5.67	8.66	0.001695	5.69	386.90	81.19	0.46
1	2061.75	2.0% Q - 50yr	2600.00	0.51	8.77	6.11	9.31	0.001696	5.94	437.76	86.06	0.46
1	2061.75	1.0% Q - 100yr	3000.00	0.51	9.36	6.54	9.94	0.001665	6.12	490.04	90.79	0.46
1	2061.75	0.5% Q - 200yr	3400.00	0.51	11.34	6.93	11.73	0.000805	5.01	678.57	95.70	0.33
1	2061.75	0.2% Q - 500yr	4100.00	0.51	12.51	7.58	12.93	0.000725	5.19	790.62	95.70	0.32
1	1888	50.0% Q - 2yr	570.00	-0.05	6.03	2.41	6.10	0.000303	2.11	269.66	68.68	0.19
1	1888	20.0% Q - 5yr	1300.00	-0.05	6.72	3.86	6.98	0.000999	4.08	318.78	74.18	0.35
1	1888	10.0% Q - 10yr	1650.00	-0.05	7.16	4.39	7.50	0.001230	4.69	352.07	77.69	0.39
1	1888	4.0% Q - 25yr	2200.00	-0.05	7.94	5.11	8.37	0.001403	5.30	414.90	83.92	0.42
1	1888	2.0% Q - 50yr	2600.00	-0.05	8.54	5.55	9.02	0.001422	5.56	467.36	88.78	0.43
1	1888	1.0% Q - 100yr	3000.00	-0.05	9.14	5.98	9.65	0.001407	5.75	521.68	93.55	0.43
1	1888	0.5% Q - 200yr	3400.00	-0.05	11.25	6.37	11.59	0.000658	4.71	722.40	95.24	0.30
1	1888	0.2% Q - 500yr	4100.00	-0.05	12.43	7.02	12.80	0.000610	4.91	834.75	95.24	0.29
1	1800	50.0% Q - 2yr	570.00	-0.34	6.01	2.12	6.07	0.000252	1.98	288.54	70.83	0.17
1	1800	20.0% Q - 5yr	1300.00	-0.34	6.66	3.57	6.89	0.000869	3.87	335.63	75.96	0.32
1	1800	10.0% Q - 10yr	1650.00	-0.34	7.08	4.10	7.39	0.001088	4.48	368.36	79.33	0.37
1	1800	4.0% Q - 25yr	2200.00	-0.34	7.84	4.82	8.24	0.001263	5.10	431.34	85.45	0.40
1	1800	2.0% Q - 50yr	2600.00	-0.34	8.45	5.26	8.89	0.001289	5.37	484.61	90.30	0.41
1	1800	1.0% Q - 100yr	3000.00	-0.34	9.04	5.69	9.52	0.001282	5.56	539.96	95.08	0.41
1	1800	0.5% Q - 200yr	3400.00	-0.34	11.21	6.08	11.53	0.000596	4.53	750.86	97.52	0.29
1	1800	0.2% Q - 500yr	4100.00	-0.34	12.40	6.73	12.74	0.000554	4.73	866.36	97.52	0.28
1	1778.5	50.0% Q - 2yr	570.00	-0.36	6.01	2.10	6.07	0.000249	1.97	289.61	70.95	0.17
1	1778.5	20.0% Q - 5yr	1300.00	-0.36	6.64	3.55	6.87	0.000868	3.87	335.72	75.98	0.32
1	1778.5	10.0% Q - 10yr	1650.00	-0.36	7.05	4.08	7.36	0.001091	4.48	368.00	79.30	0.37
1	1778.5	4.0% Q - 25yr	2200.00	-0.36	7.81	4.80	8.22	0.001270	5.11	430.52	85.38	0.40
1	1778.5	2.0% Q - 50yr	2600.00	-0.36	8.42	5.24	8.87	0.001296	5.38	483.66	90.22	0.41
1	1778.5	1.0% Q - 100yr	3000.00	-0.36	9.01	5.67	9.49	0.001289	5.57	538.98	95.00	0.41