Appendix F

Floodplain Evaluation Report

County Road 96 Bridge over Dry Slough
Yolo County, California
Federal-Aid Project No. BRLO-5922(104)
Existing Bridge No. 22C0127

Floodplain Evaluation Report

Prepared for:

County of Yolo

Prepared by:

WRECO

March 2021

This page intentionally left blank

County Road 96 Bridge over Dry Slough
Yolo County, California
Federal-Aid Project No. BRLO-5922(104)
Existing Bridge No. 22C0127

Floodplain Evaluation Report

Submitted to:
Yolo County

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

Han-Bin Liang, Ph.D., P.E.
Registered Civil Engineer

3/5/2021
Date

March 2021

This page intentionally left blank

Table of Contents

Figures

Tables

Appendices

Executive Summary

Yolo County (County) is proposing to replace the existing bridge on County Road (CR) 96 crossing over Dry Slough. The CR 96 Bridge over Dry Slough Project (Project) is located approximately 6 miles (mi) northwest of the City of Davis.

The existing single-span bridge (Bridge No. 22C0127) was constructed in 1929 and is approximately 44-feet (ft)-long and 20-ft-wide. The proposed Project will construct a new bridge along the same roadway alignment. The new bridge is anticipated to be a single-span structure, approximately 60-ft-long.

The purpose of this *Floodplain Evaluation Report* is to examine and analyze the existing floodplain within the Project limits, and to determine any potential impacts to recommend any avoidance, minimization, or mitigation measures that may be required to address the impacts.

The Project site is located in Special Flood Hazard Area (SFHA) Zone AE, which represents areas subject to flooding by the 100-year flood event determined by detailed methods where Base Flood Elevations (BFE) are shown. At the Project site, the 100-year BFE is approximately 86 ft NAVD 88 based on the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS).

The selected 100-year peak design flow for Dry Slough was obtained from the FIS. The 100-year flow is 3,359 cubic feet per second (cfs).

The hydraulic assessment was performed using the United States Army Corps of Engineers' (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) modeling software. The hydraulic analysis indicates that the proposed bridge replacement would result in no increases in water surface elevation (WSE) for the 100-year storms in the vicinity of the bridge.

The Project is not proposing to change the overall land uses within the watershed. The Project is anticipated to add impervious area. The proposed bridge replacement will provide additional fill along the roadway approach to the bridge. Based on the hydraulic model, the bridge and roadway approaches for both the existing and the proposed conditions result in overtopping of the roadway approach on either side of the bridge. Therefore, the existing and proposed bridge replacement would be expected to experience traffic interruptions during a 100-year flow.

The Project has been designed to minimize floodplain impacts and special mitigation measures are not proposed. The Project would not trigger incompatible floodplain development. The Project would maintain local and regional access, and would not create new access to developed or undeveloped lands.

Potential short-term adverse effects to natural and beneficial floodplain values during the removal and replacement of the bridge include loss of vegetation during construction

activity, and temporary disturbances to vegetation, waters, or sensitive habitats. With proposed measures, long-term adverse effects to the natural and beneficial floodplain values are not anticipated from the Project. Temporary environmental impacts from construction activities for the proposed Project could be minimized with standard measures that meet the requirements of the Project's permit conditions. The County will coordinate with local, state, and federal water resources and floodplain management agencies as necessary during all aspects of the proposed Project.

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
BFE	Base Flood Elevations
BIR	Bridge Inspection Report
Caltrans	California Department of Transportation
cfs	cubic feet per second
County	County of Yolo
CR	County Road
CVFPB	Central Valley Flood Protection Board
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
ft	feet, foot
HDM	Highway Design Manual
HEC-1	Hydraulic Engineering Center 1
HEC-RAS	Hydrologic Engineering Center's River Analysis System
LRFD	Load and Resistance Factor Design
mi	mile
mph	miles per hour
NAVD 88	North American Vertical Datum of 1988
NBI	National Bridge Inventory
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSE	water surface elevation

This page intentionally left blank

LOCATION HYDRAULIC STUDY FORM

Dist. 03 Co. Yolo Rte. CR 96 Project ID__________
Federal-Aid Project Number: BRLO-5922(104)

Floodplain Description:
The Project site is located in Special Flood Hazard Area (SFHA) Zone AE, which represents areas subject to flooding by the 100-year flood event determined by detailed methods where BFEs are shown. At the Project site, the 100-year BFE is 86 ft NAVD 88.

1. Description of Proposal *(include any physical barriers i.e. concrete barriers, sound walls, etc. and design elements to minimize floodplain impacts)*
Yolo County proposes to replace the existing bridge on County Road (CR) 96 crossing over Dry Slough. The proposed Project will construct a new bridge along the same roadway alignment. The new structure will accommodate two 11-ft travel lanes and 2-ft shoulders. The new bridge is anticipated to be a single-span structure, approximately 60 ft long.

2. ADT: Current 216 (2010) Projected 126 (2034)

3. Hydraulic Data: Base Flood Q100= 3,360 CFS
WSE100= 87.3 ft *The flood of record, if greater than Q100:*
Q= N/A CFS WSE= N/A
Overtopping flood Q= 1,500 CFS WSE= 85.2 ft

Are NFIP maps and studies available? NO____ YES ✓

4. Is the highway location alternative within a regulatory floodway?
NO ✓ YES____

5. Attach map with flood limits outlined showing all buildings or other improvements within the base floodplain.

Potential Q100 backwater damages:

		NO	YES
A.	Residences?	✓	
B.	Other Bldgs?	✓	
C.	Crops?	✓	
D.	Natural and beneficial Floodplain values?	✓	

"Natural and beneficial flood-plain values" shall include but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

6. Type of Traffic:

	NO	YES
A. Emergency supply or evacuation route?	✓	
B. Emergency vehicle access?	✓	
C. Practicable detour available?		✓
D. School bus or mail route?		✓

7. Estimated duration of traffic interruption for 100-year event hours: 12 hours

8. Estimated value of Q100 flood damages (if any) – moderate risk level.

A.	Roadway	$ N/A
B	Property	$ N/A
	Total	$ N/A

9. Assessment of Level of Risk
Low ✓
Moderate____
High____

For High Risk projects, during design phase, additional Design Study Risk Analysis may be necessary to determine design alternative.

LOCATION HYDRAULIC STUDY FORM cont.

Dist. 03 Co. Yolo Rte. CR 96 P.M. ______
Federal-Aid Project Number: BRLO-5922(104)
Project ID ______ Bridge No. 22C0127

PREPARED BY:

Signature:
I certify that I have conducted a Location Hydraulic Study consistent with 23 CFR 650 and that the information summarized in items numbers 3, 4, 5, 7, and 9 of this form is accurate.

______ Date ______
District Hydraulic Engineer *(capital and 'on' system projects)*

[signature] Date 3/5/2021
Local Agency/Consulting Hydraulic Engineer *(local assistance projects)*

Is there any longitudinal encroachment, significant encroachment, or any support of incompatible Floodplain development? NO ✓ YES ______

If yes, provide evaluation and discussion of practicability of alternatives in accordance with 23 CFR 650.113

Information developed to comply with the Federal requirement for the Location Hydraulic Study shall be retained in the project files.

I certify that item numbers 1, 2, 6 and 8 of this Location Hydraulic Study Form are accurate and will ensure that Final PS&E reflects the information and recommendations of said report:

______ Date ______
District Project Engineer *(capital and 'on' system projects)*

Mark T. Christison Date 5/11/2021
Local Agency Project Engineer *(local assistance projects)*

CONCURRED BY:
I have reviewed the quality and adequacy of the floodplain submittal consistent with the attached checklist, and concur that the submittal is adequate to meet the mandates of 23 CFR 650.

______ Date ______
District Project Manager *(capital and 'on' system projects)*

Mark T. Christison Date 5/11/2021
Local Agency Project Manager *(Local Assistance projects)*

[signature] Date 6/11/2021
District Local Assistance Engineer *(or District Hydraulic Branch for very complex projects or when required expertise is unavailable. Note: District Hydraulic Branch review of local assistance projects shall be based on reasonableness and concurrence with the information provided).*

I concur that the natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

Laura Loeffler Date 06/21/21
District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.

SUMMARY FLOODPLAIN ENCROACHMENT REPORT

Dist. 03 Co. Yolo Rte. CR 96 K.P. ______
Federal-Aid Project Number *(Local Assistance)* BRLO-5922(104)
Project No.: ______ Bridge No. 22C0127
Limits: The approximate limits for this Project are 500 ft on either side of the existing bridge crossing on CR 96 over Dry Slough.
Floodplain Description: The Project site is located in Special Flood Hazard Area (SFHA) Zone AE, which represents areas subject to flooding by the 100-year flood event determined by detailed methods where BFEs are shown. At the Project site, the 100-year the BFE is 86 ft NAVD 88.

		No	Yes
1.	Is the proposed action a longitudinal encroachment of the base floodplain?	✓	
2.	Are the risks associated with the implementation of the proposed action significant?	✓	
3.	Will the proposed action support probable incompatible floodplain development?	✓	
4.	Are there any significant impacts on natural and beneficial floodplain values?	✓	
5.	Routine construction procedures are required to minimize impacts on the floodplain. Are there any special mitigation measures necessary to minimize impacts or restore and preserve natural and beneficial floodplain values? If yes, explain.	✓	
6.	Does the proposed action constitute a significant floodplain encroachment as defined in 23 CFR, Section 650.105(q).	✓	
7.	Are Location Hydraulic Studies that document the above answers on file? If not explain.		✓

PREPARED BY:

______ *Date* ______
District Project Engineer *(capital and 'on' system projects)*

[signature] *Date* 3/5/2021
Local Agency/Consulting Hydraulic Engineer *(local assistance projects)*

CONCURRED BY:

______ *Date* ______
District Project Manager *(capital and 'on' system projects)*

[signature] *Date* 6/11/2021
District Local Assistance Engineer *(Local Assistance projects)*

I concur that impacts to natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

Laura Loeffler *Date* 06/21/21
District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.

This page intentionally left blank

1 GENERAL DESCRIPTION

Yolo County (County) proposes to replace the existing bridge on County Road (CR) 96 crossing over Dry Slough. The CR 96 Bridge over Dry Slough Project (Project) is located approximately 6 miles (mi) northwest of the City of Davis. See Figure 1 for the Project Location Map, Figure 2 for the Project Vicinity Map, and Figure 3 for the Project Aerial Map.

1.1 Project Description

The County proposes to replace the existing bridge on County Road (CR) 96 crossing over Dry Slough with funding made available through the Federal Highway Administration (FHWA) Highway Bridge Program and administered by California Department of Transportation (Caltrans). The bridge was determined to be functionally obsolete by Caltrans as recently as 2013 and currently has a sufficiency rating of 53.6.

The Project site is located within the southern region of Yolo County, between Interstate 505 and State Route 113. CR 96 is a rural local roadway that extends between Russell Boulevard on the south and CR 27 on the north. Within the Project vicinity, CR 96 is paved and has an approximate width of 20 feet (ft). The bridge, with an Average Daily Traffic (ADT) count of 216 vehicles, is bordered by agricultural and residential parcels. There are five driveways on the east side and four driveways on the west side of CR 96. There is a residential structure approximately 100 ft northwest of the bridge and an agricultural building approximately 60 ft southeast of the bridge. The posted speed limit along CR 96 within the Project vicinity is 45 miles per hour (mph).

1.2 Existing Bridge

The existing bridge (Bridge No. 22C0127) was constructed in 1929 and is approximately 44-ft-long and 20-ft-wide. The structure consists of single-span reinforced concrete T-girders. The bridge has longitudinal and shear cracking along the girders and evidence of water penetration through the deck. Additionally, the bridge railing is in poor condition with spalling and exposed rebar.

1.3 Proposed Bridge

The proposed Project will construct a new bridge along the same roadway alignment. The new structure will accommodate two 11-ft travel lanes and 2-ft shoulders. The new bridge is anticipated to be a single-span structure, approximately 60-ft-long (see Figure 4). The structure type is expected to consist of a cast-in-place, post-tensioned concrete slab. The roadway and bridge profile will be raised slightly to clear the 100-year storm event.

Construction of the bridge will involve excavation for and construction of concrete abutments, founded on driven piles. The new abutments will be constructed behind the existing abutments and most of this work will occur outside of the waterway. Construction of the roadway approaches will involve the removal of existing pavement and placement of new roadway fill material, aggregate base, hot mix asphalt pavement, and installation of a guardrail. Tree removal and removal of other vegetation along the slough will be necessary for the Project. Temporary work within Dry Slough includes removal of the existing structure, falsework erection and removal, and installation of scour countermeasures at the abutments. Temporary slough diversion is anticipated in order to complete activities within the waterway.

Relocation of overhead electrical and communication lines, including four utility poles, along the west side of CR 96 is anticipated as part of the Project. Although the traveled way and shoulders will remain within the County's right-of-way, permanent acquisitions may be needed for the approach grading and utility relocation from three to four parcels. Temporary construction easements may be needed from up to seven parcels adjacent to the project to facilitate driveway conforms, utility relocations, and allow construction access.

During construction, CR 96 will be closed to through traffic and a detour route will be made available. Vehicular traffic will be able to utilize CR 95, 31, and 29 as alternative routes. Construction is anticipated to begin in Spring 2023 and have a duration of approximately 8 months.

1.4 Study Purpose

The purpose of this *Floodplain Evaluation Report* is to examine and analyze the existing floodplain within the Project limits, and to determine any potential impacts to recommend any avoidance, minimization, or mitigation measures that may be required to address the impacts.

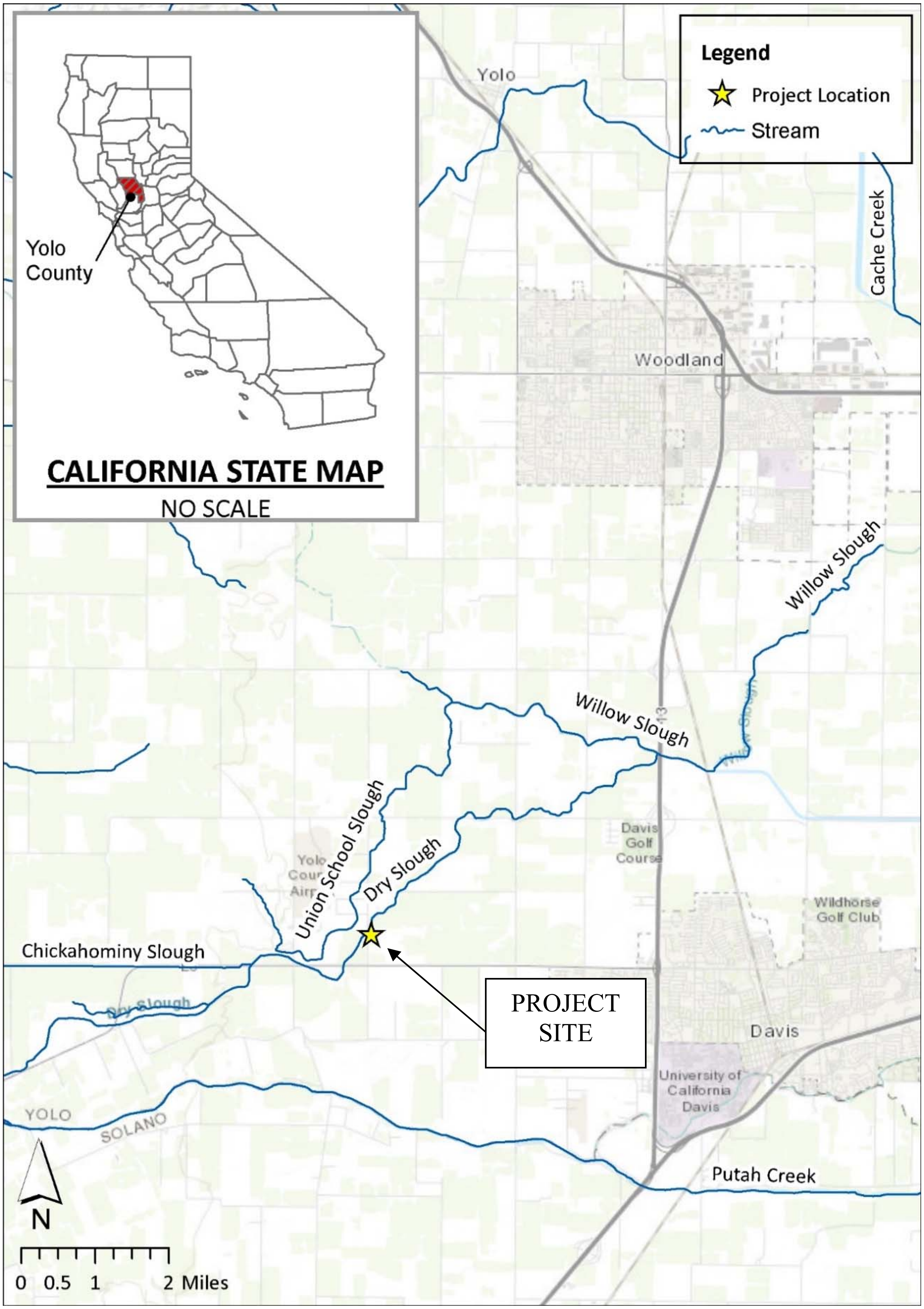


Figure 1. Project Location Map

Source: United States Geological Survey (USGS)

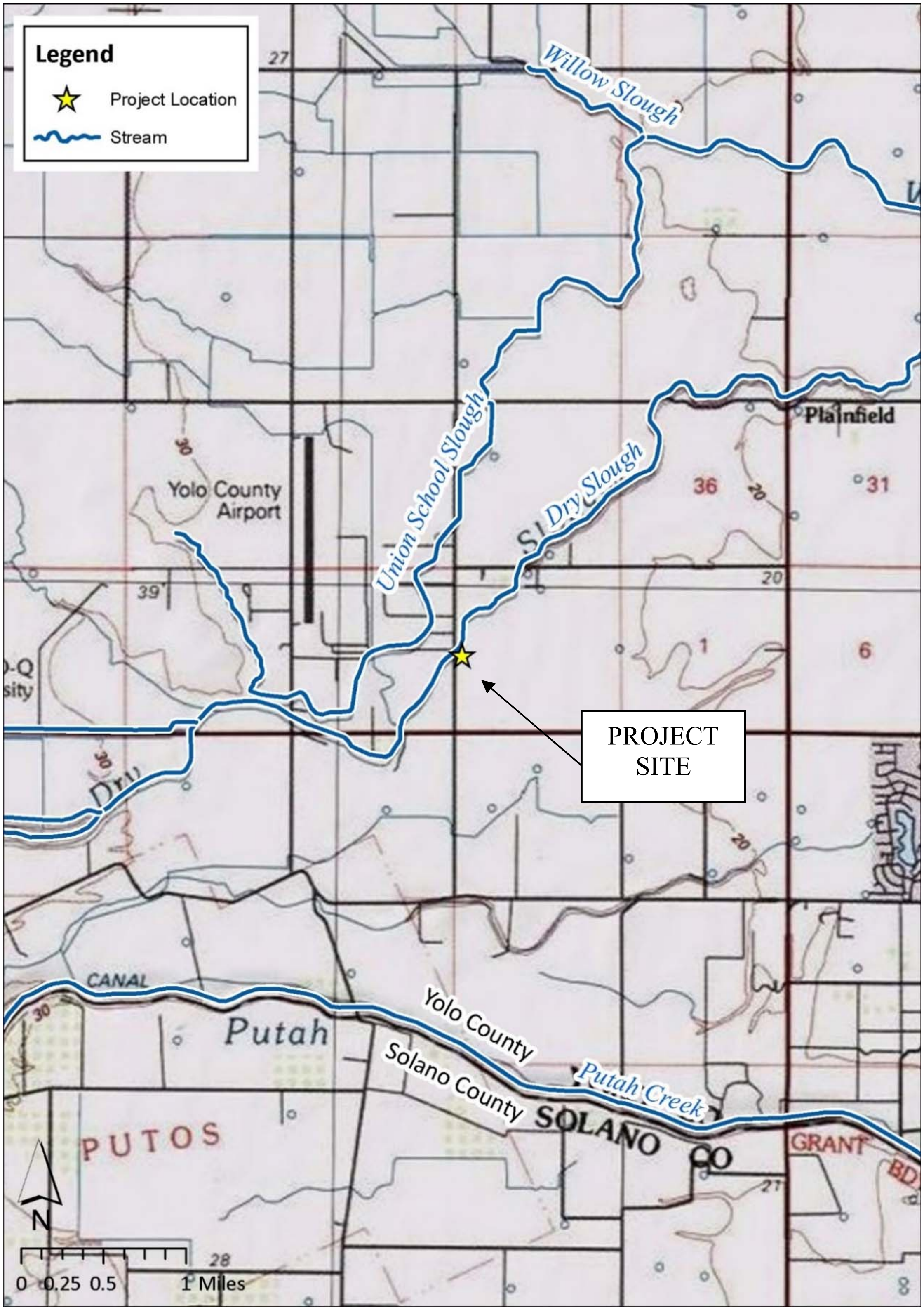


Figure 2. Project Vicinity Map

Source: USGS

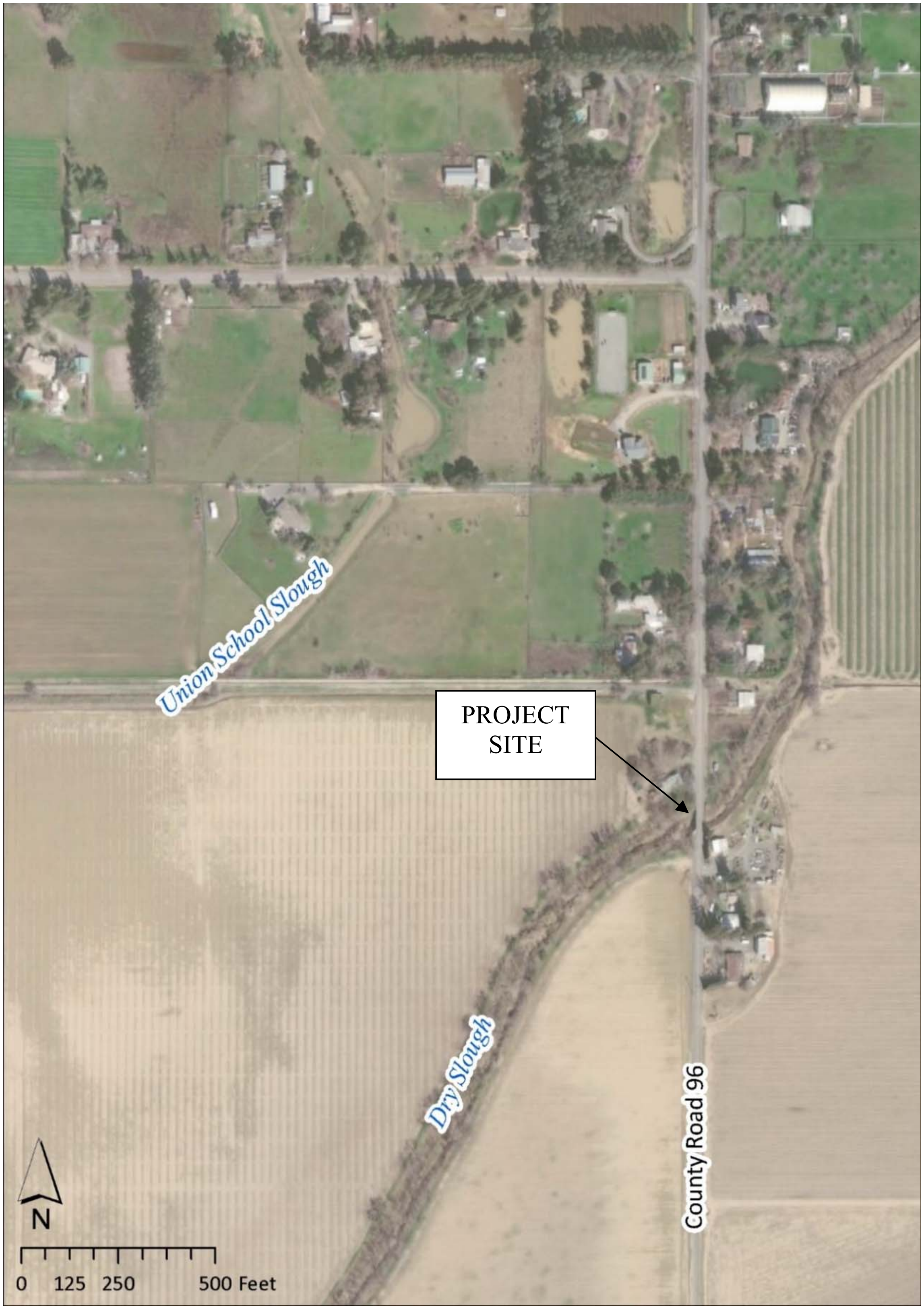


Figure 3. Project Aerial Map

Source: ESRI

This page intentionally left blank

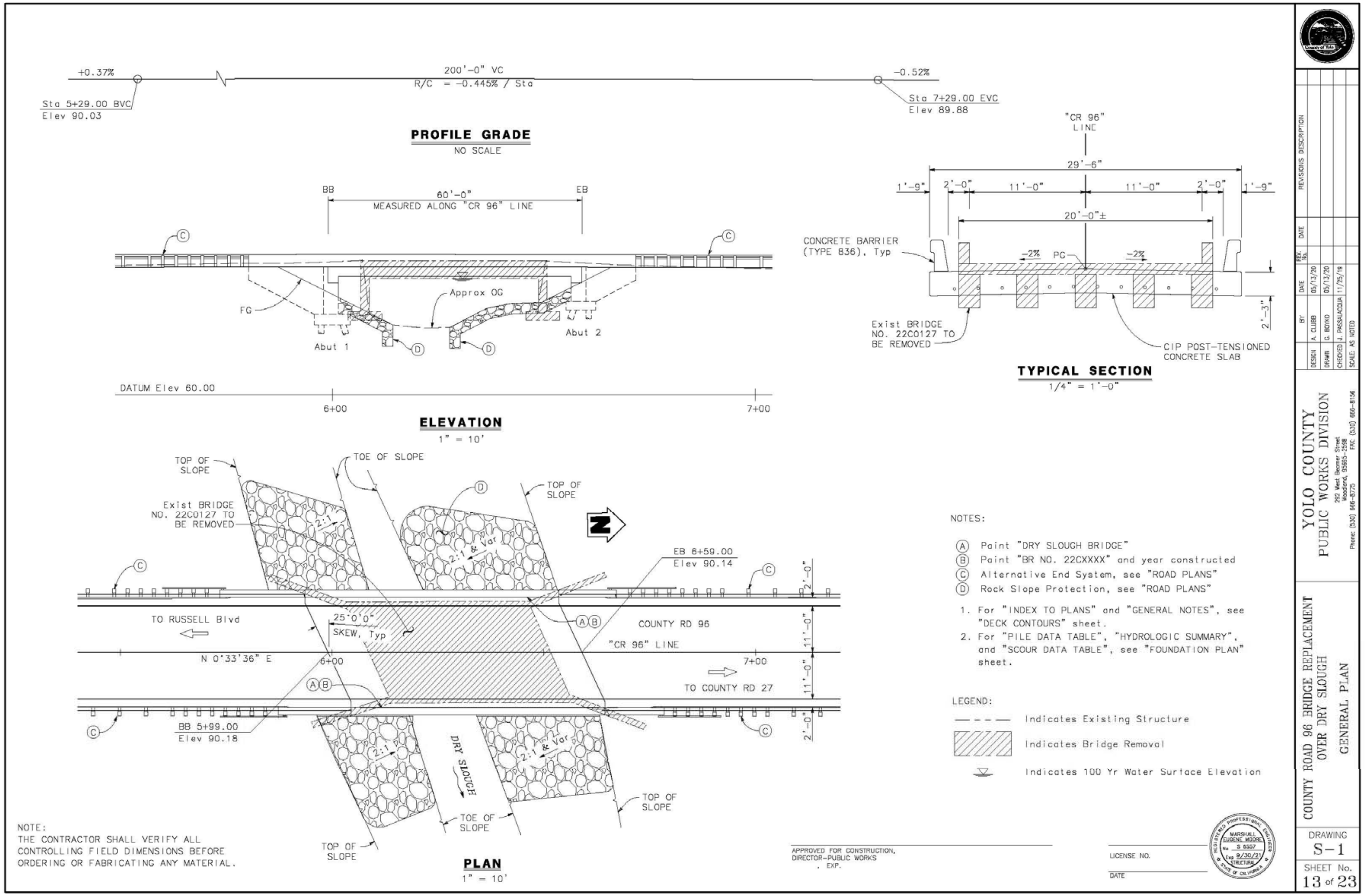


Figure 4. Proposed Bridge General Plan

Source: Mark Thomas

This page intentionally left blank

1.5 Regulatory Setting

1.5.1 Executive Order 11988 (Floodplain Management, 1977)

Executive Order 11988 (Floodplain Management) directs all federal agencies to avoid, to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative (1977). Requirements for compliance are outlined in Title 23, Code of Federal Regulations, Part 650, Subpart A (23 CFR 650A) titled “Location and Hydraulic Design of Encroachment on Floodplains” (United States, Federal Highway Administration, Department of Transportation, 2019).

If the preferred alternative involves significant encroachment onto the floodplain, the final environmental document (final Environmental Impact Statement or finding of no significant impact) must include:

- The reasons why the proposed action must be located in the floodplain,
- The alternatives considered and why they were not practicable, and
- A statement indicating whether the action conforms to applicable state or local floodplain protection standards.

1.5.2 California’s National Flood Insurance Program

The Federal Emergency Management Agency (FEMA) is the nationwide administrator of the National Flood Insurance Program (NFIP), which is a program that was established by the National Flood Insurance Act of 1968 to protect lives and property, and to reduce the financial burden of providing disaster assistance. Under the NFIP, FEMA has the lead responsibility for flood hazard assessment and mitigation, and it offers federally backed flood insurance to homeowners, renters, and business owners in communities that choose to participate in the program. FEMA has adopted the 100-year floodplain as the base flood standard for the NFIP. FEMA is also concerned with construction that would be within a 500-year floodplain for proposed projects that are considered “critical actions,” which are defined as any activities where even a slight chance of flooding is too great. FEMA issues the Flood Insurance Rate Maps (FIRM) for communities that participate in the NFIP. These FIRMs present delineations of flood hazard zones.

In California, nearly all of the State’s flood-prone communities participate in the NFIP, which is locally administered by the California Department of Water Resources’ (DWR) Division of Flood Management. Under California’s NFIP, communities have a mutual agreement with the State and federal governments to regulate floodplain development according to certain criteria and standards, which are further detailed in the NFIP.

1.5.3 Yolo County Floodplain Data

As part of the NFIP, typically, each county (or community) has a Flood Insurance Study (FIS), which is used to locally develop FIRMs and Base Flood Elevations (BFE). The County FIS Number is 06113CV000.

1.6 Design Standards

1.6.1 FEMA Standards

FEMA standards are employed for design, construction, and regulation to reduce flood loss and to protect resources. Two types of standards are often employed: design criteria and performance standards.

A design criteria or specified standard dictates that a provision, practice, requirement, or limit be met; e.g., using the 1% flood and establishing floodway boundaries so as not to cause more than a 1-ft increase in flood stages.

A performance standard dictates that a goal is to be achieved, leaving it to the individual application as to how to achieve the goal; e.g., providing protection to the regulatory flood, keeping post-development stormwater runoff the same as pre-development, or maintaining the present quantity and quality of water in a wetland.

The 1% annual chance flood and floodplain have been adopted as a common design and regulatory standard in the United States. The NFIP adopted it in the early 1970s, and it was adopted as a standard for use by all federal agencies with the issuance of Executive Order 11988. States or local agencies are free to impose a more stringent standard within their jurisdiction.

1.6.2 Hydraulic Design Criteria

1.6.2.1 FHWA Standards

According to the *California Amendments to the American Association of State Highway and Transportation Officials* (AASHTO) *Load and Resistance Factor Design* (LRFD) *Bridge Design Specifications (2017 Eighth Edition)*, the FHWA mandated that LRFD be used on all new bridge design commencing on or after October 1, 2007 (Department of Transportation State of California, 2019). In 2011, the *California Amendments to the AASHTO LRFD Bridge Design Specifications (Fourth Edition)* updated certain sections of the guidance, including Section 2 in its entirety.

From Section 2 of the *California Amendments to the AASHTO LRFD Bridge Design Specifications*, the proposed bridge profile should provide adequate freeboard to pass anticipated drift for the 50-year design flood, to pass the 100-year base flood without freeboard, or the flood of record without freeboard, whichever is greater (Department of Transportation State of California, 2011).

Subsequent revisions to the *California Amendments to the AASHTO LRFD Bridge Design Specifications* in 2014 and 2019 did not include changes to Section 2. The sections that are not revised in subsequent versions of the *California Amendments to the AASHTO LRFD Bridge Design Specifications* are still in effect.

1.6.2.2 Caltrans Standards

From Chapter 820 of the Caltrans' *Highway Design Manual* (HDM), the criteria for the hydraulic design of bridges is that they be designed to pass the 2% probability of annual exceedance flow (50-year design discharge) with adequate freeboard to pass anticipated drift and debris (2020). Two (2) ft of freeboard is commonly used in bridge designs. Alternatively, the bridge can also be designed to pass the 1% probability of annual exceedance flow (100-year design discharge, or base flood). No freeboard is added to the base flood.

1.6.2.3 Central Valley Flood Protection Board Standards

Streams regulated by the Central Valley Flood Protection Board (CVFPB) must adhere to the design criteria from Title 23 of the California Code of Regulations. The Project is not within the jurisdiction of the CVFPB.

1.6.2.4 Yolo County Standard

Per the Yolo County *City/County Drainage Design* criteria, a minimum of 2 ft of freeboard for the 100-year event and 1 ft of freeboard for the 200-year event shall be provided for bridges at crossings (Yolo County, 2010).

1.7 Traffic

Based on the Caltrans' Bridge Inspection Report (BIR), the existing bridge has a functional classification as a major collector rural road. Based on the 2019 BIR, traffic data, the ADT in 2010 was 216 vehicles per day. The future ADT is projected to be 126 vehicles per day in 2034 (Caltrans, 2019)

1.8 Vertical Datum

The Project references the North American Vertical Datum of 1988 (NAVD 88).

This page intentionally left blank

2 AFFECTED ENVIRONMENT

2.1 Geographic Location

The Project is located within the southern region of the County at 38°34’3.92” North latitude and 121°50’25.13” West longitude. The Project area is relatively flat, sloping west to east towards Willow Slough.

2.2 Watershed Description

The watershed originates in the Rocky Ridge, which is located along the Yolo/Napa county line west of the Project site. Salt Creek, Pine Creek, and Chickahominy Slough combine approximately 12 mi west of the Project site (see Figure 5 for the Project watershed). Chickahominy Slough continues flowing east for approximately 10 mi before merging with Dry Slough. From there, Dry Slough flows east and northeast approximately 2 mi to the Project site. Basin characteristics from United States Geological Survey (USGS) StreamStats are identified in Table 1.

Table 1. Basin Characteristics

Parameter	Value	Unit
Drainage area	44.4	square mi
Mean annual precipitation	24	inches
Mean basin elevation	400	ft

Source: USGS

2.3 FEMA Floodplains

The Project is within FEMA FIRM Number 06113C0580G Panel 580 of 785 (See Appendix A). The Project site is located in Special Flood Hazard Area (SFHA) Zone AE, which represents areas subject to flooding by the 100-year flood event determined by detailed methods where BFEs are shown. Based on the FEMA FIRM, BFE is approximately 86 ft NAVD 88 at the Project site. The FEMA Flood map at the Project site is shown in Figure 6.

This page intentionally left blank

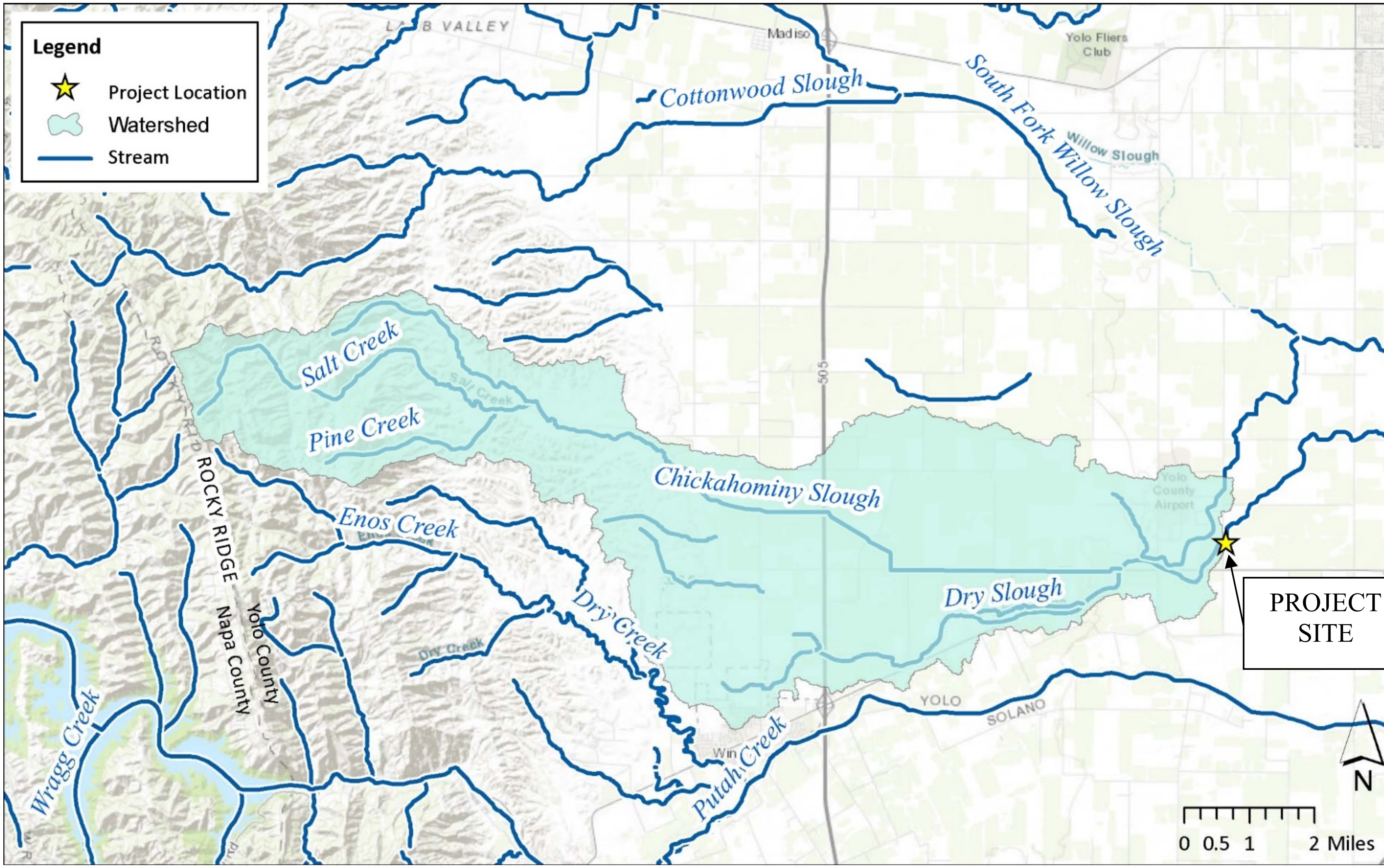


Figure 5. Project Watershed Map

Source: ESRI

This page intentionally left blank

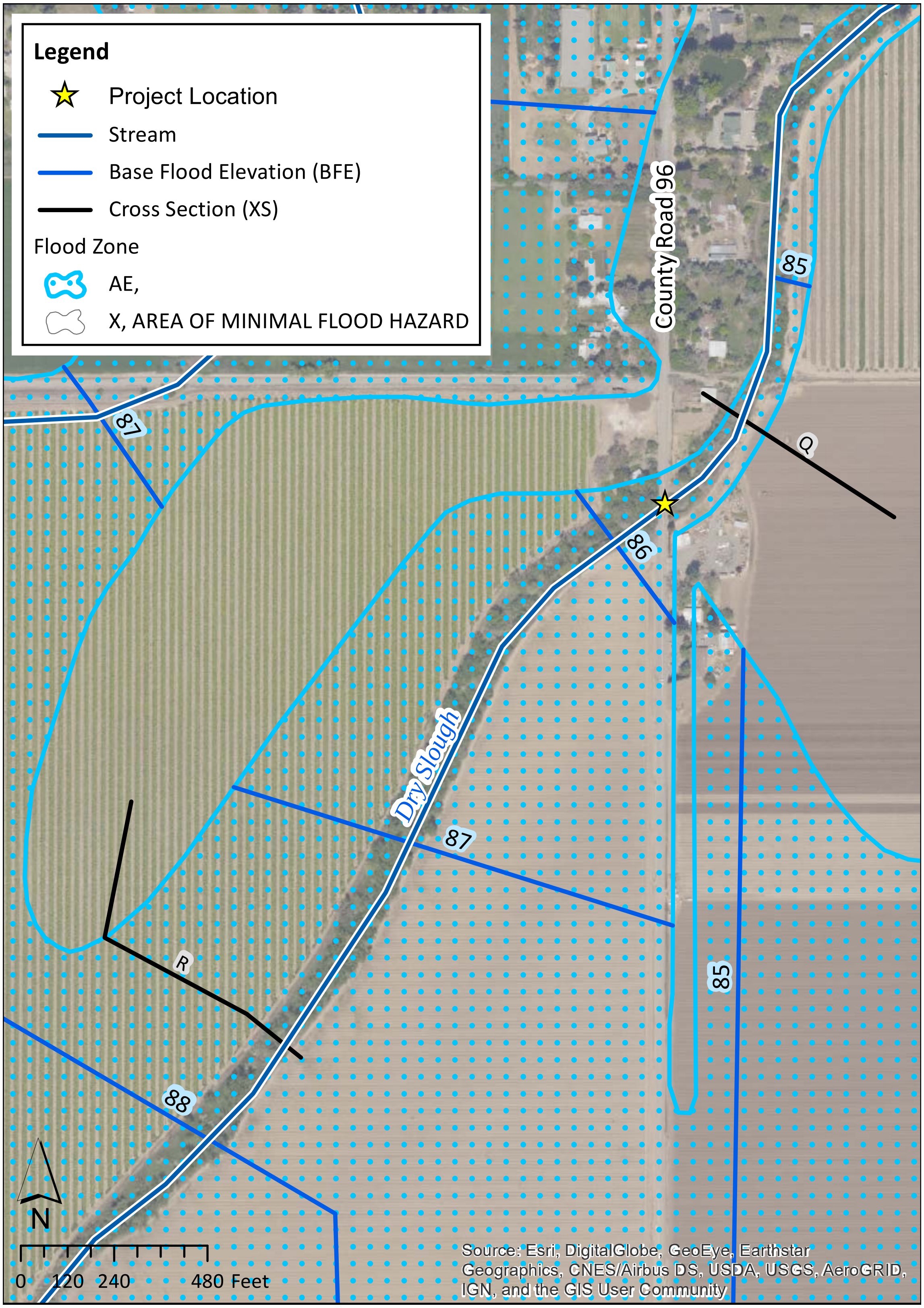


Figure 6. Floodplain Map

Source: FEMA and ESRI

This page intentionally left blank

3 HYDROLOGY AND HYDRAULICS

3.1 Hydrologic Assessment

WRECO evaluated the hydrology at the Project site using the following hydrologic design methods/sources:

1. USGS Regional Regression Equations
2. FEMA FIS

3.1.1 USGS Regional Regression Equations

Flood-frequency equations were developed by the USGS and based on analysis of data from gage stations. California is divided into six regions; the Project site is within the North Coast region. These flood-frequency equations are generally used to estimate stream flow for ungaged sites that are not affected by substantial urban development and that are natural (unregulated) streams. The 100-year flow from the reginal regression equation is 7,580 cfs.

3.1.2 Federal Emergency Management Agency Flood Insurance Study

The Project site is located within Yolo County, California. The effective FIS for Yolo County, California and Incorporated Areas included flow rates for Dry Slough at three locations, which are presented in Table 2.

Table 2. 100-year Peak Flows for Dry Slough

Location	Drainage Area (square mi)	Flow (cfs)
At State Highway 113	47.11	714*
Approximately 650 ft upstream of Road 31	46.21	3,359*
Approximately 2,500 ft upstream of CR 95	44.78	3,614

Notes: * Decrease in flow with increase in area is result of spill.

Source: FEMA

The Project site is located approximately 0.6 mi downstream of Road 31, and the 100-year peak flow most appropriate to the Project site is 3,359 cfs.

3.1.3 Selected Design Discharges

Even though the regional regression equation is more conservative, it does not give an accurate interpretation of the flows in Dry Slough. The regression equations do not consider that surface water flows that escape the channel along the bank of Dry Slough, and flows away towards the east. The USGS regional regression equations overestimate the peak flows because they do not consider escape flows. Because the USGS regional regression estimates do not account for the spill flows, the flow from the FEMA FIS was recommended for the hydraulic analyses for the Project. The selected 100-year peak flow discharge for this Project site was 3,359 cfs.

3.2 Hydraulic Assessment

The following sections discuss the development of the hydraulic models and summarize the results for the existing and proposed conditions. The water surface profile plots, hydraulic summary tables, and channel cross sections are included in Appendix B for the existing bridge and Appendix C for the proposed bridge.

3.2.1 Design Tools

The hydraulic analyses were performed for the existing and proposed conditions using the United States Army Corps of Engineers' (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) modeling software, Version 5.0.6. The hydraulic model was evaluated using the steady state flow analysis with subcritical flow regime.

3.2.2 Hydraulic Model Development

3.2.2.1 Cross-section Data

The cross-sectional channel geometry for the hydraulic model was developed using survey data provided by Mark Thomas (2019). The survey references NAVD 88. The cross section locations are shown in Figure 7.

3.2.2.2 Modeled Hydraulic Structures

The existing bridge was modeled based on survey data provided by Mark Thomas (2019). The hydraulic opening of the bridge (perpendicular to the flow direction) is modeled as 35 ft. The existing bridge has a minimum soffit elevation of 87.2 ft.

The proposed bridge was modeled based on the general plan (see Figure 4) provided by Mark Thomas (2019). The hydraulic opening of the bridge (perpendicular to the flow direction) is modeled as 55 ft. The proposed bridge has a minimum soffit elevation of 87.6 ft.

3.2.2.3 Model Boundary Condition

A normal depth slope of 0.0018 ft/ft was used as the downstream boundary condition, and it was based on the thalweg elevations from the survey of Dry Slough downstream of the bridge.

3.2.2.4 Manning's Roughness Coefficients

Manning's roughness coefficients were used in the hydraulic model to estimate energy losses in the flow due to friction. A roughness coefficient of 0.05 was used to describe the channel, and a roughness coefficient ranging from 0.05 to 0.08 were used to describe the overbank areas.

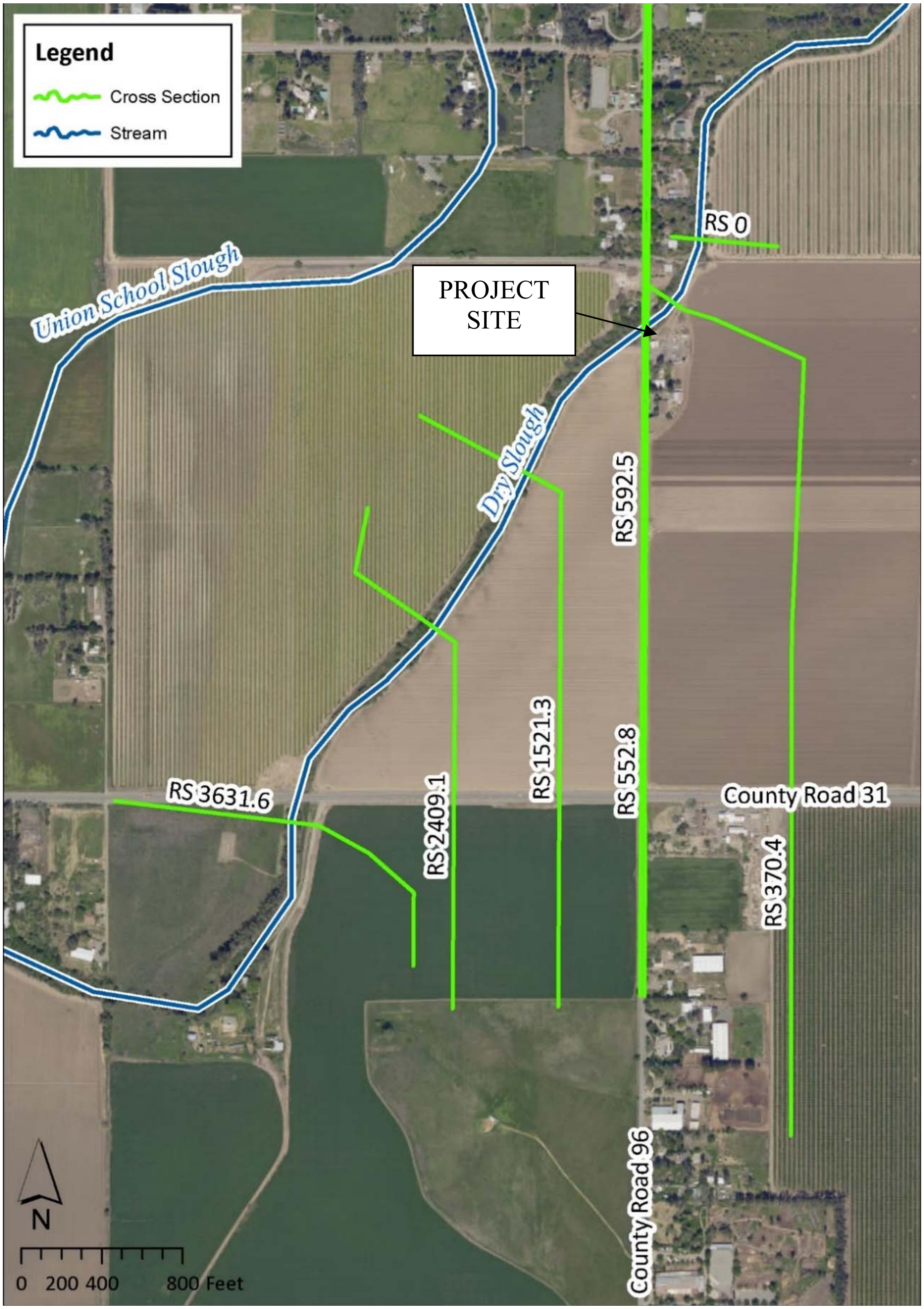


Figure 7. Cross Section Locations

Source: ESRI

3.2.3 Expansion and Contraction Coefficients

Expansion and contraction coefficients were used in the hydraulic model to represent energy losses in the channel. An expansion coefficient of 0.3 and a contraction coefficient of 0.1 were used to represent the channel. These values represent a channel with gradual transitions between cross sections. The expansion and contraction coefficients used in the vicinity of the bridges were 0.5 and 0.3, respectively. These values represent the flow interference caused by the bridge.

3.3 Hydraulic Model Results

3.3.1 Water Surface Elevations

The Water Surface Elevations (WSE) were estimated for the existing and proposed conditions as described in Section 3.2.2. The 100-year water surface profiles comparing the existing and proposed condition model results are depicted in Figure 8. The cross sections at the upstream faces of the existing and proposed structures are shown in Figure 9 and Figure 10.

Approximately a third of the total flow is conveyed through the main channel at the bridge while the remaining flow is distributed to the floodplains on either side of the bridge. The WSEs in the immediate vicinity of the bridges are shown in Table 3 for the 100-year storm events.

Table 3. Dry Slough 100-Year Water Surface Elevations

River Station	Description/Distance from Existing Bridge Centerline (feet)	Water Surface Elevation (ft NAVD 88)[1]	
		Existing	Proposed
592.5	20 feet upstream	87.4	87.4
572.7 BR U	Upstream face of bridge	87.3	87.3
572.7 BR D	Downstream face of bridge	87.3	87.3
552.8	20 feet downstream	87.3	87.3

Notes:

BR U=upstream face of bridge.
BR D=downstream face of bridge.
[1] Elevations listed are rounded to the nearest 0.1 ft.

The hydraulic analysis indicates that the proposed bridge would result in no increases in WSE for the 100-year storms in the vicinity of the bridge (see Table 3).

The approach roadways of the existing bridge are overtopped due to the wide floodplain. The proposed bridge profile will be raised slightly to clear the 100-year storm, but will not be raised to meet the 2 ft of freeboard over the 50-year WSE criteria. The proposed bridge will clear the 50-year storm with some freeboard. Raising the bridge to meet the 2 ft of freeboard over the 50-year WSE criteria would require the approach roadways be raised, which would further block the flood flows.

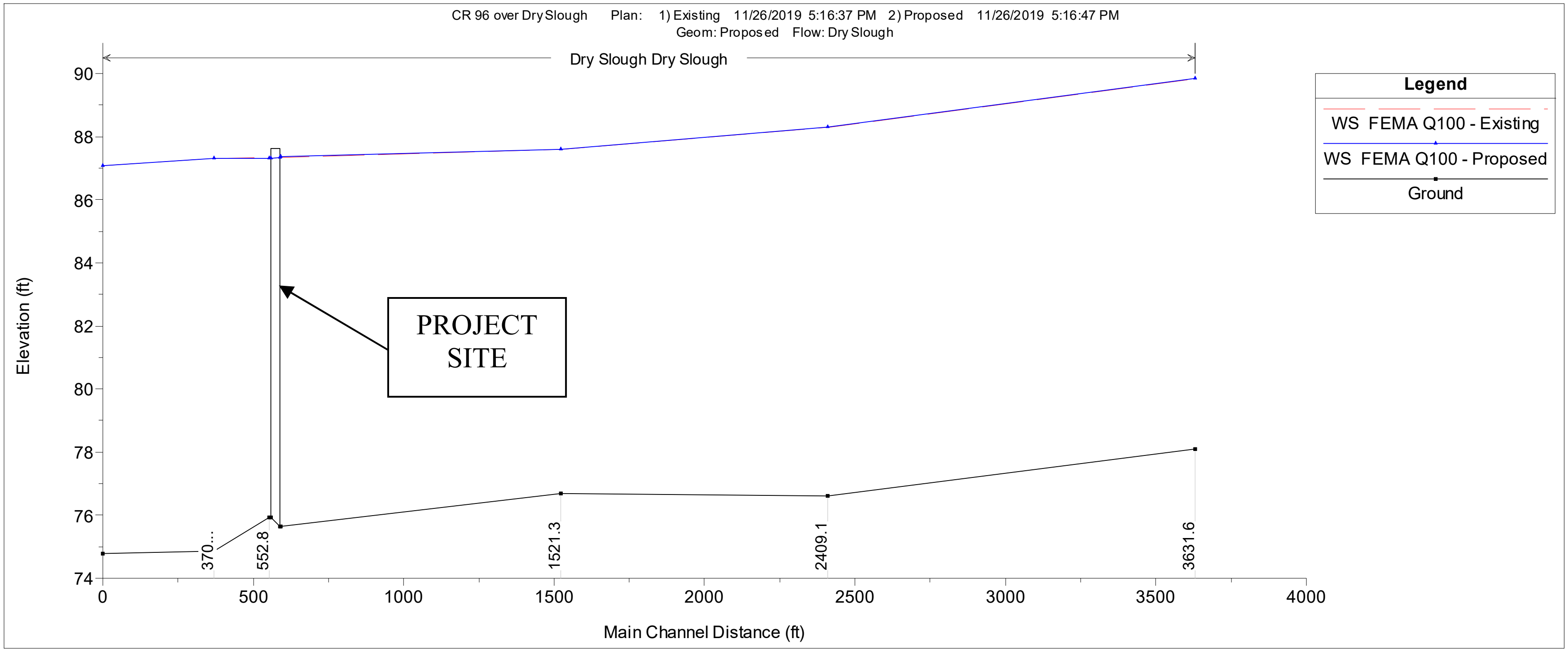


Figure 8. Dry Slough 100-Year Water Surface Profile at County Road 96

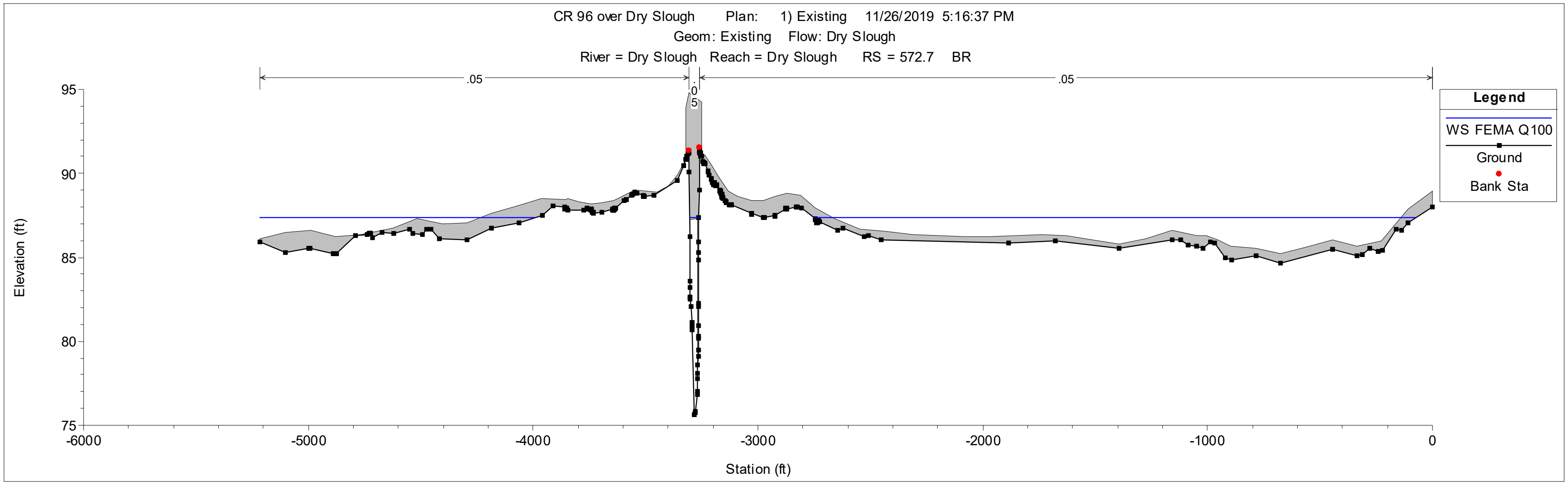


Figure 9. Upstream Face of Existing Bridge, Looking Downstream (northeast)

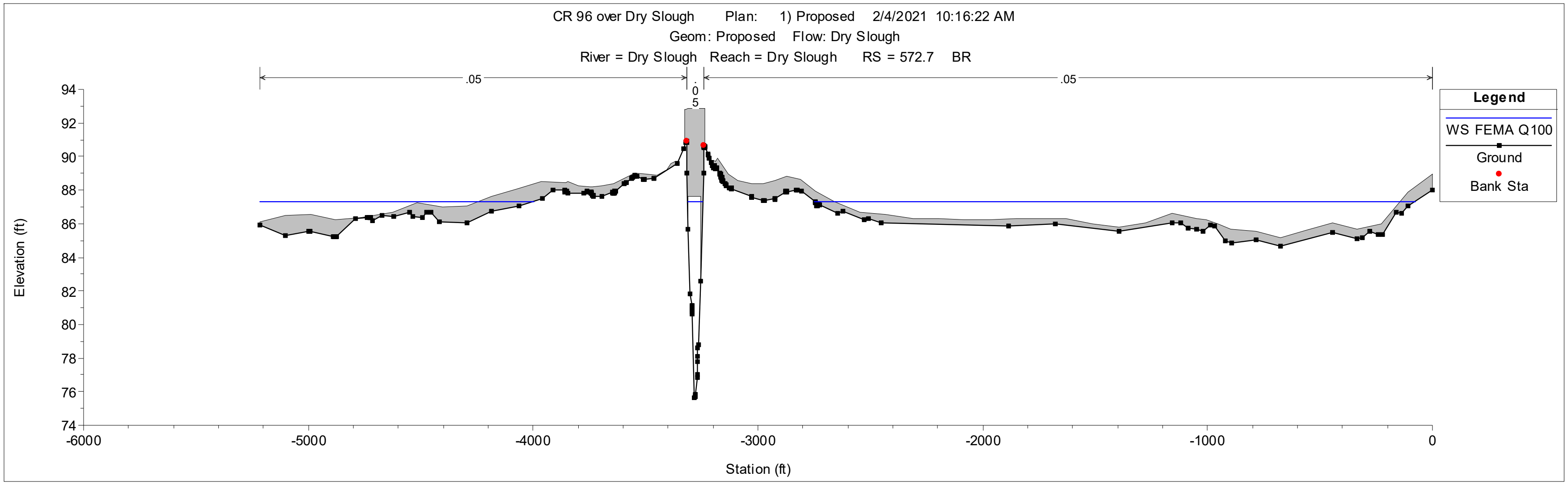


Figure 10. Upstream Face of Proposed Bridge, Looking Downstream (northeast)

4 PROJECT EVALUATION

Executive Order 11988 requires federal agencies to avoid to the maximum extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. This section analyzes the impacts associated with this Project.

4.1 Risk Associated with the Proposed Action

As defined by the FHWA, risk shall mean the consequences associated with the probability of flooding attributable to an encroachment. It shall include the potential for property loss and hazard to life during the service life of the bridge and roadway.

The potential risk associated with the implementation of the proposed action includes, but is not limited to: 1) change in land use, 2) change in impervious surface area, 3) fill inside the floodplain, or 4) change in the 100-year WSE. The measures to minimize the potential floodplain impacts associated with the action are summarized in Section 5.

4.1.1 Change in Land Use

According to the Yolo County *2030 Countywide General Plan,* the land around CR 96 crossing over Dry Slough within the Project limits consists of largely agricultural uses (County of Yolo, 2009). The Project proposes to replace the existing bridge structure. Due to the nature of the work proposed, the Project would not change the overall land use within the watershed basin.

4.1.2 Change in Impervious Surface Area

The Project is anticipated to have 0.57 acres of added impervious area. The Project will result in a net increase in impervious surface area.

4.1.3 Fill Inside the Floodplain

The proposed bridge replacement will provide additional fill along the roadway approach to the bridge to raise the bridge profile. The replacement bridge will pass the 100-year flow.

4.1.4 Change in the 100-Year Water Surface Elevation

As demonstrated by the HEC-RAS hydraulic model, the proposed bridge would result in no change in the WSE upstream or downstream of the bridge.

4.2 Summary of Potential Encroachments

The FHWA defines a significant encroachment as a highway encroachment, and any direct support of likely base floodplain development, that would involve one or more of the following construction or flood-related impacts: 1) significant potential for interruption or termination of a transportation facility that is needed for emergency vehicles or provides a community's only evacuation route, 2) a significant risk, or 3) a significant adverse impact on the natural and beneficial floodplain values (FHWA, 1994). The following sections discuss the potential impacts to the floodplain that may result from the proposed action. The risk associated with implementation of the action is discussed in Section 4.1.

4.2.1 Potential Traffic Interruptions for the Base Flood

The base flood is that flood that has a 1% chance of occurrence in any given year (100-year flood). Potential flooding conditions for the proposed Project were evaluated based on the hydraulic modeling of the existing and proposed conditions using HEC-RAS. The hydraulic modeling shows the bridge for both the existing and proposed conditions pass the 100-year storm event. Therefore, the existing and proposed bridge replacement would be expected to experience traffic interruptions during a 100-year flow.

The approach roadways of the existing bridge are overtopped due to the wide floodplain. The proposed bridge profile will be raised slightly to clear the 100-year storm, but will not be raised to meet the 2 ft of freeboard over the 50-year WSE criteria. The proposed bridge will clear the 50-year storm with some freeboard. Raising the bridge to meet the 2 ft of freeboard over the 50-year WSE criteria would require the approach roadways be raised, which would further block the flood flows.

4.2.2 Potential Impacts on Natural and Beneficial Floodplain Values

Natural and beneficial floodplain values include, but are not limited to: fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge (United States, FHWA, Department of Transportation, 2019).

The *Water Quality Control Plan (Basin Plan)* from the California Regional Water Quality Control Board Central Valley Region (2018) does not list any beneficial uses for Dry Slough, which is a tributary to the Yolo Bypass. The Yolo Bypass indicates beneficial uses in the *Basin Plan* (2018). As a tributary to the area, Dry Slough has the same beneficial uses shown in Table 4.

Potential short-term adverse effects during the removal and replacement of the bridge to natural and beneficial floodplain values include: 1) loss of vegetation during construction activity; and 2) temporary disturbance to aquatic and/or wildlife habitat. With proposed measures (see Section 5.2), long-term adverse effects to the natural and beneficial floodplain values are not anticipated from the Project.

Table 4. Beneficial Uses

Beneficial use	Yolo Bypass
Agriculture Irrigation	E
Agriculture Stock Watering	E
Water Contact Recreation	E
Other Non-Water Contact Recreation	E
Warm Freshwater Habitat	E
Cold Freshwater Habitat	P
Warm Water Spawning	E
Wildlife Habitat	E

Notes:

- Beneficial uses include but are not limited to these uses
- E = Existing beneficial uses
- P =Potential beneficial uses

4.2.3 Support of Probable Incompatible Floodplain Development

As defined by the FHWA, the support of incompatible base floodplain development will encourage, allow, serve, or otherwise facilitate incompatible base floodplain development, such as commercial development or urban growth.
The Project would not trigger incompatible floodplain development. The Project proposes to replace an already existing bridge. The proposed bridge would not create new access route to developed or undeveloped lands.

4.2.4 Longitudinal Encroachments

As defined by the FHWA, a longitudinal encroachment is an action within the limits of the base floodplain that is longitudinal to the normal direction of the floodplain.

A longitudinal encroachment is "[a]n encroachment that is parallel to the direction of flow. Example: A highway that runs along the edge of a river is usually considered a longitudinal encroachment."

Because the proposed bridge replacement would be approximately perpendicular to the direction of the flow for the 100-year flood, the Project would not be considered a longitudinal encroachment.

5 AVOIDANCE, MINIMIZATION, AND/OR MITIGATION MEASURES

The proposed Project would not change the overall land use within the Project watershed. There would be an increase in impervious area. However, based on the results of the hydraulic analysis, the proposed bridge does not change the WSE. The Project has been designed to minimize floodplain impacts and special mitigation measures are not proposed.

5.1 Minimize Floodplain Impacts

The proposed bridge profile will be raised slightly to clear the 100-year storm, but will not be raised to meet the 2 ft of freeboard over the 50-year WSE criteria. To minimize the floodplain impacts, the proposed bridge roadway approach is relatively insignificant and the WSE is maintained to prevent any additional blocking of flow in the floodplain.

5.2 Restore and Preserve Natural and Beneficial Floodplain Values

Temporary environmental impacts from construction activities for the proposed Project could be minimized with standard best management practice measures to reduce erosion such as protection of existing vegetation with erosion and sediment controls, stabilization of exposed soils, and revegetation. Other avoidance, minimization, and mitigation measures will be identified in the Project's Natural Environmental Study to ensure sensitive areas within the Project limit will not be disturbed during construction. Regulatory permits and approvals are expected to be required from the RWQCB, USACE, and California Department of Fish and Wildlife (CDFW). A Section 401 Water Quality Certification from the RWQCB, a Section 404 Nationwide Permit from the USACE, and a Section 1602 Streambed Alteration Agreement from the CDFW are expected to be required for the Project.

5.3 Alternatives to Significant Encroachments

The Project would not be a significant encroachment to the base floodplain. Therefore, alternatives to significant encroachments were not analyzed.

5.4 Coordination with Local, State, and Federal Water Resources and Floodplain Management Agencies

The County will coordinate with local, state, and federal water resources and floodplain management agencies as necessary during all aspects of the proposed Project.

This page intentionally left blank

6 REFERENCES

California Department of Transportation. (2015). Bridge Inspection Report. Structure Name: Dry Slough. Bridge Number: 22C0127. Facility Carried: C.R. #96. Location: 0.45 mi N of C.R. #31.

California Department of Transportation. (2014). *California Amendments to the AASHTO LRFD Bridge Design Specifications (2012 Sixth Edition).* <http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/ca-to-aashto-lrfd-bds/page/v6/section_2.pdf> (Last accessed: January 28, 2021).

California Department of Transportation. (2014). *California Amendments to the AASHTO LRFD Bridge Design Specifications (2012 Sixth Edition).* <http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/ca-to-aashto-lrfd-bds/page/v6/preface.pdf> (Last accessed: January 28, 2021).

California Department of Transportation. (2011). *California Amendments to AASHTO LRFD Bridge Design Specifications* – Fourth Edition. Section 2: General Design and Location Features. <http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/ca-to-aashto-lrfd-bds/page/sec_2_2011.pdf> (Last accessed January 28, 2021).

California Department of Transportation. (2010). Highway Design Manual. Chapter 820 Section 821.3 Selection of Design Flood. Page 820-2. <http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/chp0820.pdf> (Last accessed: January 28, 2021).

Department of Transportation State of California. (2019). *California Amendments to the AASHTO LRFD Bridge Design Specifications (2017 Eighth Edition).* <https://dot.ca.gov/programs/engineering-services/manuals/lrfd-ca-amendments-8th-edition> (Last accessed: January 28, 2021

Department of Transportation State of California. (2011). *California Amendments to the AASHTO LRFD Bridge Design Specifications (Fourth Edition).*

Executive Order No. 11988, 3 CFR, 42 FR 26951, p. 117 (1977). <https://www.fws.gov/r9esnepa/NEPA_Handbook/EO_11988.pdf> (Last accessed: January 28, 2021).

Federal Emergency Management Agency. (2010). *Flood Insurance Rate Map* for Yolo County, California and Incorporated Areas. Map Number 06113C580G Panel 580 of 785.

Federal Emergency Management Agency. (2010). *Flood Insurance Study* for Yolo County, California and Incorporated Areas. Flood Insurance Study Number 60119CV000B.

Federal Emergency Management Agency. (2006). National Training and Education – Emergency Management Institute. "Chapter 13: Regulatory and Design Standards for Reducing Losses." *Floodplain Management – An Integrated Approach.*

Federal Highway Administration. (1994). "Location and Hydraulic Design of Encroachment on Flood Plains." *Federal-Aid Policy Guide*. Title 23, Code of Federal Regulations, Part 650, Subpart A (23 CFR 650A December 7, 1994, Transmittal 12. <http://www.fhwa.dot.gov/legsregs/directives/fapg/cfr0650a.htm>

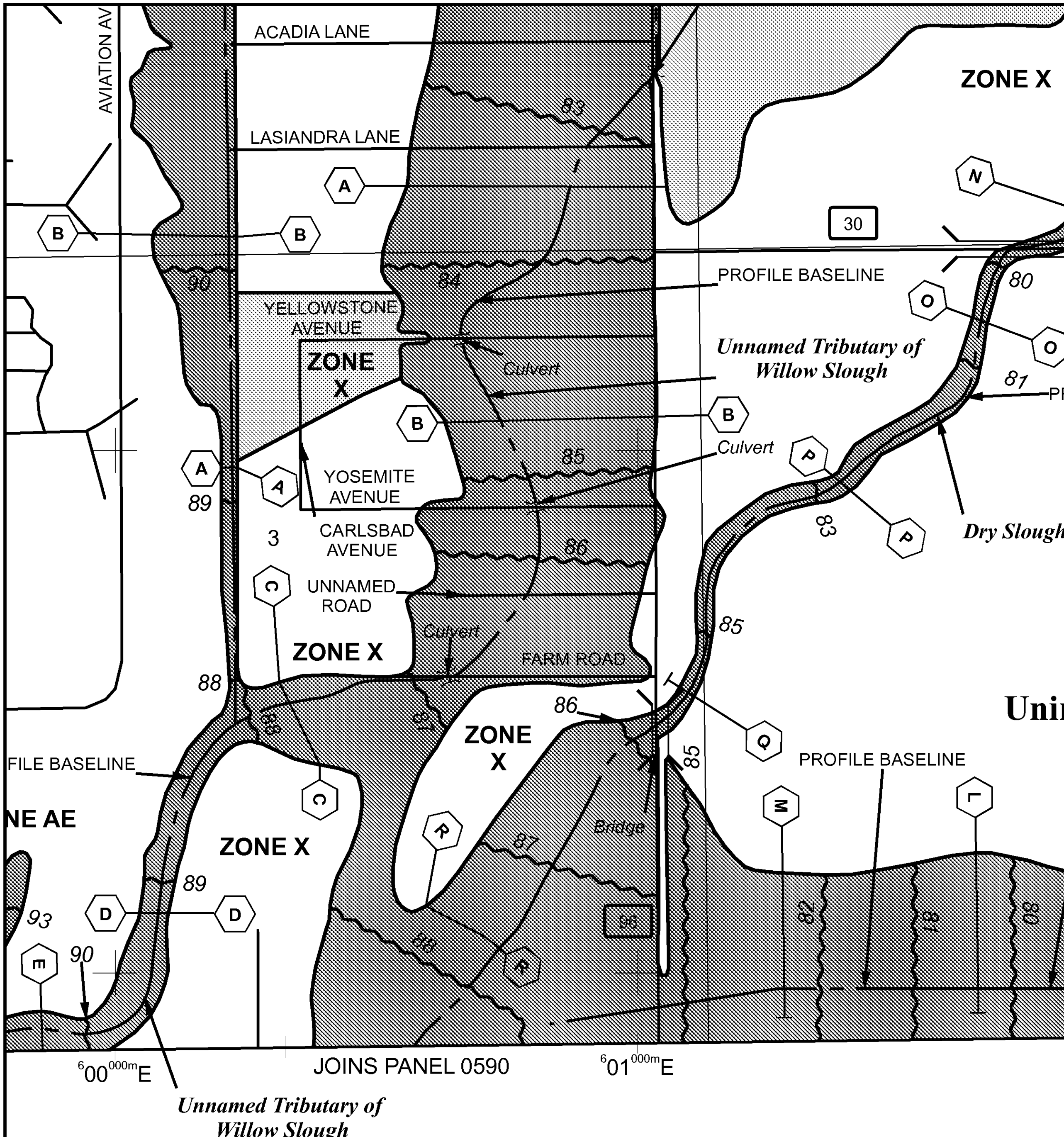
Federal Highway Administration. (1979). DOT Order 5650.2 - Floodplain Management and Protection. <http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/order56502.pdf> (Last accessed: January 15, 2021)

United States Army Corps of Engineers - Hydrologic Engineering Center. (2016). River Analysis System. HEC-RAS. (Version 5.0.6). February 2016. Available from: http://www.hec.usace.army.mil/software/hec-ras/hecras-download.html.

United States, Federal Highway Administration, Department of Transportation. (2019). Title 23 Part 650. "Bridges, Structures, and Hydraulics," *Code of Federal Regulations*, U.S. Government Publishing Office. <https://www.govinfo.gov/content/pkg/CFR-2019-title23-vol1/pdf/CFR-2019-title23-vol1-part650.pdf> (Last accessed: January 29, 2021).

Appendix A Federal Emergency Management Agency Flood Insurance Rate Maps

This page intentionally left blank



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0580G

FIRM
FLOOD INSURANCE RATE MAP

YOLO COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 580 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
YOLO COUNTY	060423	0580	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06113C0580G

EFFECTIVE DATE
JUNE 18, 2010

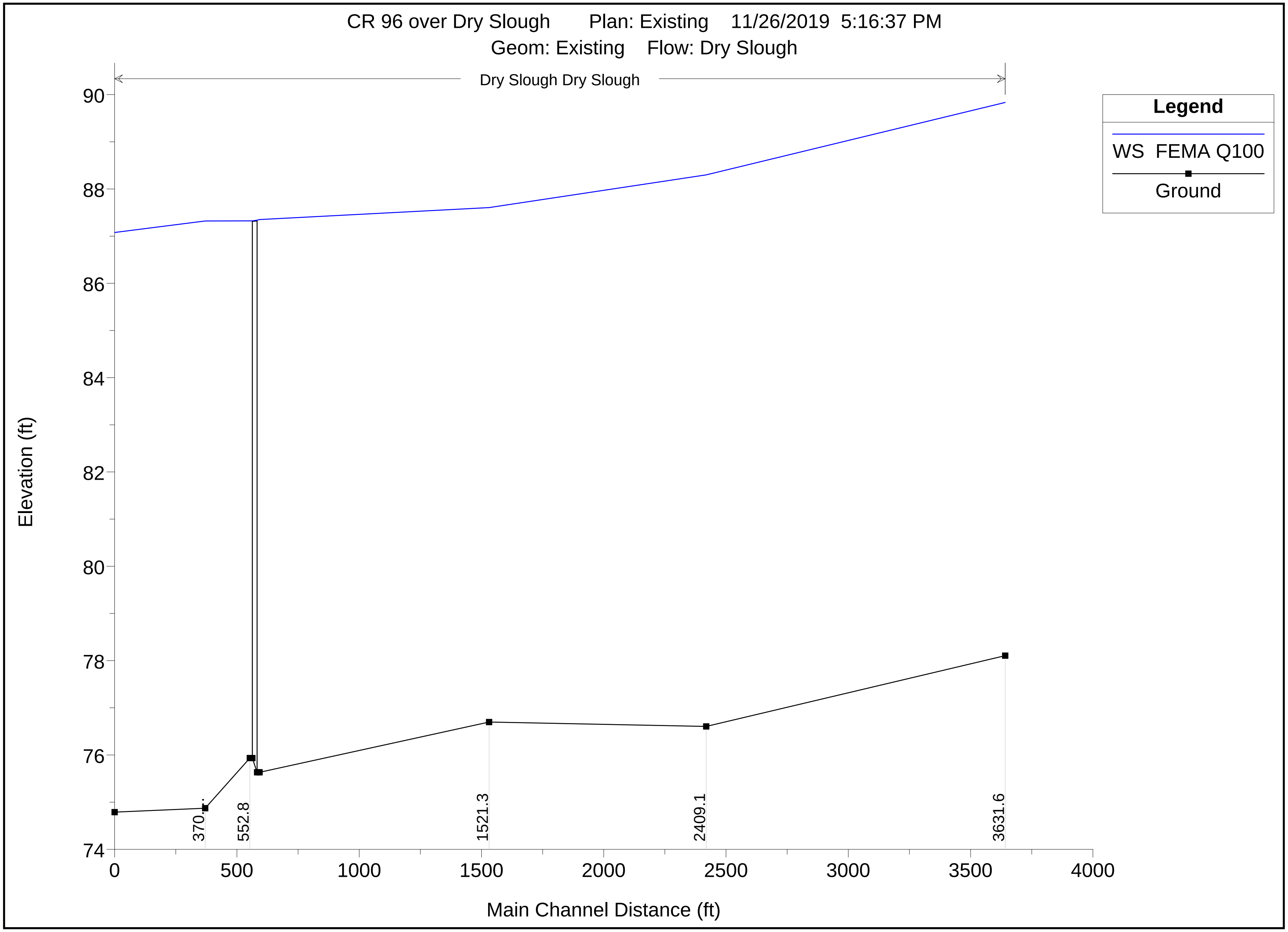
Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

This page intentionally left blank

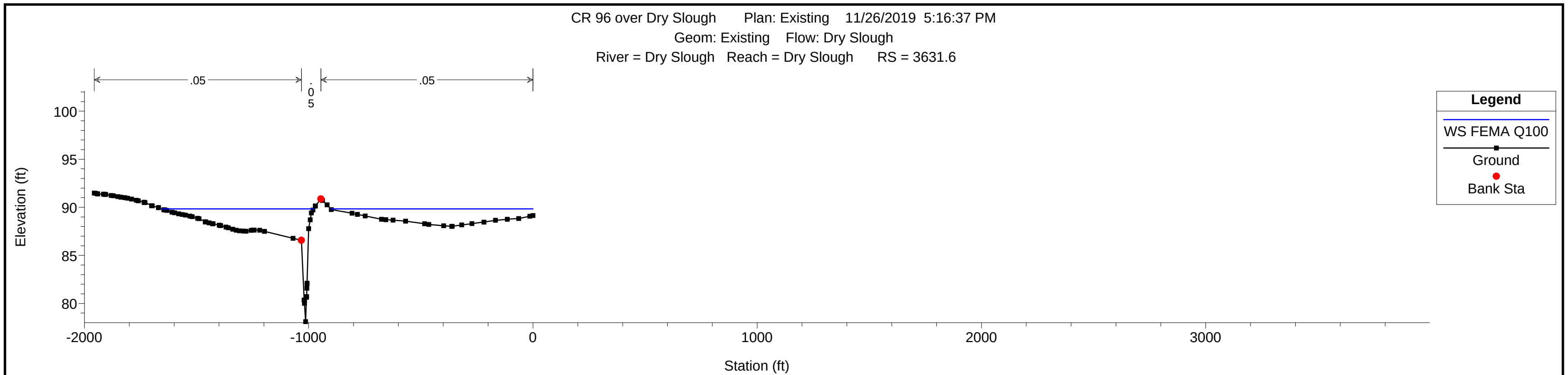
Appendix B HEC-RAS Results Output: Existing Condition

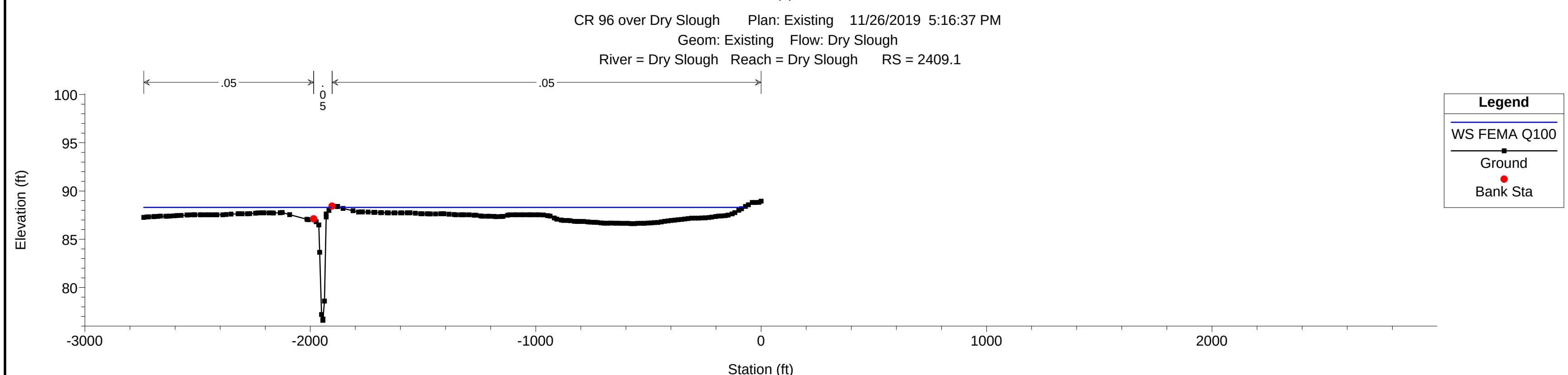
This page intentionally left blank

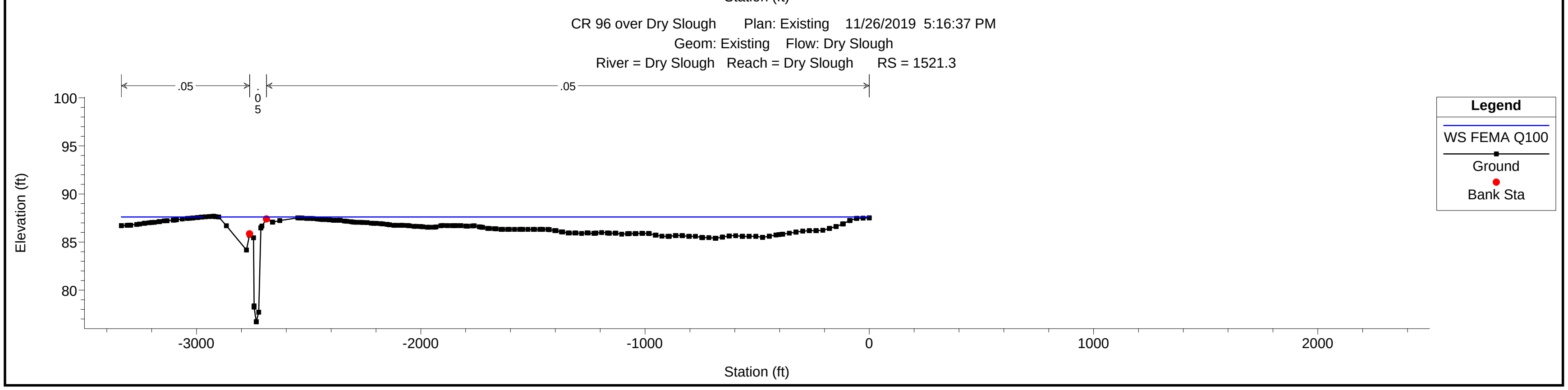

CR 96 over Dry Slough Plan: Existing 11/26/2019 5:16:37 PM
Geom: Existing Flow: Dry Slough
Dry Slough Dry Slough
Legend
WS FEMA Q100
Ground
Elevation (ft)
Main Channel Distance (ft)
90
88
86
84
82
80
78
76
74
0
500
1000
1500
2000
2500
3000
3500
4000
370.
552.8
1521.3
2409.1
3631.6

HEC-RAS Plan: Existing River: Dry Slough Reach: Dry Slough Profile: FEMA Q100

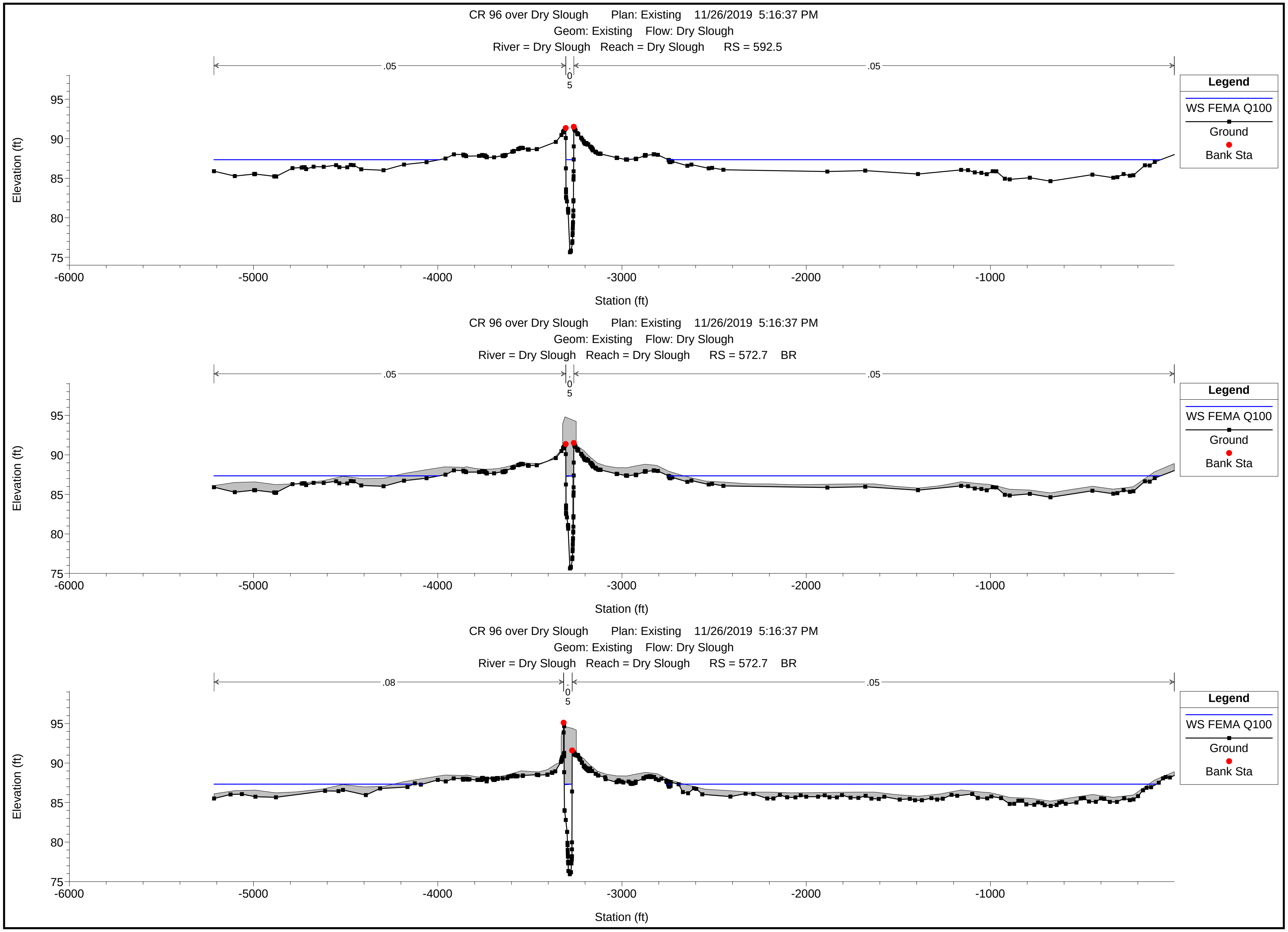
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Dry Slough	3631.6	FEMA Q100	3360.00	78.11	89.83		89.88	0.001066	2.58	2408.48	1579.50	0.21
Dry Slough	2409.1	FEMA Q100	3360.00	76.61	88.30	87.87	88.34	0.001505	2.71	2630.22	2622.16	0.24
Dry Slough	1521.3	FEMA Q100	3360.00	76.70	87.60		87.62	0.000497	1.65	4042.41	3265.29	0.14
Dry Slough	592.5	FEMA Q100	3360.00	75.63	87.35	86.02	87.36	0.000173	1.37	6028.27	3942.08	0.08
Dry Slough	572.7		Bridge									
Dry Slough	552.8	FEMA Q100	3360.00	75.94	87.32		87.33	0.000186	1.36	5980.84	3749.09	0.08
Dry Slough	370.4	FEMA Q100	3360.00	74.87	87.32		87.32	0.000014	0.26	14140.75	4570.55	0.02
Dry Slough	0	FEMA Q100	3360.00	74.79	87.08	84.50	87.28	0.001796	4.80	1298.88	517.57	0.29





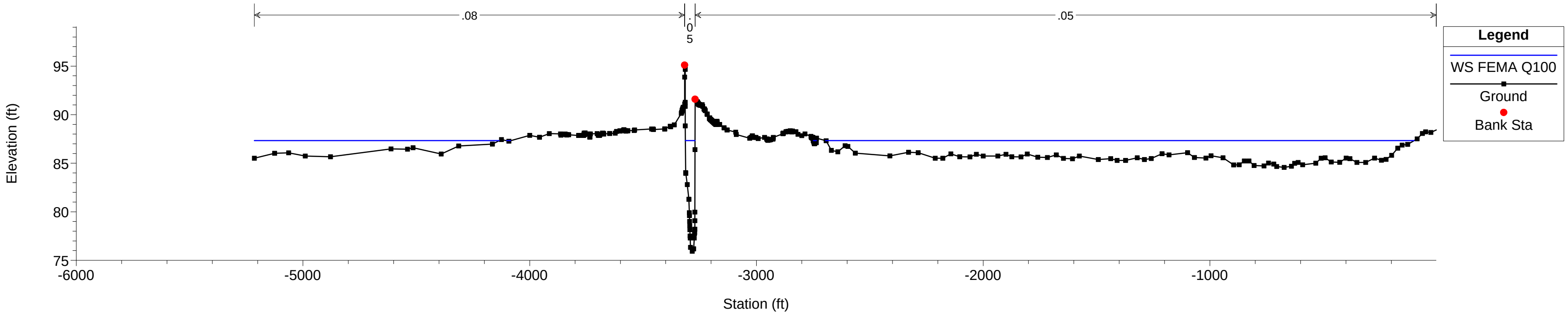


1 in Horiz. = 772 ft 1 in Vert. = 18 ft

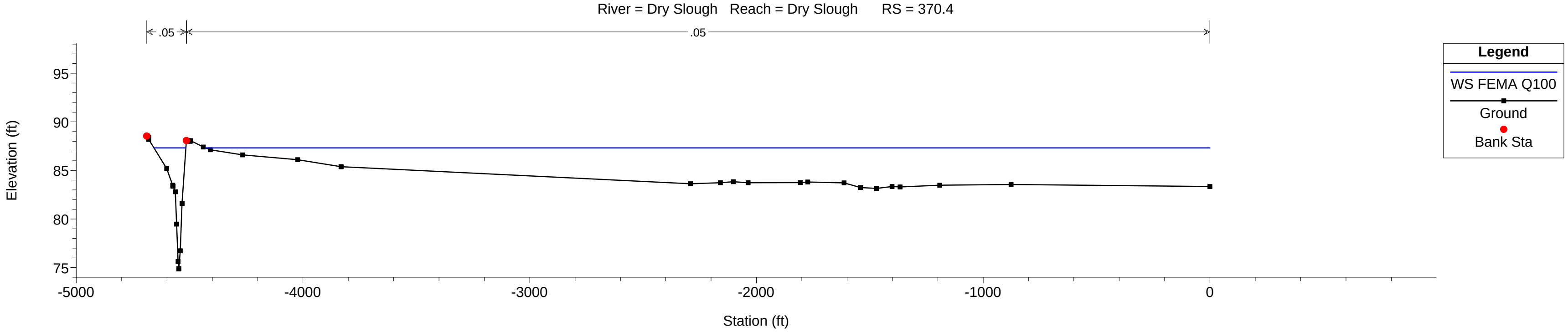


1 in Horiz. = 772 ft 1 in Vert. = 18 ft

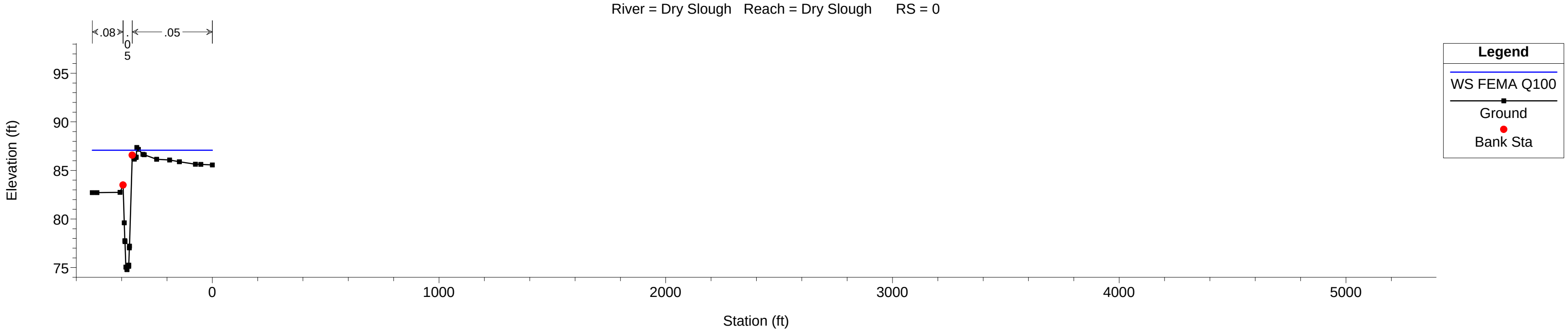
CR 96 over Dry Slough Plan: Existing 11/26/2019 5:16:37 PM
Geom: Existing Flow: Dry Slough
River = Dry Slough Reach = Dry Slough RS = 552.8



CR 96 over Dry Slough Plan: Existing 11/26/2019 5:16:37 PM
Geom: Existing Flow: Dry Slough
River = Dry Slough Reach = Dry Slough RS = 370.4



CR 96 over Dry Slough Plan: Existing 11/26/2019 5:16:37 PM
Geom: Existing Flow: Dry Slough
River = Dry Slough Reach = Dry Slough RS = 0

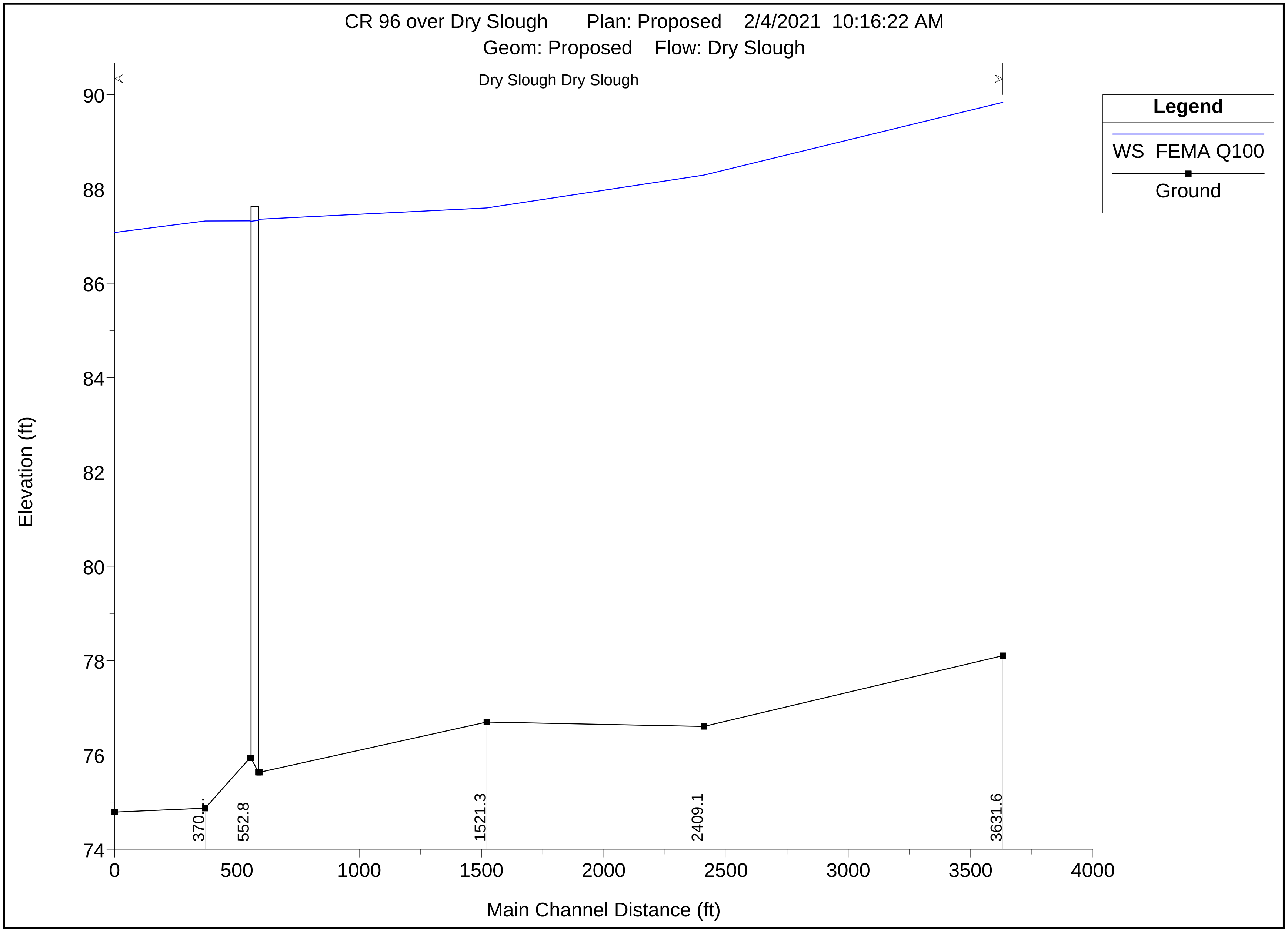


1 in Horiz. = 772 ft 1 in Vert. = 18 ft

This page intentionally left blank

Appendix C HEC-RAS Results Output: Proposed

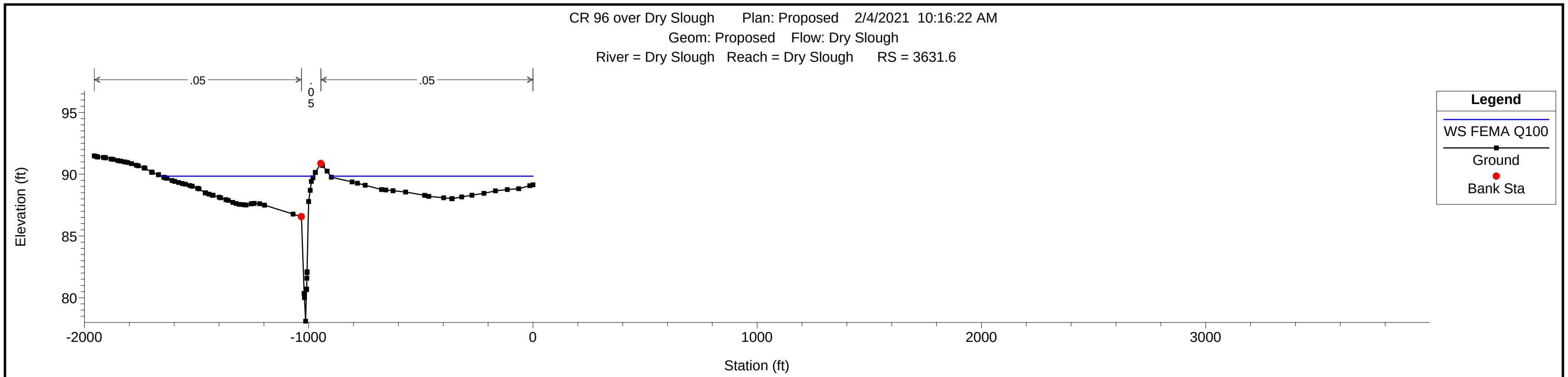
This page intentionally left blank

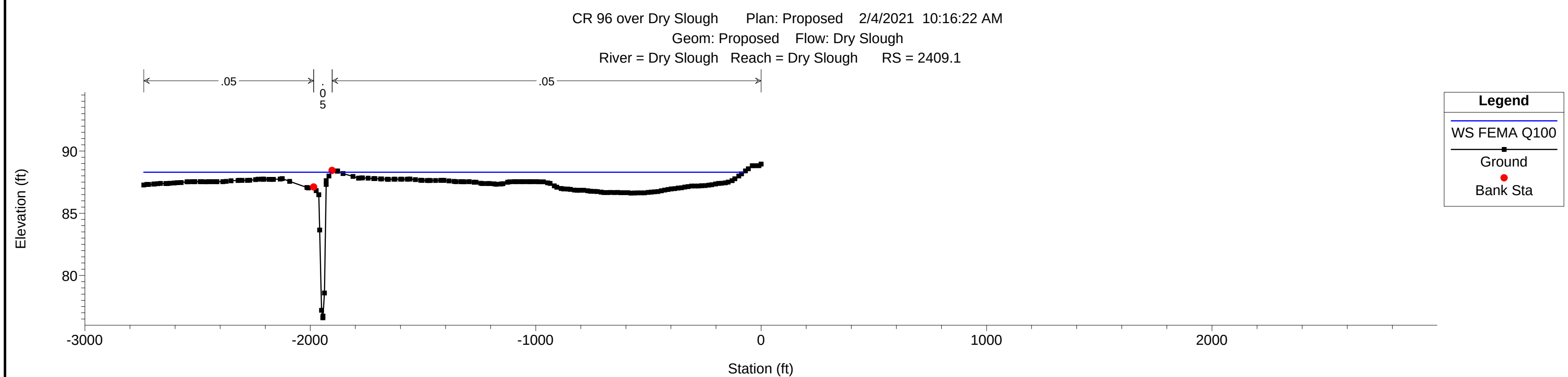


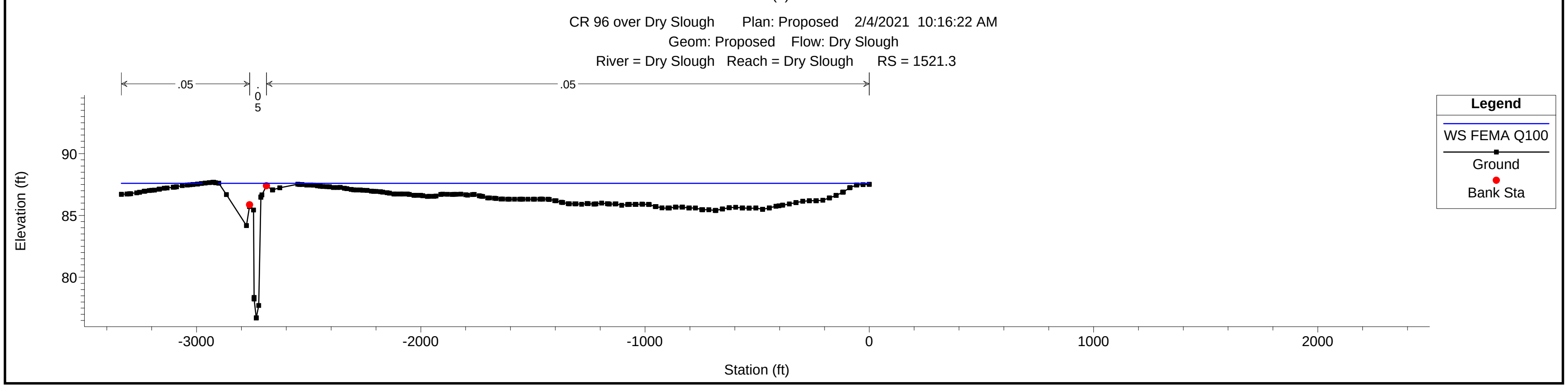
CR 96 over Dry Slough Plan: Proposed 2/4/2021 10:16:22 AM
Geom: Proposed Flow: Dry Slough
Dry Slough Dry Slough
Legend
WS FEMA Q100
Ground
Elevation (ft)
Main Channel Distance (ft)
90
88
86
84
82
80
78
76
74
0
500
1000
1500
2000
2500
3000
3500
4000
370.
552.8
1521.3
2409.1
3631.6

HEC-RAS Plan: Proposed River: Dry Slough Reach: Dry Slough Profile: FEMA Q100

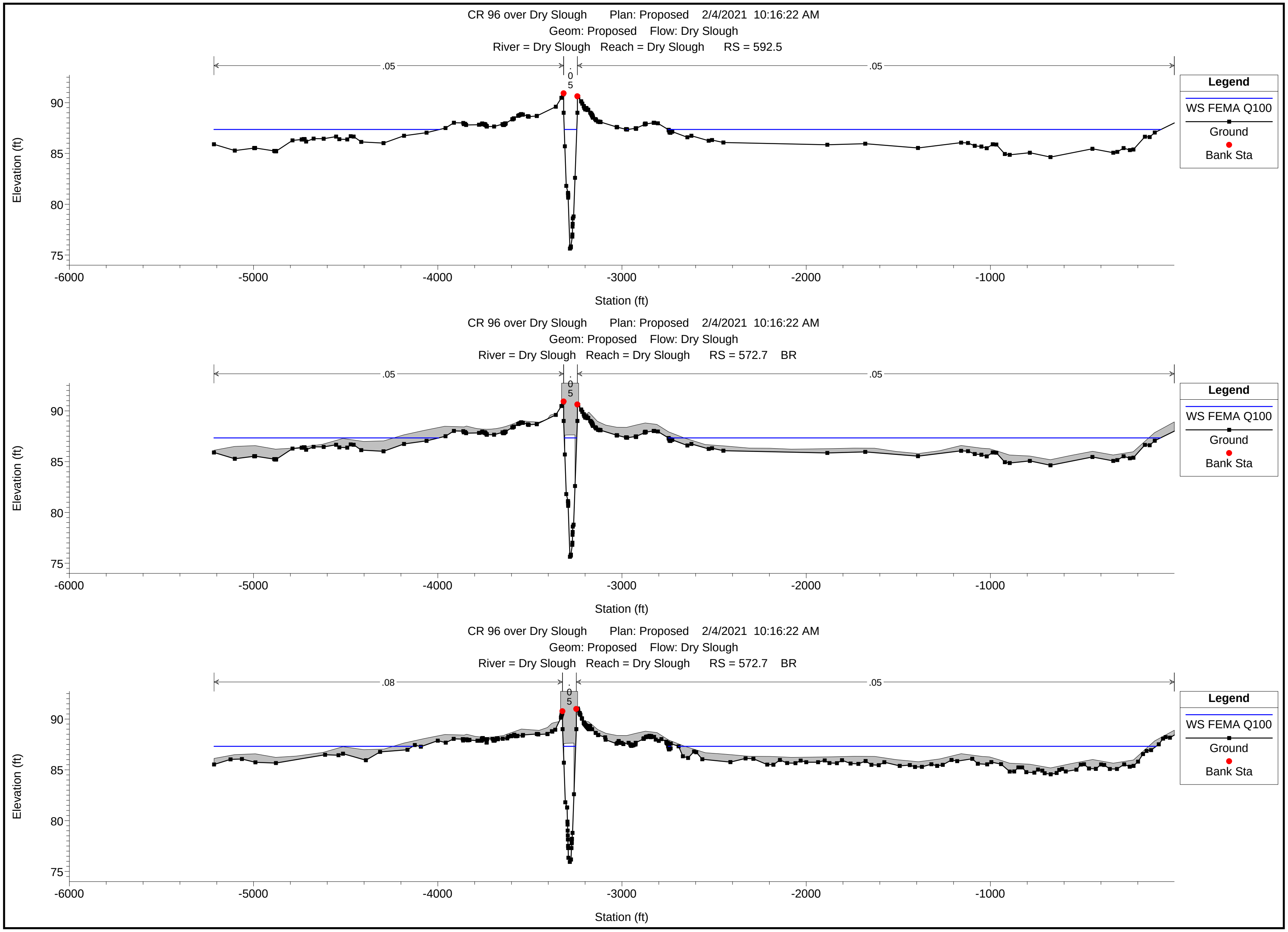
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Dry Slough	3631.6	FEMA Q100	3360.00	78.11	89.84		89.88	0.001063	2.57	2411.06	1579.79	0.21
Dry Slough	2409.1	FEMA Q100	3360.00	76.61	88.29	87.87	88.34	0.001521	2.72	2620.28	2621.30	0.24
Dry Slough	1521.3	FEMA Q100	3360.00	76.70	87.60		87.61	0.000506	1.67	4018.71	3261.51	0.14
Dry Slough	592.5	FEMA Q100	3360.00	75.63	87.36	85.84	87.37	0.000158	1.27	6170.81	3974.95	0.09
Dry Slough	572.7		Bridge									
Dry Slough	552.8	FEMA Q100	3360.00	75.94	87.32		87.33	0.000168	1.31	6099.30	3774.19	0.09
Dry Slough	370.4	FEMA Q100	3360.00	74.87	87.32		87.32	0.000014	0.26	14140.75	4570.55	0.02
Dry Slough	0	FEMA Q100	3360.00	74.79	87.08	84.50	87.28	0.001796	4.80	1298.88	517.57	0.29



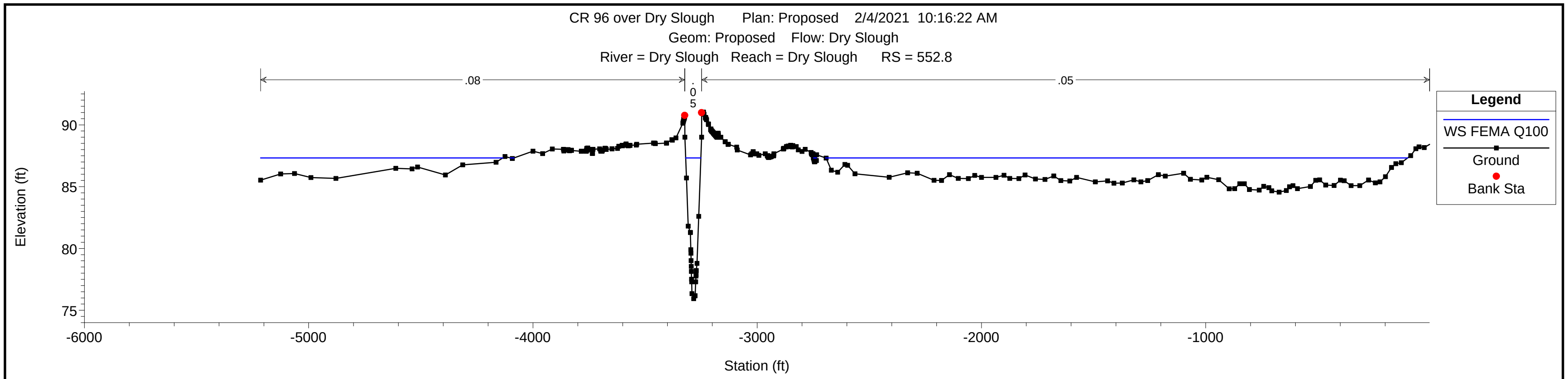


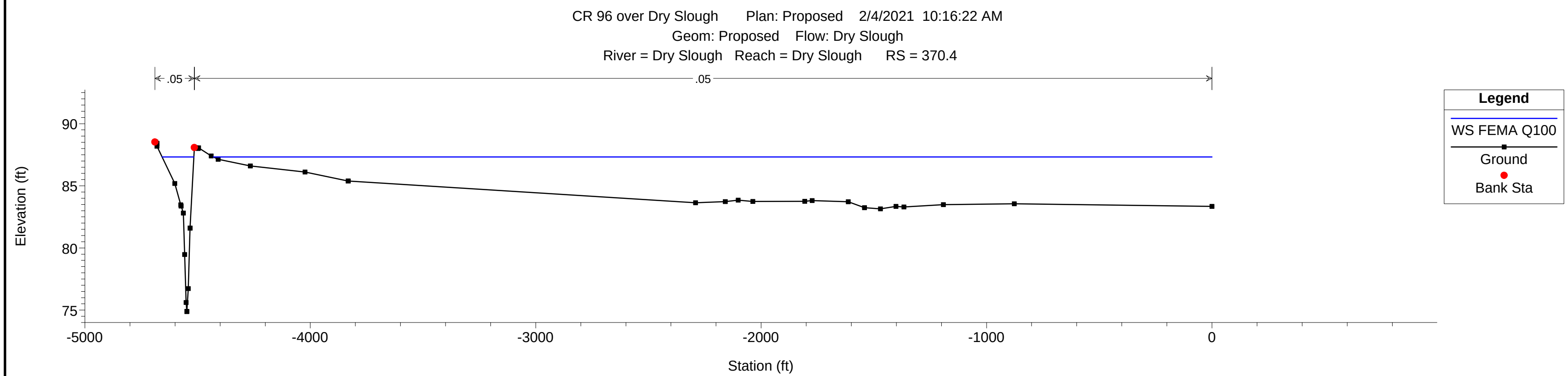


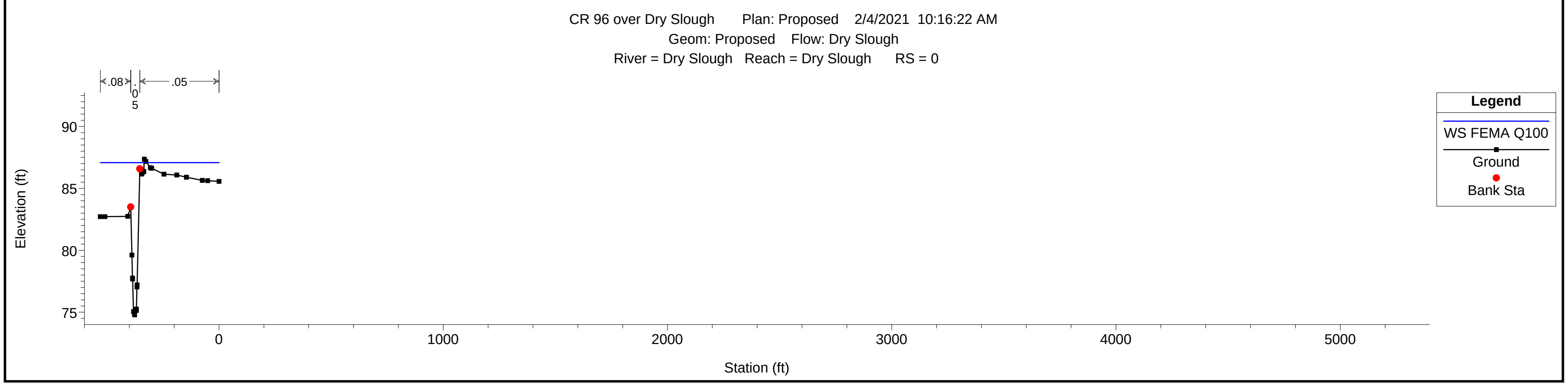
1 in Horiz. = 772 ft 1 in Vert. = 14 ft



1 in Horiz. = 772 ft 1 in Vert. = 14 ft







1 in Horiz. = 772 ft 1 in Vert. = 14 ft

This page intentionally left blank