Hydrologic and Hydraulic Drainage Study

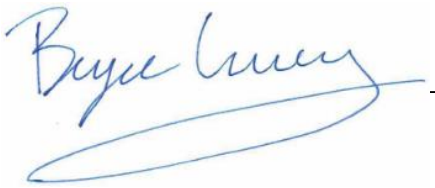
Frazier Road (29C0272) Bridge over Mosher Creek Replacement

Technical Study

San Juaquin County, CA
November 22, 2024

Certification

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.



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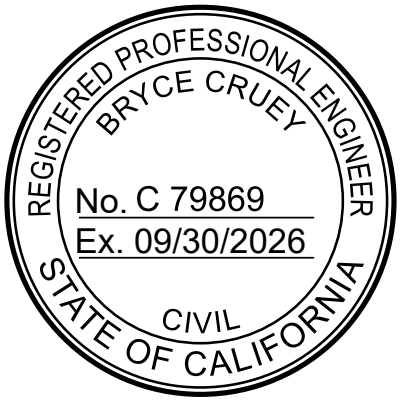

2/25/2025

Date

Executive Summary

San Joaquin County is planning to replace the Frazier Road Bridge (BR 29C0272) over Mosher Creek with either reinforced concrete pipe (RCP) or corrugated metal pipe (CMP) pipe culverts. The existing Frazier Road Bridge is a timber bridge and needs constant repairs and maintenance. HDR was tasked with performing a hydrology and hydraulic analysis to determine the number, size, and length of culverts needed for the passage of the 50- and 100-year storm.

This bridge is due for replacement and was rated as having a deck in poor condition and superstructure in fair condition during the last inspection report in 2021. Notes from the inspection report included but were not limited to 1) the deck wearing surface is deteriorating through-out the deck, 2) traverse cracks up to 1 inch wide across the deck, 3) loose fragments on the deck, 4) splits in the railing posts, and 5) splits noted on the girders.

The bridge over Mosher Creek, located at 1.5 miles west of Clements Road, is a 2-span continuous wood/timber deck supported by 16 timber girders, a corrugated steel deck filled with asphalt concrete (AC) on 4-column timber bents and timber abutments. The timber abutments and timber columns were part of the original construction in 1956. The remaining elements were placed in 2000. The two-span configuration includes one span at 14.75 feet (ft) and another span at 15 ft. The bridge is approximately 20 ft wide and 30 ft long. At this location, Mosher Creek is essentially agricultural fields upstream of the structure with no defined channel. Downstream of the structure there is a defined channel with a top and bottom width of 33 and 54 ft. The flowline elevation of the channel at the bridge in its existing condition is approximately 93.89 ft, NAVD 88.

A Private Culvert exists about 1,750 ft downstream of BR 29C0272. During the 50- and 100-year events, this culvert is at capacity and the road is overtopped, which influences the downstream hydraulics of BR 29C0272. HDR included this culvert in the field investigation and measurements of the culvert were taken in the field. According to the field investigation, the culvert(s) are two 48-inch CMPs that are 21 ft long, with upstream and downstream inverts of 90.45 and 89.55 ft, respectively.

As a part of this study, three (3) alternative configurations of culverts were analyzed hydraulically to fit withing the existing footprint and road alignment. Proposed culvert configurations included: Two cell reinforced concrete box (RCB) culverts with 90-degree headwall and 30–75-degree flared wingwalls, CMP arch culverts with 18-inch corner radius, mitered to the slope, and CON/SPAN arch culverts with 90-degree headwall and 45-degree flared wingwalls.

To determine the flow/hydraulic characteristics of the site for existing and proposed HDR was tasked with the following key tasks: determine site hydrology for the 50- and 100-year storms, estimate hydraulics for the existing structure for the 50- and 100-year storms, estimate the hydraulics of the proposed structures for the 50- and 100-year storms, and estimate scour risk and make recommendations.

The design of the bridge should meet the freeboard criteria established by Federal Highway Administration (FHWA) and Caltrans. The freeboard design criteria for FHWA and Caltrans are summarized in the table below.

Hydraulic Design Criteria Summary

Agency	Storm	Freeboard	Notes
FHWA	50-year	>0.0 ft	Floating debris needs to be included in the analysis.
Caltrans	50-year 100-year	≥2.0 ft >0.0 ft	

Source: FHWA and Caltrans

Caltrans Bridge Inspection Reports (BIRs) were used to inform values of historical bed elevation change for use in estimating scour susceptibility.

During the design phase, the evaluation of potential scour at the proposed bridges will follow the criteria described in the FHWA's Hydraulic Engineering Circular No. 18 (HEC-18), "Evaluating Scour at Bridges" (2012) and Caltrans' Memo to Designers (MTD) 16-1 (2017). The evaluation of potential scour will be based on hydraulic characteristics of the 100-year design discharge. The total scour will be estimated based upon the cumulative effects of the long-term bed elevation change, general (contraction) scour, and local scour.

There is not a Federal Emergency Management Agency (FEMA) detailed study area for Mosher Creek at the project location according to the Flood Insurance Study (FIS) of San Joaquin County and Incorporated Areas by the FEMA and there is no known hydrologic study done for the area. HDR used two methods to determine the peak discharge in Mosher Creek at the project location: the United States Geological Survey Regression equation method and the Unit Hydrograph method using HEC-HMS.

With the watershed area of 1.5 sq mi, mean annual precipitation of 16.9 inches, and mean basin elevation of 115 ft (USGS StreamStats, 2024), where the Project watershed is located, the 100- and 50-year peak discharges at the Project site were calculated using the USGS Regional Regression Equations and Unit Hydrograph method peak discharges are summarized in the table below.

Regression Equation Peak Discharge Estimates

Return Interval	Regression Equation Peak Discharge (cfs)	Unit Hydrograph Peak Discharge (cfs)
100 Year	299	375
50 Year	273	314

Source: HDR 2024

The 100- and 50-year peak discharges estimated using the unit hydrograph method was selected for use in the hydraulic analysis because the SCS unit hydrograph method provided a more detailed analysis of the watershed characteristics. Another reason is that the peak

discharges estimated using this method are more conservative than the those calculated using the USGS Regional Regression Equation.

Due to the nature of the work proposed by the Project, the Project would not change the overall land use within the watershed. Based on the land use map from San Joaquin County, future development is limited within the watershed due to the County's growth constraints. The design discharges would not be anticipated to significantly change during the lifetime of the bridge at the Project location; however, future developments within the watershed would have the potential to impact the hydrologic conditions of the watershed and at the Project site.

The hydraulic analyses were performed for the existing and proposed conditions using the USACE's Hydrologic Engineering Center's River Analysis System (HEC-RAS) modeling software, Version 6.5.

For this analysis, four model scenarios were created including (1) Existing Conditions (SC-1), (2) Proposed double cell, cast in place RCB culvert (SC-2), (3) Proposed CON/SPAN arch culverts (SC-3), and (4) Proposed CMP arch culverts (SC-4).

The water surface elevations (WSE) for Mosher Creek were estimated for the existing and proposed bridge conditions using the hydraulic models created in HEC-RAS. See the following tables for a summary of WSE changes for the 100- and 50-year storm, respectively.

Mosher Creek 100-Year Water Surface Elevations

Location	SC-1 WSE (ft)	SC-2 WSE (ft)	Change (ft)	SC-3 WSE (ft)	Change (ft)	SC-4 WSE (ft)	Change (ft)
RS-35+59	97.6	97.6	0.0	97.6	0.0	97.6	0.0
RS-33+85	97.4	97.3	-0.1	97.3	-0.1	97.3	-0.1
RS-30+93	97.2	97.2	0.0	97.2	0.0	97.2	0.0
RS-29+11	97.2	97.1	-0.1	97.1	-0.1	97.1	-0.1
RS-28+11	97.1	97.0	-0.1	97.0	-0.1	97.0	-0.1
RS-27+38	97.1	97.0	-0.1	97.0	-0.1	97.0	-0.1
RS-26+38	97.0	97.0	0.0	96.9	-0.1	97.0	0.0
RS-25+82	96.9	96.8	-0.1	96.8	-0.1	96.8	-0.1
BR 29C0272 (US)	96.3	96.1	-0.2	96.3	0.0	96.4	0.1
BR 29C0272 (DS)	96.1	96.1	0.0	96.3	0.2	96.3	0.2
RS-25+51	96.1	96.1	0.0	96.3	0.2	96.3	0.2
RS-25+30	96.1	95.9	-0.2	95.9	-0.2	95.9	-0.3
RS-25+17	95.8	95.9	0.1	95.9	0.1	95.9	0.1
RS-24+87	95.8	95.9	0.1	95.9	0.1	95.9	0.1

Location	SC-1 WSE (ft)	SC-2 WSE (ft)	Change (ft)	SC-3 WSE (ft)	Change (ft)	SC-4 WSE (ft)	Change (ft)
RS-23+49	95.6	95.6	0.0	95.6	0.0	95.6	0.0
RS-21+67	95.1	95.1	0.0	95.1	0.0	95.1	0.0
RS-19+60	94.9	94.9	0.0	94.9	0.0	94.9	0.0
RS-17+08	94.7	94.7	0.0	94.7	0.0	94.7	0.0

Notes:
Elevations were rounded to the nearest 0.1 ft.
Change is proposed WSE minus existing WSE
Source: HDR 2024

Mosher Creek 50-Year Water Surface Elevations

Location	SC-1 WSE (ft)	SC-2 WSE (ft)	Change (ft)	SC-3 WSE (ft)	Change (ft)	SC-4 WSE (ft)	Change (ft)
RS-35+59	97.4	97.4	0.0	97.4	0.0	97.4	0.0
RS-33+85	97.1	97.1	0.0	97.1	0.0	97.1	0.0
RS-30+93	97.0	96.9	-0.1	96.9	-0.1	96.9	-0.1
RS-29+11	96.9	96.8	-0.1	96.8	-0.1	96.8	-0.1
RS-28+11	96.8	96.7	-0.1	96.7	-0.1	96.7	-0.1
RS-27+38	96.8	96.7	-0.1	96.7	-0.1	96.7	-0.1
RS-26+38	96.7	96.7	0.0	96.7	-0.1	96.7	0.0
RS-25+82	96.6	96.5	-0.1	96.5	-0.1	96.5	-0.1
BR 29C0272 (US)	96.1	96.0	-0.1	96.2	0.1	96.3	0.2
BR 29C0272 (DS)	96.0	96.0	0.0	96.2	0.2	96.2	0.2
RS-25+51	96.0	96.0	0.0	96.2	0.2	96.2	0.2
RS-25+30	95.9	95.8	-0.1	95.8	-0.1	95.8	-0.1
RS-25+17	95.7	95.8	0.1	95.8	0.1	95.8	0.1
RS-24+87	95.7	95.8	0.1	95.8	0.1	95.8	0.1
RS-23+49	95.5	95.5	0.0	95.5	0.0	95.5	0.0
RS-21+67	95.0	95.0	0.0	95.0	0.0	95.0	0.0
RS-19+60	94.8	94.8	0.0	94.8	0.0	94.8	0.0
RS-17+08	94.6	94.6	0.0	94.6	0.0	94.6	0.0

Notes:
Elevations were rounded to the nearest 0.1 ft.
Change is proposed WSE minus existing WSE
Source: HDR 2024

The available freeboard for the existing and proposed bridges, the minimum soffit elevations, and WSEs at the upstream cross section of the respective bridges with the 100- and 50-year storms are summarized in the table below. Based on the results of the analyses, both the existing and proposed bridges meet the FHWA criteria but not Caltrans' design criteria for the freeboard. The freeboard is constrained by the existing grade of the road. For this analysis, it was assumed that the existing grade is maintained. Freeboard is improved by the double RCB culvert analysis in SC-2 by 0.28 ft and 0.15 ft for the 100- and 50-year events. Freeboard is slightly improved for the 100-year event under SC-3.

100-Year Water Surface Elevations and Freeboard

Condition	Minimum Bridge Soffit Elevation (ft NAVD 88)	100-Year WSE (ft NAVD 88)	Available Freeboard (ft)	50-Year WSE (ft NAVD 88)	Available Freeboard (ft)
Existing Bridge	97.42	96.33	1.09	96.14	1.28
Proposed SC-1	97.40	96.03	1.37	95.97	1.43
Proposed SC-2	97.43	96.33	1.10	96.17	1.26
Proposed SC-3	97.48	96.44	1.04	96.25	1.23

Source: HDR, 2024

The 100-year average channel flow velocities were estimated for the existing and proposed conditions from the developed hydraulic models and are summarized in the table below. The proposed bridge results in minor fluctuations inlet and outlet velocity and minor fluctuations in average channel velocity upstream and downstream of the bridge within the studied reach of Mosher Creek within the Project vicinity relative to the existing condition for the 100-year storm.

100-Year Average Channel Flow Velocities

Location	SC-1 Velocity (ft/s)	SC-2 Velocity (ft/s)	Change (ft/s)	SC-3 Velocity (ft/s)	Change (ft/s)	SC-4 Velocity (ft/s)	Change (ft/s)
RS-35+59	1.28	1.30		1.31		1.30	
RS-33+85	1.2	1.2	0.0	1.2	0.0	1.2	0.0
RS-30+93	0.9	0.9	0.0	0.9	0.0	0.9	0.0
RS-29+11	1.1	1.1	0.0	1.1	0.0	1.1	0.0
RS-28+11	1.6	1.7	0.0	1.7	0.1	1.7	0.1
RS-27+38	1.6	1.6	0.0	1.7	0.1	1.7	0.1
RS-26+38	1.2	1.2	0.0	1.2	0.0	1.2	0.0
RS-25+82	3.2	3.6	0.4	3.2	0.0	3.2	0.0
BR 29C0272 (US)	6.0	6.1	0.1	5.1	-0.9	4.7	-1.3
BR 29C0272 (DS)	6.0	5.9	-0.1	4.9	-1.1	4.7	-1.3

Location	SC-1 Velocity (ft/s)	SC-2 Velocity (ft/s)	Change (ft/s)	SC-3 Velocity (ft/s)	Change (ft/s)	SC-4 Velocity (ft/s)	Change (ft/s)
RS-25+51	5.4	6.0	0.6	4.2	-1.2	4.2	-1.2
RS-25+30	4.9	5.8	0.9	5.8	0.9	5.8	0.9
RS-25+17	5.8	5.5	-0.3	5.5	-0.3	5.5	-0.3
RS-24+87	4.3	3.9	-0.4	3.9	-0.4	3.9	-0.4
RS-23+49	3.1	3.1	0.0	3.1	0.0	3.1	0.0
RS-21+67	3.1	3.1	0.0	3.1	0.0	3.1	0.0
RS-19+60	1.9	1.9	0.0	1.9	0.0	1.9	0.0
RS-17+08	1.7	1.7	0.0	1.7	0.0	1.7	0.0

Notes:
Average channel flow velocities were rounded to the nearest 0.1 ft/s.
Existing and proposed bridge upstream faces as well as downstream faces are not at the same locations; therefore, average channel flow velocity differences were not computed for these two locations.
Source: HDR, 2024

HDR evaluated bridge scour per the criteria described in “Evaluating Scour at Bridges” (FHWA, 2012). The minimum design criterion for bridge scour is the 100-year design storm. The CON/SPAN alternative was evaluates using the bridge scour methods in the FHWA Hydraulic Engineering Circular (HEC) No. 18 (HEC-18). Scour at the outfall of the culvert alternatives was evaluated per the FHWA’s HEC-14. HDR evaluated the scour potential using the results of the steady-state flow analysis from HEC-RAS for the three proposed alternatives. The following sub-sections summarize the results of the analysis.

The Caltrans Bridge Inspection Reports (BIRs) for the existing bridge were reviewed in support of the scour analysis. The following table summarized inspections available from Caltrans’ Bridge Inspection Records Information System (BIRIS).

Calculation of the scour depths inherently assumes that the channel bed material is erodible. The calculations are based upon a field visit of the site and BIR information provided in the previous section. If there are any geologic formations, such as bedrock, underlying the proposed foundation locations, they would help to inhibit the progression of scour holes. The bed material observed to consist of compacted fine material in the field. The existing bed material gradation at the site was not quantified. Due to the limited amount of detailed bed material at the Project location, the cohesive and cohesionless calculations were analyzed and presented in this study.

The historical channel data at the bridge site was reviewed and compared to assess the long-term bed elevation changes. The stream measurements that were recorded in the Caltrans BIRs were compared to assess the long-term bed elevation changes. Historical stream measurements were taken at the bridge and were included in May 1995, March 2007, March 2013, and February 2015. The 1995 cross section was measured relative to the “Top of timber Deck” and the remaining measurements were measured off the “Top of Deck.” Both measurement descriptions were assumed to be the same locations.

The average rate of change in the thalweg records an overall aggregation to the bed over the 20-year span of data. Therefore, the long-term bed elevation change was calculated to be 0.0 ft for an extrapolated 75-year design life considering the channel characteristics at the new bridge alignment would be like those at the existing bridge alignment.

The channel bed material was evaluated for both cohesive and cohesionless equations for the purpose of analyzing scour. The cohesive contraction scour for the CON/SPAN alternative resulted in 2.5 ft scour depth. The cohesionless analysis resulted in 0.9 ft scour depth. The 2.5 ft of scour for the cohesive material was selected as the recommended design for the most conservative analysis.

The CON/SPAN alternative (SC-3) has two spans with a center pier and abutments. The cohesive pier scour was calculated to be 7.1 ft scour depth and the Cohesionless scour equation calculated a 5.0 ft scour depth. The cohesive scour depth of 7.1 ft was recommended for the CON/SPAN alternative. The local abutment scour was calculated to be 1.2 ft at the left and right abutment.

The CON/SPAN design is constructed with a natural bottom unlike the other three culvert alternatives. Since the bottom of the CON/SPAN alternative will not be armored open bottom scour was evaluated for this alternative. The open-bottom culvert scour was calculated using the equations presented in Section 6.9.2 of HEC-18 (FHWA, 2012). The CON/SPAN open bottom scour without a wingwall was 13 ft depth and the open-bottom culvert with a wingwall was 8.3 ft scour depth.

Scour depth at the outlet of the three culvert alternatives were evaluated using both the cohesive and cohesionless equations. The cohesionless pier scour was calculated using equation 5.1 and the cohesive per scour was calculated used 5.2 from HEC-14 (FHWA, 2006). The scour depth at the outfall for all culvert alternatives with cohesive and cohesionless material is presented in the table below.

Culvert Outfall Scour Depth in Cohesive and Cohesionless Material

Scenario	Cohesive Scour Depth (ft)	Cohesionless Scour Depth (ft)
SC-2	14.2	9.3
SC-3	15.4	9.4
SC-4	5.0	9.0

Source: HDR, 2024

The total scour is presented for the CON/SPAN Bridge alternative. The total scour is the sum of the local scour, contraction scour, and long-term bed elevation change. The calculated scour depths and elevations are summarized in the table below.

Scour Summary Table

Long-Term and Short-Term Scour Depths			
Frazier Road Crossing-CON/SPAN Alternative			
Support No.	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short-Term (Local) Scour Depth (ft)
Left Abutment	0.0	2.5	10.6
Pier 1	0.0	2.5	7.1
Right Abutment	0.0	2.5	10.6

Source: HDR, 2024

RSP calculations estimate a minimum recommended rock size/class to protect the embankment slopes at the abutments from scour and erosion. Two procedures were considered to determine the RSP size for the CON/SPAN alternative: HEC-23 (FHWA, 2009) and the HDM (Caltrans, 2020). The calculation following the HEC-23 and the calculation following HDM resulted in Class I RSP (20 lb median particle weight). The RSP at the culvert outfall for SC-2 and SC-4 were sized using the HEC-14 equations for riprap aprons. The RSP sizes for each alternative are presented in the table below.

Culvert RSP Recommendations

Scenario	RSP Class	Median particle diameter (inches)	Median particle weight	Minimum layer thickness (ft)	Placement method
SC-2	II	9	60 lb	1.5	B
SC-3	I	6	20 lb	1	B
SC-4	VII	24	1/2 ton	4	A or B

Source: HDR, 2024

The RSP should be placed using Method B, which involves dumping rock near its planned location, and working the rock to its final position with machinery. A Class 8 RSP geotextile filter fabric should be placed on the bank as the initial filter separator material between the layer of RSP and the channel bank. A gravel (granular) filter can be used as an alternative to geotextile filter fabric. The design of the gravel filter will depend on the underlying base soil parameters as well as the overlaying RSP. The gravel filter is typically between 6 and 15 inches thick and must meet piping and permeability requirements.

Abbreviations

AC	asphalt concrete
BIR	Bridge Inspection Report
Caltrans	California Department of Transportation
CN	Curve Number
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
Ft	foot/feet
HEC-HMS	Hydrologic Engineering Center’s Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center’s River Analysis System
LiDAR	Light Detection and Ranging
NAVD 88	North American Vertical Datum of 1988
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSE	water surface elevation

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Appendices

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General Description

Project Overview

San Joaquin County is planning to replace the Frazier Road Bridge (29C0272) over Mosher Creek with either reinforced concrete pipe (RCP) or corrugated metal pipe (CMP) pipe culvert. The existing Frazier Road Bridge is a timber bridge and needs constant repairs and maintenance. HDR was tasked with performing a Hydrology and Hydraulic analysis to determine the number, size, and length of culverts needed for the passage of the 50- and 100-year storm.

Project Purpose and Need

This bridge is due for replacement and was rated as having a deck in poor condition and superstructure in fair condition during the last inspection report in 2021. Notes from the inspection report included but were not limited to 1) the deck wearing surface is deteriorating through-out the deck, 2) traverse cracks up to 1 inch wide across the deck, 3) loose fragments on the deck, 4) splits in the railing posts, and 5) splits noted on the girders.

Existing and Proposed Bridge/Culverts

Existing Bridge No. 29C0272

The bridge over Mosher Creek, located at 1.5 miles west of Clements Road, is a 2-span continuous wood/timber deck supported by 16 timber girders, a corrugated steel deck filled with asphalt concrete (AC) on 4-column timber bents and timber abutments (Figure 1 to Figure 4). The timber abutments and timber columns were part of the original construction in 1956. The remaining elements were placed in 2000. The two-span configuration includes one span at 14.75 feet (ft) and another span at 15 ft. The bridge is approximately 20 ft wide and 30 ft long. At this location, Mosher Creek is essentially agricultural fields upstream of the structure with no defined channel. Downstream of the structure there is a defined channel with a top and bottom width of 33 and 54 ft. The flowline elevation of the channel at the bridge in its existing condition is approximately 93.89 ft, North American Vertical Datum of 1988 (NAVD 88).

Figure 1. Photo looking north, from downstream, at the right side of the bridge.

Source: HDR Field Reconnaissance, 2023

Figure 2. Photo of deck wearing surface deterioration looking at abutment 3 westbound lane.

Source: Caltrans Division of Maintenance, 2021

Figure 3. Photo of splits in the bottom 1/4 of post 2 and bottom of post 3.

Source: Caltrans Division of Maintenance, 2021

Figure 4. Photo of broken spacer block at the 2nd post from abutment 1.

Source: Caltrans Division of Maintenance, 2021

Private Road Culvert

A Private Culvert exists about 1,750 ft downstream of BR 29C0272. During the 50- and 100-year events, this culvert is at capacity and the road is overtopped, which influences the downstream hydraulics of the bridge. HDR included this culvert in the field investigation and measurements of the culvert were taken in the field. According to the field investigation, the culvert(s) are two 48-inch CMPs that are 21 ft long, with upstream and downstream inverts of 90.45 and 89.55 ft (Figure 5).

Figure 5. Private Culvert Downstream of BR 29C0272

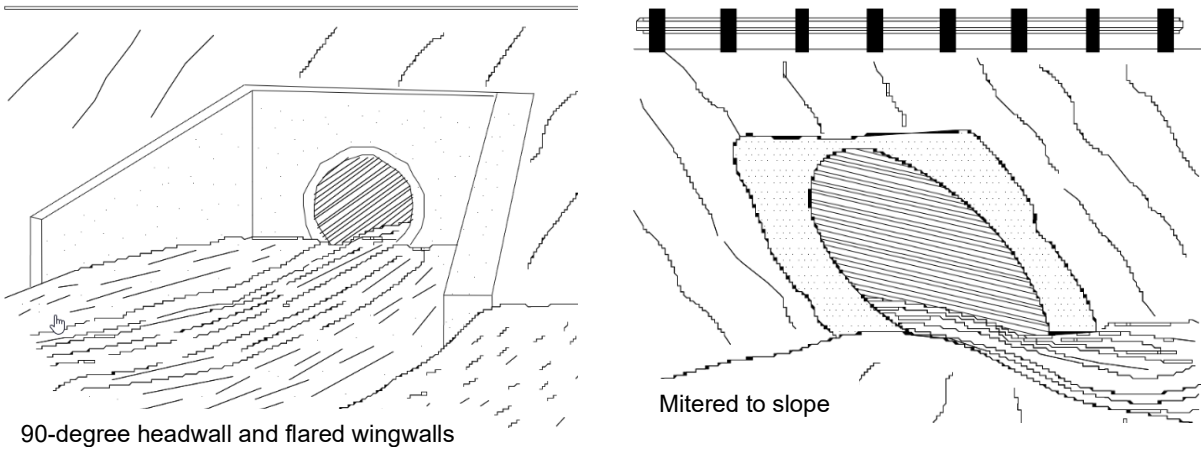
Source: HDR, 2023

Proposed Bridge

As a part of this study, three (3) alternative configurations of culverts were analyzed hydraulically to fit withing the existing footprint and road alignment similar to the conceptual configurations shown in Figure 6. Proposed culvert configurations included:

1. Two cell reinforced concrete box (RCB) culverts with 90-degree headwall and 30-75 degree flared wingwalls.
2. CMP arch culverts with 18-inch corner radius, mitered to the slope.
3. CON/SPAN arch culverts with 90-degree headwall and 45-degree flared wingwalls.

Figure 6. Conceptual culvert configurations.



Source: HEC-RAS Hydraulic Reference Manual, 2024

Study Purpose

The intent of this study is to report on findings from a hydraulic analysis to determine the design flow characteristics for the project site during existing and proposed conditions for the 50 and 100-year design floods. Additionally, to determine if there are any scour related recommendations or countermeasures necessary for the proposed configurations.

Key Tasks

To determine the flow characteristics of the site for existing and proposed HDR was tasked with the following key tasks:

1. Determine site hydrology for the 50- and 100-year storms.
2. Estimate hydraulics for the existing structure for the 50- and 100-year storms.
3. Estimate the hydraulics of the proposed structures for the 50- and 100-year storms.
4. Estimate scour risk and make recommendations.

Design Criteria

The design of the bridge should meet the freeboard criteria established by Federal Highway Administration (FHWA) and California Department of Transportation (Caltrans).

Hydraulic Design Criteria

The freeboard design criteria for FHWA and Caltrans are summarized in Table 1.

Table 1. Hydraulic Design Criteria Summary

Agency	Storm	Freeboard	Notes
FHWA	50-year	>0.0 ft	Floating debris needs to be included in the analysis.
Caltrans	50-year 100-year	≥2.0 ft >0.0 ft	

Source: FHWA and Caltrans

FHWA STANDARDS

The FHWA criterion for the hydraulic design of bridges is that they be designed to pass the 2% probability of annual exceedance flow (50-year recurrence interval design discharge) with adequate freeboard, where practicable, to account for debris and bedload.

CALTRANS STANDARDS

The Caltrans hydraulic criterion for the design of bridges requires a proposed bridge to pass the 2% probability of annual exceedance flow (50-year design discharge) with adequate freeboard to pass anticipated drift. Two (2) ft of freeboard is commonly used in preliminary bridge designs. The bridge should 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.

Scour Design Criteria

Caltrans Bridge Inspection Reports (BIRs) (Appendix A) were used to inform values of historical bed elevation change for use in estimating scour susceptibility.

During the design phase, the evaluation of potential scour at the proposed bridges will follow the criteria described in the FHWA's Hydraulic Engineering Circular No. 18 (HEC-18), "Evaluating Scour at Bridges" (2012) and Caltrans' Memo to Designers (MTD) 16-1 (2017). The evaluation of potential scour will be based on hydraulic characteristics of the 100-year design discharge. The total scour will be estimated based upon the cumulative effects of the long-term bed elevation change, general (contraction) scour, and local scour.

Rock Slope Protection Design Criteria

Two procedures for determining rock slope protection (RSP) design were considered for the proposed structure: the FHWA's Hydraulic Engineering Circular No. 23 (HEC-23), "Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance" (2009), and Caltrans' *Highway Design Manual* (HDM; 2020). The final selection considers both procedures and is based on engineering judgment.

Vertical Datum

The Project references NAVD 88.

Topographic Data

Topography used for this study is the 3DEP LiDAR dataset collected between April 13, 2021, and April 30, 2021 and published 06/19/2023 as part of the San Joaquin, Work Unit 300024 LiDAR acquisition task order issued by the United States Geological Survey (USGS).

HDR collected cross section and profile survey points during a site visit in November of 2023 using a laser, rod, and tape measure. There were no observable benchmarks to tie the survey in, so the cross sections were approximate and only used to verify LiDAR. In General, LiDAR does a pretty nice job of covering the topography of the site. HDR also made visual observations of the overall site and took measurements of the bridge.

Geographic Setting

Geographic Location

The Frazier Rd Bridge over Mosher Creek (County Bridge 29C0272) is located 1.5 miles west of Clements Road (Lat. 38°04’27.18”, Long. 121°06’21.32”). The bridge is supported by timber girders with a corrugated steel deck that is filled with AC on timber column bents and timber abutments. The timber abutments were built in 1956 and the remaining structure were replaced in 2000. The bridge is owned and maintained by San Joaquin County Public Works.

Watershed Description

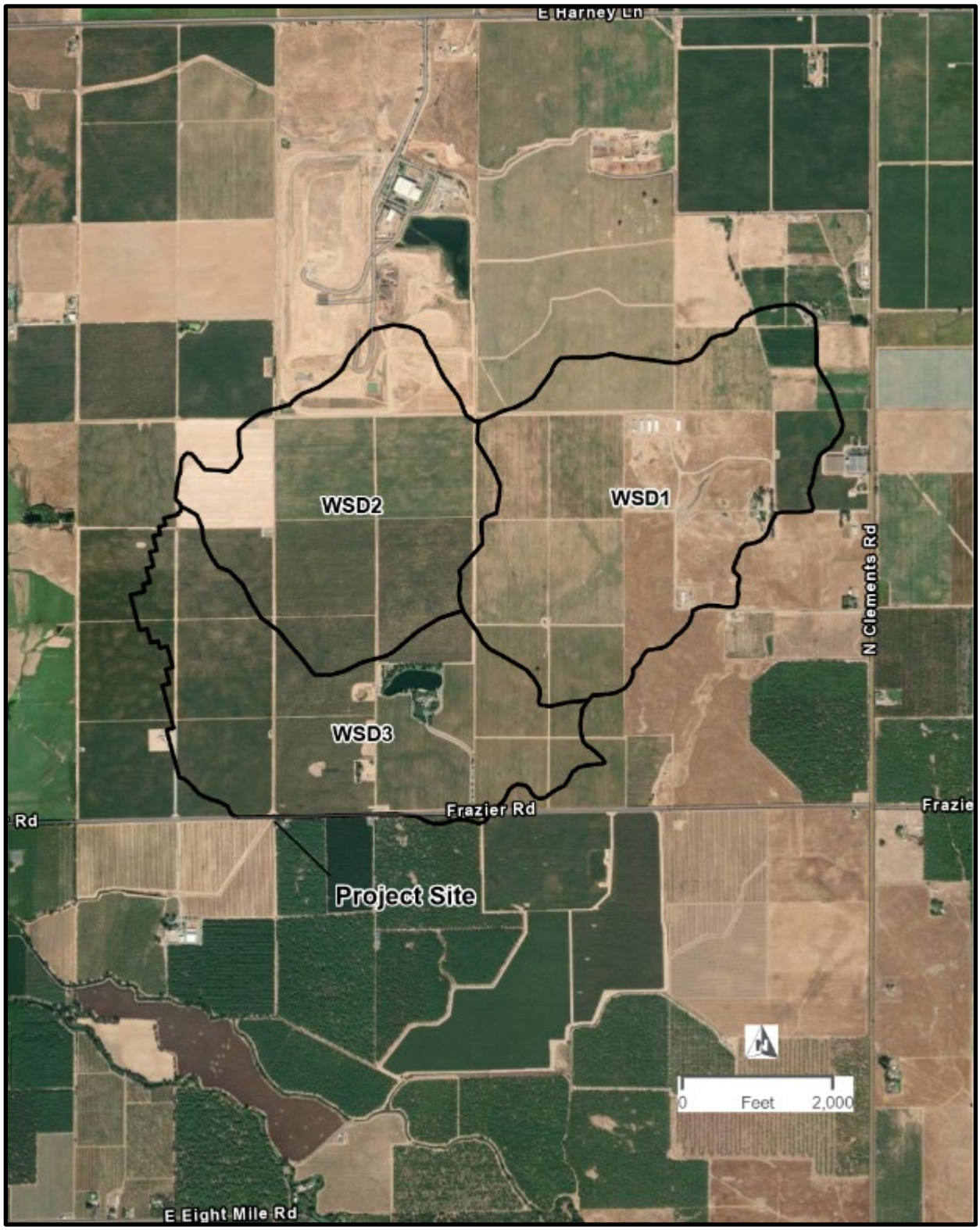
Mosher Creek generally flows from northeast to southwest above and below Frazier Road but flows from north to south at the Project location. Approximately 1,200 ft below the bridge Mosher Creek begins to generally flow east to west, making its way through the City of Stockton before entering White Slough approximately 20 mi downstream of the Project location.

According to the USGS StreamStats web application, the watershed area of Mosher Creek at the Project location is approximately 1.5 square miles (sq mi) (USGS, 2024). The watershed map of Mosher Creek at the Project location is shown in Figure 7.

Land Use

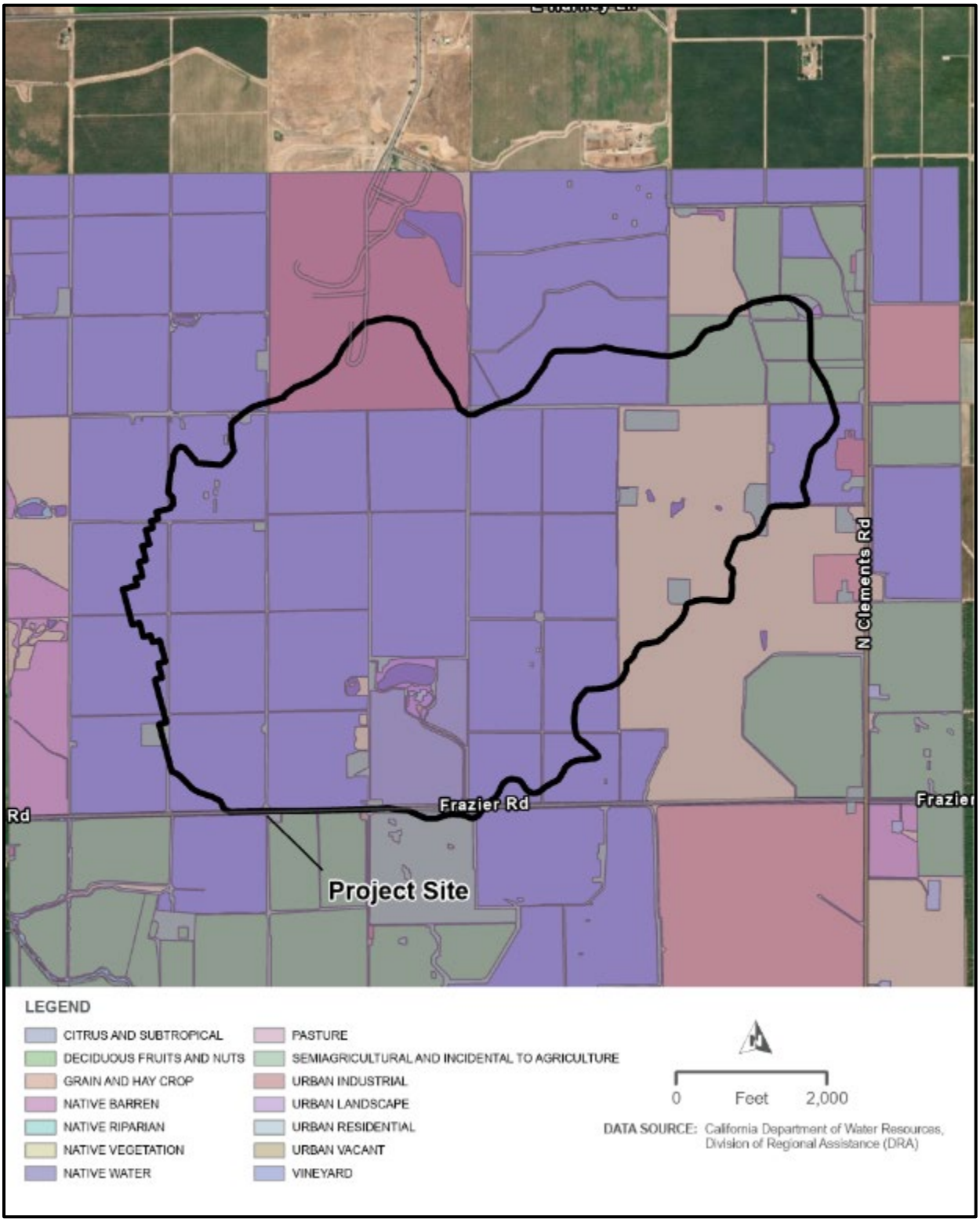
According to the planning land use survey of San Joaquin County conducted by the California Department of Water Resources, North Central (2017), the land use designated at the Project location is primarily agricultural, with some rural/urban feature. The land use map covering the Mosher Creek watershed is shown in Figure 8.

Figure 7. Watershed Map



Source: HDR, 2023

Figure 8. Land Use Map



Source: HDR, 2024

Hydrologic Analysis

There is not a Federal Emergency Management Agency (FEMA) detailed study area for Mosher Creek at the project location according to the Flood Insurance Study (FIS) of San Joaquin County and Incorporated Areas by FEMA and there is no known hydrologic study done for the area. HDR used two methods to determine the peak discharge in Mosher Creek at the project location: the USGS Regression equation method and the Unit Hydrograph method using HEC-HMS.

Design Discharge Summary

United States Geological Survey Regional Regression Equations

Flood-frequency equations were developed by the USGS and are based on an analysis of data from gaging stations. The USGS has divided California into six hydrologic regions; the Project site is within the Sierra Nevada region (Region 3). These flood-frequency equations are generally used to estimate stream flow for ungauged sites that are not affected by substantial urban development and that are natural (unregulated) streams.

On July 18, 2012, the USGS issued Methods for Determining Magnitude and Frequency of Floods in California, Based on Data through Water Year 2006 (USGS, 2012), which contains updated regional flood-frequency equations and revised boundaries of the six unique regions within California. These equations are based on annual peak-flow data through water year 2006 for 771 streamflow-gaging stations in California with 10 or more years of data. The Project site is within the Sierra Nevada region, and the 100- and 50-year peak flow equations for the Sierra Nevada region are the following:

$$Q_{100}=20.6[DRNAREA]^{0.874}\ [PRECIP]^{1.24}\ [ELEV]^{-0.25}$$

$$Q_{50}=21.1[DRNAREA]^{0.879}\ [PRECIP]^{1.31}\ [ELEV]^{-0.316}$$

Where:

Q_n = peak flow rate for return period of n-year (cubic feet per second [cfs])

DRNAREA = watershed area (sq mi)

PRECIP = average yearly precipitation (inches)

ELEV = mean basin elevation (ft)

With the watershed area of 1.5 sq mi, mean annual precipitation of 16.9 inches, and mean basin elevation of 115 ft (USGS StreamStats, 2024, where the Project watershed is located, the 100- and 50-year peak discharges at the Project site were

calculated using the USGS Regional Regression Equations and are summarized in Table 2. StreamStats results are shown in Appendix B.

Table 2. Peak Discharge for Mosher Creek at the Project Site Using USGS Regional Regression Equations

Return Interval	Peak Discharge (cfs)
100 Year	299
50 Year	273

Source: HDR 2024

Unit Hydrograph Method

HDR developed a rainfall/runoff model to estimate design peak discharges using United States Army Corps of Engineers' (USACE) Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) software and following the Soil Conservation Service's (SCS) Unit Hydrograph Method. The rainfall/runoff model simulates the rainfall/runoff process and generates discharge hydrographs. The input parameters were estimated by following the procedures in Technical Release 55 (TR-55) of the Urban Hydrology for Small Watersheds manual (Natural Resources Conservation Service (NRCS), 1986), and Chapter 810 from Caltrans' HDM (Caltrans, 2020). Some of the factors that will affect the runoff at the Project site include the watershed size, the slopes and elevations of the watershed, the land uses, and the soils. The following sections describe the characteristics of the watershed that were applied in the rainfall/runoff model of HEC-HMS to estimate the design discharges.

Frequency storms were uses to generate precipitation for the 50- and 100-year design events. Design events were modeled at 24-hour duration with a 5-minute peak intensity located at 50-percent of the event. The storm area was set equal to the centroid of the contributing watershed. The subbasins were assigned precipitation depth values from National Oceanic and Atmosphere Administration (NOAA) Atlas 14. The Atlas 14 values used are shown in Table 3. The losses were estimated using the SCS Curve Number (CN) loss method, and the excess precipitation was calculated using the SCS Unit Hydrograph transform method in HEC-HMS.

Table 3. NOAA Atlas 14 Frequency Storm Data for the 50- and 100-Year Storms

	Depth (inches)	
Duration	50 -Year Storm	100-Year Storm
15 Min	0.501	0.564
30 Min	0.693	0.781
1 Hour	0.947	1.07
2 Hour	1.22	1.37
3 Hour	1.42	1.6

Duration	Depth (inches)	
	50 -Year Storm	100-Year Storm
6 Hour	1.88	2.1
12 Hour	2.5	2.79
24 Hour	3.47	3.84

Source: NOAA Atlas 14; Last accessed Nov. 2023

The losses for the watershed were calculated using a CN, initial abstraction, and impervious area percentage. The SCS CN is based on the cover type, hydrologic condition of that cover, and the hydrologic soil group (HSG). Cover types are typically selected based on aerial photographs and land use maps. The hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff.

The HSGs of the watershed were obtained from the NRCS online Web Soil Survey (2024) (see Appendix C). Infiltration rates and runoff potential are indicated by the soil's HSG. Soils may be assigned to one of four groups (A, B, C, or D). Group A has high infiltration rates (low runoff potential) and consists mainly of deep, well-drained to excessively drained sands or gravelly sands. On the other end of the spectrum, Group D has very slow infiltration rates (high runoff potential) and consists chiefly of clays that have a high shrink-swell potential or soils with a clay or nearly impervious layer near the surface. The soils underlying each Subbasin are show in Table 4.

Table 4. HSG's within the watershed.

Subbasin	Area (acre)	% HSG C	% HSG D
SB-1	381	74	26
SB-2	278	57	43
SB-3	306	53	47

Source: HDR 2024

In the hydrologic model, the rainfall is converted to runoff by using a CN, which is based on the watershed's soils, plant cover type and treatment, amount of impervious areas, interception, and surface storage. The composite CNs were estimated using Table 2-2c from TR-55. The CNs are used to estimate the potential maximum retention after runoff begins (S=1000/CN-10) and the initial abstraction (Ia = 0.2S). The initial abstraction refers to all the losses that occur before runoff begins including water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. The CN, potential maximum retention, and initial abstraction values used in the hydrologic model are shown in Table 5.

Table 5. Hydrologic Parameters

Subbasin	Composite CN	Potential Maximum Retention (in)	Initial Abstraction (in)
SB-1	75	3.33	0.666
SB-2	78	2.82	0.564
SB-3	77	2.99	0.598

Source: HDR 2024

For the watershed, the average percentage of impervious areas also needs to be defined. In the rainfall/runoff model, no loss calculations are carried out on these impervious areas. All precipitation on these portions of the watershed become excess precipitation that is subject to direct runoff.

The lag time was estimated using the synthetic unit hydrograph lag method, developed by NRCS, 1986. The lag time was calculated for the watershed using the following equation:

$$T_l = \frac{L^{0.8}(S+1)^{0.7}}{1900Y^{0.5}}$$

$$T_c = 0.6T_l$$

Where:

T_l = Lag Time (hour)

Tc = Time of Concentration (hour)

L = Flow Length (ft)

Y = Average Watershed Land Slope (%)

S = Maximum Potential Retention (inch)

The parameters used to calculate lag time and the calculated lag time are presented in Table 6.

Table 6. Time of Concentration and Lag Parameters

Subbasin	Flow Length (ft)	Average Watershed Slope (%)	Lag Time (hr)	Time of Concentration (hr)
SB-1	7,558	3.1	1.04	0.63
SB-2	6,569	3.1	0.86	0.51

Subbasin	Flow Length (ft)	Average Watershed Slope (%)	Lag Time (hr)	Time of Concentration (hr)
SB-3	5,086	1.8	0.95	0.57

Source: HDR 2024

The 100- and 50-year peak discharges at the Project site using the unit hydrograph method are summarized in Table 7. Summary output tables from the HEC-HMS model are shown in Appendix D.

Table 7. Peak Discharge for Mosher Creek at the Project Site Using Rainfall/Runoff Model

Return Interval	Peak Discharge (cfs)
100 Year	375
50 Year	314

Source: HDR 2024

Selected Design Discharges

The 100- and 50-year peak discharges estimated using the unit hydrograph method was selected for use in the hydraulic analysis because the SCS unit hydrograph method provided a more detailed analysis of the watershed characteristics. Another reason is that the peak discharges estimated using this method are more conservative than the those calculated using the USGS Regional Regression Equation. The selected 100- and 50-year design discharges for the Project are summarized in Table 7.

Hydrologic Stability

Due to the nature of the work proposed by the Project, the Project would not change the overall land use within the watershed. Based on the land use map from San Joaquin County, future development is limited within the watershed due to the County's growth constraints. The design discharges would not be anticipated to significantly change during the lifetime of the bridge at the Project location; however, future developments within the watershed would have the potential to impact the hydrologic conditions of the watershed and at the Project site.

Hydraulic Analysis

The following sections discuss the development of the hydraulic models and summarize the results for the existing and proposed conditions. The channel cross sections are shown in Appendix E for existing and proposed conditions. The hydraulic summary tables for existing and proposed conditions are shown in Appendix F.

Hydraulic Model Development

Design Tools

The hydraulic analyses were performed for the existing and proposed conditions using the USACE's Hydrologic Engineering Center's River Analysis System (HEC-RAS) modeling software, Version 6.5.

Model Scenarios

For this analysis, four model scenarios were created.

1. Existing Conditions (SC-1)
2. Proposed double cell, cast in place RCB culvert (SC-2) – This scenario analyses a cast-in-place double RCB culvert at the Frazier Road crossing each with a 14 ft span and 3.5 ft rise.
3. Proposed CON/SPAN arch culverts (SC-3) – This scenario analyses a two-multi-cell CON/SPAN culverts each with 16 ft span and 3.5 ft rise.
4. Proposed corrugated metal pipe (CMP) arch culverts (SC-4) – This scenario analyses seven (7) CMP arch culverts at the Frazier Road crossing each with a 4.4 ft span and 3.6 ft rise.

Cross Section Data

A total of 35 cross sections along the 5,870-ft reach of Mosher Creek were used in the hydraulic analysis based on the HDR survey data and LiDAR. The upstream/downstream limits of the hydraulic model are approximately 4,163 ft upstream and 1,675 ft downstream of the existing bridge centerline. The alignment and locations of the channel cross sections are shown in Figure 9. The cross section naming convention is by river station (RS) with the cross-section number increasing in RS (measured in miles) going upstream.

Modeled Hydraulic Structures

The existing and proposed hydraulic structures within the limits of the hydraulic models are the existing and proposed Frazier Road bridge (BR 29C0272). The geometry of the existing bridge included in the existing condition hydraulic model

was based on the information included in the HDR survey data and the structural data included in the Caltrans BIR.

A rough 2D model of the reach was created to determine the effects of the private road culvert on the downstream hydraulics of BR 29C0272. From the 2D model it was determined that the private culvert influences the downstream hydraulics and was used to set the downstream boundary condition for the 1D model used for this analysis.

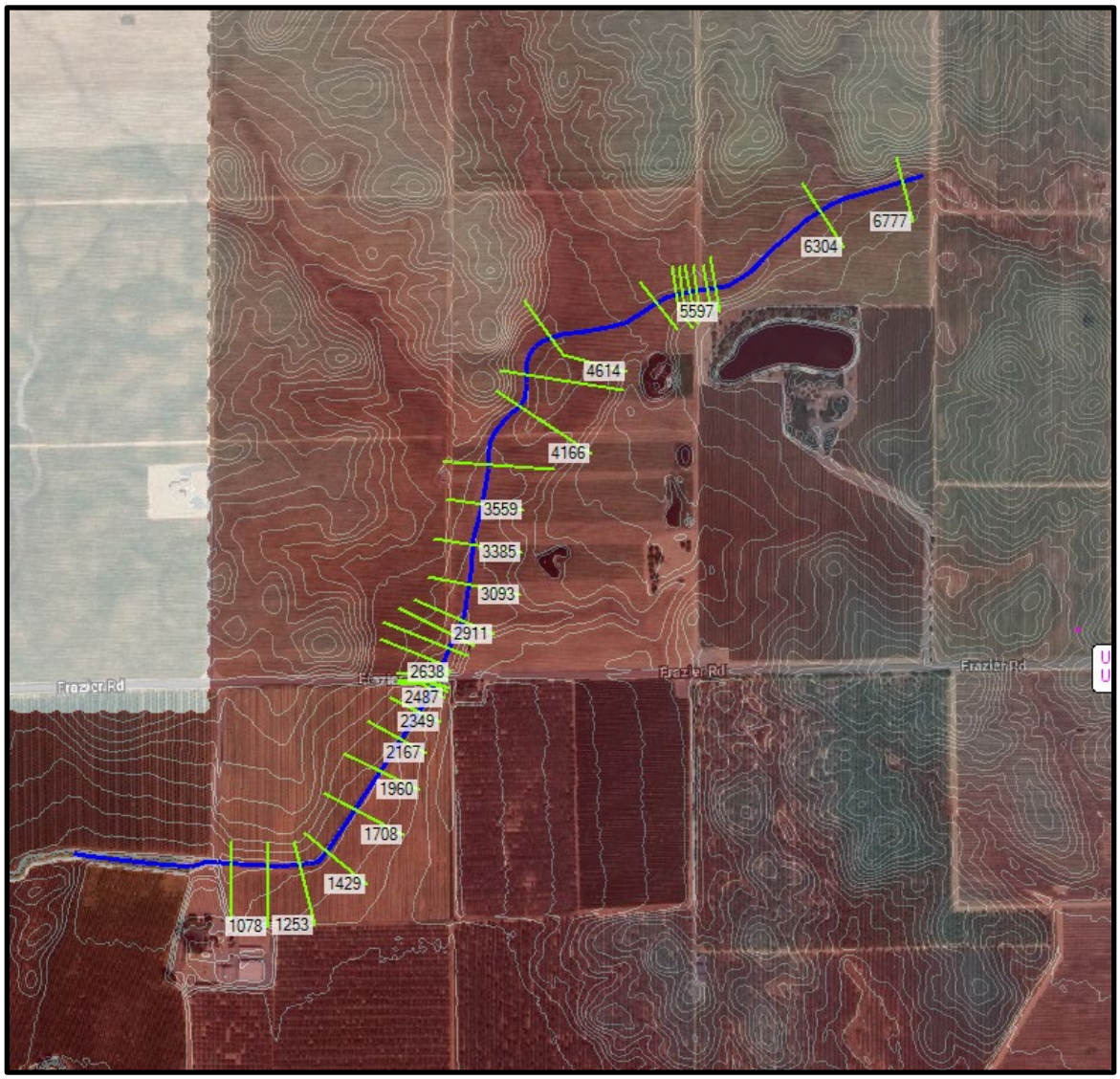
Model Boundary Conditions

A known water surface elevation was used from the rough 2D model of the reach which included the private culvert. The known water surface elevation (WSE) boundary conditions for the 50- and 100-year events are 93.35 and 94.11 ft, respectively.

Manning's Roughness Coefficients

Manning's roughness coefficients were used in the model to represent the frictional energy losses in the flow. The Manning's roughness coefficient for Mosher Creek included in the base hydraulic model was 0.033 for the low-flow channel and 0.035 to 0.045 for the embankment slope and overbank areas. These Manning's roughness coefficients were selected to represent the estimated roughness of the channel areas and are based on field observations and the areal imagery of the site.

Figure 9. Channel Cross Section/Model Extent Location Map.



Source: HDR, 2024

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. An expansion coefficient of 0.5 and a contraction coefficient of 0.3 were used for the channel cross sections immediately upstream and downstream of the bridge crossing. These values represent the abrupt changes in effective cross-sectional areas between upstream and downstream cross sections.

Hydraulic Model Results

Water Surface Elevations

The WSEs for Mosher Creek were estimated for the existing and proposed bridge conditions using the hydraulic models created in HEC-RAS. See Table 8 and Table 9 for the comparison of the WSEs in the vicinity of the bridges during the 100-year storm and 50-year storm, respectively. The cross sections facing downstream at the upstream sides of the existing and proposed bridges are shown in Figure 10 through Figure 13, respectively. The water surface profiles along the studied river reach are presented for the existing and proposed bridges in Figure 14 for the 100-year storm and Figure 15 for the 50-year storm.

Table 8. Mosher Creek 100-Year Water Surface Elevations

Location	SC-1 WSE (ft)	SC-2 WSE (ft)	Change (ft)	SC-3 WSE (ft)	Change (ft)	SC-4 WSE (ft)	Change (ft)
RS-35+59	97.6	97.6	0.0	97.6	0.0	97.6	0.0
RS-33+85	97.4	97.3	-0.1	97.3	-0.1	97.3	-0.1
RS-30+93	97.2	97.2	0.0	97.2	0.0	97.2	0.0
RS-29+11	97.2	97.1	-0.1	97.1	-0.1	97.1	-0.1
RS-28+11	97.1	97.0	-0.1	97.0	-0.1	97.0	-0.1
RS-27+38	97.1	97.0	-0.1	97.0	-0.1	97.0	-0.1
RS-26+38	97.0	97.0	0.0	96.9	-0.1	97.0	0.0
RS-25+82	96.9	96.8	-0.1	96.8	-0.1	96.8	-0.1
BR 29C0272 (US)	96.3	96.1	-0.2	96.3	0.0	96.4	0.1
BR 29C0272 (DS)	96.1	96.1	0.0	96.3	0.2	96.3	0.2
RS-25+51	96.1	96.1	0.0	96.3	0.2	96.3	0.2
RS-25+30	96.1	95.9	-0.2	95.9	-0.2	95.9	-0.3
RS-25+17	95.8	95.9	0.1	95.9	0.1	95.9	0.1
RS-24+87	95.8	95.9	0.1	95.9	0.1	95.9	0.1
RS-23+49	95.6	95.6	0.0	95.6	0.0	95.6	0.0
RS-21+67	95.1	95.1	0.0	95.1	0.0	95.1	0.0
RS-19+60	94.9	94.9	0.0	94.9	0.0	94.9	0.0
RS-17+08	94.7	94.7	0.0	94.7	0.0	94.7	0.0

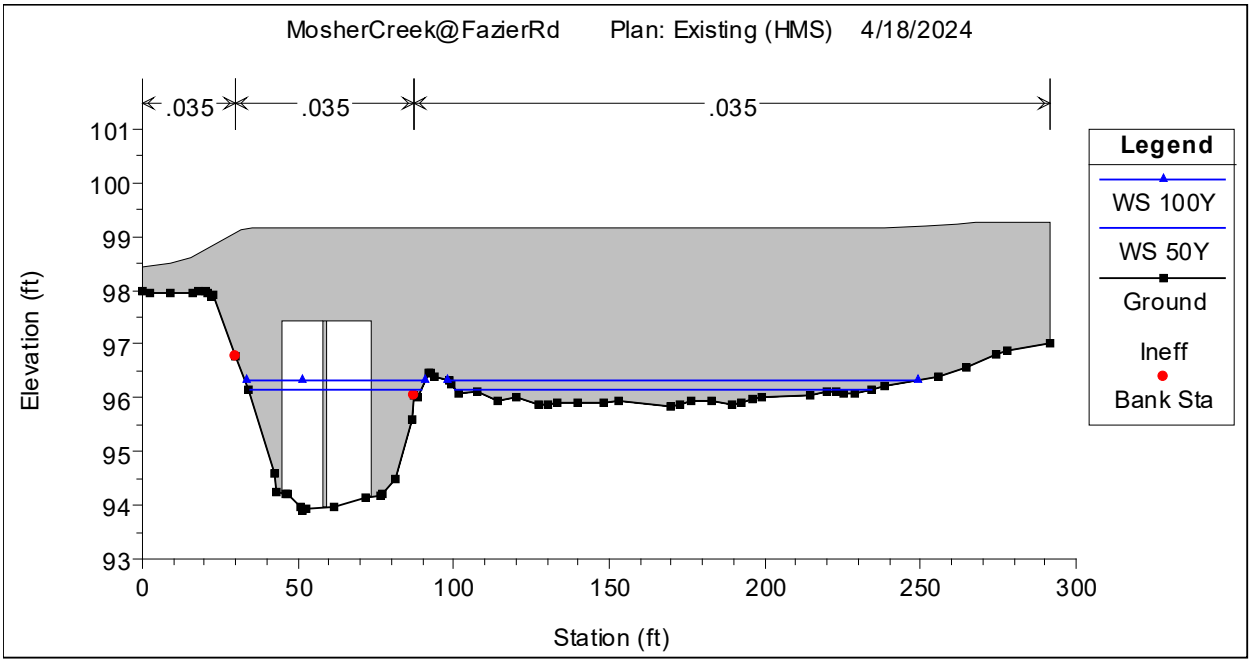
Notes:
Elevations were rounded to the nearest 0.1 ft.
Change is proposed WSE minus existing WSE
Source: HDR 2024

Table 9. Mosher Creek 50-Year Water Surface Elevations

Location	SC-1 WSE (ft)	SC-2 WSE (ft)	Change (ft)	SC-3 WSE (ft)	Change (ft)	SC-4 WSE (ft)	Change (ft)
RS-35+59	97.4	97.4	0.0	97.4	0.0	97.4	0.0
RS-33+85	97.1	97.1	0.0	97.1	0.0	97.1	0.0
RS-30+93	97.0	96.9	-0.1	96.9	-0.1	96.9	-0.1
RS-29+11	96.9	96.8	-0.1	96.8	-0.1	96.8	-0.1
RS-28+11	96.8	96.7	-0.1	96.7	-0.1	96.7	-0.1
RS-27+38	96.8	96.7	-0.1	96.7	-0.1	96.7	-0.1
RS-26+38	96.7	96.7	0.0	96.7	-0.1	96.7	0.0
RS-25+82	96.6	96.5	-0.1	96.5	-0.1	96.5	-0.1
BR 29C0272 (US)	96.1	96.0	-0.1	96.2	0.1	96.3	0.2
BR 29C0272 (DS)	96.0	96.0	0.0	96.2	0.2	96.2	0.2
RS-25+51	96.0	96.0	0.0	96.2	0.2	96.2	0.2
RS-25+30	95.9	95.8	-0.1	95.8	-0.1	95.8	-0.1
RS-25+17	95.7	95.8	0.1	95.8	0.1	95.8	0.1
RS-24+87	95.7	95.8	0.1	95.8	0.1	95.8	0.1
RS-23+49	95.5	95.5	0.0	95.5	0.0	95.5	0.0
RS-21+67	95.0	95.0	0.0	95.0	0.0	95.0	0.0
RS-19+60	94.8	94.8	0.0	94.8	0.0	94.8	0.0
RS-17+08	94.6	94.6	0.0	94.6	0.0	94.6	0.0

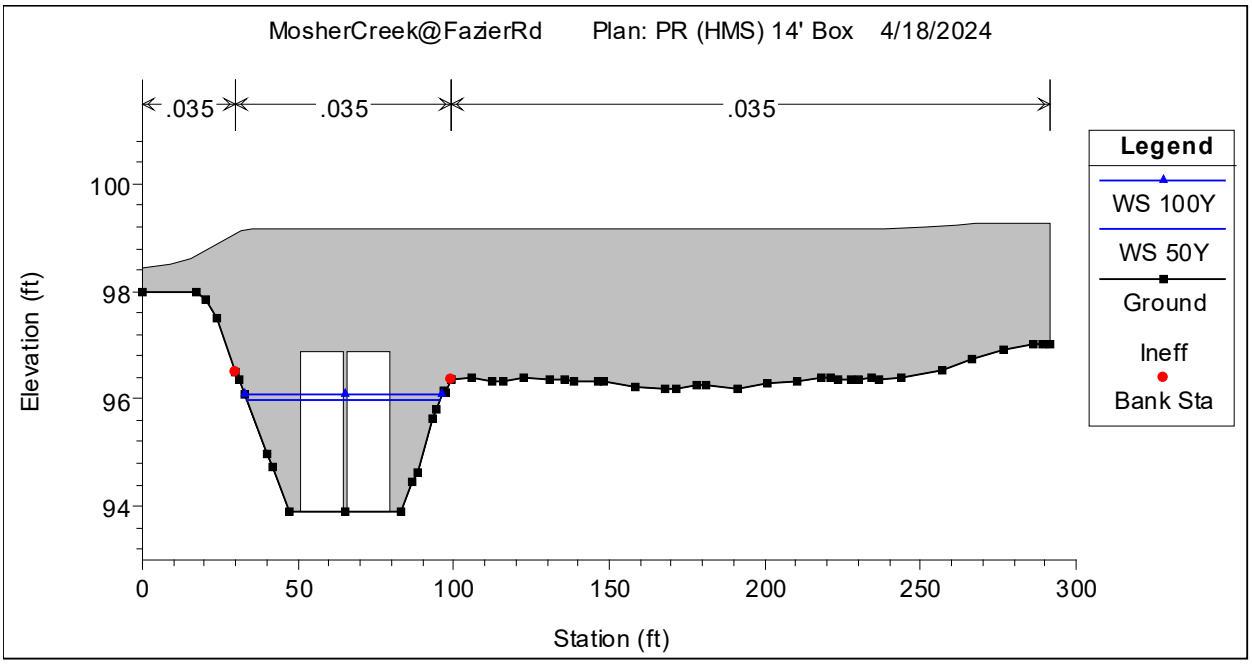
Notes:
Elevations were rounded to the nearest 0.1 ft.
Change is proposed WSE minus existing WSE
Source: HDR 2024

Figure 10. Upstream Face of Existing Bridge, Looking Downstream (South)



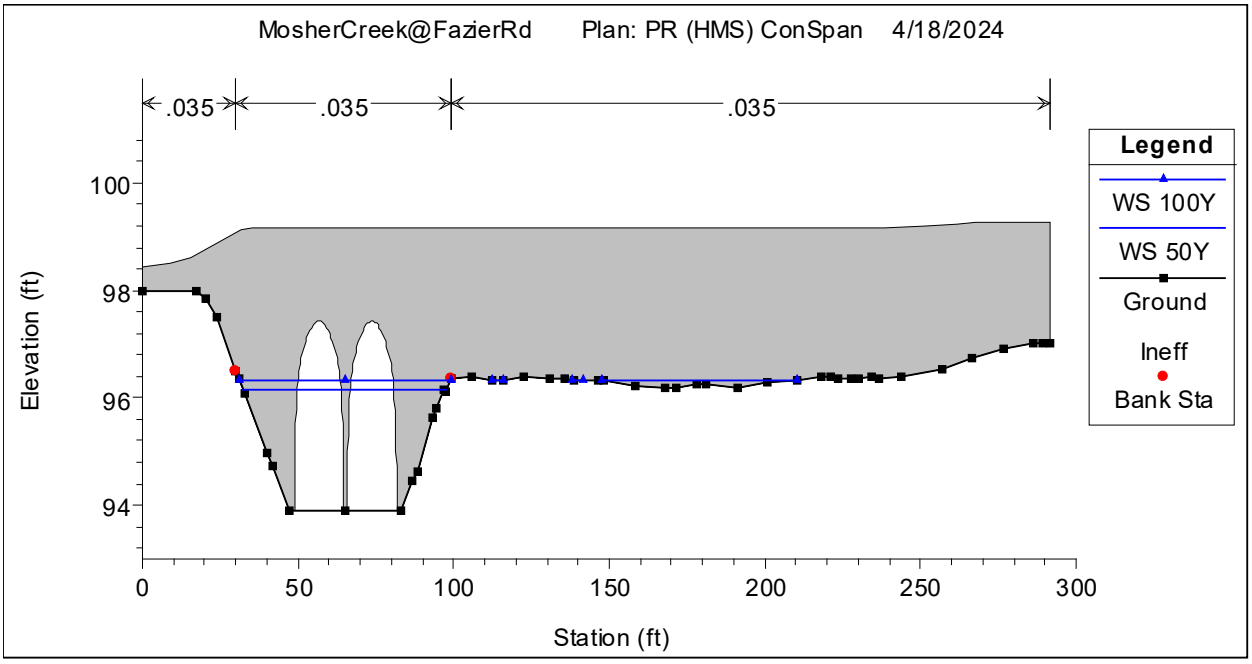
Source: HDR 2024

Figure 11. Upstream Face of Proposed Bridge SC-2, Looking Downstream (South)



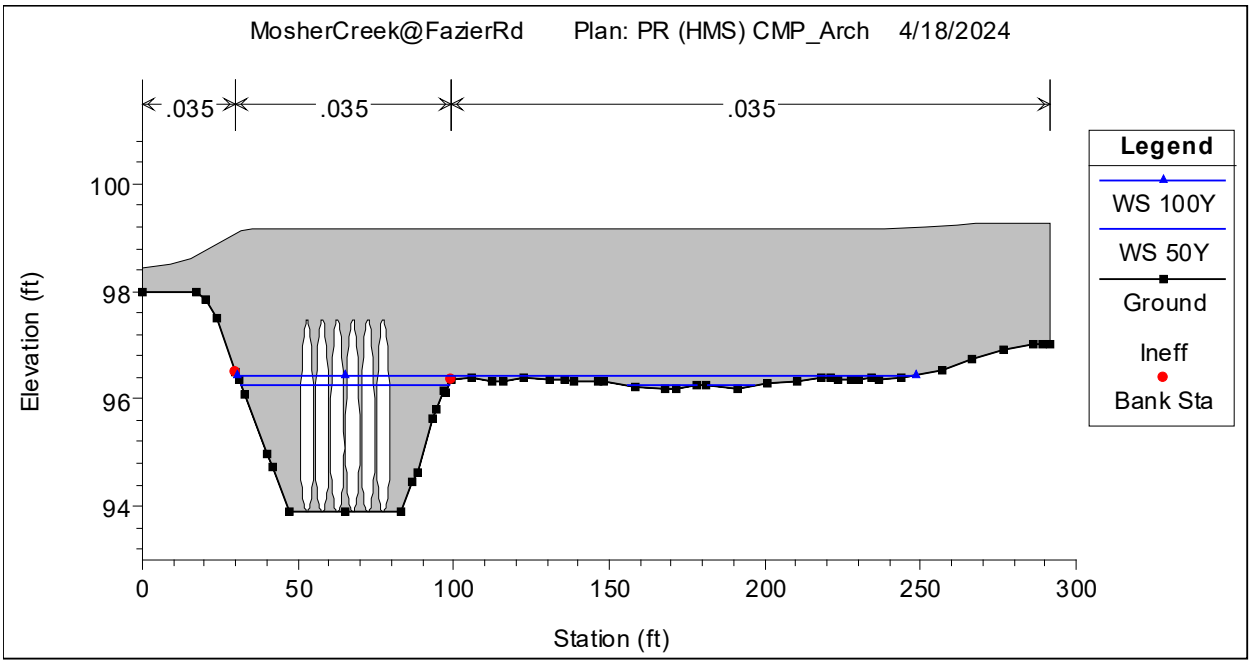
Source: HDR 2024

Figure 12. Upstream Face of Proposed Bridge SC-3, Looking Downstream (South)



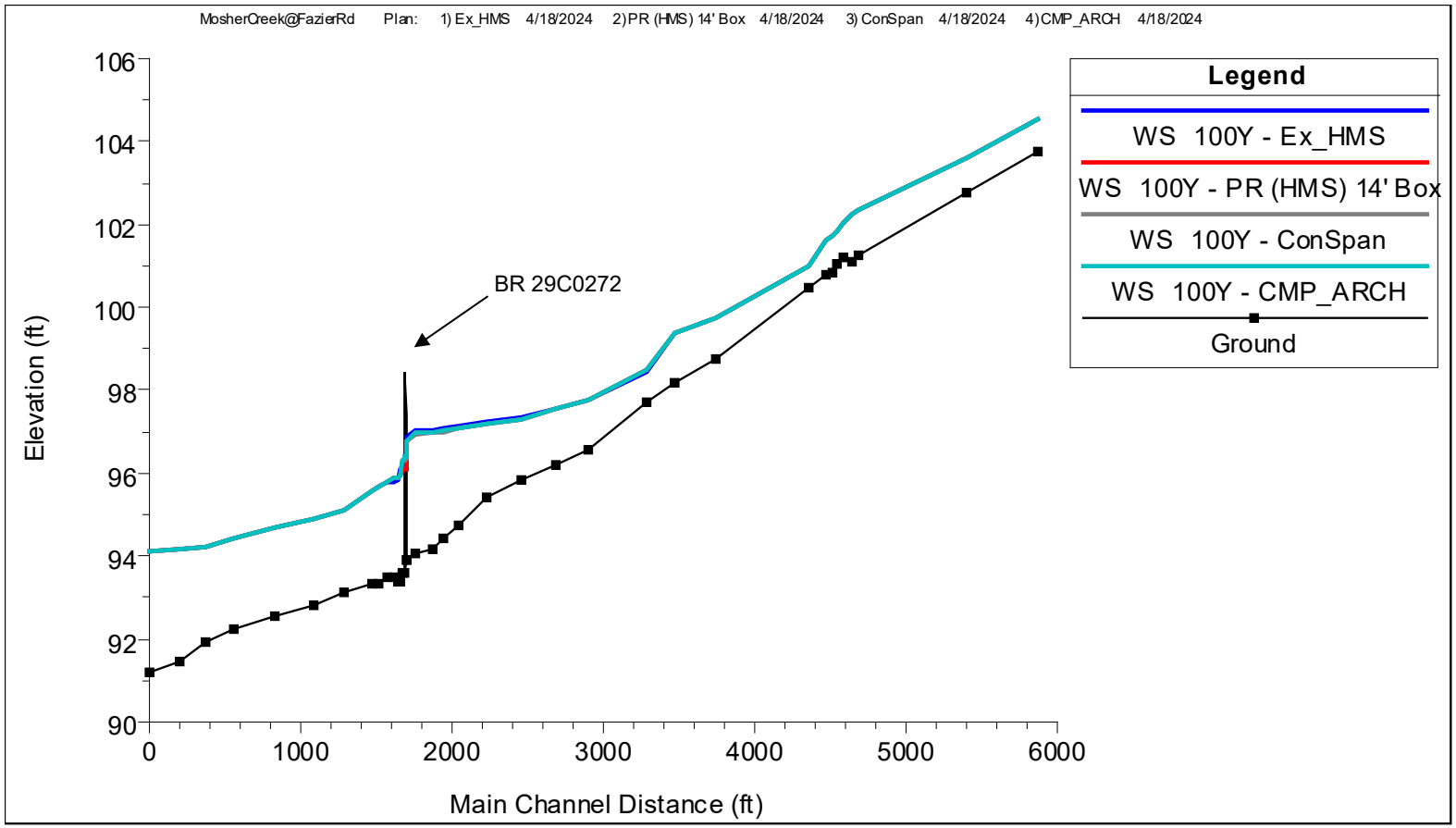
Source: HDR 2024

Figure 13. Upstream Face of Proposed Bridge SC-4, Looking Downstream (South)



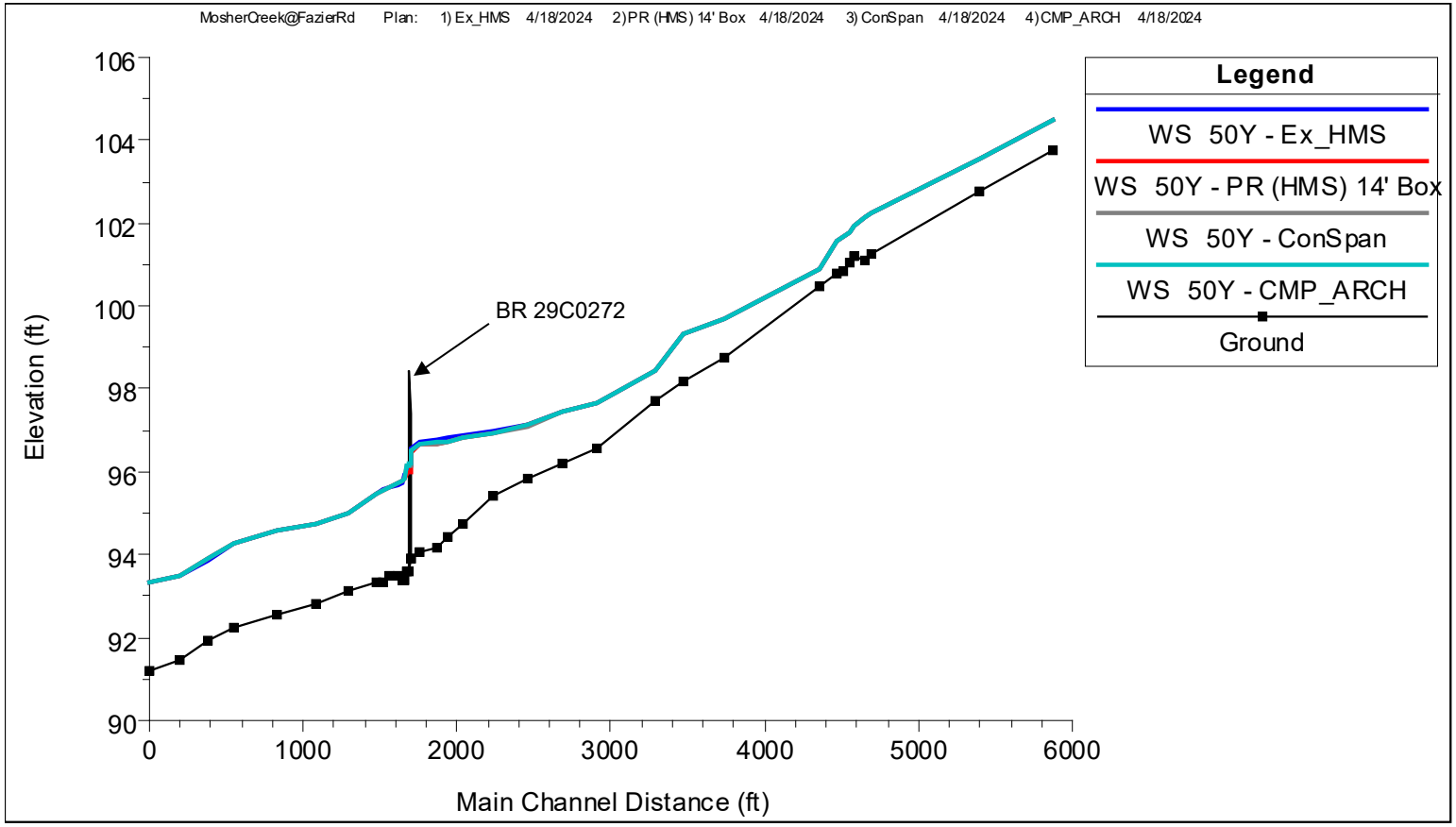
Source: HDR 2024

Figure 14. Mosher Creek 100-Year Water Surface Profile at Frazier Road



Source: HDR 2024

Figure 15. Mosher Creek 50-Year Water Surface Profile at Frazier Road



Source HDR: 2024

Freeboard

The available freeboard for the existing and proposed bridges, the minimum soffit elevations, and WSEs at the upstream cross section of the respective bridges with the 100- and 50-year storms are summarized in Table 10 and Table 11. Based on the results of the analyses, both the existing and proposed bridges meet the FHWA criteria but not Caltrans' design criteria for the freeboard. The freeboard is constrained by the existing grade of the road. For this analysis, it was assumed that the existing grade is maintained. Freeboard is improved by the double RCB culvert analysis in SC-2 by 0.28 ft and 0.15 ft for the 100- and 50-year events. Freeboard is slightly improved for the 100-year event under SC-3.

Table 10. 100-Year Water Surface Elevations and Freeboard

Condition	Minimum Bridge Soffit Elevation (ft NAVD 88)	WSE (ft NAVD 88)	Available Freeboard (ft)
Existing SC-1	97.42	96.33	1.09
Proposed SC-2	97.40	96.03	1.37
Proposed SC-3	97.43	96.33	1.10
Proposed SC-4	97.48	96.44	1.04

Source: HDR, 2024

Table 11. 50-Year Water Surface Elevations and Freeboard

Condition	Minimum Bridge Soffit Elevation (ft NAVD 88)	WSE (ft NAVD 88)	Available Freeboard (ft)
Existing SC-1	97.42	96.14	1.28
Proposed SC-2	97.40	95.97	1.43
Proposed SC-3	97.43	96.17	1.26
Proposed SC-4	97.48	96.25	1.23

Source: HDR, 2024

Velocity

The 100-year average channel flow velocities were estimated for the existing and proposed conditions from the developed hydraulic models and are summarized in Table 12 for the locations in the vicinity of the bridges. Based on the results of the analysis, the proposed bridge results in minor fluctuations inlet and outlet velocity and minor fluctuations in average channel velocity upstream and downstream of the bridge within the studied reach of Mosher Creek within the Project vicinity relative to the existing condition for the 100-year storm.

Table 12. 100-Year Average Channel Flow Velocities

Location	SC-1 Velocity (ft/s)	SC-2 Velocity (ft/s)	Change (ft/s)	SC-3 Velocity (ft/s)	Change (ft/s)	SC-4 Velocity (ft/s)	Change (ft/s)
RS-35+59	1.28	1.30		1.31		1.30	
RS-33+85	1.2	1.2	0.0	1.2	0.0	1.2	0.0
RS-30+93	0.9	0.9	0.0	0.9	0.0	0.9	0.0
RS-29+11	1.1	1.1	0.0	1.1	0.0	1.1	0.0
RS-28+11	1.6	1.7	0.0	1.7	0.1	1.7	0.1
RS-27+38	1.6	1.6	0.0	1.7	0.1	1.7	0.1
RS-26+38	1.2	1.2	0.0	1.2	0.0	1.2	0.0
RS-25+82	3.2	3.6	0.4	3.2	0.0	3.2	0.0
BR 29C0272 (US)	6.0	6.1	0.1	5.1	-0.9	4.7	-1.3
BR 29C0272 (DS)	6.0	5.9	-0.1	4.9	-1.1	4.7	-1.3
RS-25+51	5.4	6.0	0.6	4.2	-1.2	4.2	-1.2
RS-25+30	4.9	5.8	0.9	5.8	0.9	5.8	0.9
RS-25+17	5.8	5.5	-0.3	5.5	-0.3	5.5	-0.3
RS-24+87	4.3	3.9	-0.4	3.9	-0.4	3.9	-0.4
RS-23+49	3.1	3.1	0.0	3.1	0.0	3.1	0.0
RS-21+67	3.1	3.1	0.0	3.1	0.0	3.1	0.0
RS-19+60	1.9	1.9	0.0	1.9	0.0	1.9	0.0
RS-17+08	1.7	1.7	0.0	1.7	0.0	1.7	0.0

Notes:

Average channel flow velocities were rounded to the nearest 0.1 ft/s.

Existing and proposed bridge upstream faces as well as downstream faces are not at the same locations; therefore, average channel flow velocity differences were not computed for these two locations.

Source: HDR, 2024

Scour Analysis

HDR evaluated bridge scour per the criteria described in “Evaluating Scour at Bridges” (FHWA, 2012). The minimum design criterion for bridge scour is the 100-year design storm. The CON/SPAN alternative was evaluates using the bridge scour methods in the FHWA Hydraulic Engineering Circular (HEC) No. 18 (HEC-18). Scour at the outfall of the culvert alternatives was evaluated per the FHWA’s HEC-14. HDR evaluated the scour potential using the results of the steady-state flow analysis from HEC-RAS for the three proposed alternatives. The following sub-sections summarize the results of the analysis. Scour Calculations are summarized in Appendix G.

Caltrans Bridge Inspection Reports

The Caltrans Bridge Inspection Reports (BIRs) for the existing bridge were reviewed in support of the scour analysis. Table 13 summarized inspections available from Caltrans’ Bridge Inspection Records Information System (BIRIS).

Table 13. BIR Inspection Summary

Date of Inspection	Scour Information
05/26/1978	Channel is U-Shaped with dirt and stagnant water.
5/4/1993	No scour or undermining was noted. Channel Cross Section was measured.
5/23/2000	The condition of the structure continues to deteriorate. This structure is in poor condition. Immediate attention should consider removal in lieu of repairs. This structure no longer spans an active waterway. The County should consider removal in lieu of repairs. The NBI Item 113 Code is rated U which indicated this structure has an unknown foundation and has not yet been evaluated for scour.
3/18/2003	The timber abutments and timber columns were originally constructed in 1956. The remaining elements were replaced in the summer of 2000. The water depth in the creek measured approximately 0.4 meters during the investigation. The substructure portion above water was probed with a geology pick. It appears that the visible timber abutments and Bent 2 posts are still in satisfactory condition.
5/12/2005	This structure has an unknown foundation that has not been evaluated for scour. The scour risk can not be determined. This structure should be monitored for scour related problems during flood events.
03/08/2007	The footings of both abutments and the bent were exposed vertically approximately 6 inches. There is no information on the type and thickness of the footing. Channel Cross Section was measured.
8/11/2010	A Scour plan of action was developed. Annual visual monitoring was required by the county. Bridge closure steps would be evaluated based on the severity of scour damage.
3/14/2013	Channel Cross Section was measured and compared to one dated 3/8/2007. The channel has degraded .34 meters at pier 2.
2/3/2015	Channel Cross Section was measured and compared to 3/14/2013. Soil was added to the channel bottom raising the channel bed up to 3 meter at pier 2.
2/17/2021 & 2/7/2023	The Channel Cross Section dated 02/15/2015 was spot checked during this inspection. No significant discrepancies were noted.

Source: Caltrans Division of Maintenance, 1978 through 2023

Existing Channel Bed

Calculation of the scour depths inherently assumes that the channel bed material is erodible. The calculations are based upon a field visit of the site and BIR information provided in the previous section. If there are any geologic formations, such as bedrock, underlying the proposed foundation locations, they would help to inhibit the progression of scour holes. The bed material observed to consist of compacted fine material in the field. The existing bed material gradation at the site was not quantified. Due to the limited amount of detailed bed material at the Project location, the cohesive and cohesionless calculations were analyzed and presented in this study.

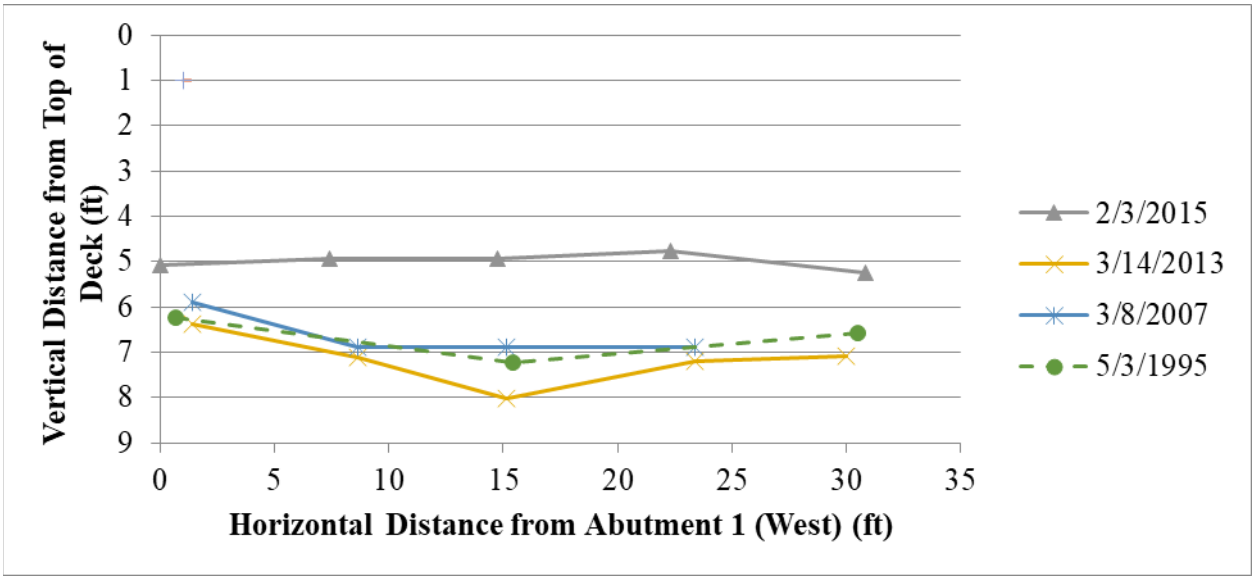
Long-Term Bed Elevation Change

Long-term bed elevation changes can be due to either aggradation or degradation. Aggradation at the bridge site is a result of the deposition of material eroded from the channel. Degradation at the bridge site is a result of scouring of the channel due to sediment deficit. Only degradation is accounted for in scour calculations. The long-term bed elevation changes (long-term bed degradation) are typically based on historical channel data at the bridge site.

The historical channel data at the bridge site was reviewed and compared to assess the long-term bed elevation changes. The stream measurements that were recorded in the Caltrans BIRs were compared to assess the long-term bed elevation changes. Historical stream measurements were taken at the bridge and were included in May 1995, March 2007, March 2013 and February 2015 (see Table 13). The 1995 cross section was measured relative to the “Top of timber Deck” and the remaining measurements were measured off the “Top of Deck”. Both measurement descriptions were assumed to be the same locations. The measurements from the top of deck are plotted in Figure 16.

The average rate of change in the thalweg records an overall aggregation to the bed over the 20-year span of data. Therefore, the long-term bed elevation change was calculated to be 0.0 ft for an extrapolated 75-year design life considering the channel characteristics at the new bridge alignment would be like those at the existing bridge alignment.

Figure 16. Historical Stream Measurement Comparison at Existing Fraizer Road Bridge.



Source: HDR, 2024

Contraction Scour

Contraction scour occurs when the flow area of a stream is reduced by 1) the natural contraction of the stream channel; 2) by a bridge structure; or 3) the overbank flow forced back to the channel by roadway embankments at the roadway approach to a bridge. From the continuity equation, a decrease in flow area results in an increase in average velocity and bed shear stress through the contraction. Hence, there is an increase in erosive forces in the contraction section, and more bed material is removed from the contracted reach than is transported into the reach. This increase in transport of bed material from the reach lowers the natural bed elevation. As the bed elevation is lowered, the flow area increases. Thus, the velocity and shear stress decrease until relative equilibrium is reached; i.e., the quantity of bed material that is transported into the reach is equal to that removed from the reach, or the bed shear stress is decreased to a value such that no sediment is transported out of the reach. Contraction scour, in a natural channel or at a bridge crossing, involves removal of material from the bed across all or most of the channel width (FHWA, 2012).

As described in the existing bed Section, the channel bed material was evaluated for both cohesive and cohesionless equations for the purpose of analyzing scour. The cohesive contraction scour for the CON/SPAN alternative resulted in 2.5 ft scour depth. The cohesionless analysis resulted in 0.9 ft scour depth. The 2.5 ft of scour for the cohesive material was selected as the recommended design for the most conservative analysis.

Pier Scour

Pier scour is caused by vortices (known as a horseshoe vortex) forming at the base of the pier. The horseshoe vortex results from the pileup of water on the upstream surface of the pier and subsequent acceleration of the flow around the base of the pier. The scour depth at a pier is influenced by pier design (shape and dimension), flow characteristics (flow rate, local velocity, and depth at the pier), and sediment particle size distribution. For piers in cohesionless materials, the HEC-18 (FHWA, 2012) manual recommends the HEC-18 pier scour equation, which is based on the Colorado State University equation to determine pier scour. The pier scour calculation assumes the footings will not be exposed to flow (i.e., that the footings will be below the estimated total scour depth). The cohesionless pier scour was calculated using equation 7.1 and the Cohesive per scour was calculated used 7.35 from HEC-18 (FHWA, 2012).

The CON/SPAN alternative has two spans with a center pier. The cohesive pier scour was calculated to be 7.1 ft scour depth and the Cohesionless scour equation calculated a 5.0 ft scour depth. The cohesive scour depth of 7.1 ft was recommended for the CON/SPAN alternative.

Abutment Scour

Abutment scour occurs when the bridge abutments and roadway embankments block approaching flow. A vortex is formed at the upstream end of the abutment and along the toe of the abutment due to the flow obstruction caused by the abutments. The highly turbulent flow caused by the abutments generates the erosive shear action and subsequently causes scouring. According to HEC-18 (FHWA, 2012), local scour at bridge abutments is commonly evaluated using either the Froehlich or HIRE live-bed scour equations. The National Cooperative Highway Research Program (NCHRP) developed alternative abutment scour equations based on a range of abutment types, locations, flow conditions, and sediment transport conditions.

While the Froehlich, HIRE, and NCHRP equations are acceptable methods that can be used to estimate scour at abutments, the NCHRP equations have several advantages. Unlike the Froehlich and HIRE equations, the NCHRP equations do not use an effective embankment length, which can be difficult to determine. The NCHRP equations are also considered to be more representative of the physical scouring processes at the abutments. Because of these reasons, the NCHRP method was used to estimate scour at the abutments.

The NCHRP method calculates a scour depth that includes both local and contraction scour components at the abutment. The NCHRP scour was calculated using the equations presented in Section 8.6.3 of HEC-18 (FHWA, 2012). The contraction scour depth calculated in the Contraction Section of this report was subtracted from the calculated scour depth to determine the local abutment scour. The local abutment scour was calculated to be 1.2 ft at the left and right abutment of the CON/SPAN alternative. The calculation of the local abutment scour for the CON/SPAN alternative is presented in Table 15.

The CON/SPAN design is constructed with a natural bottom unlike the other three culvert alternatives. Since the bottom of the CON/SPAN alternative will not be armored open bottom scour was evaluated for this alternative. The open-bottom culvert scour was calculated using the equations presented in Section 6.9.2 of HEC-18 (FHWA, 2012). The CON/SPAN open bottom scour without a wingwall was 13 ft depth and the open-bottom culvert with a wingwall was 8.3 ft scour depth. The local scour without a wingwall is presented in Table 15 for the most conservative scour depths.

Culvert Outfall Scour

Procedures in the Federal Highway Administration's (FHWA) "Hydraulic Design of Energy Dissipators for Culverts and Channels" *Hydraulic Engineering Circular No. 14* (HEC-14) include an equation to estimate the scour depth at a culvert outfall. Scour depth at the outlet of the three culvert alternatives were evaluated using both the cohesive and cohesionless equations. The cohesionless pier scour was calculated using equation 5.1 and the cohesive per scour was calculated used 5.2 from HEC-14

(FHWA, 2006). The scour depth at the outfall for all culvert alternatives with cohesive and cohesionless material is presented in Table 14. The detailed culvert outfall scour calculations are presented in Appendix G.

Table 14. Culvert Outfall Scour Depth in Cohesive and Cohesionless Material

Scenario	Cohesive Scour Depth (ft)	Cohesionless Scour Depth (ft)
SC-2	14.2	9.3
SC-3	15.4	9.4
SC-4	5.0	9.0

Source: HDR, 2024

Total Scour

The total scour is presented for the CON/SPAN Bridge alternative. The total scour is the sum of the local scour, contraction scour, and long-term bed elevation change. The calculated scour depths and elevations are summarized in Table 15 and Table 16.

Table 15. Scour Summary Table

Long-Term and Short-Term Scour Depths			
Frazier Road Crossing-CON/SPAN Alternative			
Support No.	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short-Term (Local) Scour Depth (ft)
Left Abutment	0.0	2.5	10.6
Pier 1	0.0	2.5	7.1
Right Abutment	0.0	2.5	10.6

Source: HDR, 2024

The scour data table (Table 16) identifies the long-term scour elevations as well as the short-term contraction scour depths. According to *Memo to Designers 16-1* (Caltrans, 2017), the scour data table shall be placed on the Project Foundation Plan. Per the *California Amendments to the AASHTO LRFD BDS (2017 Eighth Edition)* (Caltrans, 2019), foundations should be designed to withstand the conditions of scour.

Table 16. Scour Data Table

Support No.	Long-Term (Degradation and Contraction) Scour Elevation (ft)	Short-Term (Local) Scour Depth (ft)
Left Abutment	91.5	10.6
Pier 1	91.5	7.1
Right Abutment	91.5	10.6

Source: HDR, 2024

Scour and Erosion Counter Measures

RSP generally consists of rocks on channel and structure boundaries to limit the effects of erosion. It is the most common type of scour countermeasure due to its general availability, ease of installation, and relatively low cost. RSP sizing calculations were performed to estimate a minimum recommended rock class to protect the embankment slopes of the proposed bridge from scour and erosion.

RSP calculations estimate a minimum recommended rock size/class to protect the embankment slopes at the abutments from scour and erosion. Two procedures were considered to determine the RSP size for the CON/SPAN alternative: HEC-23 (FHWA, 2009) and the HDM (Caltrans, 2020). The calculation following the HEC-23 and the calculation following HDM resulted in Class I RSP (20 lb median particle weight) (see Table 17). The RSP at the culvert outfall were sized using the HEC-14 equations for riprap aprons. The RSP sizes for each alternative are presented in Table 17.

The RSP should be placed using Method B, which involves dumping rock near its planned location, and working the rock to its final position with machinery. A Class 8 RSP geotextile filter fabric should be placed on the bank as the initial filter separator material between the layer of RSP and the channel bank. A gravel (granular) filter can be used as an alternative to geotextile filter fabric. The design of the gravel filter will depend on the underlying base soil parameters as well as the overlaying RSP. The gravel filter is typically between 6 and 15 inches thick and must meet piping and permeability requirements.

Table 17. Culvert RSP Recommendations

Scenario	RSP class	Median particle diameter (inches)	Median particle weight	Minimum layer thickness (ft)	Placement method
SC-2	II	9	60 lb	1.5	B
SC-3	I	6	20 lb	1	B
SC-4	VII	24	1/2 ton	4	A or B

Source: HDR, 2024

Conclusions and Recommendations

This study evaluated three culvert bridge replacement alternatives under the 50-year and 100-year flood events, adhering to design criteria set forth by the FHWA, the FEMA, San Joaquin County, and Caltrans. The FHWA criteria require that the structure must pass the 50-year storm with greater than 0 ft of freeboard. FEMAs requirement is that the structure must pass the 100-year storm. The County requires that the structure not raise the 100-year floodplain Finally, Caltrans' criteria mandate that:

1. The structure must pass the 50-year flood with at least 2 ft of freeboard, and
2. The structure must pass the 100-year flood with at least greater than 0 ft of freeboard.

The three alternatives considered were:

1. SC-2: Two-cell RCB culverts with 90-degree headwall and 30–75-degree flared wingwalls.
2. SC-3: CON/SPAN arch culverts with a 90-degree headwall and 45-degree flared wingwalls.
3. SC-4: CMP arch culverts with an 18-inch corner radius.

The performance of each alternative is summarized below.

Hydraulic Performance (FHWA and Caltrans Criteria):

- SC-2:
    - 50-year flood: Passes with 1.43 ft of freeboard, meeting FHWA criteria but failing Caltrans' freeboard requirement.
    - 100-year flood: Passes with 1.37 ft of freeboard and no rise in floodplain elevations upstream, satisfying Caltrans criteria, County criteria, and FEMA Criteria.
- SC-3:
    - 50-year flood: Passes with 1.26 ft of freeboard, meeting FHWA criteria but failing Caltrans' freeboard requirement.
    - 100-year flood: Passes with 1.37 ft of freeboard and no rise in floodplain elevations upstream, satisfying Caltrans criteria, County criteria, and FEMA Criteria.

- SC-4:
    - 50-year flood: Passes with 1.23 ft of freeboard, meeting FHWA criteria but failing Caltrans' freeboard requirement.
    - 100-year flood: Passes with 1.04 ft of freeboard and no rise in floodplain elevations upstream, satisfying Caltrans criteria, County criteria, and FEMA criteria.

Scour Results:

- SC-2: Moderate scour potential, requiring additional protective measures at the culvert outlet, headwalls, and wingwalls.
- SC-3: Higher scour potential, more like a bridge than a culvert.
- SC-4 culvert outlet scour is on the higher end of scour potential of the three alternatives.

Based on the evaluation, SC-2 (Two-cell RCB culverts with 90-degree headwall and 30–75-degree flared wingwalls) is recommended as the preferred option. This alternative provides a practical balance of cost, compliance with FHWA and manageable scour potential. This option does not meet the Caltrans 50-year 2-ft freeboard requirement. To meet Caltrans criteria, the county would have to raise the road or widen the channel, which may be cost prohibitive.

While SC-3 (CON/SPAN arch culverts) has similar hydraulic performance as the SC-2 option, it has the higher scour risk and may have higher construction costs accordingly.

SC-4 (CMP arch culverts), though generally CMP is an economical choice, this option would require the most channel modification in order to fit the amount of culvert cells needed. This scenario does meet FHWA, County and FEMA hydraulic criteria.

References

California Department of Transportation (Caltrans)

2017 Memo to Designers (MTD) 16-1

2020 *Highway Design Manual* (HDM)

2021 Bridge Inspection Records Information System - Bridge 29C0272

California Department of Water Resources (DWR)

2017 San Joaquin County Land Use Survey 2017. https://gis.water.ca.gov/arcgis/rest/services/Planning/i15_LandUse_SanJoaquin2017/FeatureServer. (Last accessed: April 2024)

Environmental Systems Research Institute (ESRI)

2023 ArcGIS Pro 3.1.2. [Computer Software]

Federal Highway Administration (FHWA)

2006 "Hydraulic Design of Energy Dissipators for Culverts and Channels" *Hydraulic Engineering Circular No. 14* (HEC-14).

2009 "Bridge Scour and Stream Instability Countermeasures." *Hydraulic Engineering Circular No. 23*. Third Edition. September 2009. Publication No. FHWA-NHI-09-111.

2012 "Evaluating Scour at Bridges." *Hydraulic Engineering Circular No. 18*. Fifth Edition. Publication No. FHWA-HIF-12-03.

2013 *Hydraulic Engineering Circular 22* (HEC-22)

National Oceanic and Atmospheric Administration (NOAA)

2024 Atlas 14, Volume 6, Version 2 Precipitation Frequency Data Server (PFDS). <https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ca> (Last accessed: February 2024)

Natural Resources Conservation Service (NRCS)

1986 Urban Hydrology for Small Watersheds TR-55

2024 NRCS online Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/. (Last accessed April, 2024)

United States Geological Survey (USGS)

2012 Methods for Determining Magnitude and Frequency of Floods in California, Based on Data through Water Year 2006

2024 StreamStats. (Fourth Version) https://streamstats.usgs.gov/ss/ (Last accessed: April 2024).

Appendix A - Bridge Inspection Reports

BRIDGE INSPECTION REPORT
Routine Inspection

BRIDGE NO.: **29C0272**
STRUCTURE NAME: **MOSHER CREEK**
INSPECTION DATE: **February 17, 2021**

BRIDGE LOCATION INFORMATION

(9) LOCATION	1.5 MI W OF CLEMENTS RD	(7) FACILITY CARRIED			FRAIZER ROAD
(11) POSTMILE	0	(6) FEATURE INTERSECTED			MOSHER CREEK
(16) LATITUDE	38°04'27.18"	(5) INVENTORY RTE(ON/UNDER)	ON		140000000
(17) LONGITUDE	121°06'21.32"	(104) ON NATIONAL HIGHWAY SYSTEM			NOT ON NHS

STRUCTURAL HEALTH CONDITION SUMMARY INFORMATION

(58) DECK	(4 POOR)	DECK AREA (SF)			58
(59) SUPERSTRUCTURE	(5 FAIR)	SUFFICIENCY RATING			57.6
(60) SUBSTRUCTURE	5 FAIR	PAINT CONDITION SUPER	N/A	SUBSTR	N/A
(62) CULVERT	N N/A (NBI)	STRUCTURALLY DEFICIENT (SD) STATUS			SD
(67) STRUCTURE EVALUATION	5 ABOVE MIN TOLERABLE	(113) SCOUR			U UNKNOWN FOUNDATION

PHOTOGRAPH IDENTIFICATION

Routine-Roadway View (02/17/2021)

Routine-Elevation View (02/17/2021)

Routine-Underside View (02/17/2021)

Routine-Map View (07/30/2021)

TEAM LEADER Pamela Gagnier

REPORT AUTHOR Pamela Gagnier

INSPECTED BY P.Gagnier/P.Tran

Andrew W. Corker (Registered Civil Engineer) — 8/4/2021 Date

STRUCTURE OVERVIEW

AGENCY INFORMATION

(1) STATE NAME	CALIFORNIA 069
(2) HIGHWAY DISTRICT	10
(3) COUNTY CODE	(29)SAN JOAQUIN
(4) PLACE CODE	(00000) _____
(21) MAINTAIN	02 COUNTY HWY AGENCY
(22) OWNER	02 COUNTY HWY AGENCY
(98) BORDER BRIDGE STATE CODE	N/A % SHARE N/A
(99) BORDER BRIDGE STRUCTURE NUMBER	N/A

INSPECTION INFORMATION

(90) INSPECTION DATE	02/21	(91) FREQUENCY	24 MO
(92) CRITICAL FEATURE INSPECTION		(93) CFI DATE	
A) FRACTURE CRITICAL INSP	N-NO	MO A)	N/A
B) UNDERWATER INSP	N-NO	MO B)	N/A
C) OTHER SPECIAL INSP	N-NO	MO C)	09/99

CONSTRUCTION INFORMATION

(27) YEAR BUILT	1956	(45) MAIN SPANS	2	(43a) STRUCTURE TYPE MAIN	7: WOOD OR TIMBER
(106) YEAR MODIFIED	2000	(46) APPR SPANS	0	(43b) DESIGN TYPE MAIN	02: STRINGER/MULTI-BEAM
(34) SKEW	0	(48) MAX SPAN (M)	4.6	(44a) STRUCTURE TYPE APPR	0: OTHER/ NOT APPLICABLE
(49) LENGTH (M)	9.4	(35) STR FLARE	0-NO	(44b) DESIGN TYPE APPR	00: OTHER/NOT APPLICABLE
(112) NBIS BR LENGTH	Y	JOINTS	0	NO. OF HINGES	0

STRUCTURE DESCRIPTION

Simply supported timber girders (16) with a corrugated steel deck filled with AC on timber 4-column bents and timber abutments. The foundation is unknown. The timber abutments and timber columns were constructed in 1956. The remaining elements were replaced in the summer of 2000.

SPAN CONFIGURATION

1 @ 14.75 ft, 1 @ 15 ft

OPERATIONAL INFORMATION

LOAD CAPACITY

(31) DESIGN LOAD	5 MS 18 (HS 20)	(65) CALC METHOD	2 AS ALLOWABLE STRESS
(66) INVENTORY RATING	RF=0.78 =>25.3 metric tons	(63) CALC METHOD	2 AS ALLOWABLE STRESS
(64) OPERATING RATING	RF=1.06 =>34.3 metric tons	(70) BRIDGE POSTING	5 AT/ABOVE LEGAL LOADS
(41) STRUCTURE STATUS	A-OPEN, NO RESTRICTION	PERMIT RATING	GGGGG
OVERLAY THICKNESS	1 inches		

POSTING LOADS

	Safe Loads	Existing Ordinance/Order	Posting Signs	
Type 3	Legal	N/A	N/A	U.S. Tons
Type 3S2	Legal	N/A	N/A	U.S. Tons
Type 3-3	Legal	N/A	N/A	U.S. Tons
Speed	55	N/A	N/A	MPH

Additional Ordinance/Order Requirements

NONE

Additional Signs

NONE

Posting Date N/A
Load Rating Summary Date 04/06/09
Load Rating Type Calculated
Load Rating Tool - Date Hand Calculations - 04/06/09

MINIMUM VERTICAL CLEARANCE

(53) MIN VERT CLEAR OVER BRIDGE RDWY		Unimpaired
(54) MIN VERT UNDERCLEAR REF	N-NOT H/RR	0.00 M

MINIMUM LATERAL UNDERCLEARANCE

(55) MIN LAT UNDERCLEAR RT REF	N-NOT H/RR	0.0 M
(56) MIN LAT UNDERCLEAR LT		0.0 M

CONDITION INFORMATION

INSPECTION COMMENTARY

SCOPE AND ACCESS

CONDITION INFORMATION

INSPECTION COMMENTARY

All elements were accessible by foot on and around the structure. The creek was dry during this investigation. A complete inspection of the visible elements was performed.

MISCELLANEOUS

New routine photos were taken during this investigation and a new routine map view photo was added to this report. See Photos 1 to 4.

WATERWAY

NBI Item #113 is a U - Unknown Foundation and a Scour Plan of Action dated 08/11/2010 is on file in BIRIS. The plan calls for monitoring of the structure by San Joaquin County annually and after flood events.

The Channel Cross Section dated 02/15/2015 was spot checked during this inspection. No significant discrepancies were noted.

SPECIAL INSPECTION INFORMATION

STEEL INVESTIGATION DETAILS - NOT APPLICABLE FOR THIS BRIDGE.

UNDERWATER INVESTIGATION DETAILS - NOT APPLICABLE FOR THIS BRIDGE.

DECK AND ROADWAY

DECK CROSS SECTION

0.33 ft br, 19.75 ft, 0.33 ft br

DECK GEOMETRY

(49)	LENGTH	9.4 M
(51)	NET WIDTH	6.0 M
(52)	TOTAL WIDTH	6.2 M
(50)	CURB OR SIDEWALK	LEFT 0.0 M RIGHT 0.0 M
(32)	APPROACH RDWY WIDTH	4.6 M
(33)	BRIDGE MEDIAN	0 NO MEDIAN

DECK STRUCTURE INFORMATION

(107)	DECK STRUCTURE TYPE	6-CORRUGATED STEEL
(108)	WEARING SURFACE / PROTECTIVE SYSTEM	
	A) TYPE OF WEARING SURFACE	6-BITUMINOUS
	B) TYPE OF MEMBRANE	0-NONE
	C) TYPE OF DECK PROTECTION	0-NONE
	OVERLAY THICKNESS (inches)	1 inches
(29)	AVERAGE DAILY TRAFFIC	221
(30)	YEAR OF ADT 2013	(109) TRUCK ADT % 1 %
(19)	BYPASS, DETOUR LENGTH	13 KM
(114)	FUTURE ADT	99
(115)	YEAR OF FUTURE ADT	2041
(37)	HISTORICAL SIGNIFICANCE	5: NOT ELIGIBLE FOR NRHP

DECK ROADWAY/OPERATIONAL INFORMATION

(42a)	TYPE OF SERVICE	1-HIGHWAY
(12)	BASE HIGHWAY NETWORK	0-NOT ON NET
(13)	LRS INVENTORY RTE & SUBRTE	
(104)	NATIONAL HIGHWAY SYSTEM	0-NOT ON NHS
(26)	FUNCTIONAL CLASS	09-LOCAL RURAL
(100)	DEFENSE HIGHWAY	0-NOT STRAHNET
(101)	PARALLEL STRUCTURE	N-NONE EXISTS
(102)	DIRECTION OF TRAFFIC	2-2 WAY
(10)	INVENTORY ROUTE MIN VERT CLEAR	99.99 M
(47)	INVENTORY ROUTE TOTAL HORIZ CLEAR	6.0 M
(68)	DECK GEOMETRY	3 INTOLERABLE - CORRECT
(72)	APPR ROADWAY ALIGN	8 EQUAL DESIRABLE CRIT
(105)	FEDERAL LANDS HWY	0-NOT APPLICABLE
(110)	DESIGNATED NATIONAL NETWORK	0-NOT ON NET
(20)	TOLL	3-ON FREE ROAD
(28a)	LANES	2
	SPEED	55
(103)	TEMPORARY STRUCTURE	N/A

DECK ELEMENT INSPECTION RATINGS AND NOTES

(58) DECK RATING = (4)

Elem No.	Defect/ Prot	Defect	Element Description	Env	Total Qty	Units	Qty in each Condition State CS 1	CS 2	CS 3	CS 4
30			**Steel Deck-Orthotropic**	2	58	sq.m	58	0	0	0
	510		**Deck Wearing Surface-Asphalt**	2	58	sq.m	0	10	20	28
		3220	**Cracking-AC (WS)**	2	58		0	10	20	28
	516		**Steel Coating-Galvanized**	2	58	sq.m	58	0	0	0

DECK ELEMENT INSPECTION RATINGS AND NOTES

(58) DECK RATING = (4)

Elem No.	Defect/ Prot	Defect	Element Description	Env	Total Qty	Units	Qty in each Condition State CS 1	CS 2	CS 3	CS 4

(30) Steel Deck-Orthotropic

There were no significant defects noted.

(30-510-3220) Cracking-AC (WS)

The deck wearing surface is deteriorating through-out the deck. There are transverse cracks up to 1 inch wide x full deck width spaced 6 inches on center. The most severe locations are at Pier 2 and Abutment 3. At Pier 2, the deck wearing surface has loose fragments that are 3 inches wide x 3 inches long over an area of 3 feet x 2 feet and at Abutment 3 there are 1 inch wide transverse cracks spaced 2 inches on center and patched potholes that are unsound. In addition there are numerous patched potholes through-out. See Photos 5 to 7.

(30-516) Steel Coating-Galvanized

There were no significant defects noted.

DECK PHOTOGRAPHS

Photo 5
Typical deck wearing surface deterioration. Looking west toward Abutment 1

Photo 6
Deck wearing surface deterioration. Looking at Pier 2 westbound lane

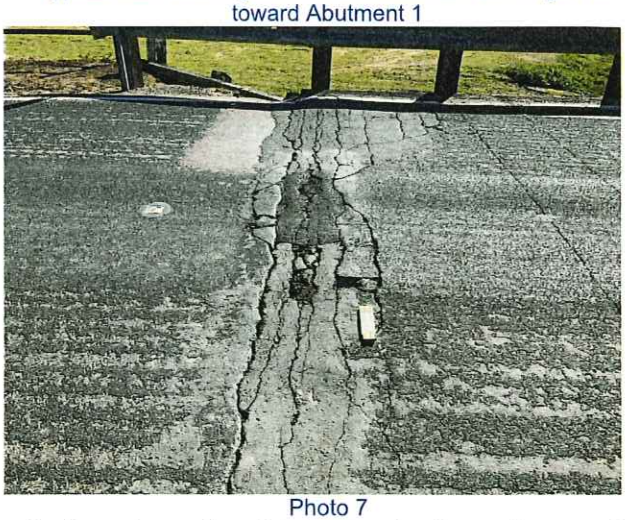


Photo 7
Deck wearing surface deterioration. Looking at Abutment 3 westbound lane

JOINT - APPROACH - RAIL

RAIL INFORMATION

(36a) Rail Code 0 (36b) Transition 0 (36c) Appr Guardrail 0 (36d) Appr Guardrail End 0 Roadway Speed 55 MPH

Rail Type	Location	Length (ft)	Rail Modifications
MBBR	**Right/Left**	**142**	**timber posts**

JOINT/APPROACH/RAIL ELEMENT INSPECTION RATINGS AND NOTES

JOINT - APPROACH - RAIL

JOINT/APPROACH/RAIL ELEMENT INSPECTION RATINGS AND NOTES

Elem No.	Defect/ Prot	Defect	Element Description	Env	Total Qty	Units	Qty in each Condition State CS 1	CS 2	CS 3	CS 4
330			**Railing-Metal**	2	19	m	19	0	0	0

(330) Railing-Metal

Two of the right rail post in Span 2 have splits. The 2nd post from Abutment 1 is split in the bottom quarter of the post. The 3rd post from Abutment 1 has a 12 inch long x 2 inch deep split in the bottom. See Photo 8.

The 2nd post from Abutment 1 on the left, half of the spacer block is missing. See Photo 9.

JOINT/RAIL PHOTOGRAPHS

Photo 8
Splits in the bottom 1/4 of Post 2 and bottom of Post 3, from Abutment 1 on the right

Photo 9
Broken spacer block at the 2nd post from Abutment 1 on the left

SUPERSTRUCTURE

SUPERSTRUCTURE ELEMENT INSPECTION RATINGS AND NOTES

(59) SUPERSTRUCTURE RATING = (5)

Elem No.	Defect/ Prot	Defect	Element Description	Env	Total Qty	Units	Qty in each Condition State CS 1	CS 2	CS 3	CS 4
111			**Girder/Beam-Timber**	2	240	m	190	42	8	0
	1150		**Check/Shake (Timber)**	2	42		0	42	0	0
	1170		**Split/Delamination (Timber)**	2	8		0	0	8	0

(111) Girder/Beam-Timber

There are shallow checks up to 0.25 inch wide in the left exterior girder. No defect is warranted at this time.

(111-1150) Check/Shake (Timber)

There is a 0.125 inch wide x intermittent full length check in the right exterior girders. The depth of the check was measured with a taper gauge to be 0.5 inch deep. See Photo 10. There is a similar condition in the left exterior girder in Span 1, except the depth of the check was measured with the taper gauge as 0.75 inch deep. See Photo 11.

There are 0.125 inch wide x intermittent full length checks in the bottoms of Girders 9, 11 and 12 in Span 2. The depth of the checks were measured with a taper gauge to be 0.5 inch deep.

(111-1170) Split/Delamination (Timber)

The exterior girders on the right side of the structure above Pier 2 exhibit multiple splits at the ends of the girders. These splits are up to 0.25 inch wide and 6 feet long. These girders are also crushed up to 0.5 inch over Pier 2. See Photo 10.

SUPERSTRUCTURE PHOTOGRAPHS

Photo 10
Checks in the right exterior girders

Photo 11
Check in the left exterior girder in Span 1

SUBSTRUCTURE

DESCRIPTION UNDER STRUCTURE

(42b) TYPE OF SERVICE UNDER	5-WATERWAY	(38) NAVIGATION CONTROL	0: NO CONTROL
(69) UNDERCLEARANCES V - H	N NOT APPLICABLE (NBI)	(111) PIER PROTECTION	**N/A**
(71) WATER ADEQUACY	8 EQUAL DESIRABLE	(39) NAVIGATION VERTICAL CLEARANCE	0.0 M
(61) CHANNEL PROTECTION	5 BANK PROT ERODED	(116) VERT-LIFT BRIDGE NAV MIN VERTICAL CLEAR	M
(113) SCOUR	U UNKNOWN FOUNDATION	(40) NAVIGATION HORIZONTAL CLEARANCE	0.0 M
SCOUR POA DATE	08/11/2010		

CHANNEL DESCRIPTION

Sinuous creek situated in a wide floodplain with heavily vegetated slopes (grass). The bed is comprised of silt and clay.

SUBSTRUCTURE ELEMENT INSPECTION RATINGS AND NOTES

(60) SUBSTRUCTURE RATING = 5

Elem No.	Defect/ Prot	Defect	Element Description	Env	Total Qty	Units	Qty in each Condition State CS 1	CS 2	CS 3	CS 4
206			**Column-Timber**	2	12	each	10	2	0	0
	1150		**Check/Shake (Timber)**	2	2		0	2	0	0
(206-1150) Check/Shake (Timber)										
There are checks up to 1 inch deep and 0.25 inch wide in the timber columns. The majority of these checks are shallow and do not warrant a downgrade at this time.										
216			**Abutment-Timber**	2	12	m	12	0	0	0
(216) Abutment-Timber										
There were no significant defects noted.										
220			**Pile Cap/Footing-RC**	2	18	m	0	18	0	0
	6000		**Scour**	2	18		0	18	0	0
(220-6000) Scour										
The tops of the footings at both abutments and Pier 2 are exposed vertically up to 2 inches without undermining.										
235			**Pier Cap-Timber**	2	18	m	6	4	8	0
	1150		**Check/Shake (Timber)**	2	12		0	4	8	0
(235-1150) Check/Shake (Timber)										
There are checks up to 4 inches deep and 0.25 inch wide in the timber caps. Based on a comparison to the 02/09/2019 Photos 1 and 2, this condition has remained unchanged.										

OTHER PHOTOGRAPHS

Photo 1
Looking east at Abutment 1

Photo 2
Looking north at the right side of the structure

Photo 3
Looking southeast from Abutment 1

Photo 4
North is at the top of the page

WORK RECOMMENDATIONS

DECK WORK RECOMMENDATIONS

Rec Date	02/01/2017	Work By	LOCAL AGENCY	Est Cost		Dist Target
Status	PROPOSED	Action	Deck-Place Overlay	Str Target	2 YEARS	EA

Remove and replace AC overlay.

JOINT/APPR/RAIL WORK RECOMMENDATIONS

Rec Date	02/17/2021	Work By	LOCAL AGENCY	Est Cost		Dist Target
Status	PROPOSED	Action	Railing-Repair	Str Target	2 YEARS	EA

Replace the rail 2nd and 3rd rail post from Abutment 1 on the right and replace the spacer block at the 2nd rail from from Abutment 1 on the left.

SUPERSTRUCTURE WORK RECOMMENDATIONS

Rec Date	05/01/2011	Work By	LOCAL AGENCY	Est Cost		Dist Target
Status	PROPOSED	Action	Super-Replace	Str Target	2 YEARS	EA

Replace the exterior girders on the right side of the structure.

SUBSTRUCTURE WORK RECOMMENDATIONS

Rec Date	02/17/2021	Work By	LOCAL AGENCY	Est Cost		Dist Target
Status	PROPOSED	Action	Sub-Replace	Str Target	2 YEARS	EA

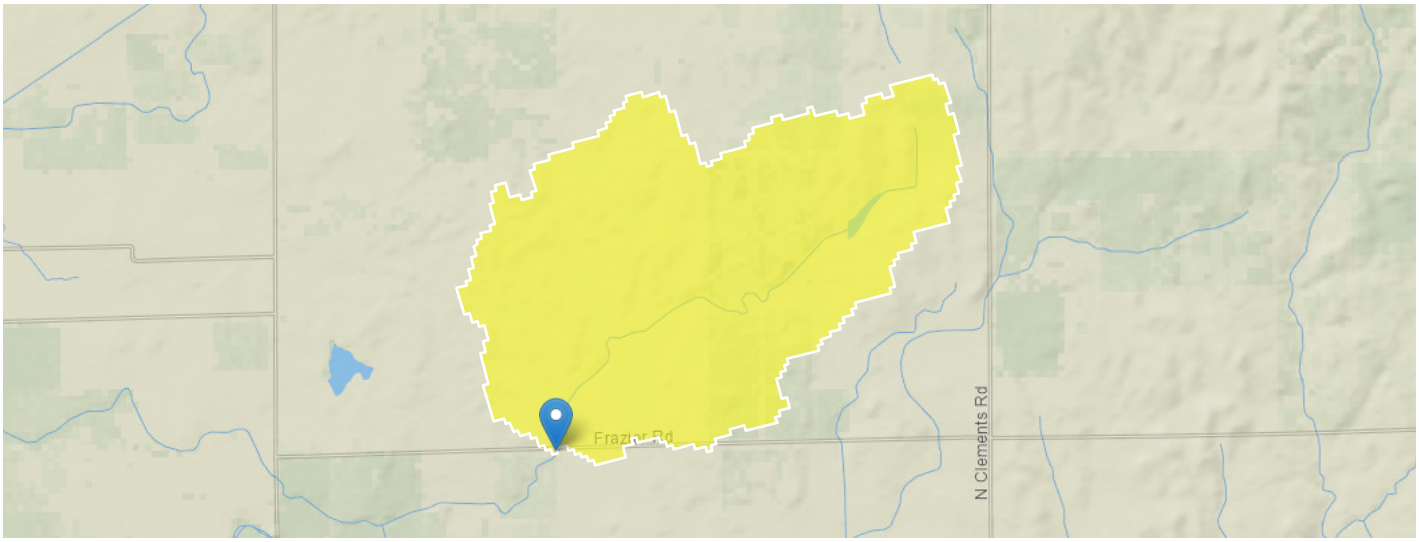
Replace the timber caps.

OTHER WORK RECOMMENDATIONS - NONE

Appendix B - USGS StreamStats Report

Frazier Road BR 29C0272 StreamStats Report

Region ID: CA
Workspace ID: CA20240423120142283000
Clicked Point (Latitude, Longitude): 38.07413, -121.10607
Time: 2024-04-23 05:02:08 -0700



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.5	square miles
ELEV	Mean Basin Elevation	115	feet
PRECIP	Mean Annual Precipitation	16.9	inches

Peak-Flow Statistics

Peak-Flow Statistics Parameters [2012 5113 Region 3 Sierra Nevada]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.5	square miles	0.07	2000
ELEV	Mean Basin Elevation	115	feet	90	11000
PRECIP	Mean Annual Precipitation	16.9	inches	15	100

Peak-Flow Statistics Flow Report [2012 5113 Region 3 Sierra Nevada]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	55.8	ft^3/s	17.5	178	74.4
20-percent AEP flood	140	ft^3/s	56.9	345	54.4
10-percent AEP flood	192	ft^3/s	80.9	456	51.5
4-percent AEP flood	242	ft^3/s	101	583	52.3
2-percent AEP flood	273	ft^3/s	109	684	54.6
1-percent AEP flood	299	ft^3/s	113	788	58
0.5-percent AEP flood	318	ft^3/s	115	882	61.5
0.2-percent AEP flood	338	ft^3/s	112	1020	67.3

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl. (http://pubs.usgs.gov/sir/2012/5113/)

Application Version: 4.20.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

Appendix C - NRCS Soils Report

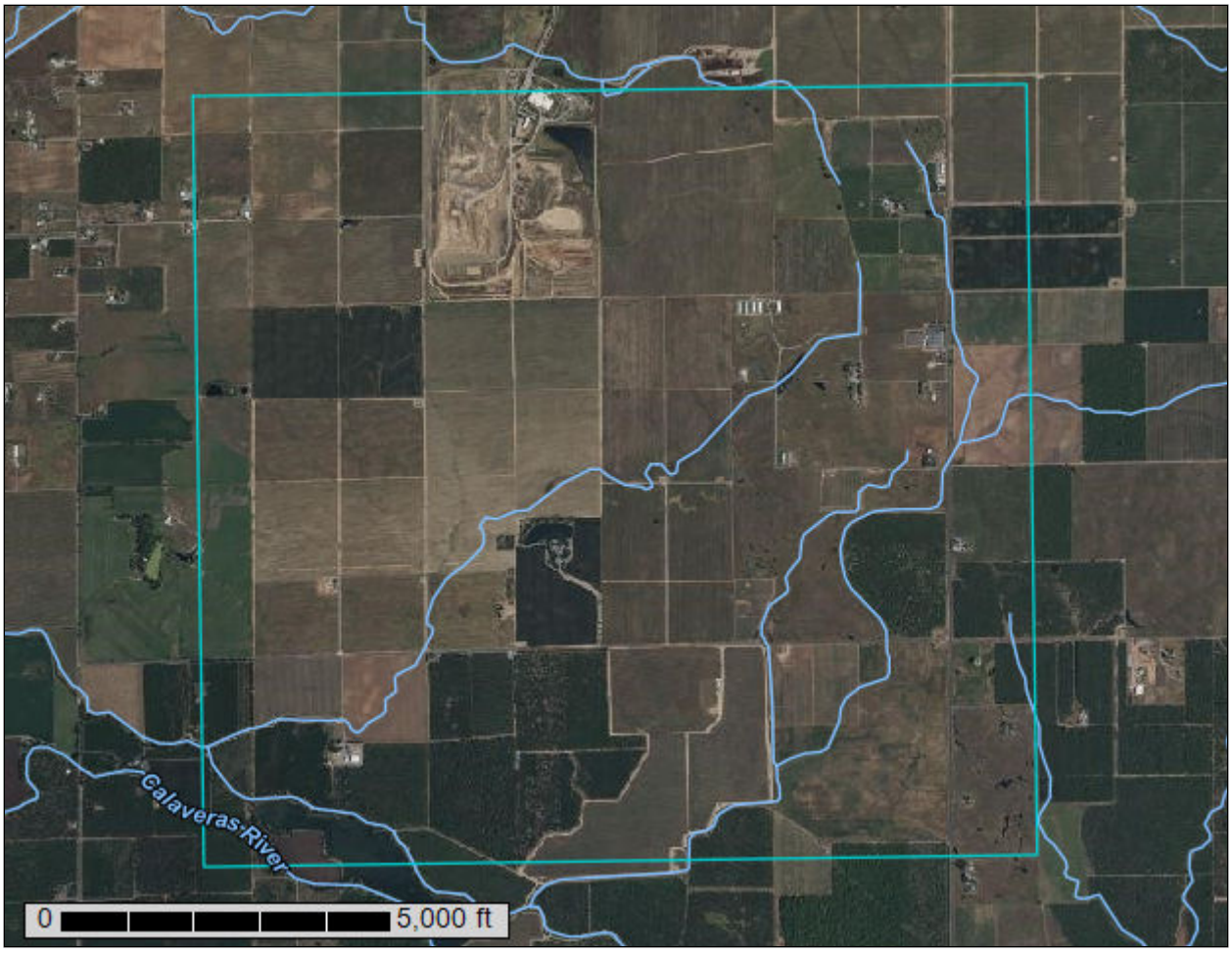
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for San Joaquin County, California



April 16, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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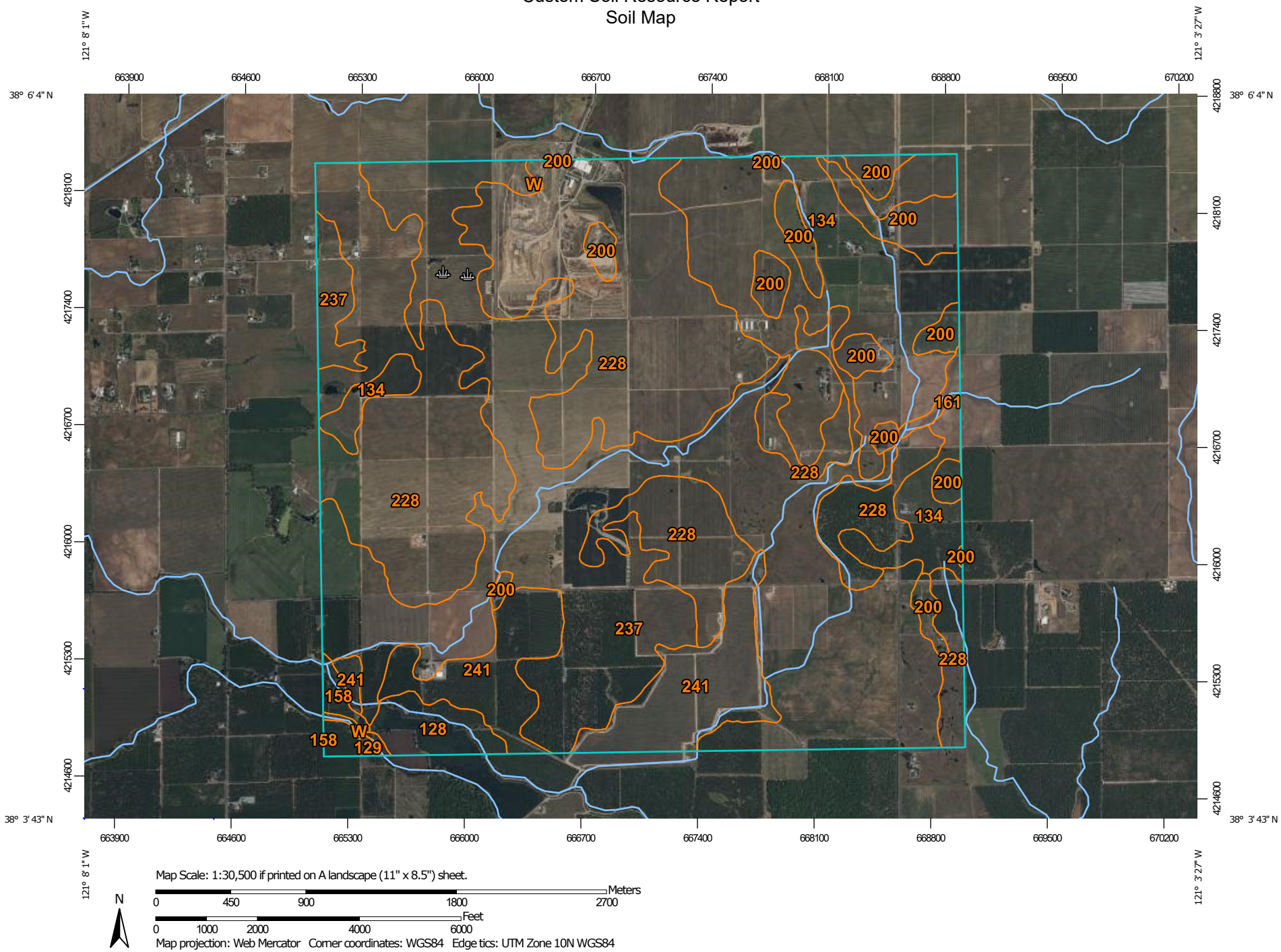
Contents

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:30,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	260.8	7.7%
W	Water	5.3	0.2%
Totals for Area of Interest		**3,389.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different

management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

San Joaquin County, California

128—Cogna loam, 0 to 2 percent slopes, overwash

Map Unit Setting

National map unit symbol: 2x8lf
Elevation: 100 to 210 feet
Mean annual precipitation: 18 to 19 inches
Mean annual air temperature: 63 degrees F
Frost-free period: 325 to 350 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Cogna and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cogna

Setting

Landform: Terraces, alluvial fans
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

A - 0 to 25 inches: loam
Bk - 25 to 38 inches: clay loam
C - 38 to 64 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 3c
Hydrologic Soil Group: B
Ecological site: R017XY905CA - Dry Alluvial Fans and Terraces
Hydric soil rating: No

Minor Components

Archerdale, clay loam

Percent of map unit: 6 percent
Landform: Stream terraces

Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Nord, loam

Percent of map unit: 4 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Veritas, fine sandy loam

Percent of map unit: 3 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Honcut, sandy loam

Percent of map unit: 1 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Columbia, occasionally flooded

Percent of map unit: 1 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

129—Cogna loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: hhrx
Elevation: 70 to 150 feet
Mean annual precipitation: 15 to 17 inches
Mean annual air temperature: 61 to 63 degrees F
Frost-free period: 230 to 250 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Cogna, loam, and similar soils: 85 percent
Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cogna, Loam

Setting

Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

A - 0 to 25 inches: loam
Bk - 25 to 38 inches: clay loam
C - 38 to 64 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: B
Ecological site: R017XY904CA - Subirrigated Deep Alluvial Fans
Hydric soil rating: No

Minor Components

Archerdale

Percent of map unit: 6 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R017XY904CA - Subirrigated Deep Alluvial Fans
Hydric soil rating: No

Nord

Percent of map unit: 4 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R017XY904CA - Subirrigated Deep Alluvial Fans
Hydric soil rating: No

Veritas

Percent of map unit: 3 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R017XY904CA - Subirrigated Deep Alluvial Fans
Hydric soil rating: No

Honcut

Percent of map unit: 1 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R017XY904CA - Subirrigated Deep Alluvial Fans
Hydric soil rating: No

Columbia

Percent of map unit: 1 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R017XY904CA - Subirrigated Deep Alluvial Fans
Hydric soil rating: Yes

134—Cometa sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: hhs2
Elevation: 100 to 300 feet
Mean annual precipitation: 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Cometa and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cometa

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Alluvium derived from granitic rock

Typical profile

A - 0 to 22 inches: sandy loam
Bt - 22 to 36 inches: sandy clay
Btq - 36 to 60 inches: stratified sandy loam to sandy clay loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 22 inches to abrupt textural change; 36 inches to densic material
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R017XE106CA - LOAMY TERRACE
Hydric soil rating: No

Minor Components

Montpellier

Percent of map unit: 5 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Redding

Percent of map unit: 3 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

San joaquin

Percent of map unit: 3 percent
Landform: Eroded fan remnants, depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Rocklin

Percent of map unit: 2 percent

Landform: Eroded fan remnants
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, on gentler slopes
Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

158—Finrod clay loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: hhsv
Elevation: 40 to 120 feet
Mean annual precipitation: 14 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 270 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Finrod and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Finrod

Setting
Landform: Alluvial fans, stream terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed rock sources

Typical profile
Ap - 0 to 8 inches: clay loam
Bw - 8 to 33 inches: clay
Bw - 33 to 48 inches: clay
Bkqm - 48 to 60 inches: cemented

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: 40 to 60 inches to duripan
Drainage class: Moderately well drained

Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: C
Ecological site: R017XY902CA - Duripan Vernal Pools
Hydric soil rating: No

Minor Components

Cogna

Percent of map unit: 4 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Archerdale

Percent of map unit: 4 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Hollenbeck

Percent of map unit: 4 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Vignolo

Percent of map unit: 3 percent
Landform: Fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

161—Galt clay, 0 to 4 percent slopes, MLRA 17

Map Unit Setting

National map unit symbol: 2w8ck
Elevation: 10 to 140 feet
Mean annual precipitation: 18 to 21 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 323 to 326 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Galt and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Galt

Setting

Landform: Basin floors on fan remnants
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium derived from igneous, metamorphic and sedimentary rock over cemented alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

A - 0 to 5 inches: clay
Bss1 - 5 to 13 inches: clay
Bss2 - 13 to 22 inches: clay
Bss3 - 22 to 32 inches: clay
2Bkqm - 32 to 60 inches: cemented material

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: 20 to 40 inches to duripan
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr)
Depth to water table: About 5 to 32 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline (0.2 to 0.5 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water supply, 0 to 60 inches: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: R017XD001CA - CLAYEY
Hydric soil rating: Yes

Minor Components

Clear lake

Percent of map unit: 10 percent
Landform: Basin floors
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

San joaquin

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

200—Montpellier-Cometa complex, 5 to 8 percent slopes

Map Unit Setting

National map unit symbol: hhv6
Elevation: 120 to 300 feet
Mean annual precipitation: 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 260 to 275 days
Farmland classification: Not prime farmland

Map Unit Composition

Montpellier and similar soils: 50 percent
Cometa and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Montpellier

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Alluvium derived from granitic rock sources

Typical profile

A - 0 to 20 inches: coarse sandy loam
Bt - 20 to 43 inches: sandy clay loam
Bt - 43 to 55 inches: coarse sandy loam
Btq - 55 to 60 inches: sandy loam

Properties and qualities

Slope: 5 to 8 percent
Depth to restrictive feature: 40 to 60 inches to cemented horizon
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R017XE106CA - LOAMY TERRACE
Hydric soil rating: No

Description of Cometa

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Alluvium derived from granitic rock

Typical profile

A - 0 to 22 inches: sandy loam
Bt - 22 to 36 inches: sandy clay
Btq - 36 to 60 inches: stratified sandy loam to sandy clay loam

Properties and qualities

Slope: 5 to 8 percent
Depth to restrictive feature: 22 inches to abrupt textural change; 36 inches to densic material
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C
Ecological site: R017XE106CA - LOAMY TERRACE
Hydric soil rating: No

Minor Components

San joaquin
Percent of map unit: 3 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Kaseberg
Percent of map unit: 3 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Hydric soil rating: No

Ramoth
Percent of map unit: 3 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Rocklin
Percent of map unit: 3 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Redding
Percent of map unit: 3 percent
Landform: Fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

228—Rocklin sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: hhw3
Elevation: 80 to 200 feet
Mean annual precipitation: 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 275 days
Farmland classification: Not prime farmland

Map Unit Composition

Rocklin and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rocklin

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Alluvium derived from granitic rock sources

Typical profile

A - 0 to 25 inches: sandy loam
Bt - 25 to 36 inches: loam
Bqm - 36 to 40 inches: indurated
BCq - 40 to 60 inches: stratified coarse sandy loam to fine sandy loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: 20 to 40 inches to duripan
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R017XE104CA - LOAMY CLAYPAN
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 3 percent
Landform: Drainageways on eroded fan remnants
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear

Cometa

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Montpellier

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Redding

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

San joaquin

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, mod coarse tex w/ hardpan

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, steeper slopes

Percent of map unit: 1 percent
Landform: Eroded fan remnants

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, on gentler slopes

Percent of map unit: 1 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

237—San Joaquin sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: hhwd
Elevation: 20 to 150 feet
Mean annual precipitation: 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 275 days
Farmland classification: Not prime farmland

Map Unit Composition

San joaquin and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of San Joaquin

Setting

Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granitic rock sources

Typical profile

Ap - 0 to 10 inches: sandy loam
2Bt - 10 to 20 inches: clay
2Bqm - 20 to 60 inches: indurated

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches; 20 to 40 inches to duripan
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: R017XE104CA - LOAMY CLAYPAN
Hydric soil rating: No

Minor Components

Bruella

Percent of map unit: 3 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, ponded

Percent of map unit: 2 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

San joaquin

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Jahant

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Rocklin

Percent of map unit: 2 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, med textured with hardpan

Percent of map unit: 1 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Redding

Percent of map unit: 1 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, on gentler slopes

Percent of map unit: 1 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, steeper slopes

Percent of map unit: 1 percent
Landform: Eroded fan remnants
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

241—San Joaquin complex, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: hhwj
Elevation: 20 to 110 feet
Mean annual precipitation: 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 275 days
Farmland classification: Not prime farmland

Map Unit Composition

San joaquin and similar soils: 45 percent
San joaquin, thick surface, and similar soils: 40 percent
Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of San Joaquin

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granitic rock sources

Typical profile

Ap - 0 to 16 inches: loam
2Bt - 16 to 26 inches: clay
2Bqm - 26 to 60 inches: indurated

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches; 20 to 40 inches to duripan
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: D
Ecological site: R017XY902CA - Duripan Vernal Pools
Hydric soil rating: No

Description of San Joaquin, Thick Surface

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granitic rock sources

Typical profile

Ap - 0 to 12 inches: loam
Bt - 12 to 26 inches: sandy clay loam
2Bt - 26 to 35 inches: clay
2Bqm - 35 to 60 inches: indurated

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches; 20 to 40 inches to duripan
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: C
Ecological site: R017XY902CA - Duripan Vernal Pools
Hydric soil rating: No

Minor Components

Rocklin

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Exeter

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, ponded

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Unnamed, mod coarse textured with hardpan

Percent of map unit: 1 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, altered soils

Percent of map unit: 1 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

W—Water

Map Unit Composition

Water: 100 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Physical Properties

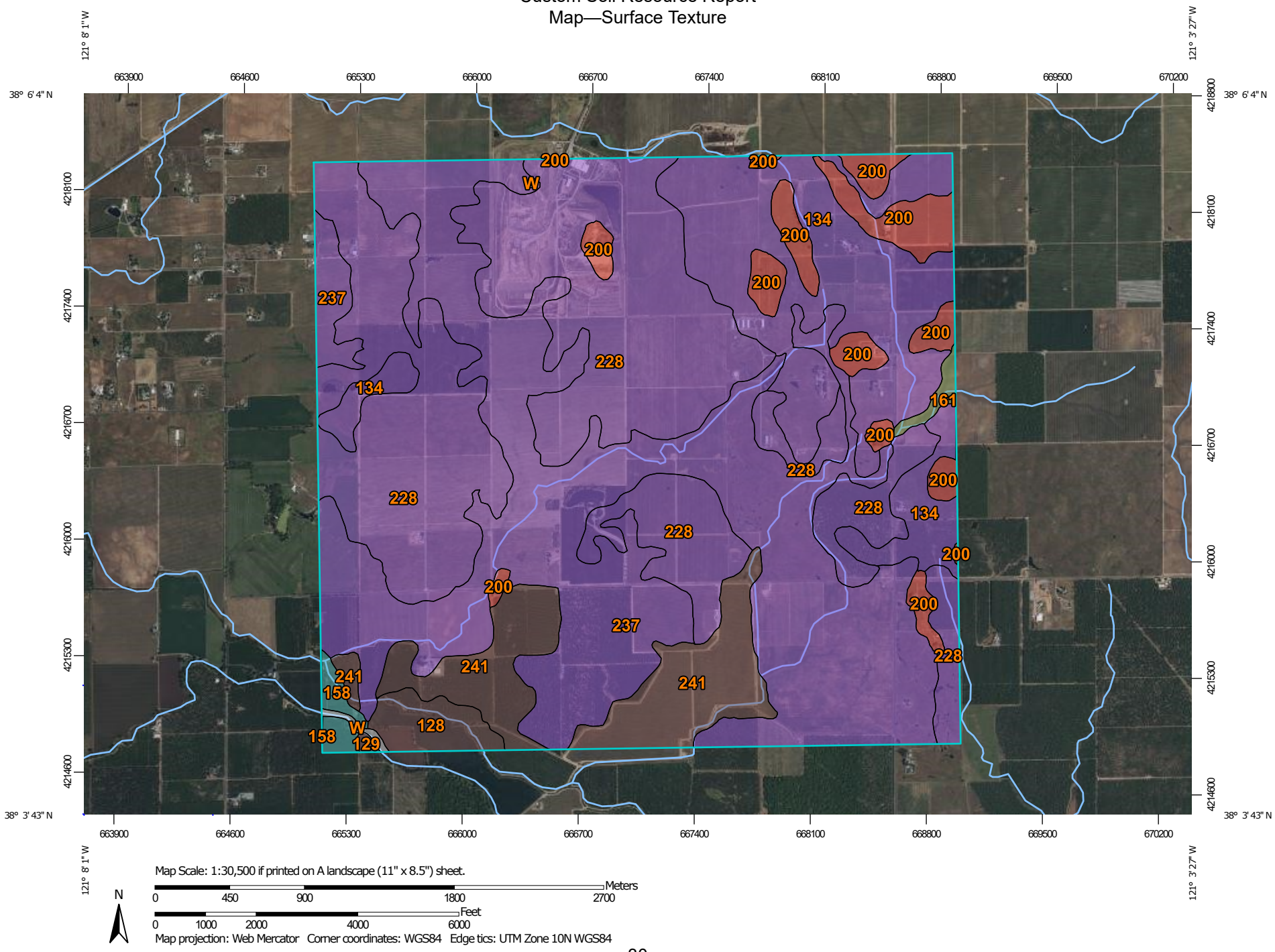
Soil Physical Properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Surface Texture

This displays the representative texture class and modifier of the surface horizon.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Custom Soil Resource Report
Map—Surface Texture



Map Scale: 1:30,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Clay
- Clay loam
- Coarse sandy loam
- Loam
- Sandy loam
- Not rated or not available

Soil Rating Lines
- Clay
- Clay loam
- Coarse sandy loam
- Loam
- Sandy loam
- Not rated or not available

Soil Rating Points
- Clay
- Clay loam
- Coarse sandy loam
- Loam
- Sandy loam
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Surface Texture

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	Loam	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	Loam	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	Sandy loam	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	Clay loam	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	Clay	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	Coarse sandy loam	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	Sandy loam	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	Sandy loam	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	Loam	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Surface Texture

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Saturated Hydraulic Conductivity (Ksat) (Zero (0) to Twelve (12) Inches)

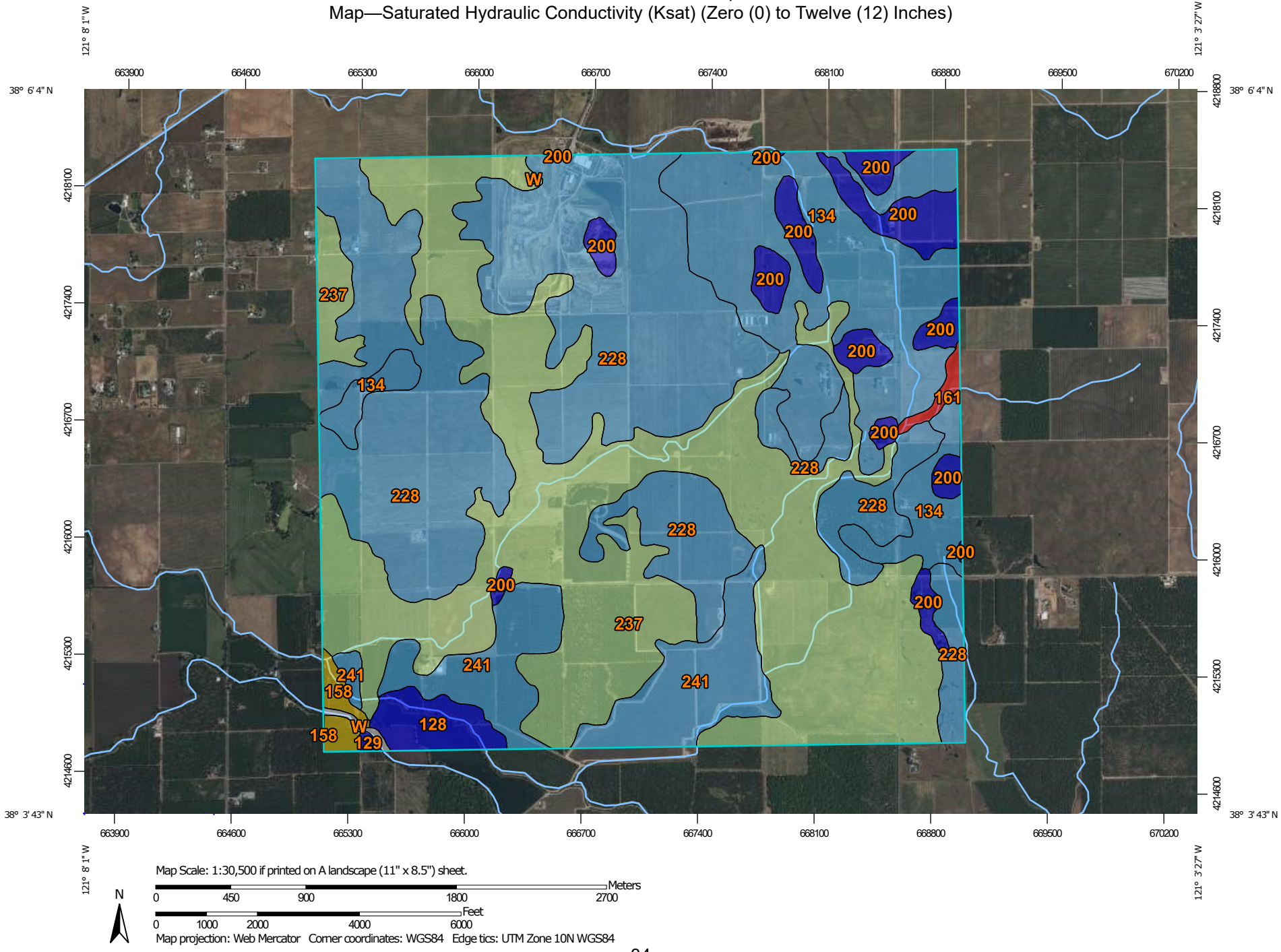
Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity is considered in the design of soil drainage systems and septic tank absorption fields.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this

attribute for the component. For this soil property, only the representative value is used.

The numeric Ksat values have been grouped according to standard Ksat class limits.

Map—Saturated Hydraulic Conductivity (Ksat) (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 1.3477
- > 1.3477 and <= 2.1033
- > 2.1033 and <= 7.5358
- > 7.5358 and <= 9.0000
- > 9.0000 and <= 28.0000
- Not rated or not available

Soil Rating Lines
- <= 1.3477
- > 1.3477 and <= 2.1033
- > 2.1033 and <= 7.5358
- > 7.5358 and <= 9.0000
- > 9.0000 and <= 28.0000
- Not rated or not available

Soil Rating Points
- <= 1.3477
- > 1.3477 and <= 2.1033
- > 2.1033 and <= 7.5358
- > 7.5358 and <= 9.0000
- > 9.0000 and <= 28.0000
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Saturated Hydraulic Conductivity (Ksat) (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	28.0000	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	28.0000	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	9.0000	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	2.1033	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	1.3477	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	28.0000	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	9.0000	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	7.5358	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	9.0000	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Saturated Hydraulic Conductivity (Ksat) (Zero (0) to Twelve (12) Inches)

Units of Measure: micrometers per second

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Fastest

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Inches

Plasticity Index (Zero (0) to Twelve (12) Inches)

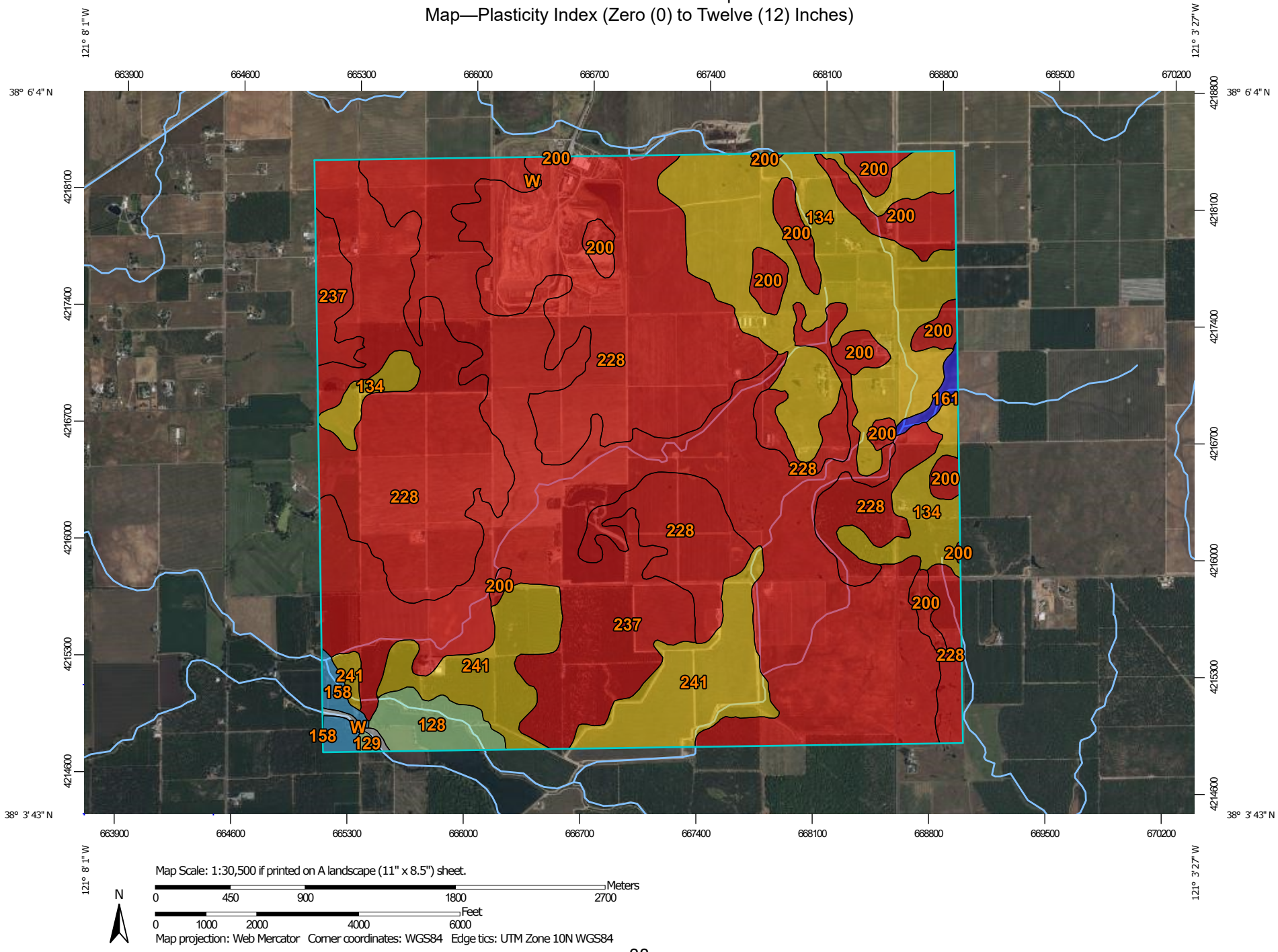
Plasticity index (PI) is one of the standard Atterberg limits used to indicate the plasticity characteristics of a soil. It is defined as the numerical difference between the liquid limit and plastic limit of the soil. It is the range of water content in which a soil exhibits the characteristics of a plastic solid.

The plastic limit is the water content that corresponds to an arbitrary limit between the plastic and semisolid states of a soil. The liquid limit is the water content, on a percent by weight basis, of the soil (passing #40 sieve) at which the soil changes from a plastic to a liquid state.

Soils that have a high plasticity index have a wide range of moisture content in which the soil performs as a plastic material. Highly and moderately plastic clays have large PI values. Plasticity index is used in classifying soils in the Unified and AASHTO classification systems.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Plasticity Index (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 2.5
- > 2.5 and <= 5.0
- > 5.0 and <= 8.0
- > 8.0 and <= 20.0
- > 20.0 and <= 30.0
- Not rated or not available

Soil Rating Lines
- <= 2.5
- > 2.5 and <= 5.0
- > 5.0 and <= 8.0
- > 8.0 and <= 20.0
- > 20.0 and <= 30.0
- Not rated or not available

Soil Rating Points
- <= 2.5
- > 2.5 and <= 5.0
- > 5.0 and <= 8.0
- > 8.0 and <= 20.0
- > 20.0 and <= 30.0
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Plasticity Index (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	8.0	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	8.0	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	5.0	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	20.0	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	30.0	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	2.5	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	2.5	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	2.5	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	5.0	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Plasticity Index (Zero (0) to Twelve (12) Inches)

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Centimeters

Percent Silt (Zero (0) to Twelve (12) Inches)

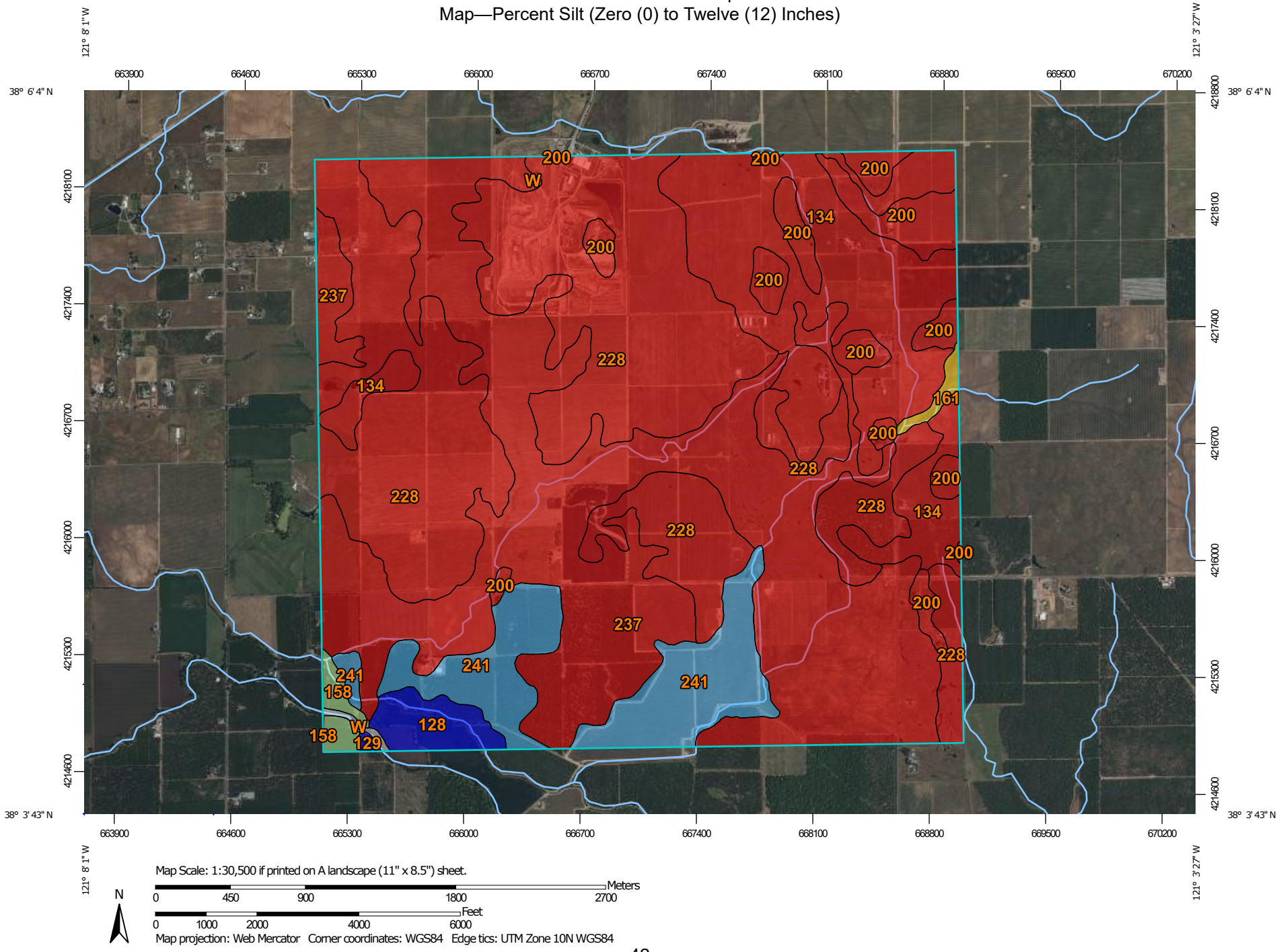
Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In the database, the estimated silt content of each soil layer

is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Percent Silt (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 19.1
- > 19.1 and <= 30.0
- > 30.0 and <= 31.7
- > 31.7 and <= 37.9
- > 37.9 and <= 42.0
- Not rated or not available

Soil Rating Lines

- <= 19.1
- > 19.1 and <= 30.0
- > 30.0 and <= 31.7
- > 31.7 and <= 37.9
- > 37.9 and <= 42.0
- Not rated or not available

Soil Rating Points

- <= 19.1
- > 19.1 and <= 30.0
- > 30.0 and <= 31.7
- > 31.7 and <= 37.9
- > 37.9 and <= 42.0
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Percent Silt (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	42.0	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	42.0	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	19.1	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	31.7	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	30.0	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	18.9	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	19.1	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	19.1	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	37.9	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Percent Silt (Zero (0) to Twelve (12) Inches)

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Centimeters

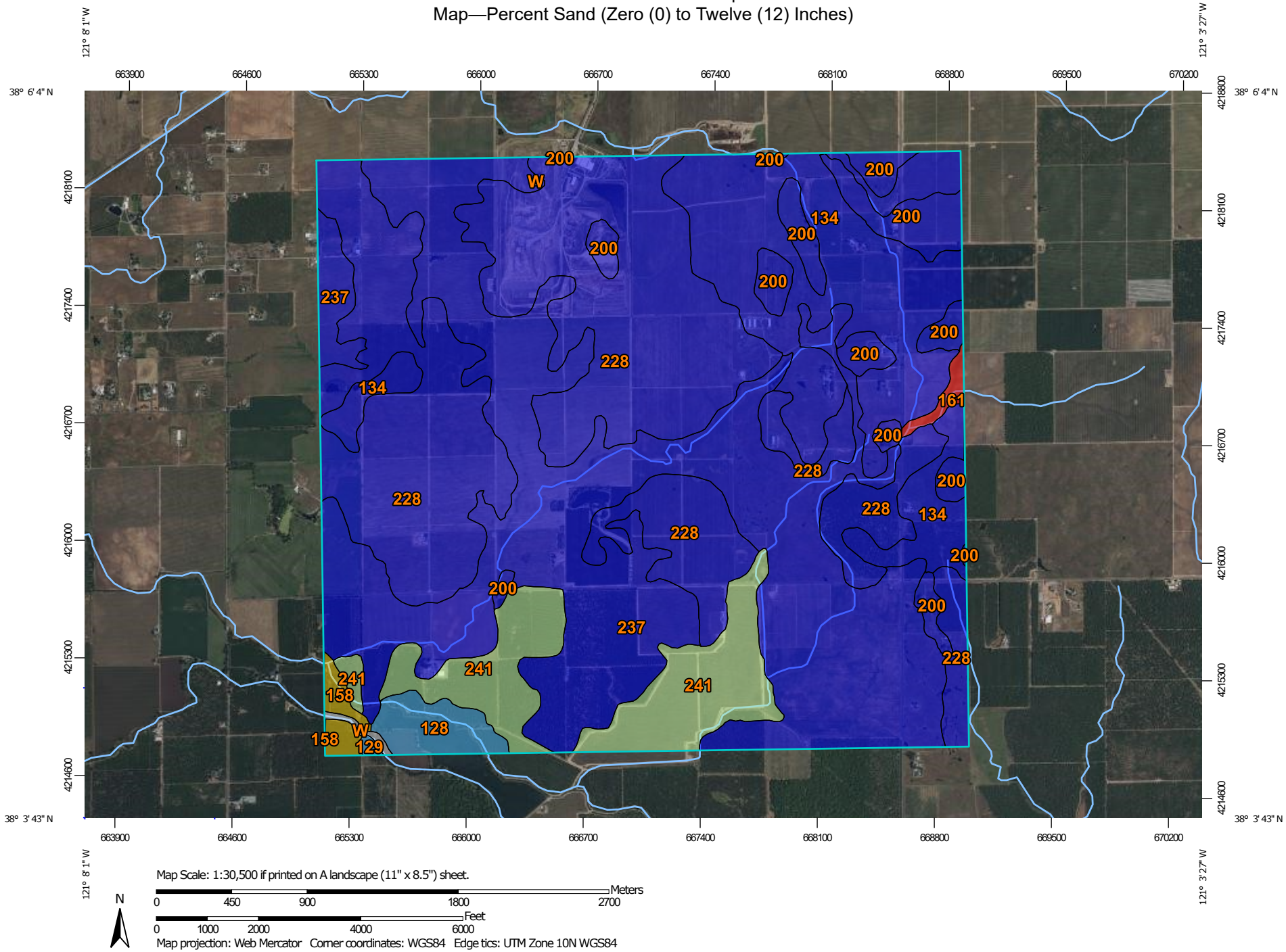
Percent Sand (Zero (0) to Twelve (12) Inches)

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In the database, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2

millimeters in diameter. The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Percent Sand (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 30.0
- > 30.0 and <= 33.3
- > 33.3 and <= 42.1
- > 42.1 and <= 45.0
- > 45.0 and <= 67.1
- Not rated or not available

Soil Rating Lines

- <= 30.0
- > 30.0 and <= 33.3
- > 33.3 and <= 42.1
- > 42.1 and <= 45.0
- > 45.0 and <= 67.1
- Not rated or not available

Soil Rating Points

- <= 30.0
- > 30.0 and <= 33.3
- > 33.3 and <= 42.1
- > 42.1 and <= 45.0
- > 45.0 and <= 67.1
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Percent Sand (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	45.0	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	45.0	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	65.9	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	33.3	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	30.0	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	67.1	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	65.9	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	65.9	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	42.1	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Percent Sand (Zero (0) to Twelve (12) Inches)

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Centimeters

Percent Clay (Zero (0) to Twelve (12) Inches)

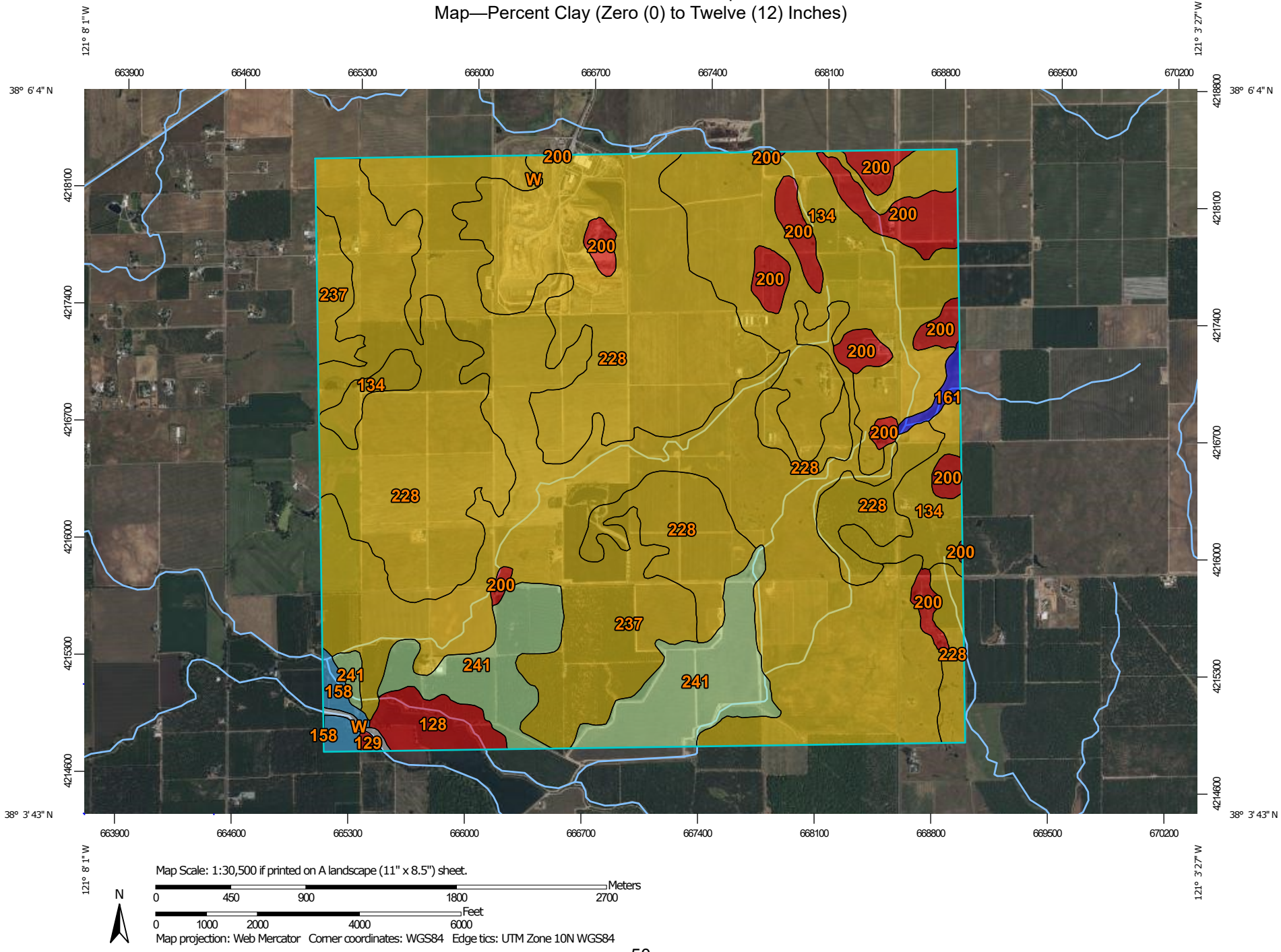
Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. The estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Most of the material is in one of three groups of clay minerals or a mixture of these clay minerals. The groups are kaolinite, smectite, and hydrous mica, the best known member of which is illite.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Percent Clay (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 14.0
- > 14.0 and <= 15.0
- > 15.0 and <= 20.0
- > 20.0 and <= 35.0
- > 35.0 and <= 40.0
- Not rated or not available

Soil Rating Lines

- <= 14.0
- > 14.0 and <= 15.0
- > 15.0 and <= 20.0
- > 20.0 and <= 35.0
- > 35.0 and <= 40.0
- Not rated or not available

Soil Rating Points

- <= 14.0
- > 14.0 and <= 15.0
- > 15.0 and <= 20.0
- > 20.0 and <= 35.0
- > 35.0 and <= 40.0
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Percent Clay (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	13.0	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	13.0	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	15.0	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	35.0	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	40.0	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	14.0	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	15.0	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	15.0	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	20.0	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Percent Clay (Zero (0) to Twelve (12) Inches)

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Centimeters

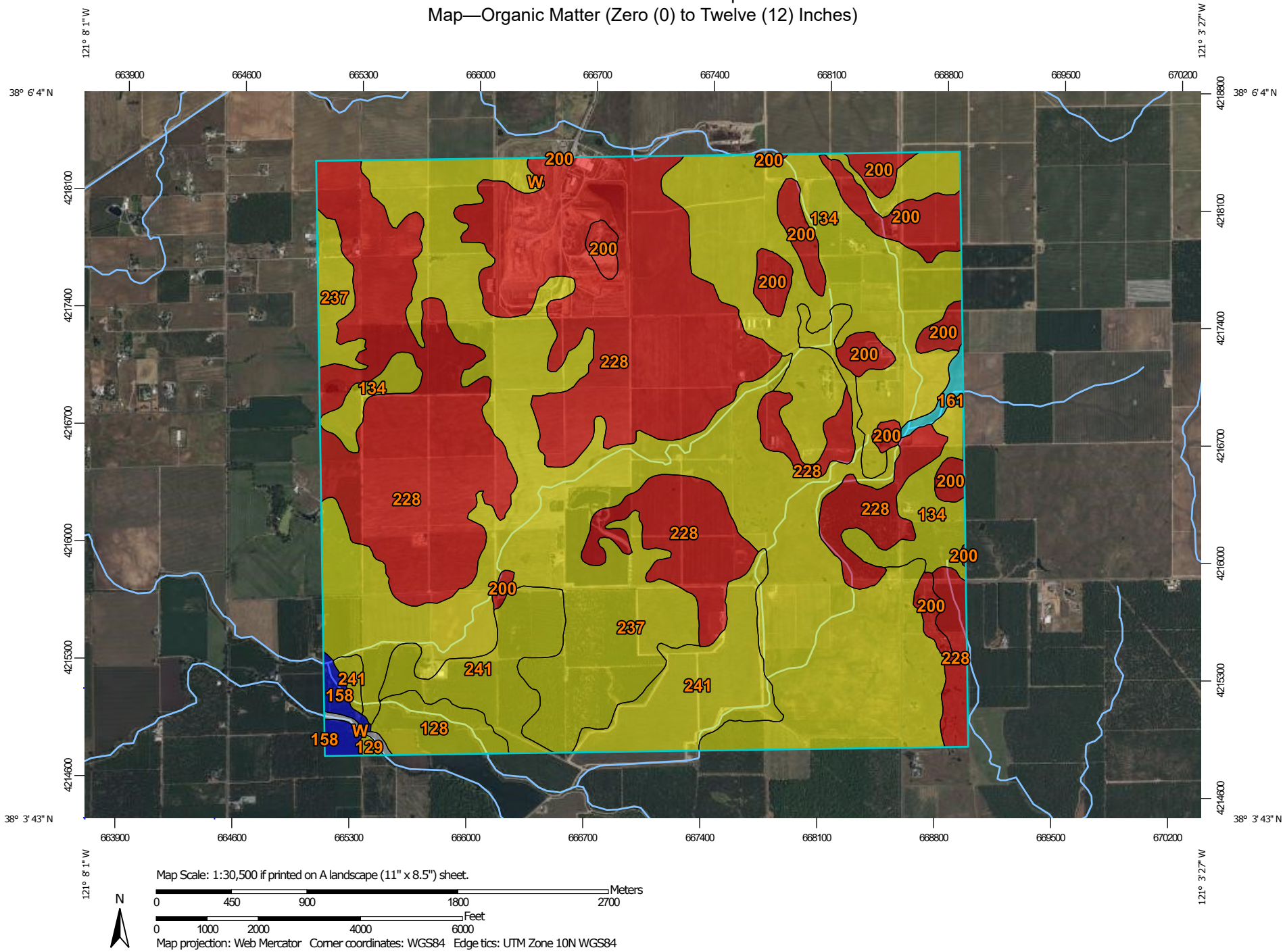
Organic Matter (Zero (0) to Twelve (12) Inches)

Organic matter is the plant and animal residue in the soil at various stages of decomposition. The estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained by returning crop residue to the soil. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms. An irregular distribution of organic carbon with depth may indicate different episodes of soil deposition or soil formation. Soils that are very high in organic matter have poor engineering properties and subside upon drying.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Organic Matter (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 0.50
- > 0.50 and <= 0.75
- > 0.75 and <= 1.60
- > 1.60 and <= 2.00
- Not rated or not available

Soil Rating Lines
- <= 0.50
- > 0.50 and <= 0.75
- > 0.75 and <= 1.60
- > 1.60 and <= 2.00
- Not rated or not available

Soil Rating Points
- <= 0.50
- > 0.50 and <= 0.75
- > 0.75 and <= 1.60
- > 1.60 and <= 2.00
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Organic Matter (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	0.75	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	0.75	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	0.75	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	2.00	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	1.60	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	0.50	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	0.50	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	0.75	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	0.75	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Organic Matter (Zero (0) to Twelve (12) Inches)

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Centimeters

Liquid Limit (Zero (0) to Twelve (12) Inches)

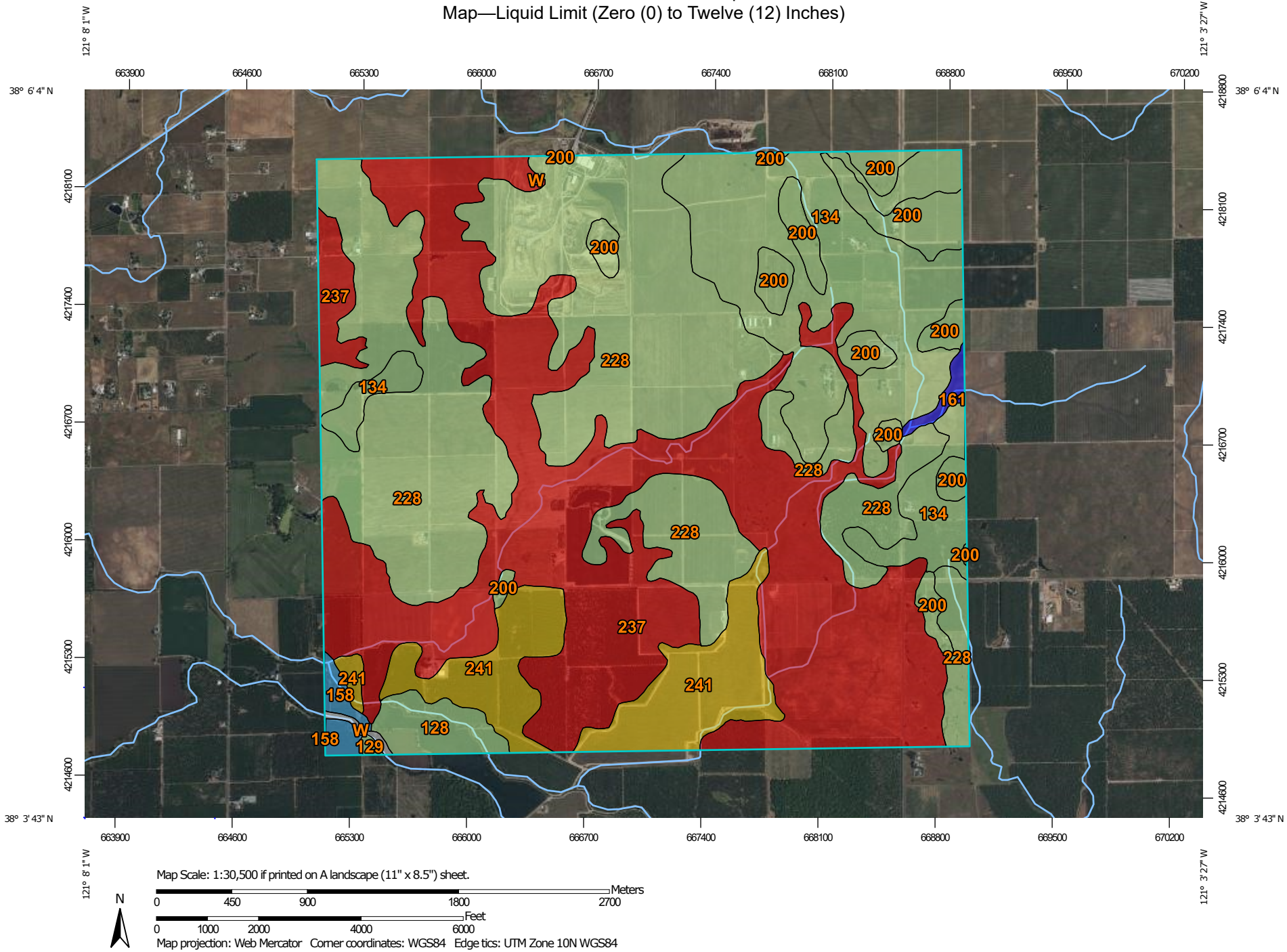
Liquid limit (LL) is one of the standard Atterberg limits used to indicate the plasticity characteristics of a soil. It is the water content, on a percent by weight basis, of the soil (passing #40 sieve) at which the soil changes from a plastic to a liquid state.

Generally, the amount of clay- and silt-size particles, the organic matter content, and the type of minerals determine the liquid limit. Soils that have a high liquid limit have the capacity to hold a lot of water while maintaining a plastic or semisolid state.

Liquid limit is used in classifying soils in the Unified and AASHTO classification systems.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Liquid Limit (Zero (0) to Twelve (12) Inches)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- <= 20.0
- > 20.0 and <= 22.5
- > 22.5 and <= 25.0
- > 25.0 and <= 42.5
- > 42.5 and <= 54.0
- Not rated or not available

Soil Rating Lines
- <= 20.0
- > 20.0 and <= 22.5
- > 22.5 and <= 25.0
- > 25.0 and <= 42.5
- > 42.5 and <= 54.0
- Not rated or not available

Soil Rating Points
- <= 20.0
- > 20.0 and <= 22.5
- > 22.5 and <= 25.0
- > 25.0 and <= 42.5
- > 42.5 and <= 54.0
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Liquid Limit (Zero (0) to Twelve (12) Inches)

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	25.0	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	25.0	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	25.0	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	42.5	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	54.0	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	25.0	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	25.0	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	20.0	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	22.5	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Liquid Limit (Zero (0) to Twelve (12) Inches)

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 12

Units of Measure: Centimeters

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil

features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

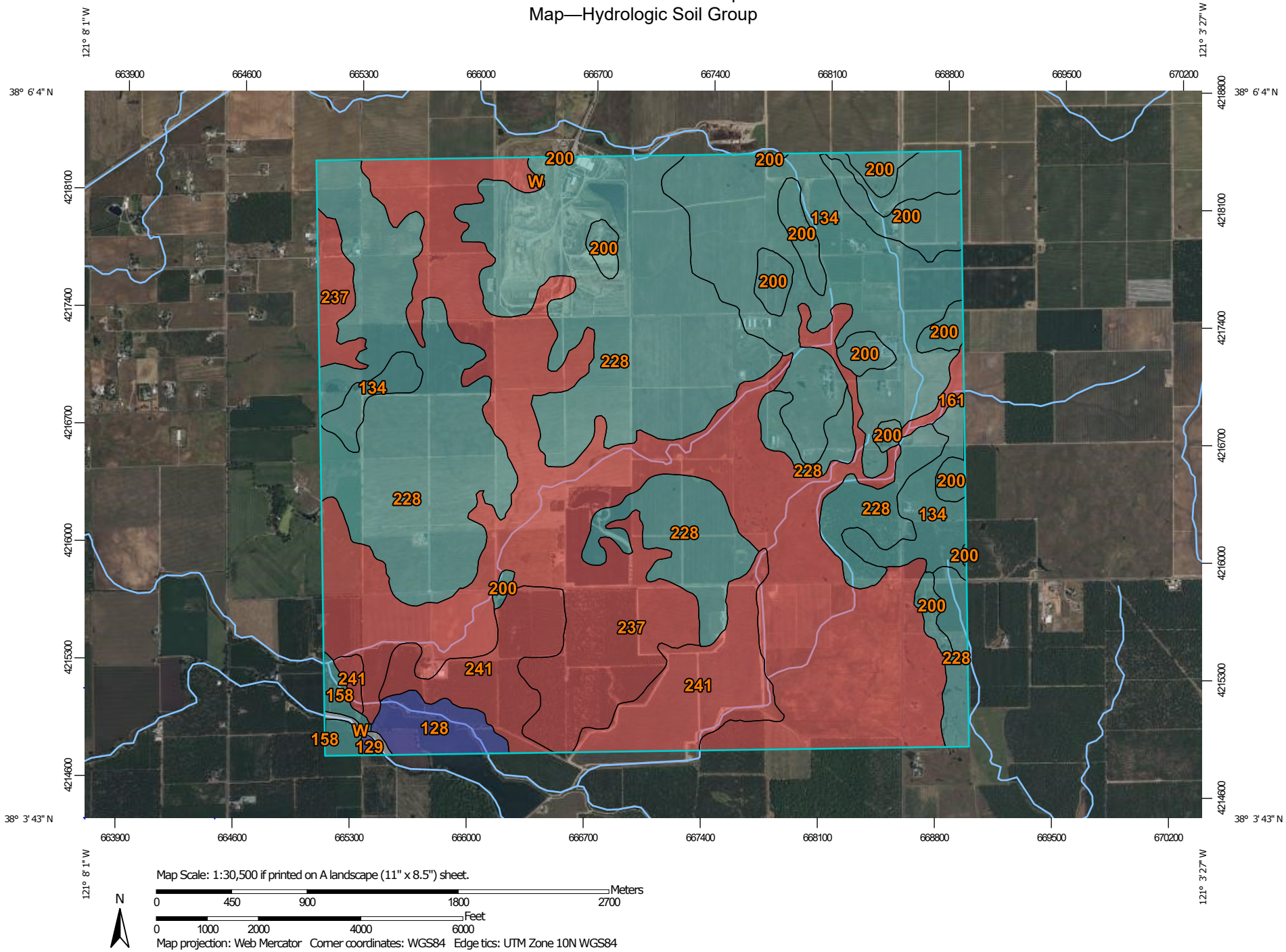
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Custom Soil Resource Report
Map—Hydrologic Soil Group



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	B	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	B	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	C	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	C	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	D	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	C	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	C	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	D	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	D	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the

sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

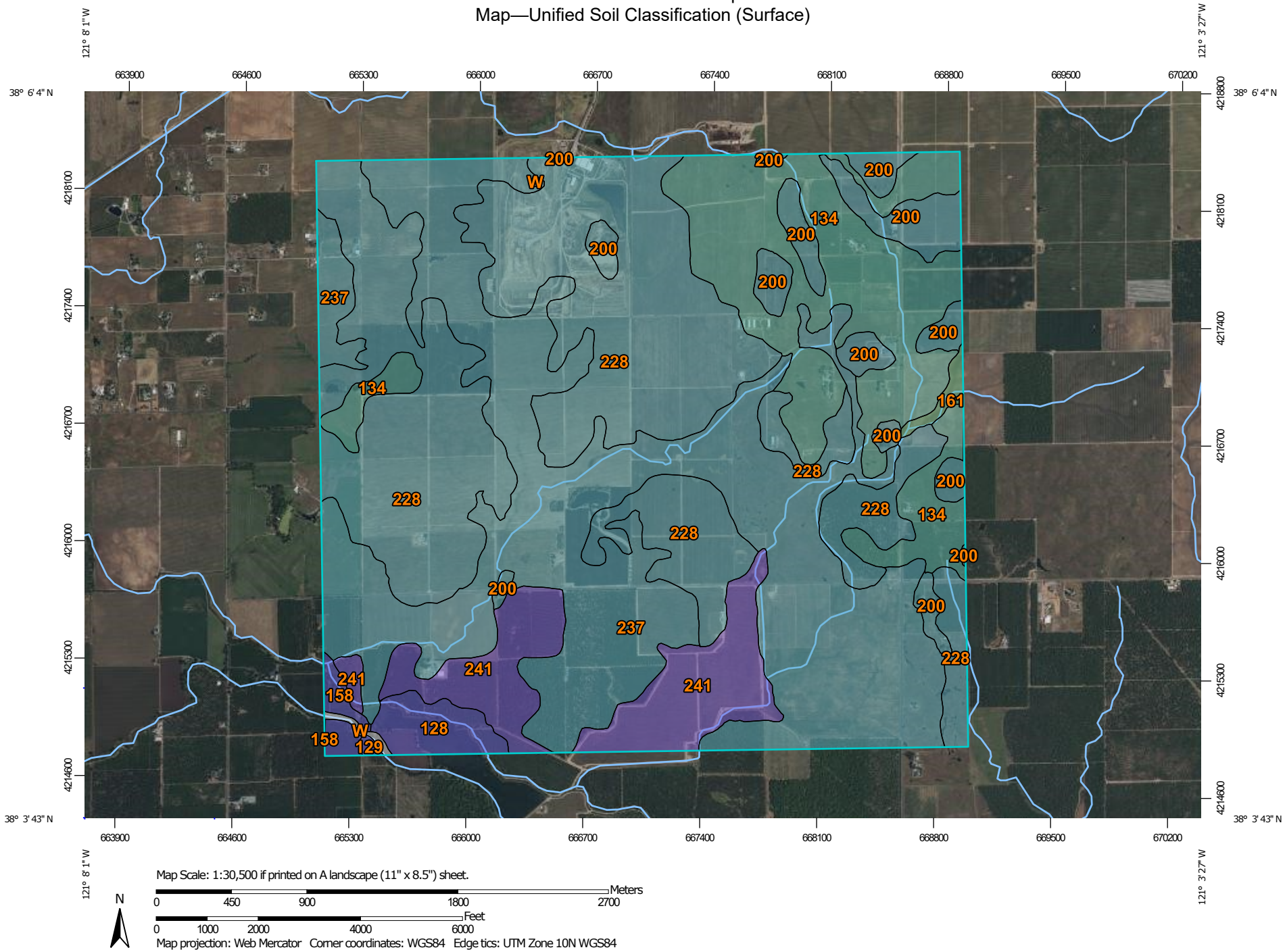
Unified Soil Classification (Surface)

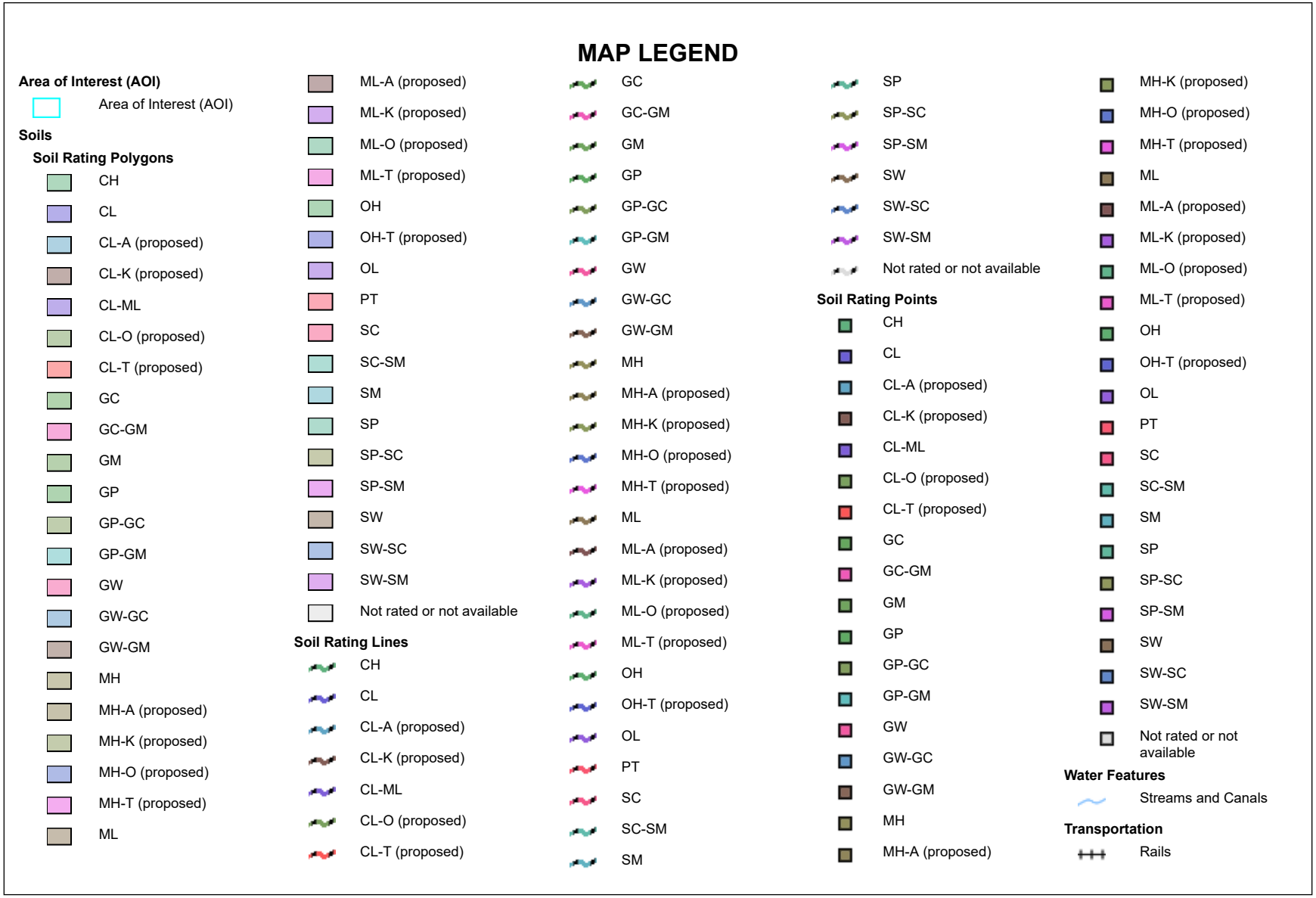
The Unified soil classification system classifies mineral and organic mineral soils for engineering purposes on the basis of particle-size characteristics, liquid limit, and plasticity index. It identifies three major soil divisions: (i) coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074 mm in diameter; (ii) fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter; and (iii) highly organic soils that demonstrate certain organic characteristics. These divisions are further subdivided into a total of 15 basic soil groups. The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM D 2487 shows the criteria chart used for classifying soil in the Unified system and the 15 basic soil groups of the system and the plasticity chart for the Unified system.

The various groupings of this classification correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can serve to make some general interpretations relating to probable performance of the soil for engineering uses.

For each soil horizon in the database one or more Unified soil classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

Custom Soil Resource Report
Map—Unified Soil Classification (Surface)




MAP LEGEND
Area of Interest (AOI)
Area of Interest (AOI)
Soils
Soil Rating Polygons
CH
CL
CL-A (proposed)
CL-K (proposed)
CL-ML
CL-O (proposed)
CL-T (proposed)
GC
GC-GM
GM
GP
GP-GC
GP-GM
GW
GW-GC
GW-GM
MH
MH-A (proposed)
MH-K (proposed)
MH-O (proposed)
MH-T (proposed)
ML
ML-A (proposed)
ML-K (proposed)
ML-O (proposed)
ML-T (proposed)
OH
OH-T (proposed)
OL
PT
SC
SC-SM
SM
SP
SP-SC
SP-SM
SW
SW-SC
SW-SM
Not rated or not available
Soil Rating Lines
CH
CL
CL-A (proposed)
CL-K (proposed)
CL-ML
CL-O (proposed)
CL-T (proposed)
GC
GC-GM
GM
GP
GP-GC
GP-GM
GW
GW-GC
GW-GM
MH
MH-A (proposed)
MH-K (proposed)
MH-O (proposed)
MH-T (proposed)
ML
ML-A (proposed)
ML-K (proposed)
ML-O (proposed)
ML-T (proposed)
OH
OH-T (proposed)
OL
PT
SC
SC-SM
SM
SP
SP-SC
SP-SM
SW
SW-SC
SW-SM
Not rated or not available
Soil Rating Points
CH
CL
CL-A (proposed)
CL-K (proposed)
CL-ML
CL-O (proposed)
CL-T (proposed)
GC
GC-GM
GM
GP
GP-GC
GP-GM
GW
GW-GC
GW-GM
MH
MH-A (proposed)
MH-K (proposed)
MH-O (proposed)
MH-T (proposed)
ML
ML-A (proposed)
ML-K (proposed)
ML-O (proposed)
ML-T (proposed)
OH
OH-T (proposed)
OL
PT
SC
SC-SM
SM
SP
SP-SC
SP-SM
SW
SW-SC
SW-SM
Not rated or not available
Water Features
Streams and Canals
Transportation
Rails

MAP INFORMATION


Interstate Highways


US Routes

Major Roads

Local Roads

Background


Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Unified Soil Classification (Surface)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	CL	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	CL	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	SC-SM	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	CL	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	CH	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	SM	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	SM	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	SM	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	CL-ML	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—Unified Soil Classification (Surface)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

AASHTO Group Index

The AASHTO Group Index is a refinement to the seven major groups of the AASHTO soil classification system. According to

this system, soil is classified into seven major groups: A -l through A-7. Soils classified into groups A-1, A-2. and A-3 are granular materials of which 35% or less of the particles pass through the No. 200 sieve. Soils of which more than 35% pass through the No. 200 sieve are classified into groups A-4, A-5, A-6, and A-7. These soils are mostly silt and clay-type materials.

The classifications system is based on the following criteria:

1. Grain size

a. Gravel ; fraction passing the 75-mm(3-in.) sieve and retained on the No. 10 (2-mm) U.S. sieve

b. sand: fraction passing the No. 10 (2-mm) U.S. sieve and retained on the No.200 (0.075-mm) U.S. sieve

c. Silt and clay: fraction passing the No. 200 U.S. sieve

2. Plasticity The term silty is applied when the fine fractions of the soil have a plasticity index of 10 or less. The term clayey is applied when the fine fractions have a plasticity index of 11 or more.

3. If cobbles and boulders (size larger than 75 mm) are encountered, they are excluded from the portion of the soil sample from which classification is made.

To evaluate the quality of a soil as a highway subgrade material, one must also incorporate a number called the group index (GI) with the groups and subgroups of the soil. This index is written in parentheses after the group or subgroup designation.

The group index is given by the equation:

GI = (F200-35)[0.2+ 0.005(LL- 40)] + 0.01(.F200-15)(PI- 10)

where:

F200 = percentage passing through the No. 200 sieve

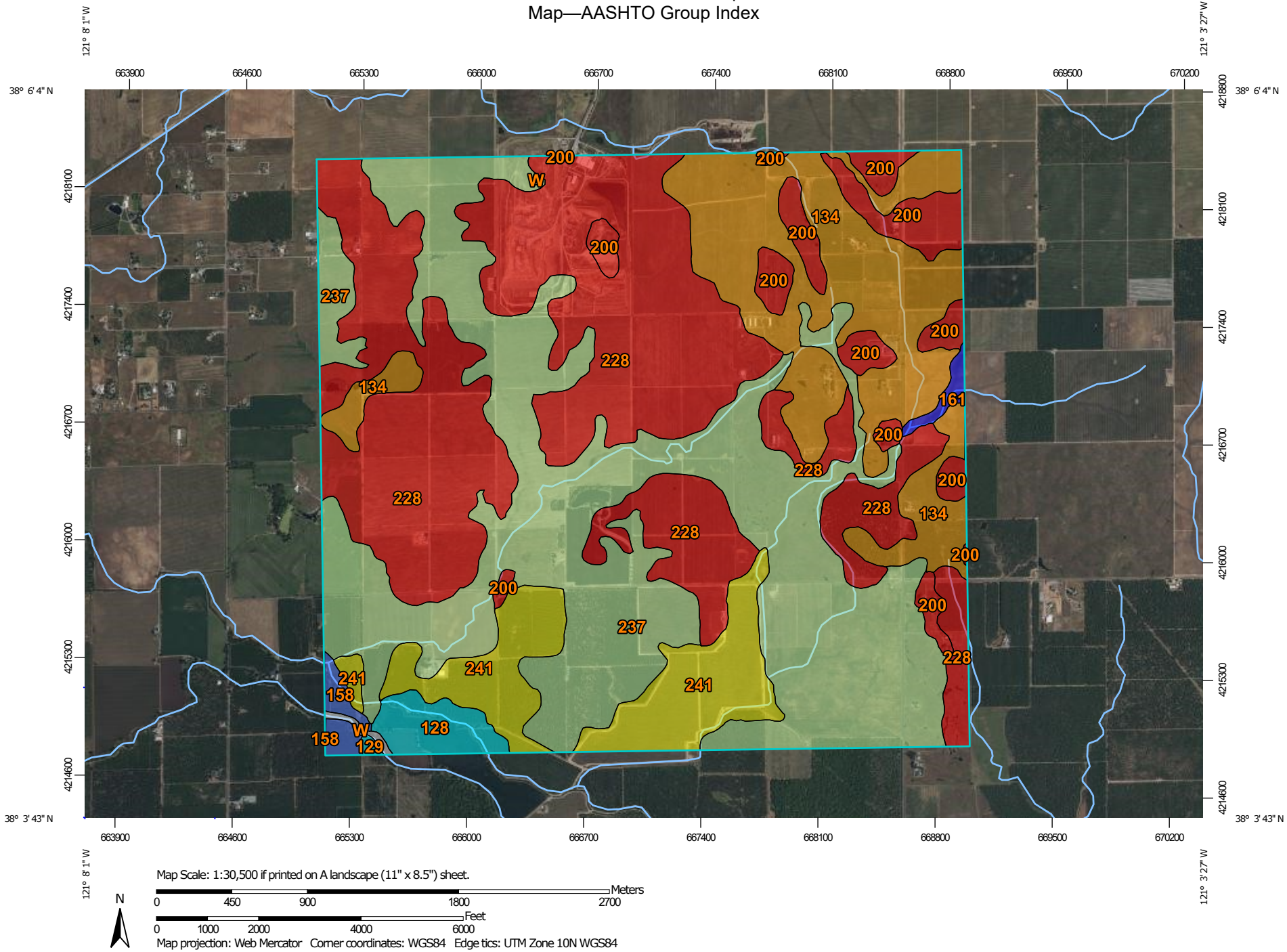
LL — liquid limit

PI : plasticity index

The group index is used typically to refine an AASHTO class but in the soil survey database is often used as a standalone soil attribute.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—AASHTO Group Index



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 1
- > 1 and <= 4
- > 4 and <= 6
- > 6 and <= 8
- > 8 and <= 9
- > 9 and <= 24
- > 24 and <= 28
- Not rated or not available

Soil Rating Lines

- <= 1
- > 1 and <= 4
- > 4 and <= 6
- > 6 and <= 8
- > 8 and <= 9
- > 9 and <= 24
- > 24 and <= 28
- Not rated or not available

Soil Rating Points

- <= 1
- > 1 and <= 4
- > 4 and <= 6
- > 6 and <= 8
- > 8 and <= 9
- > 9 and <= 24
- > 24 and <= 28
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Joaquin County, California
Survey Area Data: Version 17, Sep 11, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2022—Apr 24, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—AASHTO Group Index

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
128	Cogna loam, 0 to 2 percent slopes, overwash	9	54.2	1.6%
129	Cogna loam, 0 to 2 percent slopes	9	2.8	0.1%
134	Cometa sandy loam, 2 to 5 percent slopes	4	515.6	15.2%
158	Finrod clay loam, 0 to 2 percent slopes	24	22.6	0.7%
161	Galt clay, 0 to 4 percent slopes, MLRA 17	28	12.2	0.4%
200	Montpellier-Cometa complex, 5 to 8 percent slopes	1	179.1	5.3%
228	Rocklin sandy loam, 2 to 5 percent slopes	1	1,148.0	33.9%
237	San Joaquin sandy loam, 2 to 5 percent slopes	8	1,188.3	35.1%
241	San Joaquin complex, 0 to 1 percent slopes	6	260.8	7.7%
W	Water		5.3	0.2%
Totals for Area of Interest			**3,389.1**	**100.0%**

Rating Options—AASHTO Group Index

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): All Layers (Weighted Average)

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: “National Soil Survey Handbook.”

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology)

from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left

behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^{1}/_{3}$- or $^{1}/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth’s crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can

occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and

promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to $Ca^{++} + Mg^{++}$. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1
Moderate: 13-30:1
Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0
Coarse sand: 1.0 to 0.5
Medium sand: 0.5 to 0.25
Fine sand: 0.25 to 0.10
Very fine sand: 0.10 to 0.05
Silt: 0.05 to 0.002
Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated

Prismatic: Vertically elongated and having flat tops

Columnar: Vertically elongated and having rounded tops

Angular blocky: Having faces that intersect at sharp angles (planes)

Subangular blocky: Having subrounded and planar faces (no sharp angles)

Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand

Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field

generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth’s surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.

Appendix D - Hydrologic Model Summary Report

Project: Frazier_Rd_Bridge
Simulation Run: 1% Atlas 14 Event
Simulation Start: 7 November 2023, 24:00
Simulation End: 9 November 2023, 06:00

HMS Version: 4.11
Executed: 17 April 2024, 21:59

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	0.6
Subbasin - 3	0.48
Subbasin - 2	0.43

Downstream

Element Name	Downstream
Subbasin - 1	Junction - 1
Subbasin - 3	Junction - 1
Subbasin - 2	Junction - 1

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number	Initial Abstraction
Subbasin - 1	0	75	0.67
Subbasin - 3	0	77	0.6
Subbasin - 2	0	78	0.56

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	63	Standard
Subbasin - 3	51	Standard
Subbasin - 2	57	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	0.6	132.98	08Nov2023, 13:15	1.55
Subbasin - 3	0.48	131.6	08Nov2023, 13:00	1.69
Subbasin - 2	0.43	117.27	08Nov2023, 13:15	1.76
Junction - 1	1.5	375.3	08Nov2023, 13:15	1.65

Project: Frazier_Rd_Bridge
Simulation Run: 2% Atlas 14 Event
Simulation Start: 7 November 2023, 24:00
Simulation End: 9 November 2023, 06:00

HMS Version: 4.11
Executed: 17 April 2024, 21:59

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	0.6
Subbasin - 3	0.48
Subbasin - 2	0.43

Downstream

Element Name	Downstream
Subbasin - 1	Junction - 1
Subbasin - 3	Junction - 1
Subbasin - 2	Junction - 1

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number	Initial Abstraction
Subbasin - 1	0	75	0.67
Subbasin - 3	0	77	0.6
Subbasin - 2	0	78	0.56

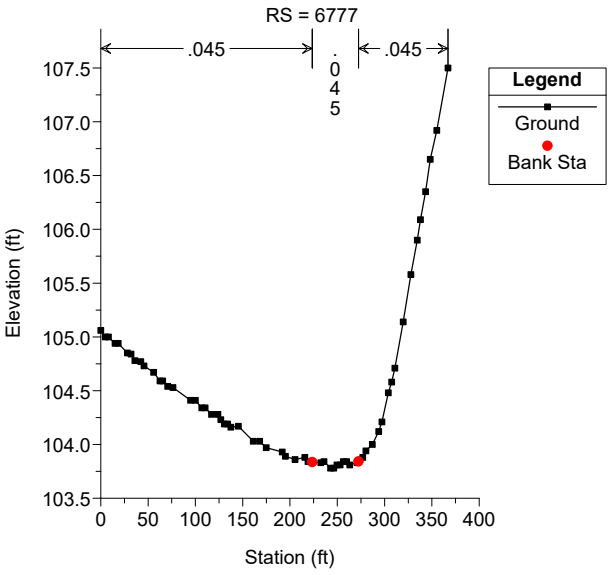
Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	63	Standard
Subbasin - 3	51	Standard
Subbasin - 2	57	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	0.6	106.64	08Nov2023, 13:15	1.28
Subbasin - 3	0.48	106.76	08Nov2023, 13:00	1.41
Subbasin - 2	0.43	95.98	08Nov2023, 13:15	1.47
Junction - 1	1.5	304.63	08Nov2023, 13:15	1.38

Appendix E - Hydraulic Model Cross Sections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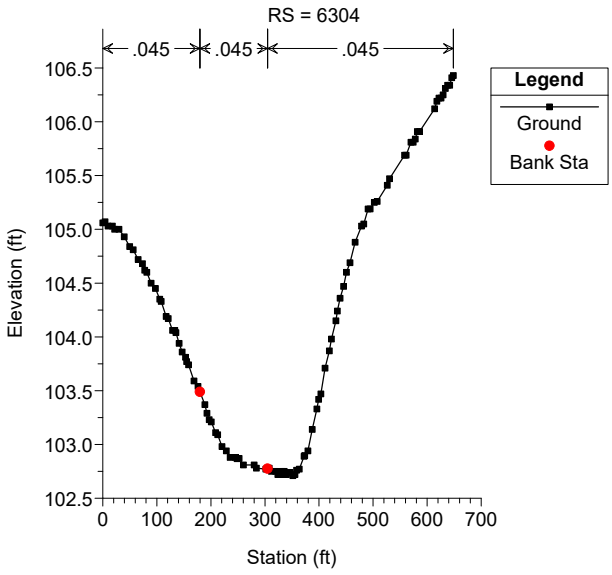
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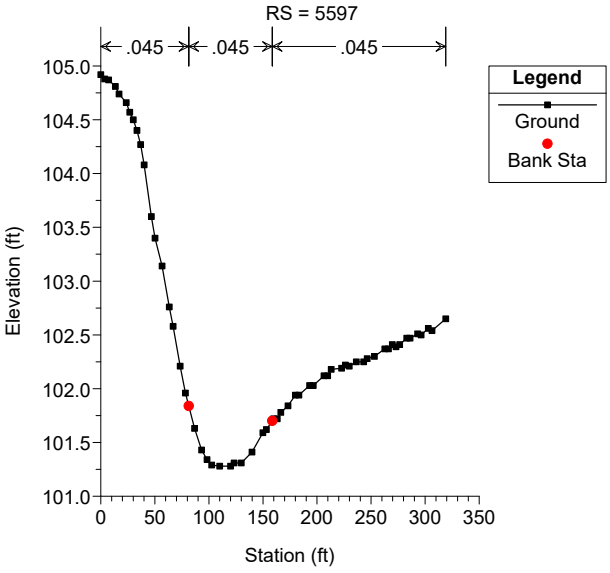
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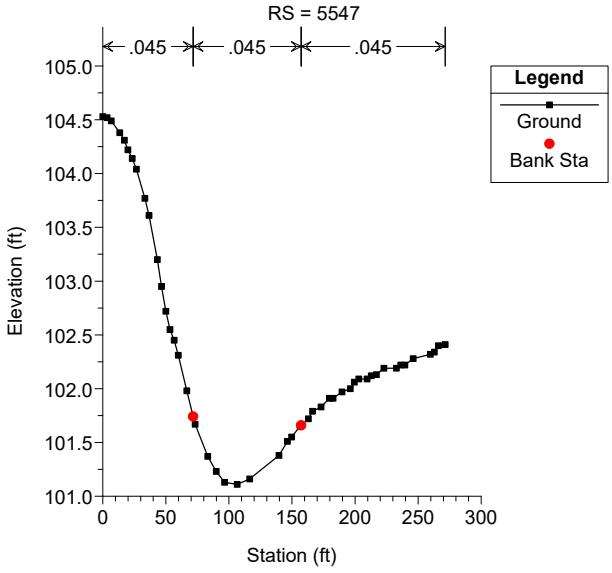
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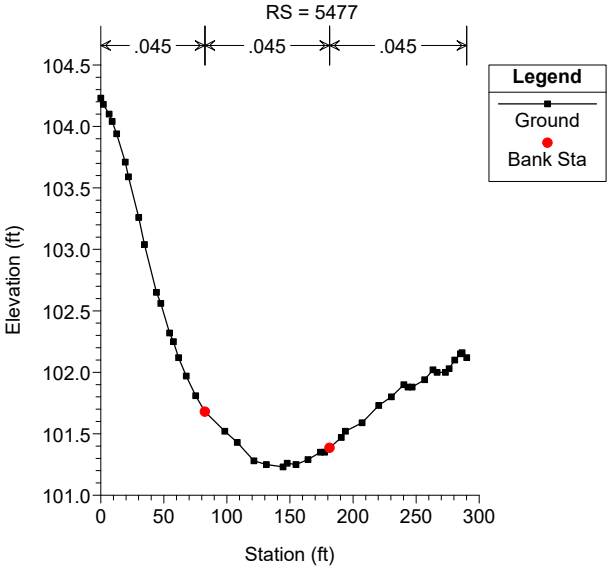
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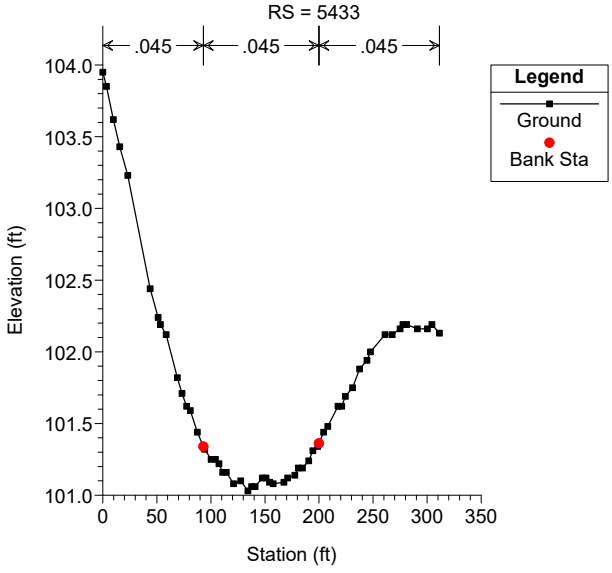
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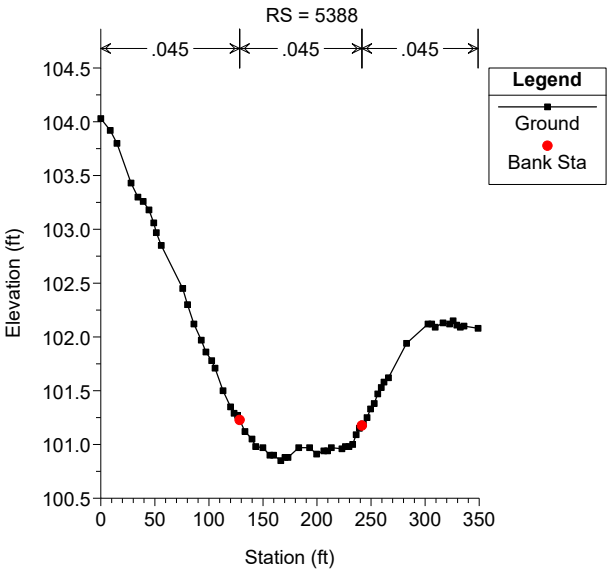
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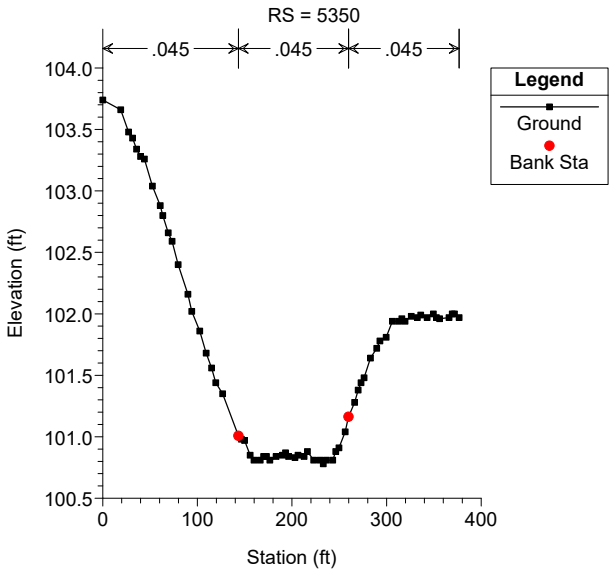
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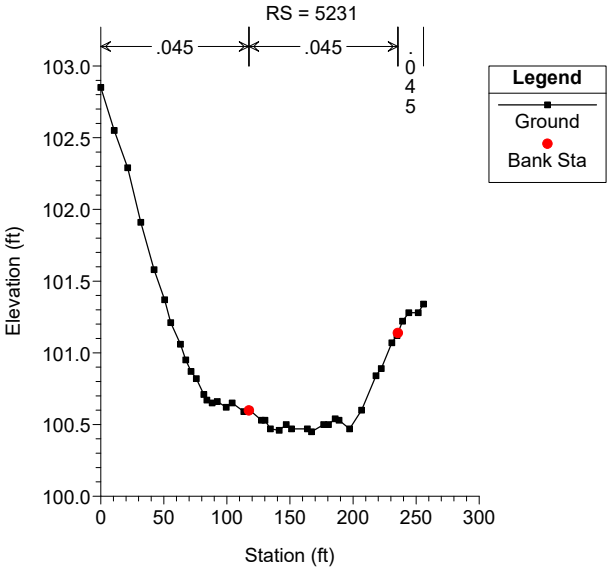
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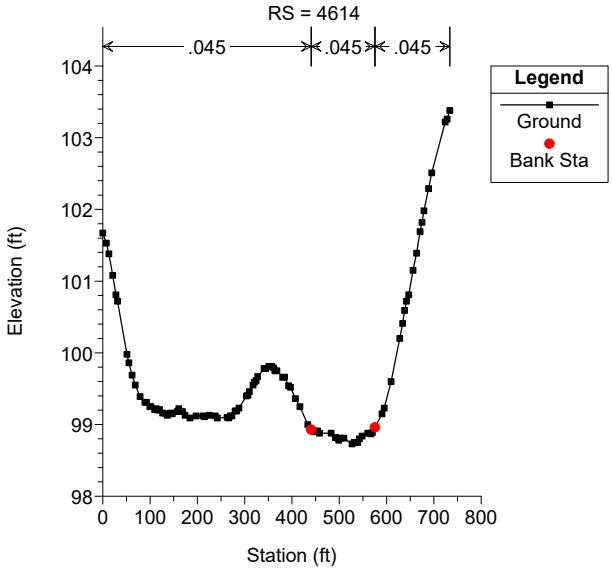
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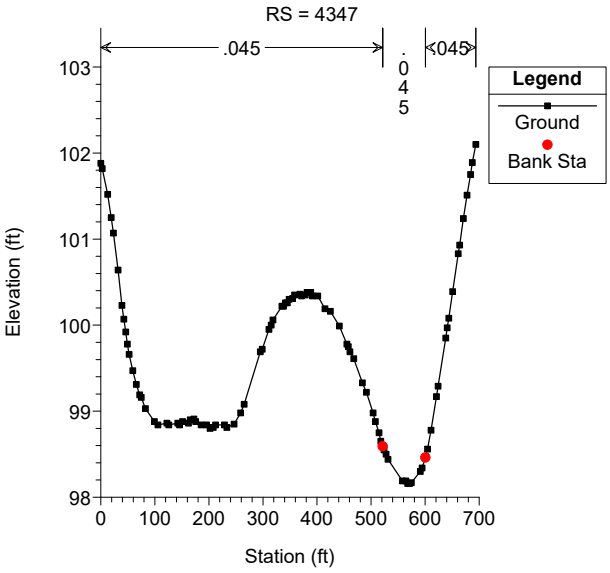
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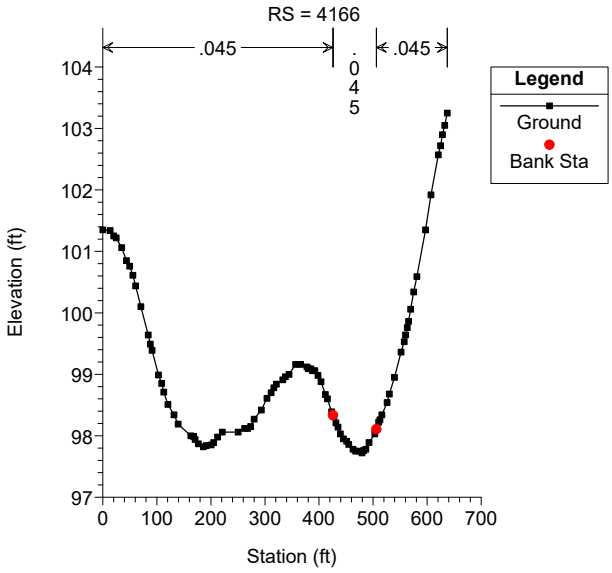
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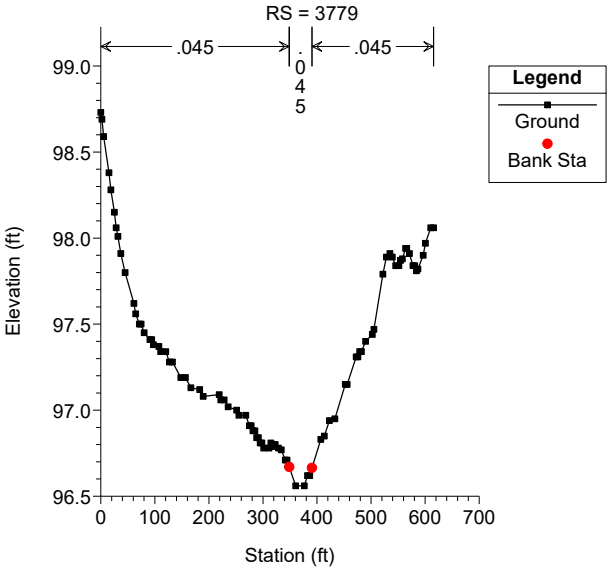
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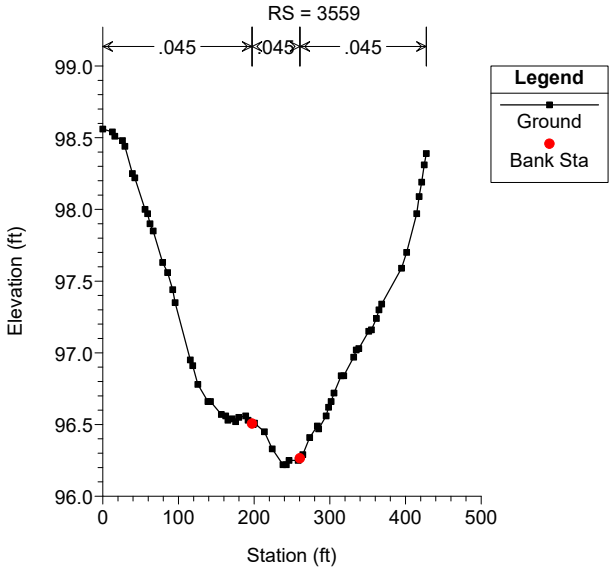
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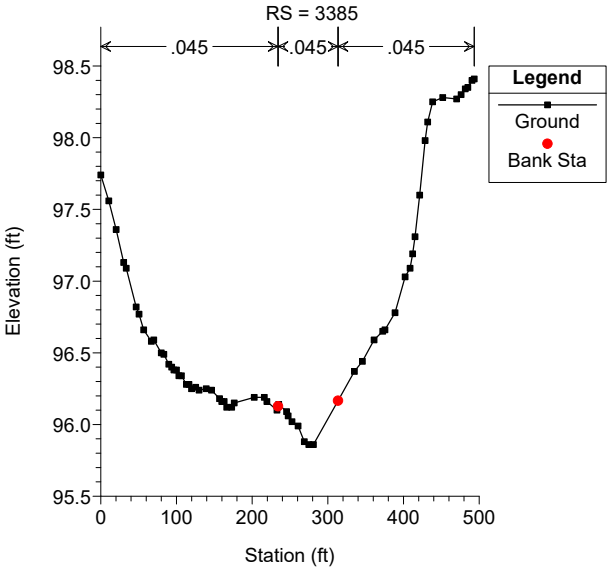
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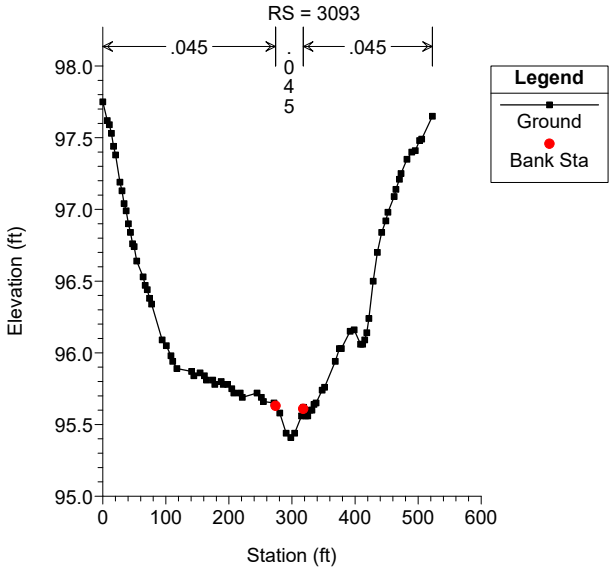
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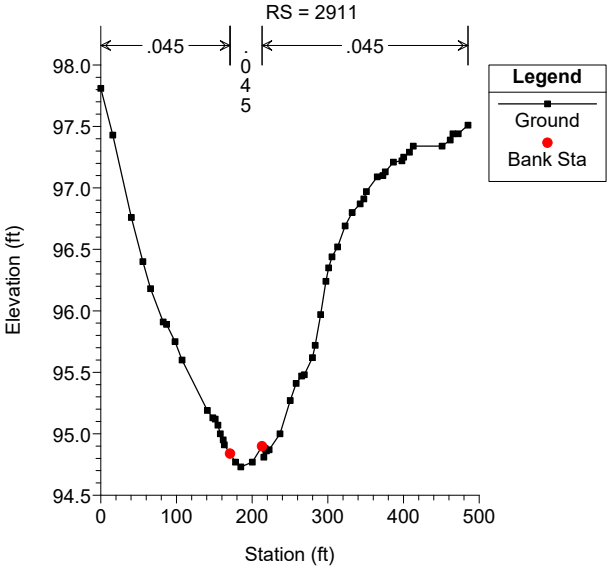
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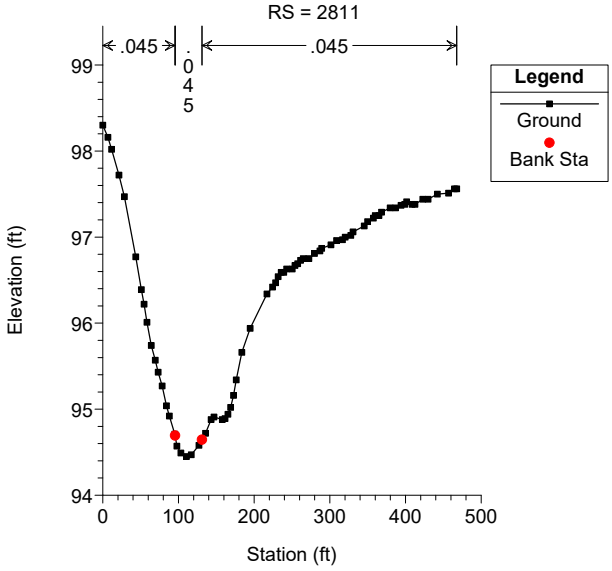
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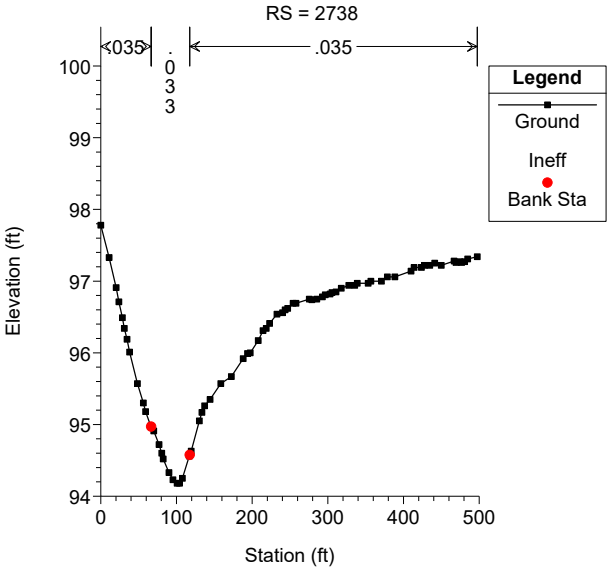
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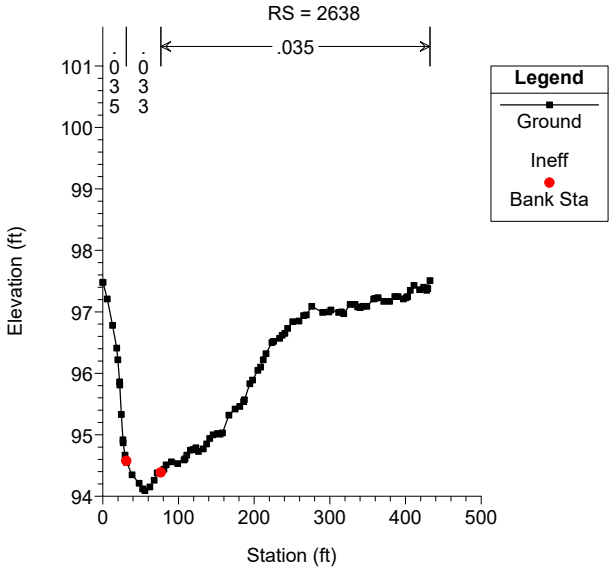
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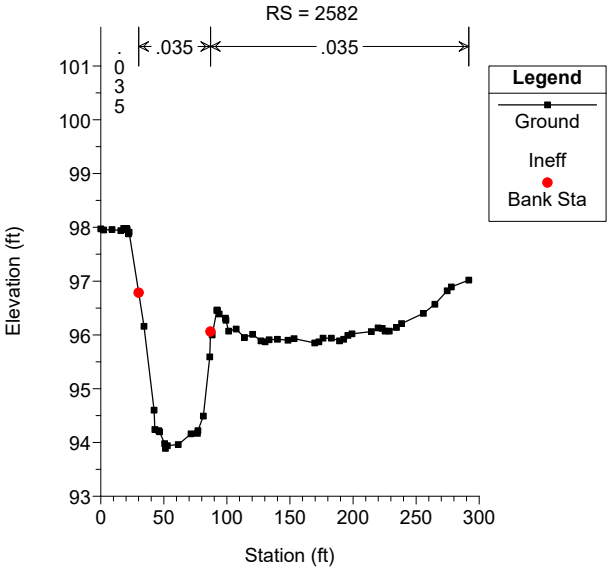
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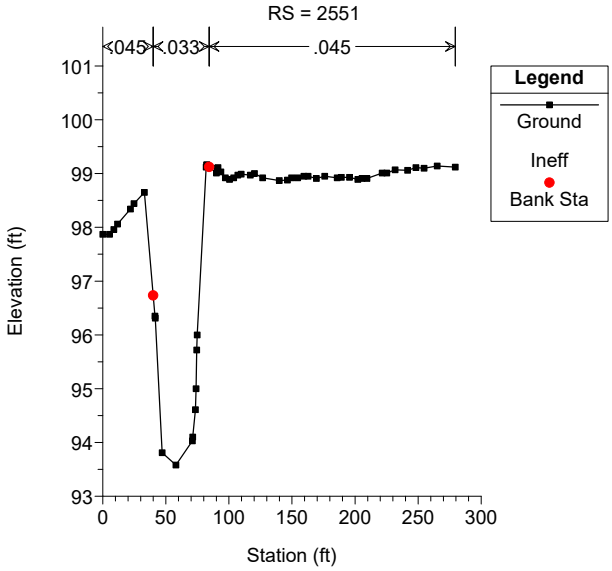
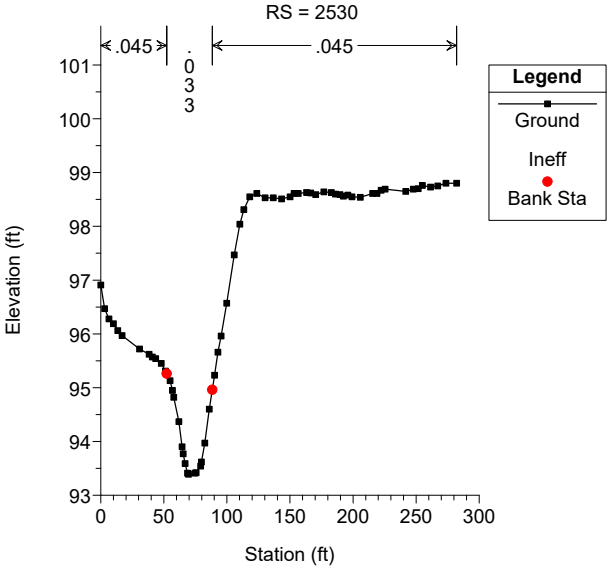
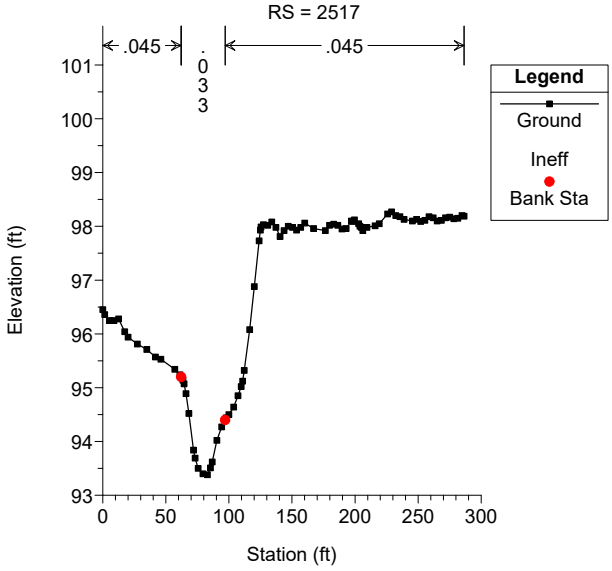
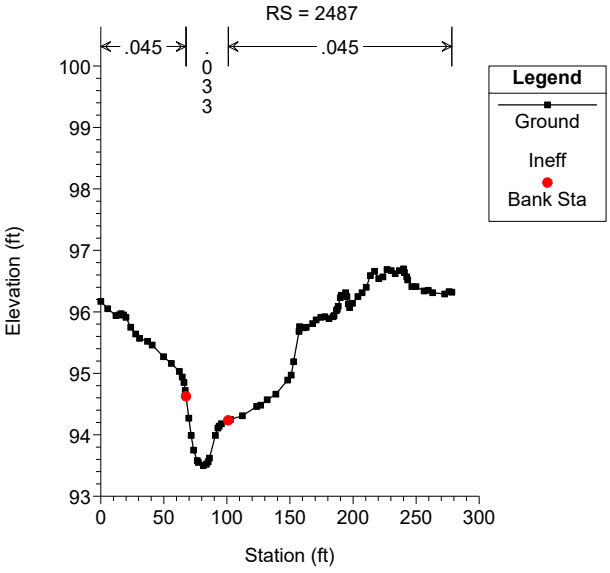
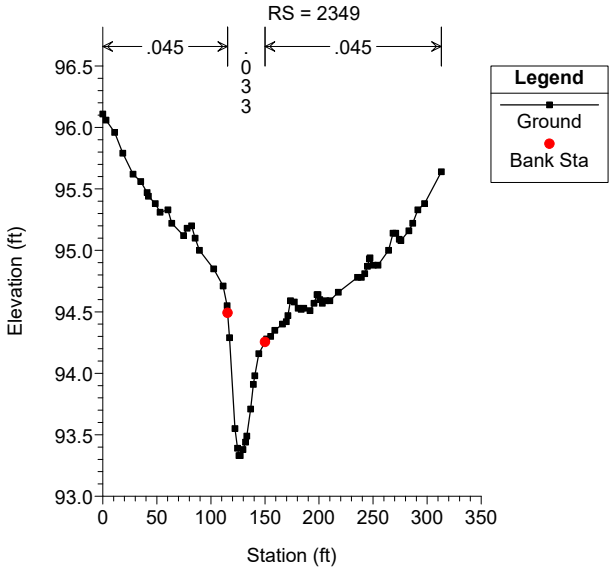
.035
.035
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

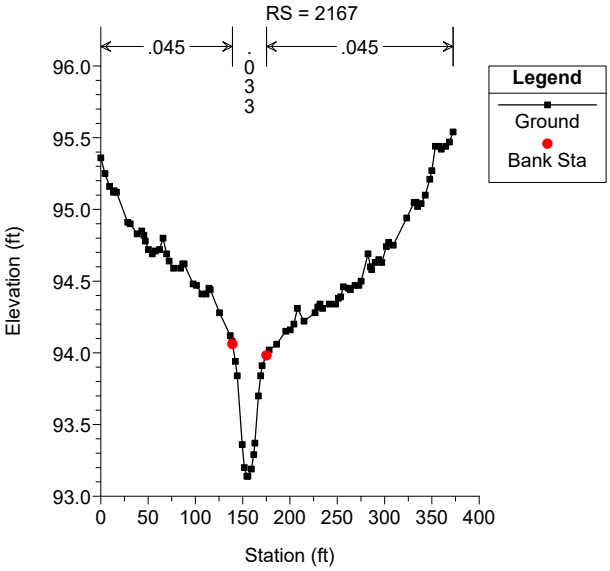

RS = 2551
.045
.033
.045
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

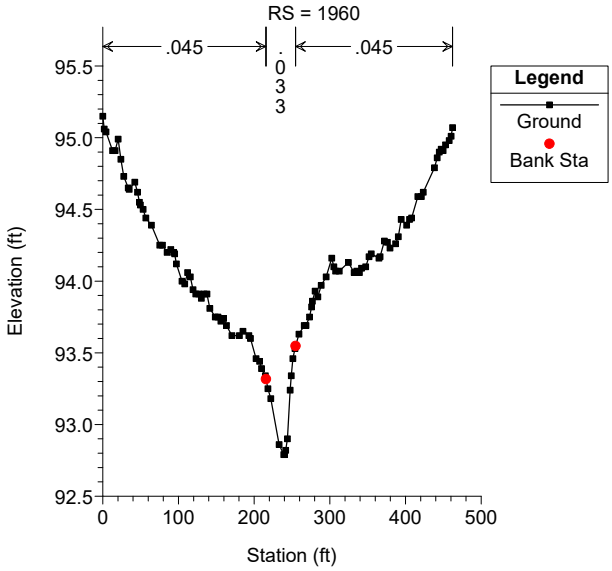

RS = 2530
.045
.033
.045
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

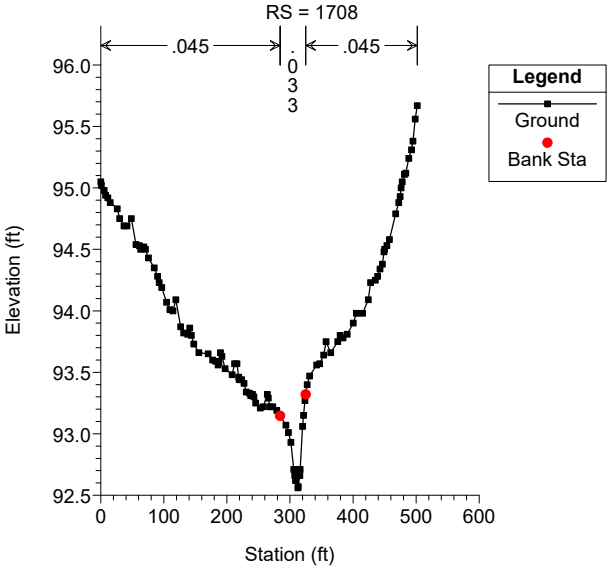

RS = 2517
.045
.033
.045
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

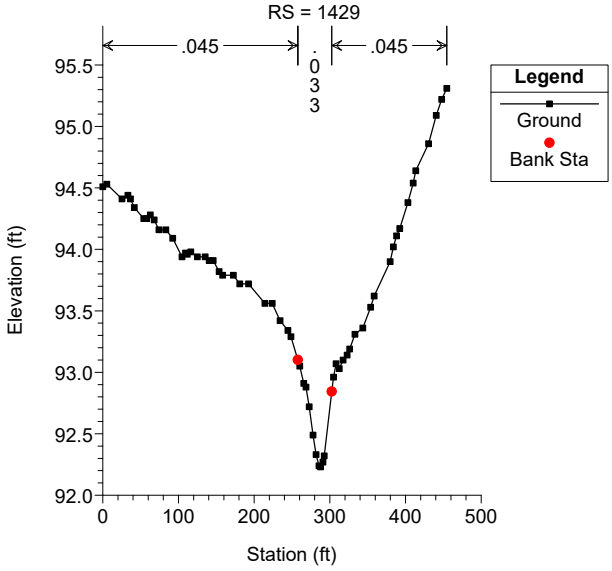

RS = 2487
.045
.033
.045
Legend
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

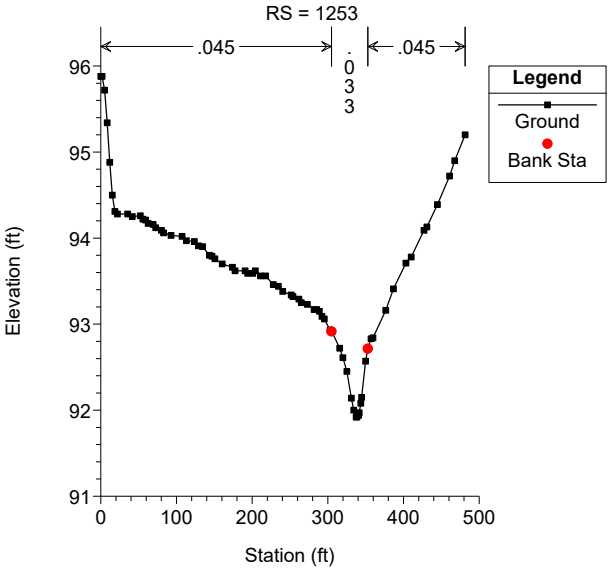

RS = 2349
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)

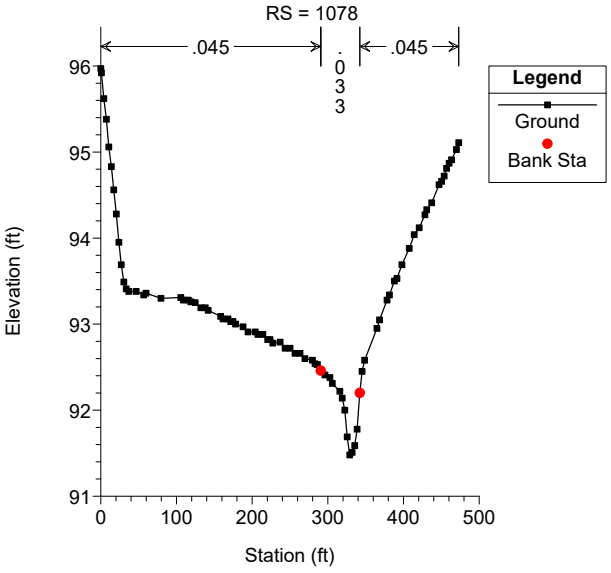

RS = 2167
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)

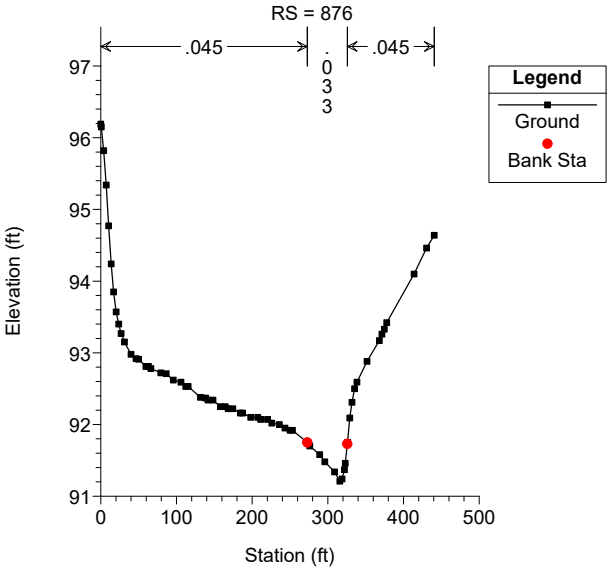

RS = 1960
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)


RS = 1708
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)

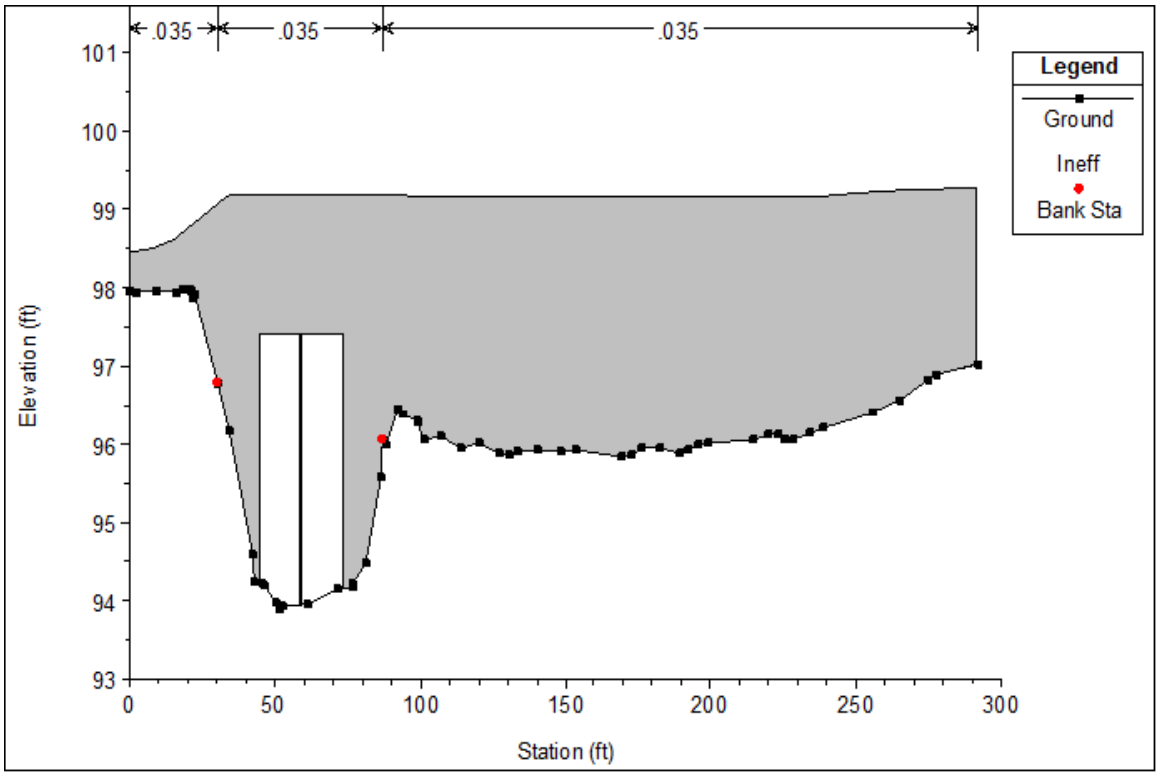

RS = 1429
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)


RS = 1253
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)
96
95
94
93
92
91
0
100
200
300
400
500

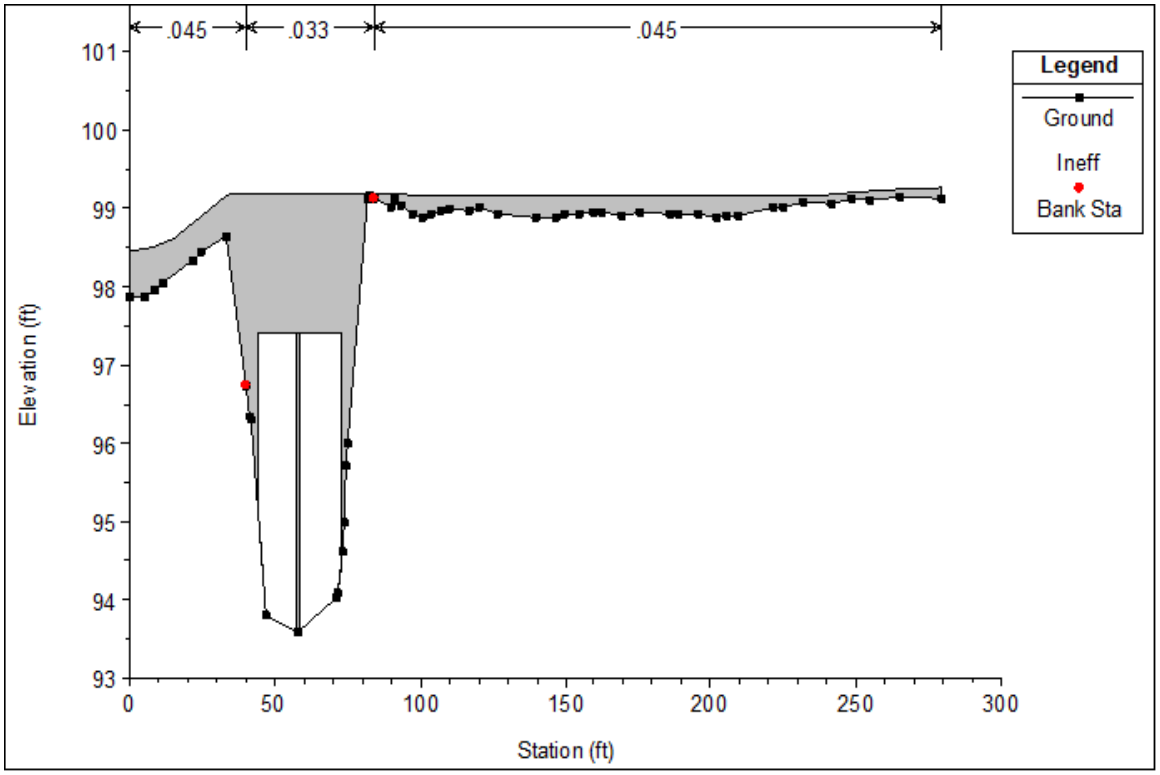

RS = 1078
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)
96
95
94
93
92
91
0
100
200
300
400
500


RS = 876
.045
.033
.045
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)
97
96
95
94
93
92
91
0
100
200
300
400
500

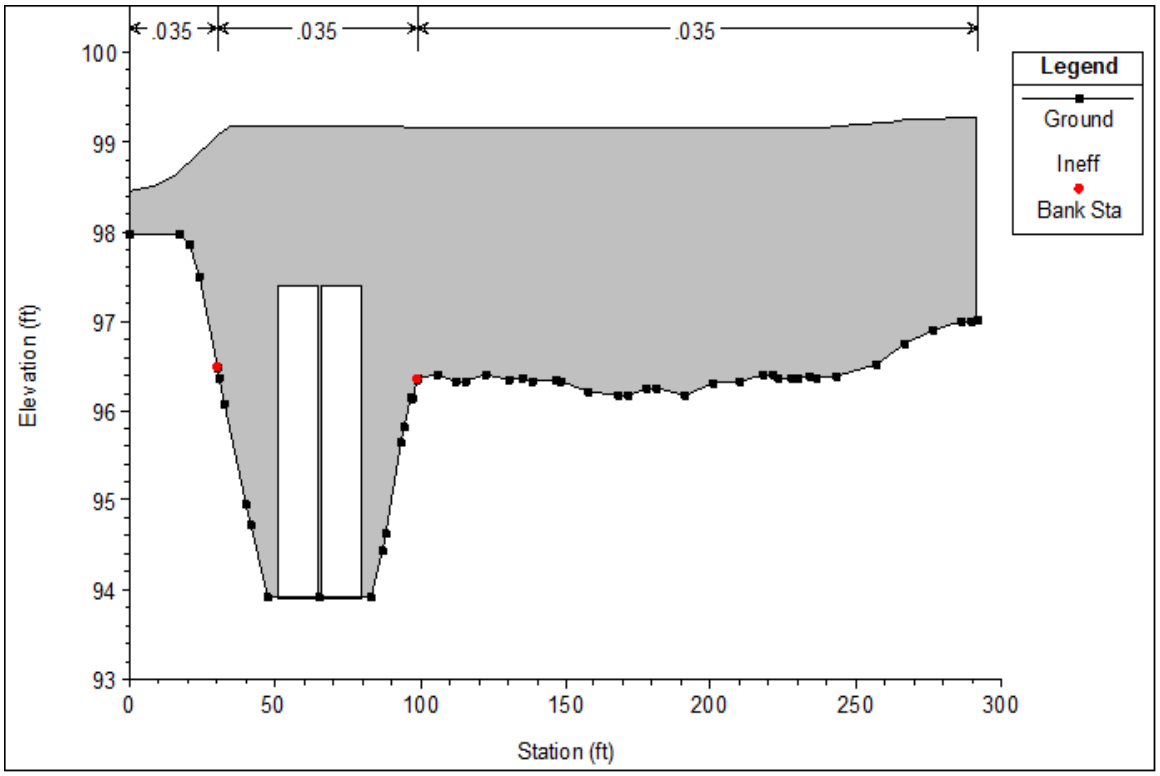
Existing Bridge (U/S)



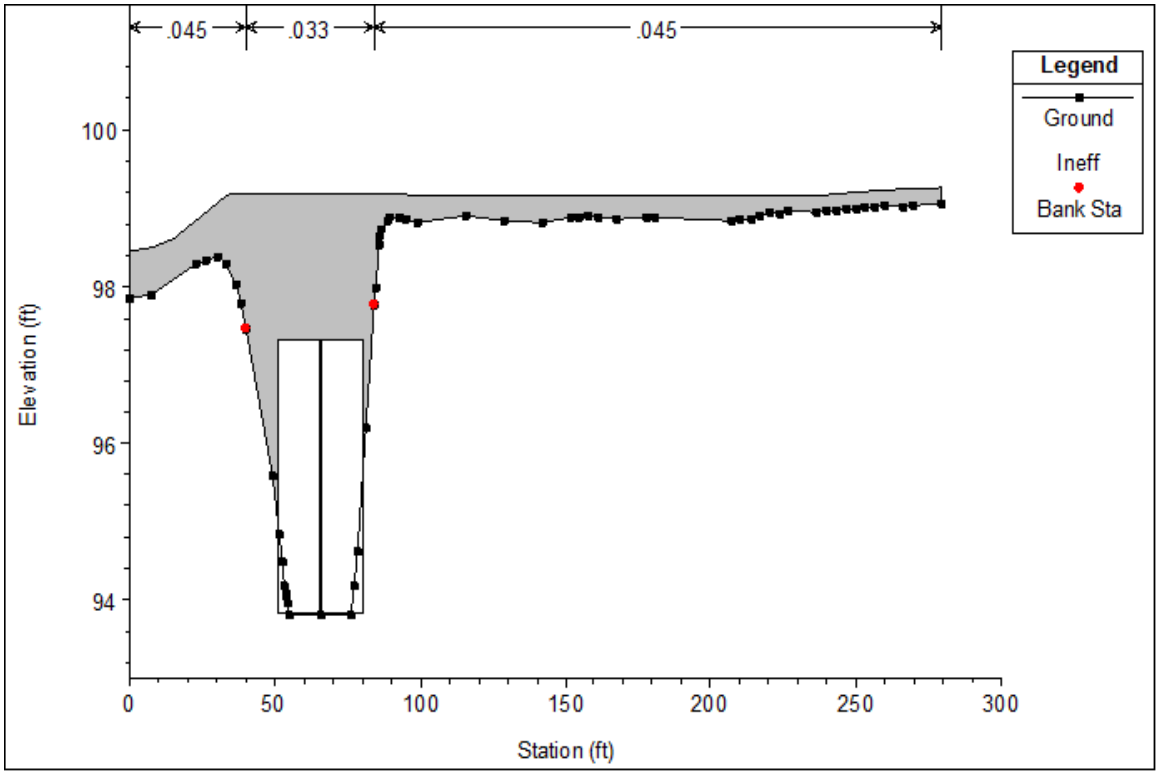
Existing Bridge (D/S)



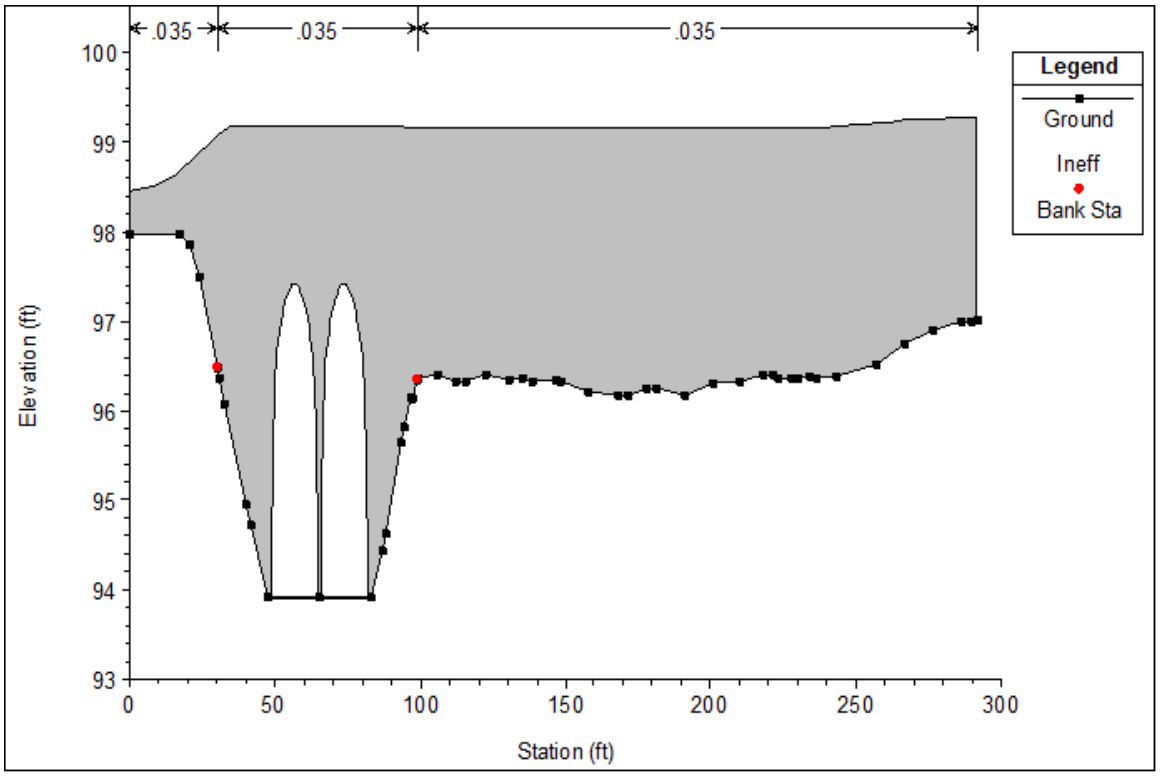
Proposed Double Cell 14 ft by 3.5 ft RCB Culvert (SC-2) (U/S)



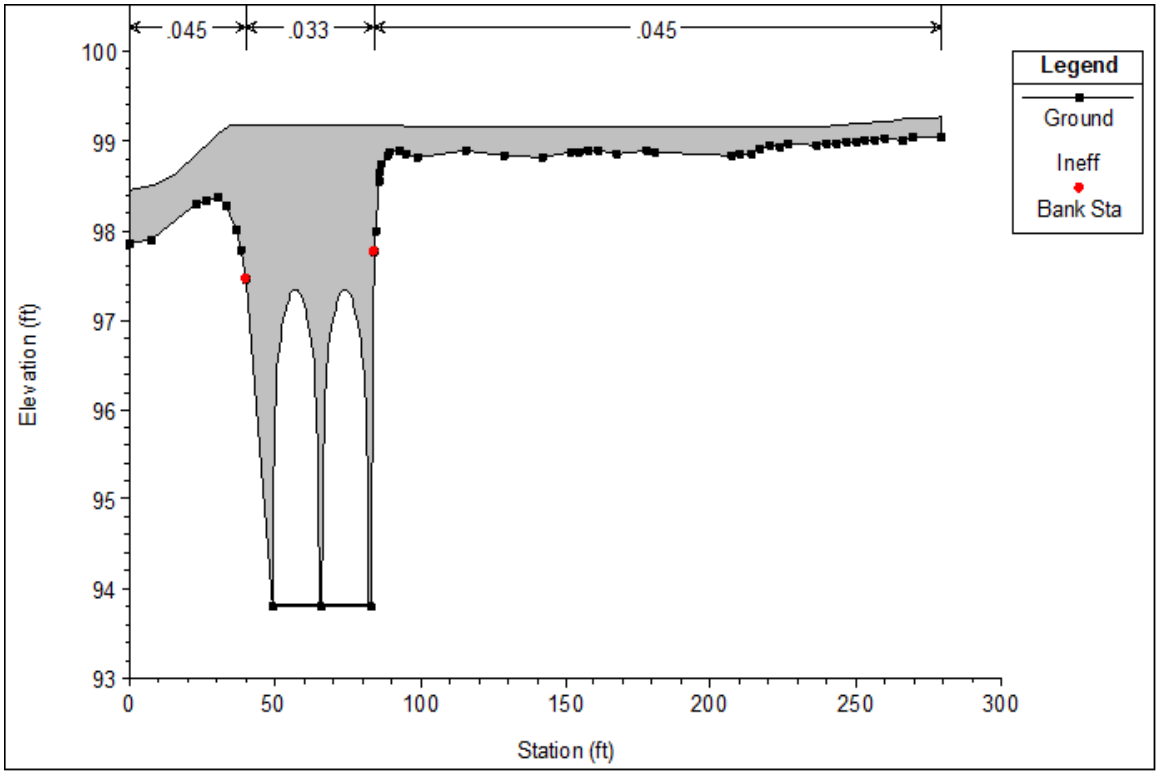
Proposed Double Cell 14 ft by 3.5 ft RCB Culvert (SC-2) (D/S)



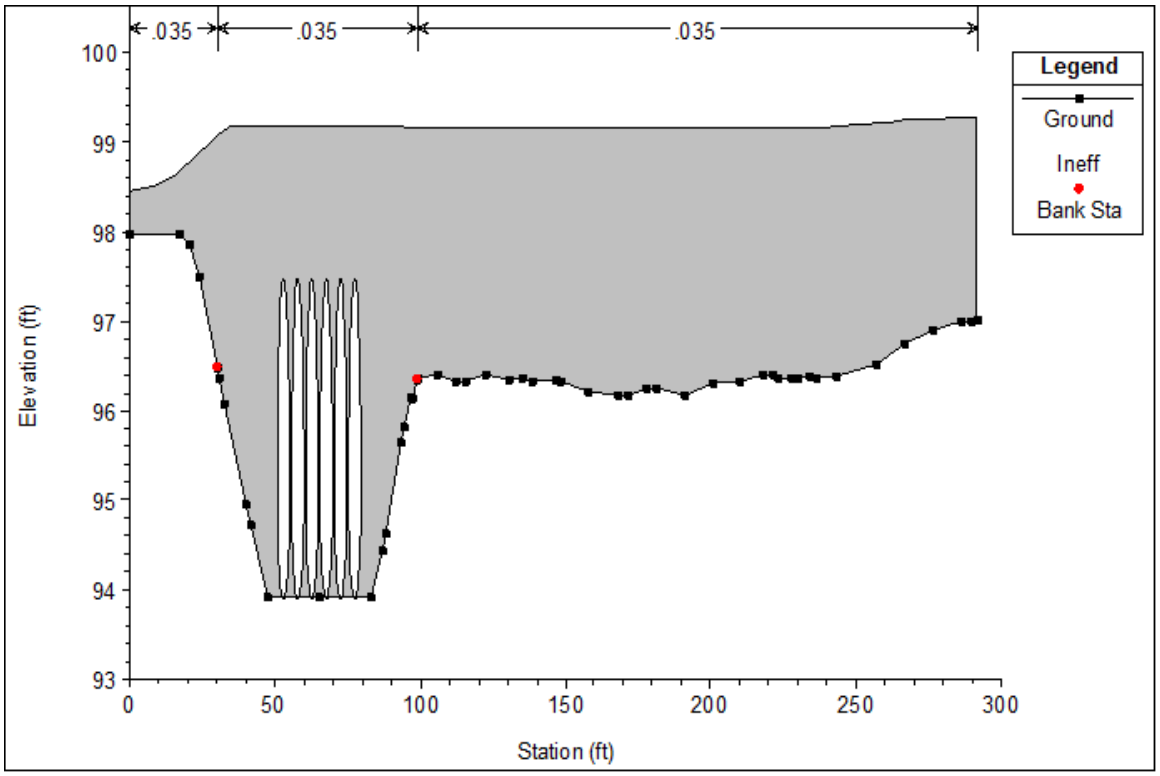
Proposed Double CON/SPAN Culvert (SC-3) (U/S)



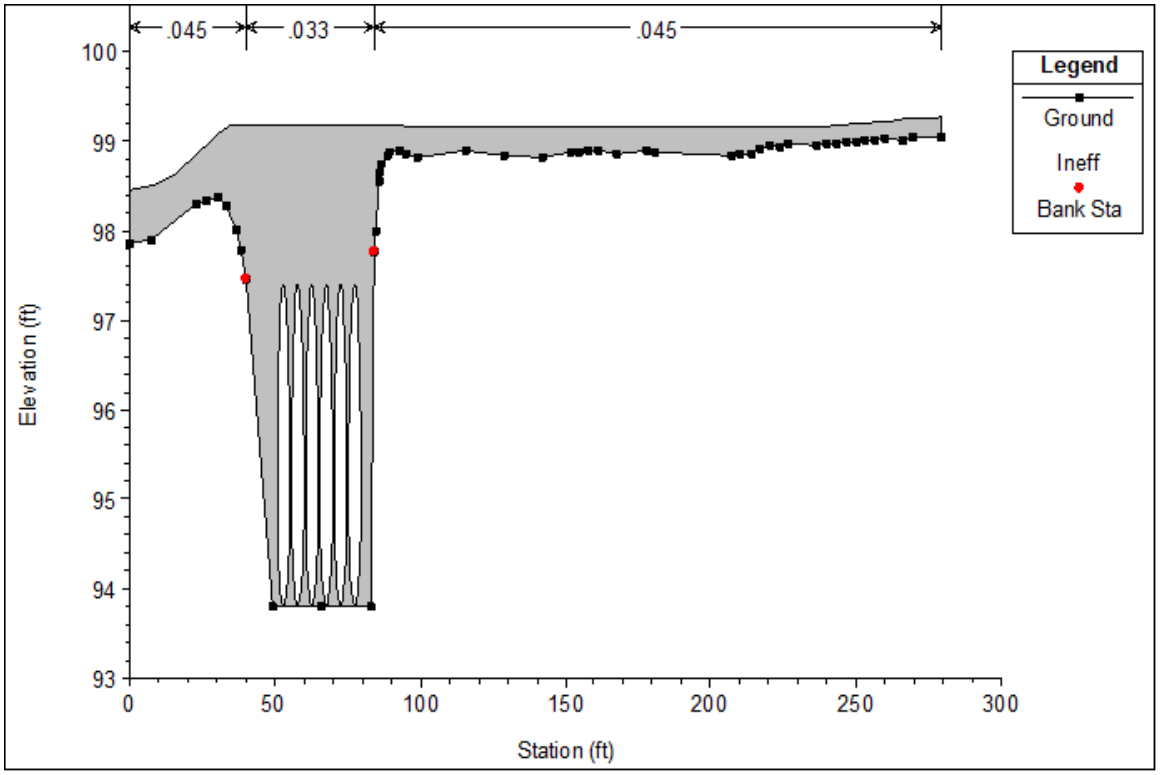
Proposed Double CON/SPAN Culvert (SC-3) (D/S)



Proposed CMP Arch Culverts (SC-4) (U/S)



Proposed CMP Arch Culverts (SC-4) (U/S)



Appendix F - Hydraulic Model Summary Tables

Existing Conditions (SC-1)

Bridge Output

File Type Options Help

River: River 1 Profile: 100Y

Reach Reach 1 RS: 2565 Plan: Ex_HMS

Plan: Ex_HMS River 1 Reach 1 RS: 2565 Profile: 100Y

		Element	Inside BR US	Inside BR DS
E.G. US. (ft)	97.02	E.G. Elev (ft)	96.88	96.69
W.S. US. (ft)	96.86	W.S. Elev (ft)	96.33	96.13
Q Total (cfs)	375.00	Crit W.S. (ft)	95.83	95.67
Q Bridge (cfs)	375.00	Max Chl Dpth (ft)	2.44	2.54
Q Weir (cfs)		Vel Total (ft/s)	5.96	6.03
Weir Sta Lft (ft)		Flow Area (sq ft)	62.95	62.21
Weir Sta Rgt (ft)		Froude # Chl	0.67	0.67
Weir Submerg		Specif Force (cu ft)	141.52	141.78
Weir Max Depth (ft)		Hydr Depth (ft)	2.29	2.26
Min El Weir Flow (ft)	99.19	W.P. Total (ft)	36.55	35.61
Min El Prs (ft)	97.42	Conv. Total (cfs)	3839.7	4062.4
Delta EG (ft)	0.41	Top Width (ft)	27.53	27.53
Delta WS (ft)	0.71	Frctn Loss (ft)	0.18	0.03
BR Open Area (sq ft)	93.07	C & E Loss (ft)	0.00	0.05
BR Open Vel (ft/s)	6.03	Shear Total (lb/sq ft)	1.03	0.93
BR Sluice Coef		Power Total (lb/ft s)	6.11	5.60
BR Sel Method	Energy only			

Bridge Output

File Type Options Help

River: River 1 Profile: 50Y

Reach Reach 1 RS: 2565 Plan: Ex_HMS

Plan: Ex_HMS River 1 Reach 1 RS: 2565 Profile: 50Y

		Element	Inside BR US	Inside BR DS
E.G. US. (ft)	96.72	E.G. Elev (ft)	96.60	96.44
W.S. US. (ft)	96.58	W.S. Elev (ft)	96.14	95.98
Q Total (cfs)	314.30	Crit W.S. (ft)	95.64	95.46
Q Bridge (cfs)	314.30	Max Chl Dpth (ft)	2.25	2.39
Q Weir (cfs)		Vel Total (ft/s)	5.44	5.40
Weir Sta Lft (ft)		Flow Area (sq ft)	57.79	58.24
Weir Sta Rgt (ft)		Froude # Chl	0.64	0.61
Weir Submerg		Specif Force (cu ft)	113.90	115.56
Weir Max Depth (ft)		Hydr Depth (ft)	2.10	2.12
Min El Weir Flow (ft)	99.19	W.P. Total (ft)	35.80	35.04
Min El Prs (ft)	97.42	Conv. Total (cfs)	3375.8	3680.1
Delta EG (ft)	0.35	Top Width (ft)	27.53	27.53
Delta WS (ft)	0.59	Frctn Loss (ft)	0.16	0.03
BR Open Area (sq ft)	93.07	C & E Loss (ft)	0.00	0.04
BR Open Vel (ft/s)	5.44	Shear Total (lb/sq ft)	0.87	0.76
BR Sluice Coef		Power Total (lb/ft s)	4.75	4.08
BR Sel Method	Energy only			

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: Ex_HMS River: River 1 Reach: Reach 1 Profile: 100Y

Reload Data

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)	
Reach 1	6777	100Y	135.60	103.78	104.5	104.23	104.56	0.003594	1.58	109.10	232.63	0.33
Reach 1	6304	100Y	135.60	102.77	103.6		103.62	0.001244	0.87	152.83	240.03	0.19
Reach 1	5597	100Y	135.60	101.28	102.3		102.38	0.002747	1.63	99.32	187.59	0.30
Reach 1	5547	100Y	135.60	101.11	102.2		102.26	0.002675	1.59	97.48	178.30	0.30
Reach 1	5477	100Y	135.60	101.23	102.0		102.05	0.004579	1.69	92.18	207.84	0.37
Reach 1	5433	100Y	135.60	101.03	101.8		101.89	0.004098	1.66	89.44	167.78	0.35
Reach 1	5388	100Y	135.60	100.85	101.7		101.75	0.002959	1.48	98.80	165.96	0.30
Reach 1	5350	100Y	135.60	100.78	101.6		101.66	0.002515	1.39	104.97	170.91	0.28
Reach 1	5231	100Y	135.60	100.45	101.0		101.06	0.016743	2.40	59.96	159.88	0.65
Reach 1	4614	100Y	253.90	98.73	99.8		99.77	0.001120	1.04	309.13	528.98	0.19
Reach 1	4347	100Y	253.90	98.16	99.4	99.02	99.41	0.002137	1.61	214.10	363.24	0.27
Reach 1	4166	100Y	253.90	97.72	98.5		98.55	0.013388	2.58	114.46	274.31	0.61
Reach 1	3779	100Y	253.90	96.56	97.8		97.80	0.000807	1.06	334.04	475.76	0.17
Reach 1	3559	100Y	253.90	96.22	97.6		97.59	0.001135	1.28	251.68	308.45	0.20
Reach 1	3385	100Y	375.00	95.86	97.4		97.37	0.000854	1.18	385.42	395.67	0.18
Reach 1	3093	100Y	375.00	95.41	97.2		97.25	0.000337	0.88	538.39	447.22	0.12
Reach 1	2911	100Y	375.00	94.73	97.2		97.17	0.000342	1.09	480.10	354.82	0.12
Reach 1	2811	100Y	375.00	94.45	97.1		97.12	0.000671	1.61	355.13	302.42	0.18
Reach 1	2738	100Y	375.00	94.18	97.1		97.09	0.000343	1.58	377.61	371.97	0.17
Reach 1	2638	100Y	375.00	94.09	97.0		97.06	0.000182	1.20	424.90	304.71	0.13
Reach 1	2582	100Y	375.00	93.89	96.9	95.51	97.02	0.001574	3.18	118.07	246.95	0.35
Reach 1	2565 Fazier Rd		Bridge									
Reach 1	2551	100Y	375.00	93.58	96.1		96.61	0.005807	5.44	68.90	33.28	0.67
Reach 1	2530	100Y	375.00	93.39	96.1		96.44	0.004723	4.89	86.17	83.72	0.61
Reach 1	2517	100Y	375.00	93.38	95.8	95.61	96.32	0.007485	5.81	72.16	87.64	0.76
Reach 1	2487	100Y	375.00	93.50	95.8		96.03	0.003831	4.28	113.23	144.29	0.55
Reach 1	2441.00	100Y	375.00	93.51	95.8		95.85	0.002199	3.16	210.66	256.22	0.41
Reach 1	2395.00	100Y	375.00	93.34	95.7		95.75	0.001953	2.99	223.04	265.88	0.39
Reach 1	2349	100Y	375.00	93.33	95.6		95.65	0.002233	3.10	215.85	273.99	0.41
Reach 1	2167	100Y	375.00	93.14	95.1		95.21	0.002613	3.09	226.40	330.08	0.44
Reach 1	1960	100Y	375.00	92.79	94.9		94.91	0.000819	1.91	368.40	420.54	0.25
Reach 1	1708	100Y	375.00	92.56	94.7		94.73	0.000625	1.66	404.77	423.12	0.22
Reach 1	1429	100Y	375.00	92.23	94.4		94.49	0.001128	2.27	303.71	387.28	0.30
Reach 1	1253	100Y	375.00	91.92	94.2		94.28	0.001229	2.34	290.98	381.20	0.31
Reach 1	1078	100Y	375.00	91.48	94.1		94.16	0.000359	1.39	462.12	400.12	0.17
Reach 1	876	100Y	375.00	91.21	94.1	92.50	94.12	0.000117	0.93	652.49	399.66	0.10

Total flow in cross section.

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: Ex_HMS River: River 1 Reach: Reach 1 Profile: 50Y

Reload Data

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach 1	6777	50Y	113.30	103.78	104.5	104.19	104.50	0.003573	1.49	95.89	219.45	0.32
Reach 1	6304	50Y	113.30	102.77	103.5		103.54	0.001259	0.80	135.61	228.77	0.19
Reach 1	5597	50Y	113.30	101.28	102.3		102.30	0.002700	1.53	86.38	172.86	0.29
Reach 1	5547	50Y	113.30	101.11	102.2		102.19	0.002477	1.46	86.70	156.86	0.28
Reach 1	5477	50Y	113.30	101.23	102.0		101.99	0.004752	1.61	80.06	189.36	0.37
Reach 1	5433	50Y	113.30	101.03	101.8		101.82	0.004146	1.56	78.67	162.03	0.35
Reach 1	5388	50Y	113.30	100.85	101.7		101.68	0.002853	1.37	88.49	160.37	0.29
Reach 1	5350	50Y	113.30	100.78	101.6		101.60	0.002340	1.27	95.16	165.65	0.27
Reach 1	5231	50Y	113.30	100.45	100.9		101.00	0.019413	2.38	50.66	154.41	0.69
Reach 1	4614	50Y	212.60	98.73	99.7		99.69	0.001116	0.98	272.48	501.60	0.19
Reach 1	4347	50Y	212.60	98.16	99.3	98.97	99.34	0.002137	1.54	188.06	350.48	0.27
Reach 1	4166	50Y	212.60	97.72	98.4		98.50	0.012256	2.36	104.57	266.71	0.58
Reach 1	3779	50Y	212.60	96.56	97.7		97.69	0.000913	1.06	284.85	460.78	0.18
Reach 1	3559	50Y	212.60	96.22	97.4		97.45	0.001301	1.27	210.72	285.88	0.21
Reach 1	3385	50Y	314.30	95.86	97.1		97.16	0.001240	1.27	303.61	380.74	0.21
Reach 1	3093	50Y	314.30	95.41	97.0		96.99	0.000464	0.93	427.45	415.32	0.13
Reach 1	2911	50Y	314.30	94.73	96.9		96.90	0.000410	1.10	388.59	308.74	0.13
Reach 1	2811	50Y	314.30	94.45	96.8		96.83	0.000809	1.63	276.78	236.79	0.19
Reach 1	2738	50Y	314.30	94.18	96.8		96.79	0.000421	1.61	285.42	265.68	0.19
Reach 1	2638	50Y	314.30	94.09	96.7		96.76	0.000201	1.17	354.79	231.46	0.13
Reach 1	2582	50Y	314.30	93.89	96.6	95.36	96.72	0.001621	2.99	105.27	233.66	0.35
Reach 1	2565 Fazier Rd		Bridge									
Reach 1	2551	50Y	314.30	93.58	96.0		96.37	0.005111	4.92	63.83	32.60	0.62
Reach 1	2530	50Y	314.30	93.39	95.9		96.23	0.004628	4.56	76.02	75.56	0.59
Reach 1	2517	50Y	314.30	93.38	95.7	95.37	96.13	0.006256	5.15	66.64	80.93	0.69
Reach 1	2487	50Y	314.30	93.50	95.7		95.89	0.003299	3.84	104.32	131.98	0.50
Reach 1	2441.00	50Y	314.30	93.51	95.7		95.74	0.002145	3.00	183.97	241.22	0.40
Reach 1	2395.00	50Y	314.30	93.34	95.6		95.64	0.001874	2.82	196.07	252.89	0.38
Reach 1	2349	50Y	314.30	93.33	95.5		95.54	0.002180	2.94	188.61	261.25	0.40
Reach 1	2167	50Y	314.30	93.14	95.0		95.10	0.002744	3.02	191.54	306.53	0.44
Reach 1	1960	50Y	314.30	92.79	94.8		94.78	0.000888	1.89	314.84	408.30	0.26
Reach 1	1708	50Y	314.30	92.56	94.6		94.59	0.000686	1.64	346.19	401.54	0.23
Reach 1	1429	50Y	314.30	92.23	94.3		94.31	0.001397	2.35	236.12	339.17	0.32
Reach 1	1253	50Y	314.30	91.92	93.9		93.98	0.002617	2.97	175.36	279.55	0.43
Reach 1	1078	50Y	314.30	91.48	93.5		93.55	0.002087	2.59	212.38	356.74	0.38
Reach 1	876	50Y	314.30	91.21	93.4	92.45	93.37	0.000430	1.42	367.04	350.50	0.18

Total flow in cross section.

Double Cast-In-Place 14 ft by 3.5 ft RCB (SC-2)

Culvert Output

File Type Options Help

River: River 1 Profile: 100Y Culv Group: Culvert #1

Reach Reach 1 RS: 2565 Plan: PR (HMS) 14' Box

Plan: PR (HMS) 14' Box River 1 Reach 1 RS: 2565 Culv Group: Culvert #1 Profile: 100Y

Q Culv Group (cfs)	375.00	Culv Full Len (ft)	
# Barrels	2	Culv Vel US (ft/s)	6.11
Q Barrel (cfs)	187.50	Culv Vel DS (ft/s)	5.88
E.G. US. (ft)	96.96	Culv Inv El Up (ft)	93.90
W.S. US. (ft)	96.75	Culv Inv El Dn (ft)	93.82
E.G. DS (ft)	96.63	Culv Frctn Ls (ft)	0.03
W.S. DS (ft)	96.07	Culv Exit Loss (ft)	0.00
Delta EG (ft)	0.33	Culv Entr Loss (ft)	0.29
Delta WS (ft)	0.68	Q Weir (cfs)	
E.G. IC (ft)	96.74	Weir Sta Lft (ft)	
E.G. OC (ft)	96.96	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	96.09	Weir Max Depth (ft)	
Culv WS Outlet (ft)	96.10	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.71	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.77	Min El Weir Flow (ft)	99.18

Culvert Output

File Type Options Help

River: River 1 Profile: 50Y Culv Group: Culvert #1

Reach Reach 1 RS: 2565 Plan: PR (HMS) 14' Box

Plan: PR (HMS) 14' Box River 1 Reach 1 RS: 2565 Culv Group: Culvert #1 Profile: 50Y

Q Culv Group (cfs)	314.30	Culv Full Len (ft)	
# Barrels	2	Culv Vel US (ft/s)	5.40
Q Barrel (cfs)	157.15	Culv Vel DS (ft/s)	5.20
E.G. US. (ft)	96.65	Culv Inv El Up (ft)	93.90
W.S. US. (ft)	96.48	Culv Inv El Dn (ft)	93.82
E.G. DS (ft)	96.40	Culv Frctn Ls (ft)	0.03
W.S. DS (ft)	95.95	Culv Exit Loss (ft)	0.00
Delta EG (ft)	0.26	Culv Entr Loss (ft)	0.23
Delta WS (ft)	0.52	Q Weir (cfs)	
E.G. IC (ft)	96.41	Weir Sta Lft (ft)	
E.G. OC (ft)	96.65	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	95.97	Weir Max Depth (ft)	
Culv WS Outlet (ft)	95.98	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.53	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.58	Min El Weir Flow (ft)	99.18

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: PR (HMS) 14' Box River: River 1 Reach: Reach 1 Profile: 100Y

Reload Data

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)	
Reach 1	6777	100Y	135.60	103.78	104.5		104.56	0.003594	1.58	109.10	232.63	0.33
Reach 1	6304	100Y	135.60	102.77	103.6		103.62	0.001244	0.87	152.83	240.03	0.19
Reach 1	5597	100Y	135.60	101.28	102.3		102.38	0.002747	1.63	99.32	187.59	0.30
Reach 1	5547	100Y	135.60	101.11	102.2		102.26	0.002675	1.59	97.48	178.31	0.30
Reach 1	5477	100Y	135.60	101.23	102.0		102.05	0.004577	1.69	92.19	207.86	0.37
Reach 1	5433	100Y	135.60	101.03	101.8		101.89	0.004091	1.65	89.49	167.81	0.35
Reach 1	5388	100Y	135.60	100.85	101.7		101.75	0.002949	1.48	98.91	166.03	0.30
Reach 1	5350	100Y	135.60	100.78	101.6		101.66	0.002503	1.39	105.15	171.01	0.28
Reach 1	5231	100Y	135.60	100.45	101.0		101.05	0.017204	2.42	59.42	159.60	0.66
Reach 1	4614	100Y	253.90	98.73	99.8		99.77	0.001121	1.04	309.01	528.92	0.19
Reach 1	4347	100Y	253.90	98.16	99.4	99.02	99.41	0.002147	1.61	213.75	363.07	0.27
Reach 1	4166	100Y	253.90	97.72	98.5		98.55	0.013114	2.56	115.27	274.92	0.60
Reach 1	3779	100Y	253.90	96.56	97.8		97.80	0.000820	1.06	332.37	475.27	0.17
Reach 1	3559	100Y	253.90	96.22	97.6		97.58	0.001184	1.30	247.70	305.86	0.21
Reach 1	3385	100Y	375.00	95.86	97.3		97.34	0.000943	1.22	373.07	393.66	0.19
Reach 1	3093	100Y	375.00	95.41	97.2		97.21	0.000376	0.91	518.86	442.56	0.12
Reach 1	2911	100Y	375.00	94.73	97.1		97.12	0.000378	1.13	461.64	346.38	0.13
Reach 1	2811	100Y	375.00	94.45	97.0		97.06	0.000757	1.68	337.32	291.30	0.19
Reach 1	2738	100Y	375.00	94.18	97.0		97.02	0.000385	1.64	354.64	337.96	0.18
Reach 1	2638	100Y	375.00	94.10	97.0		96.99	0.000179	1.17	381.84	260.78	0.13
Reach 1	2582	100Y	375.00	93.91	96.8	95.38	96.95	0.001756	3.57	105.11	238.85	0.37
Reach 1	2565 Fazier Rd		Culvert									
Reach 1	2551	100Y	375.00	93.80	96.1	95.71	96.63	0.007372	6.01	62.38	34.39	0.75
Reach 1	2530	100Y	375.00	93.73	95.9		96.44	0.008210	5.83	69.82	73.66	0.78
Reach 1	2517	100Y	375.00	93.68	95.9	95.63	96.30	0.006815	5.47	79.66	91.39	0.72
Reach 1	2487	100Y	375.00	93.55	95.9		96.05	0.003076	3.90	127.71	138.26	0.49
Reach 1	2349	100Y	375.00	93.39	95.6		95.65	0.002272	3.10	216.03	275.23	0.41
Reach 1	2167	100Y	375.00	93.12	95.1		95.21	0.002522	3.08	227.39	327.75	0.43
Reach 1	1960	100Y	375.00	92.86	94.9		94.91	0.000822	1.89	370.57	424.74	0.25
Reach 1	1708	100Y	375.00	92.61	94.7		94.73	0.000635	1.67	407.47	427.61	0.22
Reach 1	1429	100Y	375.00	92.23	94.4		94.50	0.001125	2.27	304.11	387.50	0.29
Reach 1	1253	100Y	375.00	91.92	94.2		94.28	0.001220	2.34	291.89	381.53	0.31
Reach 1	1078	100Y	375.00	91.59	94.1		94.16	0.000370	1.40	458.60	399.42	0.17
Reach 1	876	100Y	375.00	91.21	94.1	92.50	94.12	0.000117	0.93	652.49	399.66	0.10

Total flow in cross section.

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: PR (HMS) 14' Box River: River 1 Reach: Reach 1 Profile: 50Y

Reload Data

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach 1	6777	50Y	113.30	103.78	104.5		104.50	0.003572	1.49	95.89	219.45	0.32
Reach 1	6304	50Y	113.30	102.77	103.5		103.54	0.001259	0.80	135.62	228.78	0.19
Reach 1	5597	50Y	113.30	101.28	102.3		102.30	0.002700	1.53	86.38	172.86	0.29
Reach 1	5547	50Y	113.30	101.11	102.2		102.19	0.002477	1.46	86.70	156.86	0.28
Reach 1	5477	50Y	113.30	101.23	102.0		101.99	0.004753	1.61	80.06	189.36	0.37
Reach 1	5433	50Y	113.30	101.03	101.8		101.82	0.004147	1.56	78.66	162.03	0.35
Reach 1	5388	50Y	113.30	100.85	101.7		101.68	0.002854	1.37	88.48	160.37	0.29
Reach 1	5350	50Y	113.30	100.78	101.6		101.60	0.002341	1.27	95.14	165.65	0.27
Reach 1	5231	50Y	113.30	100.45	100.9		101.00	0.019372	2.38	50.70	154.43	0.69
Reach 1	4614	50Y	212.60	98.73	99.7		99.69	0.001116	0.98	272.44	501.58	0.19
Reach 1	4347	50Y	212.60	98.16	99.3	98.97	99.34	0.002141	1.54	187.92	350.41	0.27
Reach 1	4166	50Y	212.60	97.72	98.4		98.50	0.012152	2.35	104.87	266.95	0.58
Reach 1	3779	50Y	212.60	96.56	97.7		97.69	0.000918	1.06	284.30	460.61	0.18
Reach 1	3559	50Y	212.60	96.22	97.4		97.45	0.001319	1.27	209.68	285.36	0.21
Reach 1	3385	50Y	314.30	95.86	97.1		97.14	0.001359	1.31	294.49	378.44	0.22
Reach 1	3093	50Y	314.30	95.41	96.9		96.95	0.000528	0.97	409.46	411.09	0.14
Reach 1	2911	50Y	314.30	94.73	96.8		96.84	0.000455	1.14	372.05	298.95	0.14
Reach 1	2811	50Y	314.30	94.45	96.7		96.77	0.000896	1.69	262.35	220.47	0.20
Reach 1	2738	50Y	314.30	94.18	96.7		96.73	0.000461	1.65	268.93	235.73	0.19
Reach 1	2638	50Y	314.30	94.10	96.7		96.69	0.000204	1.15	327.82	225.24	0.13
Reach 1	2582	50Y	314.30	93.91	96.5	95.22	96.65	0.001732	3.31	94.94	222.26	0.36
Reach 1	2565 Fazier Rd		Culvert									
Reach 1	2551	50Y	314.30	93.80	96.0	95.52	96.40	0.006247	5.35	58.79	33.62	0.69
Reach 1	2530	50Y	314.30	93.73	95.8		96.24	0.007289	5.26	64.18	67.10	0.73
Reach 1	2517	50Y	314.30	93.68	95.8		96.13	0.006052	4.95	72.37	84.58	0.67
Reach 1	2487	50Y	314.30	93.55	95.8		95.91	0.002738	3.54	116.26	132.82	0.46
Reach 1	2349	50Y	314.30	93.39	95.5		95.54	0.002228	2.94	188.37	260.87	0.41
Reach 1	2167	50Y	314.30	93.12	95.0		95.10	0.002653	3.01	191.71	303.79	0.44
Reach 1	1960	50Y	314.30	92.86	94.8		94.78	0.000900	1.88	314.40	406.46	0.26
Reach 1	1708	50Y	314.30	92.61	94.6		94.58	0.000678	1.63	347.34	400.32	0.22
Reach 1	1429	50Y	314.30	92.23	94.3		94.32	0.001395	2.35	236.30	339.43	0.32
Reach 1	1253	50Y	314.30	91.92	93.9		93.98	0.002567	2.95	176.83	280.31	0.43
Reach 1	1078	50Y	314.30	91.59	93.5		93.55	0.002186	2.63	209.73	356.63	0.39
Reach 1	876	50Y	314.30	91.21	93.4	92.45	93.37	0.000430	1.42	367.04	350.50	0.18

Total flow in cross section.

Double Cell CON/SPAN Bridge (SC-3)

Culvert Output

File Type Options Help

River: River 1 Profile: 100Y Culv Group: Culvert #1

Reach Reach 1 RS: 2565 Plan: ConSpan

Plan: ConSpan River 1 Reach 1 RS: 2565 Culv Group: Culvert #1 Profile: 100Y

Q Culv Group (cfs)	375.00	Culv Full Len (ft)	
# Barrels	2	Culv Vel US (ft/s)	5.05
Q Barrel (cfs)	187.50	Culv Vel DS (ft/s)	4.92
E.G. US. (ft)	96.93	Culv Inv El Up (ft)	93.90
W.S. US. (ft)	96.76	Culv Inv El Dn (ft)	93.82
E.G. DS (ft)	96.60	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	96.33	Culv Exit Loss (ft)	0.10
Delta EG (ft)	0.33	Culv Entr Loss (ft)	0.20
Delta WS (ft)	0.43	Q Weir (cfs)	
E.G. IC (ft)	96.78	Weir Sta Lft (ft)	
E.G. OC (ft)	96.93	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	96.33	Weir Max Depth (ft)	
Culv WS Outlet (ft)	96.33	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.59	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.62	Min El Weir Flow (ft)	98.46

Culvert Output

File Type Options Help

River: River 1 Profile: 50Y Culv Group: Culvert #1

Reach Reach 1 RS: 2565 Plan: ConSpan

Plan: ConSpan River 1 Reach 1 RS: 2565 Culv Group: Culvert #1 Profile: 50Y

Q Culv Group (cfs)	314.30	Culv Full Len (ft)	
# Barrels	2	Culv Vel US (ft/s)	4.51
Q Barrel (cfs)	157.15	Culv Vel DS (ft/s)	4.38
E.G. US. (ft)	96.64	Culv Inv El Up (ft)	93.90
W.S. US. (ft)	96.50	Culv Inv El Dn (ft)	93.82
E.G. DS (ft)	96.38	Culv Frctn Ls (ft)	0.02
W.S. DS (ft)	96.16	Culv Exit Loss (ft)	0.08
Delta EG (ft)	0.26	Culv Entr Loss (ft)	0.16
Delta WS (ft)	0.33	Q Weir (cfs)	
E.G. IC (ft)	96.46	Weir Sta Lft (ft)	
E.G. OC (ft)	96.64	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	96.17	Weir Max Depth (ft)	
Culv WS Outlet (ft)	96.16	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.42	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.44	Min El Weir Flow (ft)	98.46

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: ConSpan River: River 1 Reach: Reach 1 Profile: 100Y

Reload Data

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)	
Reach 1	6777	100Y	135.60	103.78	104.5	104.23	104.56	0.003594	1.58	109.10	232.63	0.33
Reach 1	6304	100Y	135.60	102.77	103.6		103.62	0.001244	0.87	152.83	240.03	0.19
Reach 1	5597	100Y	135.60	101.28	102.3		102.38	0.002747	1.63	99.32	187.59	0.30
Reach 1	5547	100Y	135.60	101.11	102.2		102.26	0.002675	1.59	97.48	178.31	0.30
Reach 1	5477	100Y	135.60	101.23	102.0		102.05	0.004577	1.69	92.19	207.86	0.37
Reach 1	5433	100Y	135.60	101.03	101.8		101.89	0.004092	1.65	89.48	167.81	0.35
Reach 1	5388	100Y	135.60	100.85	101.7		101.75	0.002950	1.48	98.90	166.02	0.30
Reach 1	5350	100Y	135.60	100.78	101.6		101.66	0.002504	1.39	105.13	171.00	0.28
Reach 1	5231	100Y	135.60	100.45	101.0		101.06	0.017157	2.42	59.48	159.62	0.66
Reach 1	4614	100Y	253.90	98.73	99.8		99.77	0.001122	1.04	308.94	528.88	0.19
Reach 1	4347	100Y	253.90	98.16	99.4	99.02	99.41	0.002152	1.62	213.57	362.98	0.27
Reach 1	4166	100Y	253.90	97.72	98.5		98.55	0.012967	2.55	115.71	275.25	0.60
Reach 1	3779	100Y	253.90	96.56	97.8		97.79	0.000826	1.07	331.46	474.99	0.17
Reach 1	3559	100Y	253.90	96.22	97.6		97.57	0.001208	1.31	245.92	304.93	0.21
Reach 1	3385	100Y	375.00	95.86	97.3		97.32	0.000992	1.24	366.95	392.63	0.19
Reach 1	3093	100Y	375.00	95.41	97.2		97.18	0.000398	0.93	508.92	439.66	0.13
Reach 1	2911	100Y	375.00	94.73	97.1		97.10	0.000391	1.14	452.65	336.09	0.13
Reach 1	2811	100Y	375.00	94.45	97.0		97.04	0.000804	1.72	328.69	285.27	0.19
Reach 1	2738	100Y	375.00	94.18	97.0		96.99	0.000403	1.67	344.09	319.26	0.19
Reach 1	2638	100Y	375.00	94.10	96.9		96.96	0.000188	1.19	375.93	254.32	0.13
Reach 1	2582	100Y	375.00	93.91	96.8	95.31	96.92	0.001458	3.24	115.84	239.29	0.34
Reach 1	2565 Fazier Rd		Culvert									
Reach 1	2551	100Y	375.00	93.80	96.3	95.32	96.60	0.002614	4.18	89.74	41.13	0.46
Reach 1	2530	100Y	375.00	93.73	95.9		96.44	0.008210	5.83	69.82	73.66	0.78
Reach 1	2517	100Y	375.00	93.68	95.9	95.63	96.30	0.006815	5.47	79.66	91.39	0.72
Reach 1	2487	100Y	375.00	93.55	95.9		96.05	0.003076	3.90	127.71	138.26	0.49
Reach 1	2349	100Y	375.00	93.39	95.6		95.65	0.002272	3.10	216.03	275.23	0.41
Reach 1	2167	100Y	375.00	93.12	95.1		95.21	0.002522	3.08	227.39	327.75	0.43
Reach 1	1960	100Y	375.00	92.86	94.9		94.91	0.000822	1.89	370.57	424.74	0.25
Reach 1	1708	100Y	375.00	92.61	94.7		94.73	0.000635	1.67	407.47	427.61	0.22
Reach 1	1429	100Y	375.00	92.23	94.4		94.50	0.001125	2.27	304.11	387.50	0.29
Reach 1	1253	100Y	375.00	91.92	94.2		94.28	0.001220	2.34	291.89	381.53	0.31
Reach 1	1078	100Y	375.00	91.59	94.1		94.16	0.000370	1.40	458.60	399.42	0.17
Reach 1	876	100Y	375.00	91.21	94.1	92.50	94.12	0.000117	0.93	652.49	399.66	0.10

Total flow in cross section.

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: ConSpan River: River 1 Reach: Reach 1 Profile: 50Y

Reload Data

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach 1	6777	50Y	113.30	103.78	104.5	104.19	104.50	0.003573	1.49	95.89	219.45	0.32
Reach 1	6304	50Y	113.30	102.77	103.5		103.54	0.001259	0.80	135.61	228.77	0.19
Reach 1	5597	50Y	113.30	101.28	102.3		102.30	0.002700	1.53	86.38	172.86	0.29
Reach 1	5547	50Y	113.30	101.11	102.2		102.19	0.002477	1.46	86.70	156.86	0.28
Reach 1	5477	50Y	113.30	101.23	102.0		101.99	0.004753	1.61	80.06	189.35	0.37
Reach 1	5433	50Y	113.30	101.03	101.8		101.82	0.004147	1.56	78.66	162.03	0.35
Reach 1	5388	50Y	113.30	100.85	101.7		101.68	0.002854	1.37	88.48	160.36	0.29
Reach 1	5350	50Y	113.30	100.78	101.6		101.60	0.002342	1.27	95.14	165.64	0.27
Reach 1	5231	50Y	113.30	100.45	100.9		101.00	0.019363	2.38	50.71	154.44	0.69
Reach 1	4614	50Y	212.60	98.73	99.7		99.69	0.001116	0.98	272.43	501.57	0.19
Reach 1	4347	50Y	212.60	98.16	99.3	98.97	99.34	0.002142	1.54	187.89	350.39	0.27
Reach 1	4166	50Y	212.60	97.72	98.4		98.50	0.012130	2.35	104.93	266.99	0.57
Reach 1	3779	50Y	212.60	96.56	97.7		97.69	0.000919	1.06	284.19	460.57	0.18
Reach 1	3559	50Y	212.60	96.22	97.4		97.45	0.001323	1.28	209.46	285.26	0.21
Reach 1	3385	50Y	314.30	95.86	97.1		97.13	0.001386	1.32	292.51	377.83	0.22
Reach 1	3093	50Y	314.30	95.41	96.9		96.94	0.000545	0.98	405.34	410.16	0.14
Reach 1	2911	50Y	314.30	94.73	96.8		96.83	0.000467	1.14	368.17	296.48	0.14
Reach 1	2811	50Y	314.30	94.45	96.7		96.76	0.000921	1.70	259.05	217.38	0.20
Reach 1	2738	50Y	314.30	94.18	96.7		96.71	0.000470	1.66	265.23	228.67	0.20
Reach 1	2638	50Y	314.30	94.10	96.7		96.67	0.000210	1.17	324.87	223.97	0.13
Reach 1	2582	50Y	314.30	93.91	96.5	95.16	96.63	0.001418	2.99	105.07	224.30	0.33
Reach 1	2565 Fazier Rd		Culvert									
Reach 1	2551	50Y	314.30	93.80	96.2	95.16	96.38	0.002307	3.75	83.80	40.67	0.43
Reach 1	2530	50Y	314.30	93.73	95.8		96.24	0.007289	5.26	64.18	67.10	0.73
Reach 1	2517	50Y	314.30	93.68	95.8		96.13	0.006052	4.95	72.37	84.58	0.67
Reach 1	2487	50Y	314.30	93.55	95.8		95.91	0.002738	3.54	116.26	132.82	0.46
Reach 1	2349	50Y	314.30	93.39	95.5		95.54	0.002228	2.94	188.37	260.87	0.41
Reach 1	2167	50Y	314.30	93.12	95.0		95.10	0.002653	3.01	191.71	303.79	0.44
Reach 1	1960	50Y	314.30	92.86	94.8		94.78	0.000900	1.88	314.40	406.46	0.26
Reach 1	1708	50Y	314.30	92.61	94.6		94.58	0.000678	1.63	347.34	400.32	0.22
Reach 1	1429	50Y	314.30	92.23	94.3		94.32	0.001395	2.35	236.30	339.43	0.32
Reach 1	1253	50Y	314.30	91.92	93.9		93.98	0.002567	2.95	176.83	280.31	0.43
Reach 1	1078	50Y	314.30	91.59	93.5		93.55	0.002186	2.63	209.73	356.63	0.39
Reach 1	876	50Y	314.30	91.21	93.4	92.45	93.37	0.000430	1.42	367.04	350.50	0.18

Total flow in cross section.

CMP Arch Culvert (SC-4)

Culvert Output

File Type Options Help

River: River 1 Profile: 100Y Culv Group: Culvert #1

Reach Reach 1 RS: 2565 Plan: CMP_ARCH

Plan: CMP_ARCH River 1 Reach 1 RS: 2565 Culv Group: Culvert #1 Profile: 100Y

Q Culv Group (cfs)	375.00	Culv Full Len (ft)	
# Barrels	6	Culv Vel US (ft/s)	4.67
Q Barrel (cfs)	62.50	Culv Vel DS (ft/s)	4.72
E.G. US. (ft)	96.95	Culv Inv El Up (ft)	93.90
W.S. US. (ft)	96.78	Culv Inv El Dn (ft)	93.82
E.G. DS (ft)	96.60	Culv Frctn Ls (ft)	0.10
W.S. DS (ft)	96.33	Culv Exit Loss (ft)	0.07
Delta EG (ft)	0.34	Culv Entr Loss (ft)	0.17
Delta WS (ft)	0.45	Q Weir (cfs)	
E.G. IC (ft)	96.54	Weir Sta Lft (ft)	
E.G. OC (ft)	96.95	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	96.44	Weir Max Depth (ft)	
Culv WS Outlet (ft)	96.33	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.98	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.68	Min El Weir Flow (ft)	98.46

Culvert Output

File Type Options Help

River: River 1 Profile: 50Y Culv Group: Culvert #1

Reach Reach 1 RS: 2565 Plan: CMP_ARCH

Plan: CMP_ARCH River 1 Reach 1 RS: 2565 Culv Group: Culvert #1 Profile: 50Y

Q Culv Group (cfs)	314.30	Culv Full Len (ft)	
# Barrels	6	Culv Vel US (ft/s)	4.19
Q Barrel (cfs)	52.38	Culv Vel DS (ft/s)	4.20
E.G. US. (ft)	96.66	Culv Inv El Up (ft)	93.90
W.S. US. (ft)	96.52	Culv Inv El Dn (ft)	93.82
E.G. DS (ft)	96.38	Culv Frctn Ls (ft)	0.08
W.S. DS (ft)	96.16	Culv Exit Loss (ft)	0.06
Delta EG (ft)	0.27	Culv Entr Loss (ft)	0.14
Delta WS (ft)	0.35	Q Weir (cfs)	
E.G. IC (ft)	96.26	Weir Sta Lft (ft)	
E.G. OC (ft)	96.66	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	96.25	Weir Max Depth (ft)	
Culv WS Outlet (ft)	96.16	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.44	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.51	Min El Weir Flow (ft)	98.46

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: CMP_ARCH River: River 1 Reach: Reach 1 Profile: 100Y

Reload Data

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach 1	6777	100Y	135.60	103.78	104.5	104.23	104.56	0.003594	1.58	109.10	232.63	0.33
Reach 1	6304	100Y	135.60	102.77	103.6		103.62	0.001244	0.87	152.83	240.03	0.19
Reach 1	5597	100Y	135.60	101.28	102.3		102.38	0.002747	1.63	99.32	187.59	0.30
Reach 1	5547	100Y	135.60	101.11	102.2		102.26	0.002675	1.59	97.48	178.31	0.30
Reach 1	5477	100Y	135.60	101.23	102.0		102.05	0.004577	1.69	92.19	207.86	0.37
Reach 1	5433	100Y	135.60	101.03	101.8		101.89	0.004091	1.65	89.49	167.81	0.35
Reach 1	5388	100Y	135.60	100.85	101.7		101.75	0.002949	1.48	98.91	166.03	0.30
Reach 1	5350	100Y	135.60	100.78	101.6		101.66	0.002503	1.39	105.15	171.01	0.28
Reach 1	5231	100Y	135.60	100.45	101.0		101.05	0.017188	2.42	59.44	159.61	0.66
Reach 1	4614	100Y	253.90	98.73	99.8		99.77	0.001121	1.04	308.98	528.90	0.19
Reach 1	4347	100Y	253.90	98.16	99.4	99.02	99.41	0.002149	1.61	213.68	363.04	0.27
Reach 1	4166	100Y	253.90	97.72	98.5		98.55	0.013053	2.55	115.45	275.06	0.60
Reach 1	3779	100Y	253.90	96.56	97.8		97.79	0.000822	1.06	332.00	475.15	0.17
Reach 1	3559	100Y	253.90	96.22	97.6		97.58	0.001193	1.30	246.98	305.48	0.21
Reach 1	3385	100Y	375.00	95.86	97.3		97.33	0.000962	1.23	370.64	393.26	0.19
Reach 1	3093	100Y	375.00	95.41	97.2		97.20	0.000385	0.92	514.93	441.52	0.12
Reach 1	2911	100Y	375.00	94.73	97.1		97.11	0.000386	1.14	457.92	344.59	0.13
Reach 1	2811	100Y	375.00	94.45	97.0		97.05	0.000779	1.70	333.66	290.09	0.19
Reach 1	2738	100Y	375.00	94.18	97.0		97.01	0.000397	1.66	349.93	335.96	0.18
Reach 1	2638	100Y	375.00	94.10	97.0		96.98	0.000183	1.18	379.25	258.52	0.13
Reach 1	2582	100Y	375.00	93.91	96.8	95.31	96.94	0.001422	3.21	116.72	240.69	0.34
Reach 1	2565 Fazier Rd		Culvert									
Reach 1	2551	100Y	375.00	93.80	96.3	95.32	96.60	0.002614	4.18	89.74	41.13	0.46
Reach 1	2530	100Y	375.00	93.73	95.9		96.44	0.008210	5.83	69.82	73.66	0.78
Reach 1	2517	100Y	375.00	93.68	95.9	95.63	96.30	0.006815	5.47	79.66	91.39	0.72
Reach 1	2487	100Y	375.00	93.55	95.9		96.05	0.003076	3.90	127.71	138.26	0.49
Reach 1	2349	100Y	375.00	93.39	95.6		95.65	0.002272	3.10	216.03	275.23	0.41
Reach 1	2167	100Y	375.00	93.12	95.1		95.21	0.002522	3.08	227.39	327.75	0.43
Reach 1	1960	100Y	375.00	92.86	94.9		94.91	0.000822	1.89	370.57	424.74	0.25
Reach 1	1708	100Y	375.00	92.61	94.7		94.73	0.000635	1.67	407.47	427.61	0.22
Reach 1	1429	100Y	375.00	92.23	94.4		94.50	0.001125	2.27	304.11	387.50	0.29
Reach 1	1253	100Y	375.00	91.92	94.2		94.28	0.001220	2.34	291.89	381.53	0.31
Reach 1	1078	100Y	375.00	91.59	94.1		94.16	0.000370	1.40	458.60	399.42	0.17
Reach 1	876	100Y	375.00	91.21	94.1	92.50	94.12	0.000117	0.93	652.49	399.66	0.10

Total flow in cross section.

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: CMP_ARCH River: River 1 Reach: Reach 1 Profile: 50Y

Reload Data

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach 1	6777	50Y	113.30	103.78	104.5	104.19	104.50	0.003572	1.49	95.89	219.45	0.32
Reach 1	6304	50Y	113.30	102.77	103.5		103.54	0.001259	0.80	135.62	228.78	0.19
Reach 1	5597	50Y	113.30	101.28	102.3		102.30	0.002700	1.53	86.38	172.86	0.29
Reach 1	5547	50Y	113.30	101.11	102.2		102.19	0.002477	1.46	86.70	156.86	0.28
Reach 1	5477	50Y	113.30	101.23	102.0		101.99	0.004753	1.61	80.06	189.36	0.37
Reach 1	5433	50Y	113.30	101.03	101.8		101.82	0.004147	1.56	78.66	162.03	0.35
Reach 1	5388	50Y	113.30	100.85	101.7		101.68	0.002854	1.37	88.48	160.37	0.29
Reach 1	5350	50Y	113.30	100.78	101.6		101.60	0.002341	1.27	95.15	165.65	0.27
Reach 1	5231	50Y	113.30	100.45	100.9		101.00	0.019376	2.38	50.69	154.43	0.69
Reach 1	4614	50Y	212.60	98.73	99.7		99.69	0.001116	0.98	272.44	501.58	0.19
Reach 1	4347	50Y	212.60	98.16	99.3	98.97	99.34	0.002141	1.54	187.93	350.41	0.27
Reach 1	4166	50Y	212.60	97.72	98.4		98.50	0.012152	2.35	104.87	266.95	0.58
Reach 1	3779	50Y	212.60	96.56	97.7		97.69	0.000918	1.06	284.30	460.61	0.18
Reach 1	3559	50Y	212.60	96.22	97.4		97.45	0.001319	1.27	209.68	285.36	0.21
Reach 1	3385	50Y	314.30	95.86	97.1		97.14	0.001358	1.31	294.51	378.45	0.22
Reach 1	3093	50Y	314.30	95.41	96.9		96.95	0.000528	0.97	409.51	411.10	0.14
Reach 1	2911	50Y	314.30	94.73	96.8		96.84	0.000455	1.14	372.10	298.98	0.14
Reach 1	2811	50Y	314.30	94.45	96.7		96.78	0.000896	1.69	262.40	220.51	0.20
Reach 1	2738	50Y	314.30	94.18	96.7		96.73	0.000461	1.65	268.98	235.80	0.19
Reach 1	2638	50Y	314.30	94.10	96.7		96.69	0.000204	1.15	327.86	225.26	0.13
Reach 1	2582	50Y	314.30	93.91	96.5	95.16	96.65	0.001382	2.97	105.88	226.42	0.33
Reach 1	2565 Fazier Rd		Culvert									
Reach 1	2551	50Y	314.30	93.80	96.2	95.16	96.38	0.002307	3.75	83.80	40.67	0.43
Reach 1	2530	50Y	314.30	93.73	95.8		96.24	0.007289	5.26	64.18	67.10	0.73
Reach 1	2517	50Y	314.30	93.68	95.8		96.13	0.006052	4.95	72.37	84.58	0.67
Reach 1	2487	50Y	314.30	93.55	95.8		95.91	0.002738	3.54	116.26	132.82	0.46
Reach 1	2349	50Y	314.30	93.39	95.5		95.54	0.002228	2.94	188.37	260.87	0.41
Reach 1	2167	50Y	314.30	93.12	95.0		95.10	0.002653	3.01	191.71	303.79	0.44
Reach 1	1960	50Y	314.30	92.86	94.8		94.78	0.000900	1.88	314.40	406.46	0.26
Reach 1	1708	50Y	314.30	92.61	94.6		94.58	0.000678	1.63	347.34	400.32	0.22
Reach 1	1429	50Y	314.30	92.23	94.3		94.32	0.001395	2.35	236.30	339.43	0.32
Reach 1	1253	50Y	314.30	91.92	93.9		93.98	0.002567	2.95	176.83	280.31	0.43
Reach 1	1078	50Y	314.30	91.59	93.5		93.55	0.002186	2.63	209.73	356.63	0.39
Reach 1	876	50Y	314.30	91.21	93.4	92.45	93.37	0.000430	1.42	367.04	350.50	0.18

Total flow in cross section.

Appendix G - Scour Calculations

HDR | WRECO

Frazier Road Bridge 29C-272

SanJoaquin County

Local Scour at Piers - Cohesionless

350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (SI or English) =	English	
Complex Pier Scour? (Yes or No)	No	
Pier Number (Plan)	1	
Pier Number (HEC-RAS)	1	
Pier Scour component		
Water Surface Elevation	96.8	ft
Ground Elevation at Pier	93.9	ft
y1 = Approach flow depth at the beginning of computations =	2.9	ft
V1 = Approach velocity used at the beginning of computations =	3.2	ft/s
a = pier width =	3.6	ft
L = length of pier =	25.0	ft
L/a (if L/a is larger than 12, then use 12 as a maximum	7.02247191	
Θ = angle of attack of flow =	0	degrees
Pier shape	Square nose	
K1 = correction factor for pier nose shape =	1.1	
K2 = correction factor for angle of attack = (cosΘ+(L/a)*sinΘ)^0.65	1.0	
K3 = correction factor for bed condition =	1.1	
D50 = grain size for which 50% of bed material is finer =	0.0033	ft
g = acceleration due to gravity =	32.2	ft/s^2

Yspier = scour component for the pier stem in the flow =

y1*(Khpier*(2*K1*K2*K3*((a/y1)^0.65)*((V1/((g*y1)^0.5))^0.43)) = **5.0** **ft**

HDR | WRECO

Frazier Road Bridge 29C-272

SanJoaquin County

Local Scour at Piers - Cohesive

350

Calculation guideline from HEC-18 5th Edition

ConSpan

Equation 7.35:

$$y_s = 2.2K_1K_2a^{0.65}\left(\frac{2.6V_1 - V_c}{\sqrt{g}}\right)^{0.7}$$

Variable	Value		Description
Pier Number (Plan)	1		
Pier Number (HEC-RAS)	1		
L	25	ft	Pier length
a	3.56	ft	Pier width
L/a	7.02247191		If L/a is larger than 12, then use 12 as a maximum
Θ	0	degrees	Angle of attack of flow
	Square nose		Pier shape
K1	1.1		Correction factor for pier shape
K2	1.0		Correction factor for angle of attack
V1	3.24	ft/s	Approach velocity
Vc	0.1	m/s	critical velocity (from Figure 4.7 in HEC-18)
Vc	0.3	ft/s	critical velocity (from Figure 4.7 in HEC-18)
g	32.2	ft/s^2	
ys	**7.08**	**ft**	**Pier Scour**

HDR | WRECO

Frazier Road Bridge 29C-272

SanJoaquin County

Local Scour at Abutments - NCHRP 350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (Metric or English)	English	

Left Overbank = Abutment x (x)

y1 = Upstream flow depth	2.9	ft
Upstream velocity	3.2	ft/s
Upstream flow	375.0	cfs
Upstream channel width	41.0	ft
Unit discharge (depth x velocity)	9.2	ft2/s
Unit discharge (flow / top width)	9.1	ft2/s
q1 = Upstream unit discharge	9.2	ft2/s
Flow depth through bridge	2.9	ft
Velocity through bridge	5.1	ft/s
Flow through bridge	375.0	cfs
Bridge opening width less pier widths	27.0	ft
Unit discharge (depth x velocity)	14.4	ft2/s
Unit discharge (flow / top width)	13.9	ft2/s
q2 = Unit discharge in the constricted opening	14.4	ft2/s
Abutment scour equation =	**Live-Bed**	

Live-Bed Condition Abutment Scour

$$y_c = y_1 \left(\frac{q_{2c}}{q_1} \right)^{6/7}$$ Equation 8.5

yc = Flow depth including live-bed contraction scour	4.2	ft

Cohesive Condition Abutment Scour

$$y_c = \left(\frac{\gamma}{\tau_c} \right)^{3/7} \left(\frac{n q_{2f}}{K_u} \right)^{6}$$ Equation 8.7

τ_c = Critical shear stress for the floodplain material	0.002	lb/ft^2
n = Manning n of the floodplain material under the bridge	0.035	
γ = Unit weight of water	62.4	lb/ft^3
Ku = 1.486 English units, 1.0 SI units	1.486	

Frazier Road Bridge 29C-272

SanJoaquin County

Local Scour at Abutments - NCHRP 350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (Metric or English)	English	
yc = Flow depth including contraction scour	32.9	ft

$y_{max} = \alpha_A y_c \; or \; y_{max} = \alpha_B y_c$ Equation 8.3

$y_s = y_{max} - y_0$ Equation 8.4

yc = Flow depth including live-bed or clear-water contraction scour	4.2	ft
q2/q1	1.6	
Type of abutment (Wingwall vs Spill-through)	Wingwall	
αA = Amplification factor for live-bed conditions	1.55	
y max = Maximum flow depth resulting from abutment scour	6.5	ft
y0 = Flow depth prior to scour	2.9	ft
ys = Abutment scour depth	**3.6**	ft
Contraction scour component	**2.5**	ft
Local scour component	**1.2**	ft

Note: ys is a combination of local and contraction scour.

Frazier Road Bridge 29C-272

SanJoaquin County

Local Scour at Abutments - NCHRP 350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (Metric or English)	English	

Right Overbank = Abutment x (x)

y1 = Upstream flow depth	2.9	ft
Upstream velocity	3.2	ft/s
Upstream flow	375.0	cfs
Upstream channel width	239.3	ft
Unit discharge (depth x velocity)	9.2	ft2/s
Unit discharge (flow / top width)	1.6	ft2/s
q1 = Upstream unit discharge	9.2	ft2/s
Flow depth through bridge	2.9	ft
Velocity through bridge	5.1	ft/s
Flow through bridge	375.0	cfs
Bridge opening width less pier widths	27.0	ft
Unit discharge (depth x velocity)	14.4	ft2/s
Unit discharge (flow / top width)	13.9	ft2/s
q2 = Unit discharge in the constricted opening	14.4	ft2/s
Abutment scour equation =	**Live-Bed**	

Live-Bed Condition Abutment Scour

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$ Equation 8.5

yc = Flow depth including live-bed contraction scour	4.2	ft

Cohesive Condition Abutment Scour

$$y_c = \left(\frac{\gamma}{\tau_c}\right)^{3/7}\left(\frac{nq_{2f}}{K_u}\right)^{6}$$ Equation 8.7

τ_c = Critical shear stress for the floodplain material	0.004	lb/ft^2
n = Manning n of the floodplain material under the bridge	0.035	
γ = Unit weight of water	62.4	lb/ft^3
Ku = 1.486 English units, 1.0 SI units	1.486	

Frazier Road Bridge 29C-272

SanJoaquin County

Local Scour at Abutments - NCHRP 350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (Metric or English)	English	
yc = Flow depth including contraction scour	23.9	ft

$y_{max} = \alpha_A y_c \; or \; y_{max} = \alpha_B y_c$ Equation 8.3

$y_s = y_{max} - y_0$ Equation 8.4

yc = Flow depth including live-bed or clear-water contraction scour	4.2	ft
q2/q1	1.6	
Type of abutment (Wingwall vs Spill-through)	Wingwall	
αA = Amplification factor for live-bed conditions	1.55	
y max = Maximum flow depth resulting from abutment scour	6.5	ft
y0 = Flow depth prior to scour	2.9	ft
ys = Abutment scour depth	**3.6**	ft
Contraction scour component	**2.5**	ft
Local scour component	**1.2**	ft

Note: ys is a combination of local and contraction scour.

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Frazier Road Bridge 29C-272

SanJoaquin County

Contraction Scour

350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (SI or English)	English	
Ku = constant = 6.19 (SI) or 11.17 (English)	11.17	
g = acceleration due to gravity =	32.2	ft/s^2

Channel

Vchannel = Mean velocity of flow in main channel just upstream of bridge =	3.2	ft/s
D50channel = grain size in channel for which 50% of bed material is finer =	0.0033	ft
Yochannel = existing depth in the contracted channel section before scour =	2.9	ft
Ychannel = depth of flow just upstream of bridge in channel =	2.8	ft
VcD50channel = Ku*(Ychannel^(1/6))*(D50channel^(1/3))	2.0	ft/s
Contraction scour equation for channel =	**Live-Bed**	

Live-Bed

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$ Equation 6.2

$$y_s = y_2 - y_o$$ Equation 6.3

Q1 channel = Flow in the upstream channel transporting sediment =	375.0	ft^3/s
Q2 channel = Flow in the contracted channel = transporting sediment =	375.0	ft^3/s
W1 channel = bottom or top width (consistent with W2 definition) of the upstream channel that is transporting bed material =	41.0	ft
W2 channel = bottom or top width (consistent with W1 definition) of the contracted channel section less pier widths =	27.0	ft
ω channel = fall velocity of bed material based on D50 =	0.42	ft/s
S channel = slope of energy grade line in main channel =	0.00146	ft/ft
V* channel = shear velocity in the upstream channel section = (Ychannel*g*S channel)^.5 =	0.4	ft/s
V* channel/ω channel =	0.9	
k1 channel = (if V*/ω <0.5, 0.59, if(0.5<=V*/ω<=2,0.64,0.69)) =	0.69	
Y2channel = average depth in contracted section after scour = Ychannel*((Q2 channel/Q1 channel)^(6/7))*((W1 channel/W2 channel)^k1 channel) =	3.8	ft
Ys channel = Y2 channel - Yo channel =	**0.9**	**ft**

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Frazier Road Bridge 29C-272

SanJoaquin County

Ultimate (Contraction) Scour

350

Calculation guideline from HEC-18 5th Edition
ConSpan

Equation 6.7:

$$\tau = \gamma \left(\frac{V_2 n}{K_U} \right)^2 {y_0}^{-1/3}$$

Variable	English Units		Metric Units		Description
τ	0.6	lb/ft^2	29.9	N/m^2=Pa	initial shear stress for a specific flow
g	62.4	lb/ft^3	9800	N/m^3	unit weight of water (62.4 lb/ft^3 and 9800 N/m^3)
V_2	5.1	ft/s	1.5	m/s	average velocity in contracted section
n	0.035		0.035		Manning's roughness coefficient
K_u	1.486		1		1.486 for U.S. Customary, and 1.0 for S.I.
y_o	2.8	ft	0.9	m	Upstream flow depth
τ_c	0.004	lb/ft^2	0.21	N/m^2=Pa	Critical shear stress (from Figure 6.11)
CHECK	Contraction scour will occur				If initial shear stress exceeds critical value, then contraction scour will occur during that flow period, and the ultimate scour is computed from Equation 6.6.

Equation 6.6:

$$y_{s-ult} = 0.94 y_1 \left(\frac{1.83 V_2}{\sqrt{g y_1}} - \frac{K_u \sqrt{\frac{\tau_c}{\rho}}}{g n y_1^{1/3}} \right)$$

Variable	English Units		Metric Units		Description
y_1	2.8	ft	0.9	m	Upstream average flow depth
V_2	5.1	ft/s	1.5	m/s	Average velocity in contracted section
τ_c	0.00		0.21	N/m^2=Pa	Critical shear stress of channel bed material
n	0.035		0.035		Manning's roughness coefficient
K_u	1.486		1		1.486 for U.S. Customary, and 1.0 for S.I.
ρ	1.9	slugs/ft^3	1000	kg/m^3	Density of water
g	32.2	ft/s^2	9.81	m/s^2	acceleration due to gravity
D_{50}			1	mm	grain size for which 50% of bed material is finer
y_{s_ult}	2.5	ft	0.7	m	Ultimate contraction scour

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Frazier Road Bridge 29C-272

SanJoaquin County

Contraction Scour for Open-Bottom Culvert

350

Calculation guideline from HEC-18 5th Edition

ConSpan

Units = (SI or English)	English	
g = acceleration due to gravity =	32.2	ft/s^2

Channel: Clear-Water Equation

Q = Discharge through culvert associated with the width W =	**375**	ft^3/s
QBI = Discharge blocked by road embankment on one side of the culvert	**151.8**	ft^3/s
y1 = depth of flow at abutment on the overbank or in the main channel =	2.86	ft
L' = length of active flow obstructed by the embankment =	37.90	ft
Ae = flow area of the approach cross section obstructed by the embankment =	54.20	ft^2
Ve = flow velocity = Qe/Ae =	5.05	ft/s
W = Width of the culvert	**27.0**	ft
Vchannel = Mean velocity of flow in main channel just upstream of bridge =	**3.24**	ft/s
D50channel = grain size in channel for which 50% of bed material is finer =	0.0033	ft
Yochannel = existing depth in the contracted channel section before scour =	**2.83**	ft

Clear Water Equation - Without Wingwall

Ku = constant = 0.57 (English) or 0.88 (SI) =	0.57	
Ymax = Flow depth at culvert entrance corner including contraction and local scour	15.85	ft
Ys channel = Ymax channel - Yo channel =	**13.0**	**ft**

Clear Water Equation - With Wingwall

Ku = constant = 0.84 (English) or 1.16 (SI) =	0.84	
Ymax = Flow depth at culvert entrance corner including contraction and local scour	11.15	ft
Ys channel = Ymax channel - Yo channel =	**8.3**	**ft**

Frazier Road Bridge 29C-272
San Joaquin County
Riprap Apron
Calculation guideline from FHWA HEC-14 3rd Edition Chapter 10 (Page 10-16/217 of 287)
100-year Flow

		Two 14'x3' RCB	Two ConSpan 16'x3.5'	Five CMP Arch	Four 7'x3' RCB	
D	Culvert diameter (circular) Rise	6.5	7.5	2.5	6.5	ft
Q	Design discharge	187.5	187.5	75	93.75	ft^3/s
g	Acceleration due to gravity	32.2	32.2	32.2	32.2	ft/s^2
TW	Depth downstream/tailwater depth	2.3	2.5	2.5	2.5	ft
	Critical depth	1.8	1.6	1.7	1.8	ft
Tailwater depth should be limited to between 0.4D and 1.0D. If tailwater is unknown, use 0.4D.						
Is tailwater depth known?		yes	yes	yes	yes	*<<yes or no*
	Tailwater check	not within range	not within range	not within range	not within range	
	Adjusted TW	2.6	3.0	1.0	2.6	ft
If flow is supercritical in the culvert, the culvert diameter is adjusted as follows:						
Is culvert flow supercritical?		no	no	no	no	*<<yes or no*
yn	Normal (supercritical) depth in the culvert					ft
D'	Adjusted culvert rise					ft

Assumes that the rock specific gravity is 2.65. If the actual specific gravity differs significantly from this value, the D50 should be adjusted inversely to specific gravity.

D_{50}	Riprap size	0.7	0.5	1.9	0.3	ft
D_{50}	Riprap size	8.1	5.8	22.7	3.2	inch
	Median particle diameter (inches)	**9**	**6**	**24**	**6**	inch
	Median particle weight	**60 lb**	**20 lb**	**1/2 ton**	**20 lb**	
	RSP class	**II**	**I**	**VII**	**I**	
	Minimum layer thickness	**1.5**	**1.0**	**4.0**	**1.0**	ft
	Placement method	**B**	**B**	**A or B**	**B**	

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Frazier Road Bridge 29C-272
San Joaquin County
Estimating Scour at Culvert Outlets
Calculation guideline from FHWA HEC-14 3rd Edition Chapter 5 (Page 5-1/54 of 287)
100-year Flow

Scour for cohesionless soils		Two 14'x3' RCB	Two ConSpan 16'x3.5'	Five CMP Arch	Four 7'x3' RCB	
D	Culvert diameter (circular) (total Span)	28.0	32.0	22.0	28.0	ft
D_{84}	Channel bed particle size	5.0	5.0	5.0	5.0	mm
D_{16}	Channel bed particle size	1.0	1.0	1.0	1.0	mm
σ*	Material standard deviation	1.9	1.9	1.9	1.9	
Q	Discharge	375.0	375.0	375.0	375.0	cfs
g	Acceleration of gravity	32.2	32.2	32.2	32.2	ft/s^2
Rc	Hydraulic radius at the end of the culvert (assuming full flow)	1.2	1.4	1.0	1.1	ft
t**	Time of scour	5.0	5.0	5.0	5.0	minute
Hd	Culvert invert height above the bed ratio for slopes > 0%	2.0	2.0	1.0	1.0	ft
S	Culvert slope	0.0	0.0	0.0	0.0	%
α	Culvert outlet scour coefficient (Table 5.1)	2.27	2.27	2.27	2.27	
β	Culvert outlet scour coefficient (Table 5.1)	0.39	0.39	0.39	0.39	
θ	Culvert outlet scour coefficient (Table 5.1)	0.06	0.06	0.06	0.06	
Ch	Drop height adjustment coefficient (Table 5.3)	1.26	1.26	1.22	1.22	
Cs	Slope correction coefficient (Table 5.2)	1.00	1.00	1.00	1.00	
hs	Depth of scour	**9.3**	**9.4**	**9.0**	**9.0**	ft

Notes:

* The bed-material grain-size distribution is determined by performing a sieve analysis (ASTM DA22-63). The values of D84 and D16 are extracted from the grain size distribution. If σ <1.5, the material is considered to be uniform. If σ >1.5, the material is classified as graded. Typical values for σ are 2.10 for gravel and 1.87 for sand.

** The time of scour is estimated based upon knowledge of peak flow duration. Lacking this knowledge, it is recommended that a time of 30 minutes be used in Equation 5.1. The tests indicate that approximately 2/3 to 3/4 of the maximum scour depth occurs in the first 30 minutes of the flow duration. The exponents for the time parameter in Table 5.1 reflect the relatively flat part of the scour-time relationship (t > 30 minutes) and are not applicable for the first 30 minutes of the scour process.

Frazier Road Bridge 29C-272
San Joaquin County
Riprap Apron
Calculation guideline from FHWA HEC-14 3rd Edition (Page 10-16/217 of 287)
100-year Flow

Scour for cohesive soils for other shaped culverts		Two 14'x3' RCB	Two ConSpan 16'x3	Five CMP Arch	Four 7'x3' RCB	
ye	Equivalent depth	6.5	7.5	2.5	6.5	ft
A	Cross-sectional area of flow	84.0	112.0	12.2	84.0	ft^2
V	Mean outlet velocity	5.88	4.92	4.72	5.43	ft/s
Sv	Saturated shear strength	418	418	418	418	lb/ft^2
PI	Plasticity index from the Atterberg limits	5.5	5.5	5.5	5.5	
α_u	Unit conversion constant	180	180	180	180	lb/ft^2
τc	Critical tractive shear stress	0.49	0.49	0.49	0.49	lb/ft^2
ρ	Fluid density of water	1.94	1.94	1.94	1.94	$slugs/ft^3$
t**	Time of scour	5.0	5.0	5.0	5.0	minute
Hd	Culvert invert height above the bed ratio for slopes > 0%	0.0	0.0	0.0	0.0	ft
S	Culvert slope	0.0	0.0	0.0	0.0	%
β	Culvert outlet scour coefficient (Table 5.4)	0.18	0.18	0.18	0.18	
θ	Culvert outlet scour coefficient (Table 5.4)	0.10	0.10	0.10	0.10	
α_e	Culvert outlet scour coefficient (Table 5.4)	1.37	1.37	1.37	1.37	
Ch	Drop height adjustment coefficient (Table 5.3)	1.00	1.00	1.00	1.00	
Cs	Slope correction coefficient (Table 5.2)	1.00	1.00	1.00	1.00	
hs	Depth of scour	**14.2**	**15.4**	**5.0**	**13.8**	ft

Notes:

* This equation is limited to sandy clay soils with a plasticity index of 5 to 16.

** The time of scour is estimated based upon knowledge of peak flow duration. Lacking this knowledge, it is recommended that a time of 30 minutes be used in Equation 5.1. The tests indicate that approximately 2/3 to 3/4 of the maximum scour depth occurs in the first 30 minutes of the flow duration. The exponents for the time parameter in Table 5.1 reflect the relatively flat part of the scour-time relationship (t > 30 minutes) and are not applicable for the first 30 minutes of the scour process.