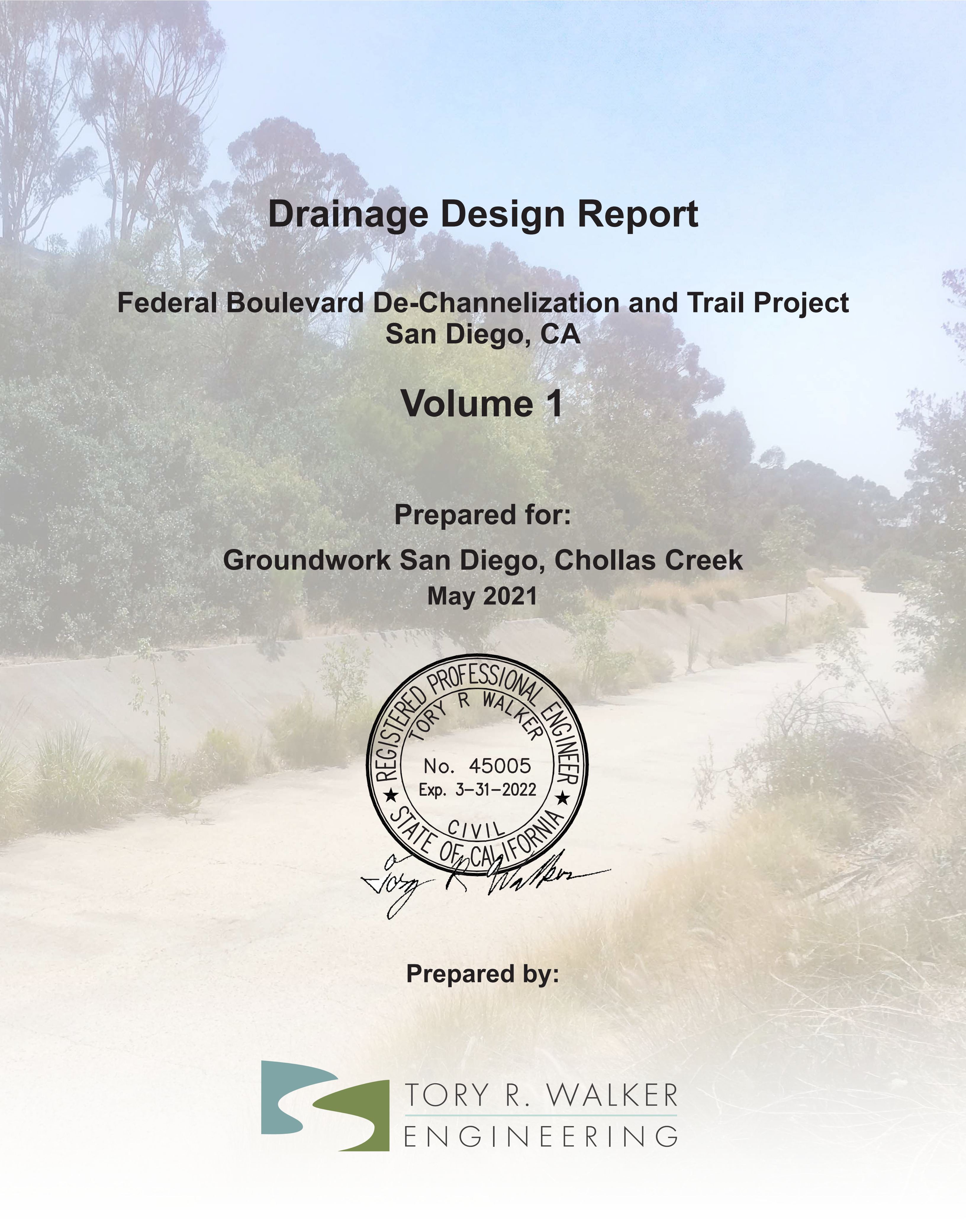

Drainage Design Report

Federal Boulevard De-Channelization and Trail Project
San Diego, CA

Volume 1

Prepared for:

Groundwork San Diego, Chollas Creek

May 2021

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TABLE OF CONTENTS

VOLUME 1

TABLE OF CONTENTS
(CONTINUED)

VOLUME 2

Appendices

Drainage Design Report
Federal Boulevard De-Channelization and Trail Project
San Diego, CA

1. Introduction

1.1 Purpose

The City of San Diego's Chollas Creek Enhancement Program has identified this project area as one that will benefit from habitat restoration and the development of a trail system, with the goal of both improving water quality and quality of life. Consistent with that goal, the purpose of this project is then to restore natural creek functions and augment recreational spaces that connect communities to the emerging Chollas Creek Watershed Regional Park. The outcome will be improved water quality and reduced high volume flooding.

Chollas Creek is in an urbanized watershed, where much of the creek has been channelized or put into underground culverts. As a result, many of the natural benefits of the creek have been reduced, including water quality improvement via natural filtration, groundwater recharge, and habitat. The existing concrete channel does not contain a 100-year flood event; the channel design proposed for this project will have the capacity to convey a 100-year flood flow.

Channelization reduces opportunities for neighborhood recreation and enjoyment. This project proposes to remove the existing concrete channel and nonnative plant species along the banks in this reach of Chollas Creek. These will be replaced with a natural bottom creek bed and native vegetation. In addition, a recreational trail with native plant landscaping will be installed alongside the creek.

1.2 Key Participants

Groundwork San Diego (Groundwork) is a non-profit organization whose mission is to improve the Chollas Creek Watershed. The project design and construction phases have been funded through competitive grants awarded to Groundwork. Project design is funded through DWR's IRWM program, and the design and Phase 1 of the construction is funded by the California Natural Resources Agency (CNRA). The drainage channel in the project area is primarily the property of the City of San Diego, with Caltrans owning a portion of the channel.

2. Existing Conditions

2.1 Project Location

The Chollas Creek channel section currently proposed for de-channelization runs parallel to Federal Boulevard to the north and is located between Home Avenue on the west and the Highway I-805 to SR-94 connector to the east. The project is located in the city of San Diego community of City Heights, an area characterized as a Disadvantaged Community according to the California Department of Water Resources DAC Mapping Tool. The area is also identified as "park-poor" according to the San Diego Foundation's Parks for Everyone report, and in need of recreational opportunities for local residents.

Figure 1: Project Location

2.2 Site History

The current channel was constructed in approximately 1966 when Caltrans built Highway 94. That required moving Federal Boulevard north to allow for freeway interchanges between SR-94 and I-805. This resulted in constructing a realigned concrete lined trapezoidal channel for Chollas Creek through this area. Portions of the existing channel are seen in **Figures 2, 3 and 4** below.

Figure 2: Existing Channel - Upstream

2.3 Existing Facilities

This section of Chollas Creek is a concrete-lined trapezoidal channel. Upstream, the creek exits a concrete box culvert passing under I-805; at the downstream portion of the proposed project, the Home Avenue channel enters Chollas Creek just east of Home Avenue (see **Figure 4**). The previous Federal Boulevard alignment used to cross the creek over a reinforced concrete box (RCB), which impedes high volume flows (see **Figure 3**).

Old Federal Boulevard RCB to be removed

Figure 3: Existing Channel - Downstream

Figure 4: Existing Home Avenue Channel at Confluence

2.4 Data Sources

Data was obtained from the following agencies:

- City of San Diego - Survey information, as-builts for sewers and water mains
- Caltrans - Highway 94 topography, storm drains, bridge plans
- Utilities - AT&T conduits

All of this data has been used to inform the proposed design, including consideration of horizontal and vertical constraints, and transitions both upstream and downstream.

2.5 Existing FEMA Floodway/Floodplain

The hydraulic analysis of Chollas Creek begins upstream at the RCB outfall into the existing concrete open channel located just east of the State Route 94 on-ramp to Interstate 805; the analysis ends downstream where Home Avenue crosses over the existing concrete channel. The hydraulic analysis also includes a portion of the Home Avenue Channel, located immediately east of Home Avenue, which confluences with Chollas Creek just before the Home Avenue crossing.

Flood Insurance Rate Maps (FIRMs) covering the site are Map Numbers 06073C1901G and 1903H, both dated December 20, 2019. The FIRMs delineate a Zone AE floodplain, a regulatory floodway, and a 500-year floodplain along this portion of the creek. The section of Chollas Creek included in this analysis is located approximately between FEMA's Flood Insurance Study (FIS) Cross Sections T and Q. The section of Home Avenue Channel analyzed is between FIS Cross Sections A and B. See **Figure 5** below.

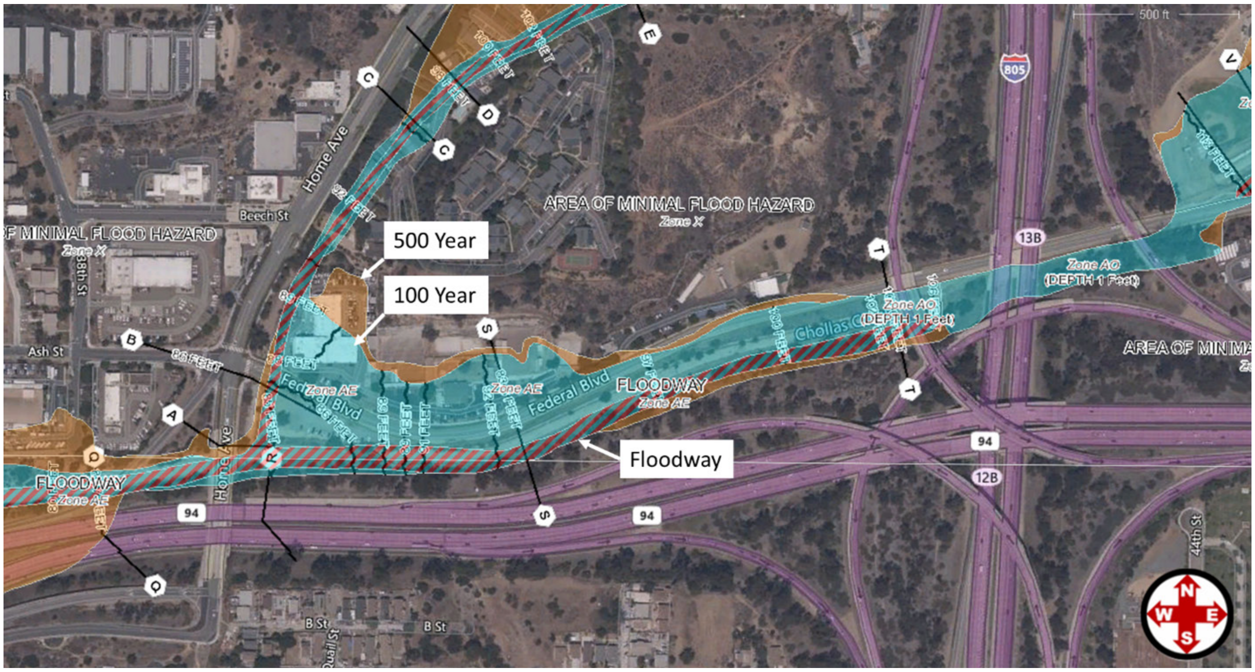


Figure 5: FEMA Zones

3. Proposed Channel Modifications

3.1 Investigations and Results

3.1.1 Topography

For this project, we had Gold Coast Surveying profile the existing concrete channel, visible utilities, measure the existing RCB, and take cross sections of the upstream and downstream portions of the project. The topography and field survey data was provided by the surveyors in National Geodetic Vertical Datum of 1929 (NGVD29, also referred to as Mean Sea Level vertical datum).

3.1.2 Sewer Utilities

To reduce risk of storm flows entering the sanitary sewer and to accommodate the proposed channel cross section, the proposed project includes removal of an existing sewer manhole (MH) on the south side of the channel (Station 29+00) and re-construction of the 8-inch sewer lateral in its place. The old Federal Boulevard RCB crossing of Chollas Creek is currently used by the City to access the MH for the 8-inch sewer lateral. The old RCB is a significant obstruction to flow, and removing it will provide a channel that contains the 100-year design storm.

Eliminating the RCB and City access to the MH means modifying the sewer lateral so that City access is no longer needed. We are proposing the southside MH be replaced with a sweep/ vertical curve as shown on the improvement plans. The vertical curve is designed to bring the sewer line below the stone layer of the proposed channel. The relocation will consist of 60 linear feet of 8-inch vitrified clay pipe (VCP), concrete encased**.** Existing sewer locations, invert elevations, slopes, and manholes were obtained from as-built drawings.

3.1.3 AT&T Utilities

Our utility location research indicated a potential AT&T utility line crossing underneath the existing concrete channel. Plan sheets showing the location of AT&T lines in the project area were therefore obtained from AT&T and reviewed. After discussion with AT&T staff, we confirmed that a live fiber optic conduit bundle runs underneath the channel. Starting from the north side of the channel, the conduit bundle heads south from AT&T manhole #5719 (**Figure 6**), runs underneath the channel, and continues underground towards SR-94. The conduit bundle crosses the channel at approximately channel centerline Station 33+75.

Further investigation did not produce any elevation data for the cable, and AT&T staff were unable to confirm the depth. Therefore, we contracted with AirX Utility Surveyors to perform a field investigation using duct rodding to establish vertical conduit locations. The accuracy for duct rodding measurements is typically on the order of 3 to 6 inches or less. Based on the depth measurements from the duct rodding, the conduit bundle was determined to be approximately 1 to 1.5 feet below the existing channel bottom (**Figure 7**).

We then consulted with AT&T staff to determine possible relocation options for the conduit bundle. Relocating the conduit was determined to be incompatible with the overall project's schedule. As an alternative to relocating, AT&T staff suggested excavating beneath the conduit bundle along its length, and allowing it to sag. Based on field experience from the AT&T staff, they estimated that the conduit bundle could be sagged at approximately 3-feet at the center of the sag, which provided enough clearance to accommodate a modified version of the proposed channel profile and cross section at this location. The proposed conduit sagged profile and channel cross section are shown in the improvement plans. As recommended by AT&T, reinforced concrete will be placed over the conduit bundle after it is sagged into place. Prior to demolition and construction, the contractor will pothole the AT&T conduit bundle to confirm precise location and depth of the conduit.

Figure 6: AT&T Manhole #5719

Figure 7: Markout from Duct-Rodding

3.1.4 Geotechnical Investigation

Our team selected Ninyo & Moore (N&M) for the geotechnical investigation. They developed a plan and obtained required permits for the project. Borings were done on each side of the channel (**Figure 8**) and in the channel bottom (**Figure 9**). Additionally, N&M provided boring data from previous projects that are adjacent to the project site.

Analysis of the subsurface borings determined that the project area is underlain by fill from the Highway 94 construction, younger alluvium, and materials of the San Diego Formation. Groundwater was not encountered in the subsurface investigation but may be present during the wet season. The liquefaction analysis concluded that liquefaction-induced settlement is not a major hazard for the project site, with differential settlements of approximately ¼-inch.

During construction of the proposed retaining wall on the south side of the channel, temporary backcut slopes of 1:1 (horizontal to vertical) are acceptable in the San Diego Formation and older highway fill material. For the proposed slope improvements and temporary slope conditions, the slope stability analysis found adequate factors of safety and determined that the project will not destabilize the ascending slope and SR-94 on the south of side of the channel.

Figure 8: Boring Equipment

Figure 9: Channel Bottom Boring

3.1.5 Retaining Wall Selection

The proposed natural channel must be wider and deeper than the existing concrete channel to convey the design storm peak flow. This extra width will require an earth retaining structure along the south side, adjacent to the Caltrans right-of-way. The retaining wall was incorporated into the design to increase flow capacity of the channel and reinforce the slope along SR-94. Three wall types were considered: standard cast in place reinforced concrete, sheet piling, and concrete modular block (gravity wall). The sheet piling option was eliminated due to aesthetics, as one of the purposes of the project was to enhance the neighborhood.

The project team ultimately selected the modular block gravity wall (Enviro-Block retaining wall system, **Figure 10**) because of several advantages over the other wall types. The installed cost of the Enviro-Block wall was estimated to be approximately 40% less than a cast-in-place reinforced concrete wall. Ease of construction and construction time are considerably less than a cast-in-place reinforced concrete wall because the blocks are precast and can be installed and backfilled in the same day. The blocks also have longer service life because they 1) do not use steel reinforcement (corrosion is not an issue), 2) do not hold water in the backfill as water escapes freely from joints between blocks, and 3) are a flexible structure which can accept some settlement without compromising structural integrity.

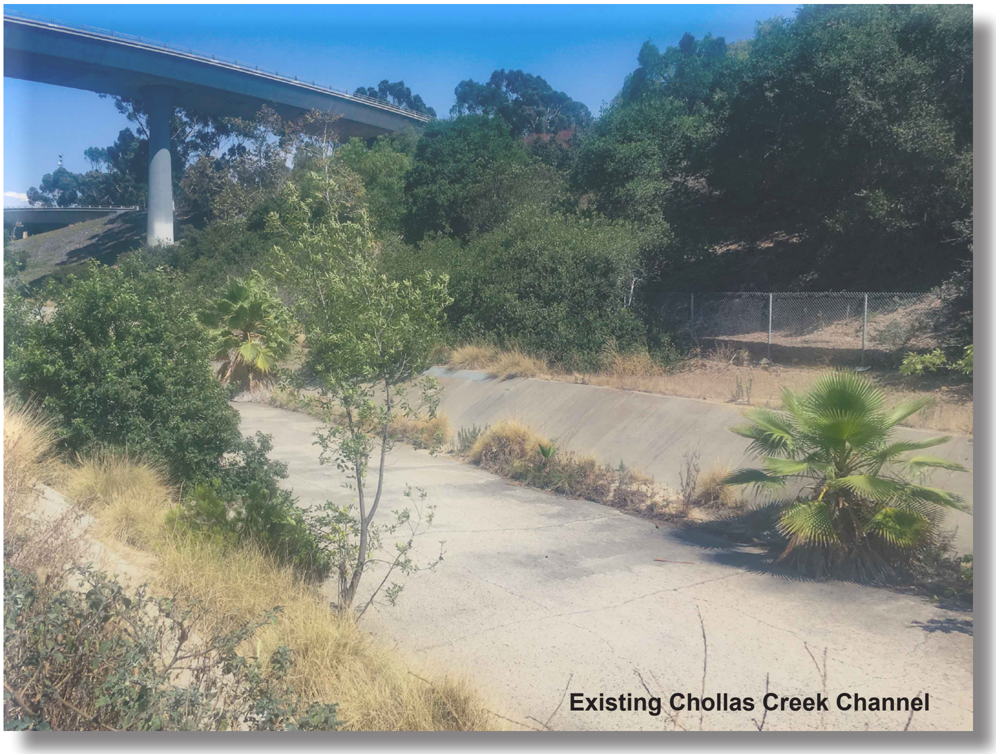
Finally, the project team considered the aesthetic benefits of the Enviro-Blocks to be superior, as they can be manufactured with a natural looking stone face finish which blends better with the stone lined channel and natural vegetated slopes. Furthermore, as graffiti is a significant issue in the vicinity of the project, the segmented nature of the block system and the rough face finish will be less susceptible to graffiti than the uniform surface of reinforced concrete or sheet piling.

Figure 10: Typical Enviro-Block Wall Installation

3.1.6 Spillway, Drop Structure Selection

At the upstream end of the proposed channel, a reinforced concrete spillway is proposed as a transitional structure to safely convey flow from the existing concrete trapezoidal channel into the proposed natural channel. The proposed spillway matches the existing channel flowline at the top and then slopes downward at 3:1 (H:V) to meet the proposed channel bottom. Concrete warped walls on both sides of the spillway will transition from the existing concrete channel banks to the restored channel bank on the north side and the gravity block retaining wall on the south side. The vertical drop of the spillway is 5 feet. At the base of the spillway is a 1.85-foot high concrete sill and two-ton stone, modeled after a US Bureau of Reclamation design, causing a hydraulic jump to subcritical flow. This reduced velocity flow then enters the proposed 40-foot long stone energy dissipator composed of one-ton stone. Calculations for the energy dissipator length and stone sizing are included in the **Section 4.3** and the **Appendix**.

Downstream from the spillway, four stone drop structures are proposed along the channel length. The drop structures dissipate energy and will allow the proposed channel to have a shallow uniform slope along the entire reach, reducing flow velocities and allowing the use of appropriately sized stone for the channel. Stone sizing is discussed in **Section 4.3**.


Existing Chollas Creek Channel

3.2 Proposed Channel Cross Sections

The reach of Chollas Creek for this project is currently a concrete lined trapezoidal channel, with a top width of about 50 feet, bottom width of 28 feet, and depth of 6.5 feet. The length of the channel project is about 2,100 feet. About 1,885 feet of this concrete channel will be removed and replaced with stone and vegetation on the bottom and north side slope. The southern edge of the channel will be an interlocking stacked concrete block retaining wall with a roughened finish (**Figure 11**). Transition structures between the natural channel and the existing concrete channel will be constructed at each end of the project. To convey the 100-year design storm, the proposed channel will be wider than the existing channel. To lower flow velocities, the channel bed will be flattened by using a series of natural stone drop structures.

With the existing channel, Federal Boulevard will be flooded in the 100-year storm, due primarily to a flow constriction at the old Federal Boulevard RCB crossing. This proposed project will remove the RCB. By widening the channel to the Caltrans right-of-way on the south side with a retaining wall, extra capacity is provided.

The HEC-RAS models contain two reaches: Chollas Creek and the Home Avenue Channel. The Chollas Creek cross sections from Station 4261.38 upstream to 2375.43 downstream were drawn according to the proposed grading plans. Portions of cross sections that lie outside of the grading plan limits were drawn using the existing topography.

The remaining cross sections within the Chollas Creek and Home Avenue reaches remain unchanged from the existing condition cross sections.

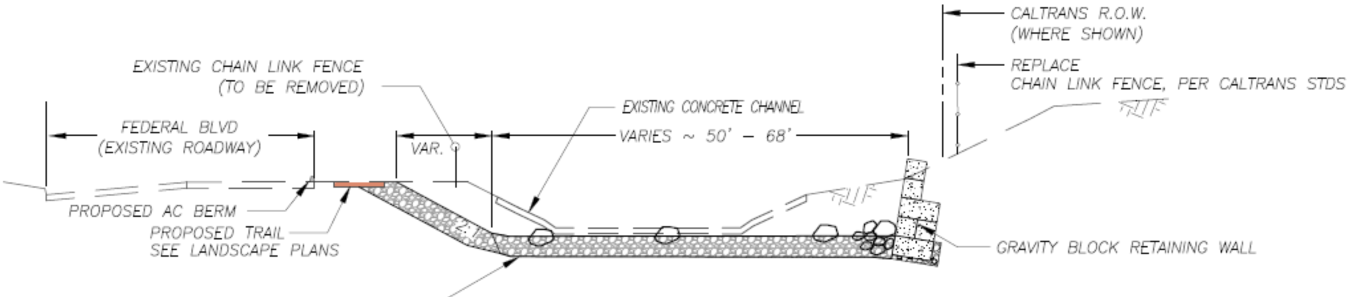


Figure 11: Typical Section of Proposed Project (Looking Upstream/East)

3.3 Proposed Drainage Features

Natural stone will be placed in the channel bottom and on the north side slope to form a more natural channel in function and appearance. The channel bottom will also have larger, imported natural stone spaced throughout to encourage a meandering type of flow and to provide even more stability to the creek.

3.4 Proposed Floodplain/Floodway Conditions

According to FEMA regulations and City floodplain ordinances for development within a Zone AE with a floodway, the hydraulic model must show that water surface elevations during the 100-year storm for this project can tie in upstream and downstream within 0.5 feet, and not increase by more than one foot along the length of the project. Furthermore, the proposed project should not increase the regulatory floodway water surface elevations. The effective FIRM for this reach of Chollas Creek maps an effective 100-year floodplain, regulatory floodway, and a 500-year floodplain. The regulatory floodway and 500-year floodplain were not included in this analysis but will be included with the Conditional Letter of Map Revision (CLOMR) request to FEMA.

Existing Chollas Creek Channel

4. Methodology, Calculations, and Results

4.1 Hydrology

The effective FEMA Flood Insurance Study (FIS) 06073CV002E, dated December 20, 2019, lists peak flow rates for the 10-year, 50-year, and 100-year storm at Chollas Creek and Home Avenue. Flow rates for the 2-year, 5-year, and 25-year storm events were estimated by interpolating NOAA 14 precipitation frequency estimates. These flow rates are listed below in **Table 1**. The higher frequency storm events were added to this study in order to assess sediment transport within the channel.

Table 1: Summary of Peak Flows

Location	Peak Discharge (cfs)				
	2-year	5-year	10-year	50-year	100-year
Chollas Creek	1,050	1,225	1,500	2,800	3,500
Home Avenue Channel	360	420	430	950	1,200

4.2 Hydraulics

This reach of Chollas Creek was analyzed using the US Army Corps of Engineers' Hydrologic Engineering Center - River Analysis System (HEC-RAS). HEC-RAS is an industry standard program that generates water surface profiles and flow velocities. HEC-RAS version 5.0.7 was used for the hydraulic analysis.

We used a one-dimensional (1D) model within HEC-RAS to design the proposed creek rehabilitation, based primarily on average channel velocities and water surface elevations in the channel reach. Since channel flow is only in one direction, we determined that a 1D model was more appropriate than a 2D model for this project.

The Home Avenue Channel confluences with Chollas Creek just downstream of the proposed channel improvements. An additional 1,200 cfs from Home Avenue Channel is added to Chollas Creek at the confluence. The Home Avenue Channel was modeled as a separate reach and connected to the main Chollas Creek reach with a junction node in the model. The junction node accounts for additional hydraulic losses at the confluence and calculates the water surface elevation through the junction.

4.2.1 Effective Model

This drainage design report does not include a FEMA effective model. A data request was sent to FEMA on November 24, 2020. All applicable models will be included with a CLOMR application to FEMA. The models presented in this report are in support of the proposed design.

4.2.2 Existing Condition

Methodology and Calculations

The existing condition HEC-RAS hydraulic model was produced using existing topography to draw each cross section (**Table 2** below). The details for the existing RCB along Chollas Creek at Cross Section 2587.43 were created using as-built drawings and the surveyor's notes. Cross section locations are shown on **Figure 12** below. Detailed sections are shown on the plans.

The Manning's n coefficient for the existing concrete channels along Chollas Creek and Home Ave is 0.015. The values for the existing banks vary between 0.03, and 0.04 for natural, vegetated areas along the banks. A value of 0.02 was assigned to natural areas along the banks without vegetation. Refer to the HEC-RAS cross section results in **Appendix A** for the existing condition Manning's n values.

The 100-year starting water surface elevation (WSEL) in the FIS effective model was used for the downstream boundary condition at Cross Section 1900. The starting water surface elevation is 81.1 (NGVD 29) at HEC-RAS Cross Section 1900. The existing condition HEC-RAS file names are listed in the table below.

Table 2: Files

Existing HEC-RAS Model	
File:	388-07 Federal Blvd.prj
Project:	Federal Blvd
Plan:	EX
Geometry:	EX
Flow:	EX

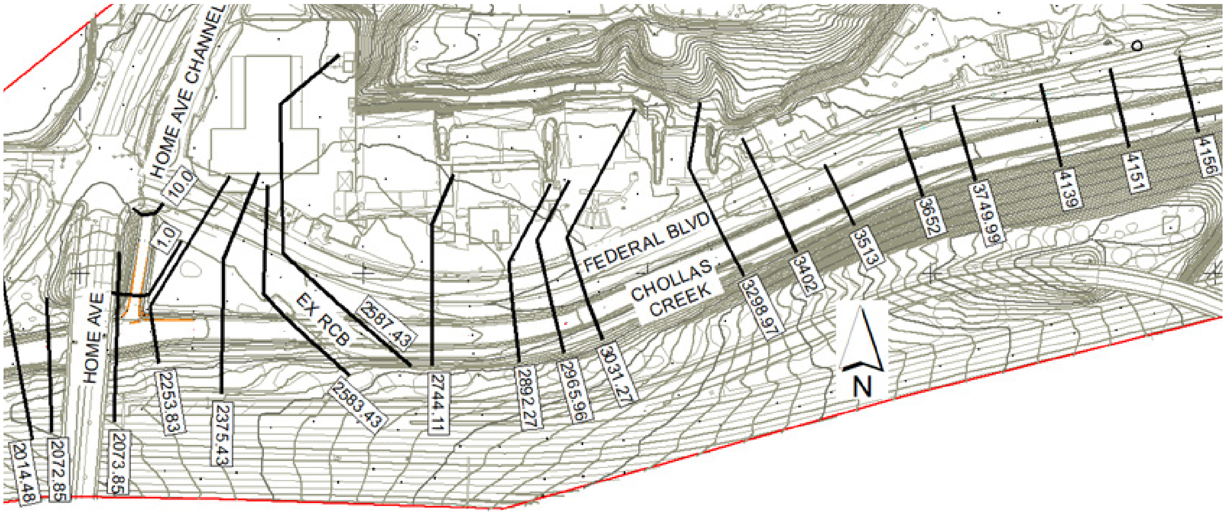


Figure 12: HEC-RAS Cross Sections

Existing Condition Results

The resulting HEC-RAS Work Map in **Appendix A** shows that, under existing conditions, flows within Chollas Creek are contained within the channel until Cross Section 3298.97, where they spill over the banks of the creek to the north, flooding Federal Boulevard. This flooding proceeds along Federal Boulevard until the Home Avenue bridge, where it becomes once again contained within the channel.

The flooding along Federal Boulevard occurs due to the 90-degree confluence of the Home Avenue channel with Chollas Creek, as well as the existing RCB at section 2585.39. The quadruple RCB is under inlet control, which causes flows to back up and flood Federal Boulevard (see **Figure 13)**.

A separate "existing condition" HEC-RAS model without the existing quadruple RCB from Chollas Creek was also prepared. Results of that hyothetical analysis show that although flooding is improved along Federal Boulevard, Chollas Creek still cannot completely contain the 100-year flood within the channel banks (**Figures 13** and **14)**. However, the proposed design combines the improved flood capacity by removing the existing RCB and widening the channel (as shown in **Section 4.2.3** below).

Figure 13: Existing 100-Year Floodplains With and Without the Quadruple RCB

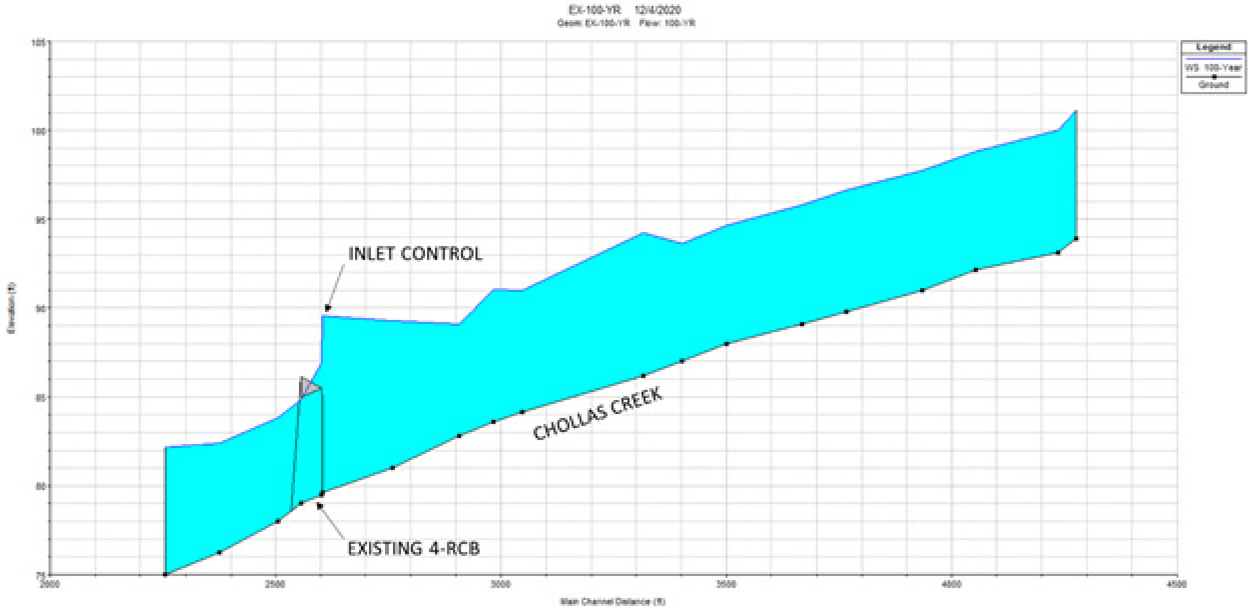


Figure 14: Existing Condition HEC-RAS Profile Results With RCB

4.2.3 Proposed Condition

Methodology and Calculations

The Proposed Condition HEC-RAS model was developed by modifying the Existing Condition model between Cross Sections 2375.43 and 4261.38 to reflect the proposed topographic changes to the channel as shown on the grading plans. The proposed grading increases the capacity of the channel overall. A Manning's n value was chosen based on the stone size using the **San Diego Drainage Design Manual** (SDDDM) Table 7-4. Cross sections were chosen based on changes in geometry at drop structures, changes in horizontal alignment, channel width changes and where an additional cross section was needed to check hydraulic parameters.

The proposed project does encroach within the effective FEMA floodway and therefore must show that the proposed channel construction does not increase water surface elevations. Since there is not yet an effective FEMA model for this project, a more conservative approach has been taken in analyzing the 100-year floodplain water surface elevations for a no-rise condition. Refer to the **Appendix** for the Proposed Condition HEC-RAS model results. The proposed condition HEC-RAS file names are listed in **Table 3**.

Table 3: Files

Proposed HEC-RAS Model	
File:	388-07 Federal Blvd.prj
Project:	Federal Blvd
Plan:	PROP
Geometry:	PROP
Flow:	PROP

Proposed Condition Results

The removal of the existing RCB greatly improves the flooding scenario in the immediate and surrounding areas. Although the removal of the RCB creates an increase in water surface elevation downstream at Cross Section 2375.43, all flow is contained within Chollas Creek, and Federal Boulevard does not flood. Refer to the proposed condition flood map in **Figures 15 and 16** below.

These results show that, overall, the construction of this project will contain peak flows within the proposed channel, and will remove flood hazards from the surrounding areas along Federal Boulevard.

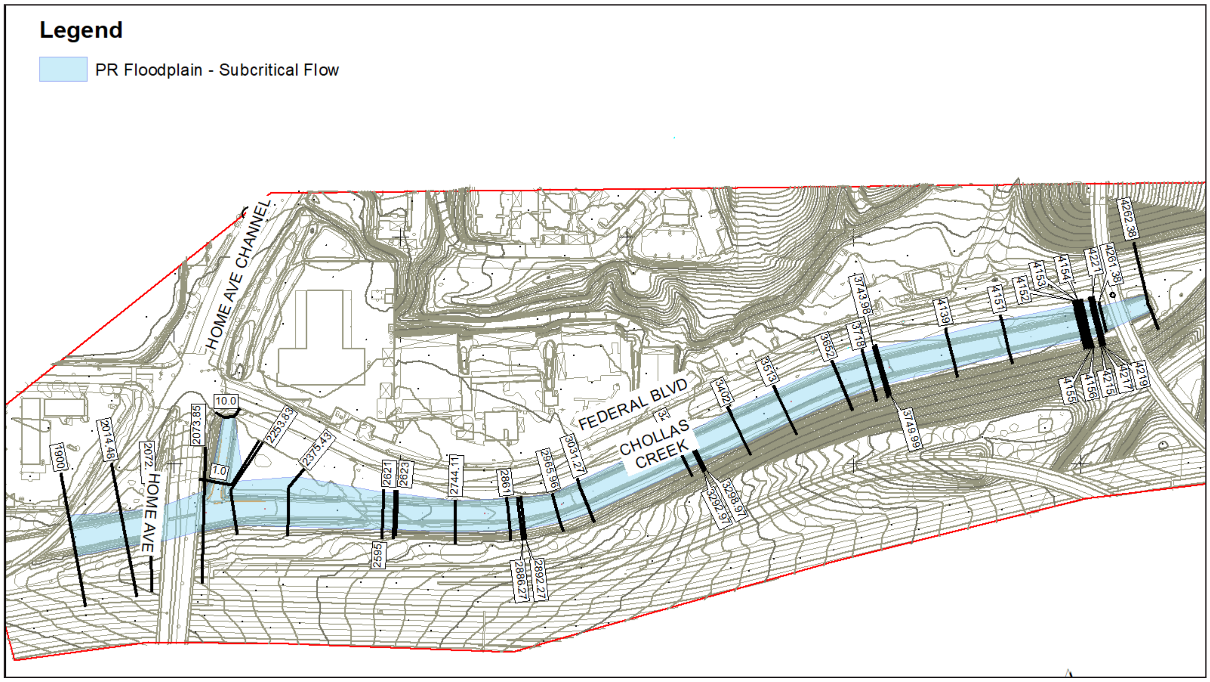


Figure 15: Proposed 100-Year Floodplain

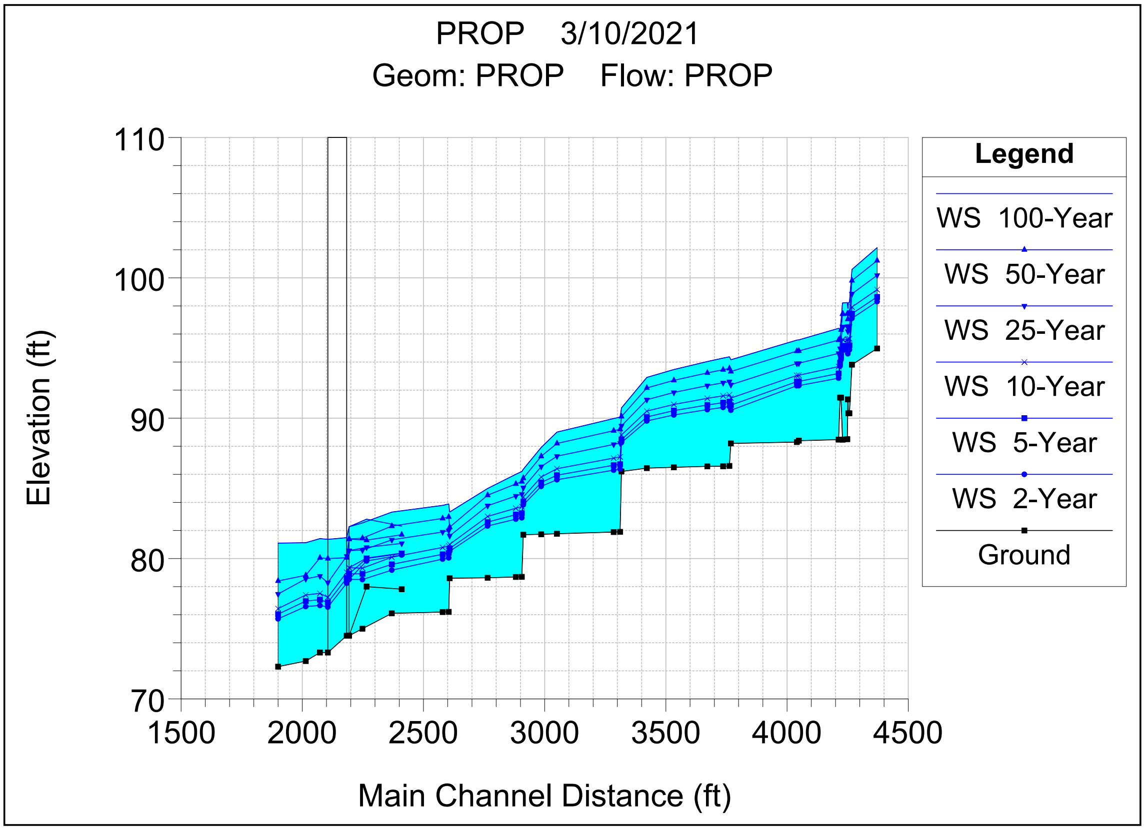


Figure 16: Proposed Condition HEC-RAS Profile Results for Chollas Creek

4.2.4 Velocity Distribution

A velocity distribution analysis was prepared for each proposed cross section in order to size stone for the proposed channel and banks. Each cross section was assigned five flow distributions including the left overbank, channel, and the right overbank. This was used to identify the area of highest velocity to size the proposed stone. This hydraulic study also includes several smaller, more frequent storm events as well as the larger storm events up to the 100-year, in order to assess scour and deposition along the channel during the existing and proposed conditions. This is assessed in detail in the Sediment Transport Analysis.

Figure 17 shows a five segment velocity distribution within a typical cross section. Complete velocity distribution cross section results are located in **Appendices B** and **C.**

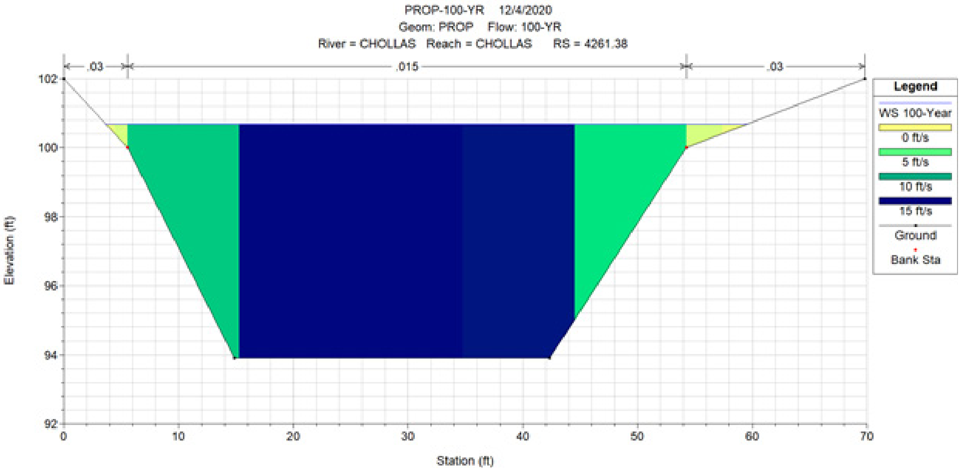


Figure 17: Typical Velocity Distribution

4.2.5 Existing and Proposed Condition Comparison

In general, proposed condition channel velocities are less than the existing condition due to the flattened slope of the channel between the drop structures. There are two slight increases of 1 to 2 ft/s at Stations 3298.97 and 2965.96. Cross Section 2744.1 produces a velocity increase of 3.57 ft/s due to the removal of the existing quadruple RCB, since flows are no longer blocked in the proposed condition. Stone is sized for the proposed Chollas Creek channel bed and banks based on these values.

Table 4 below shows that the proposed project will lower all water surface elevations within the footprint of the project and will, in no case, increase water surface elevations for the 100-year floodplain by more than one foot, when compared with the existing condition HEC-RAS model. Furthermore, the project ties into the upstream and downstream cross sections with less than 0.5 foot of variance.

Overall, the project reduces water surface elevations along Chollas Creek, with the exception of Cross Section 2375.43. At this location, the water surface elevation increases by 0.59 feet from existing to proposed conditions. This increase is due to the fact that, under existing conditions, the RCB at Station 2585.39 creates an inlet control which acts as a weir, backing up flows. This produces a corresponding lower water surface elevation downstream, while at the same time flooding the areas upstream of the existing RCB.

Table 4: Channel Water Surface Elevations and Velocities

HEC-RAS Cross Station	Subcritical Flow								Mixed Flow			
	WSE (ft)			Velocity (ft/s)			Flow Depth (ft)	Froude Number	WSE (ft)	Velocity	Flow Depth (ft)	Froude Number
	Existing	Proposed Subcritical	Change	Existing	Proposed Subcritical	Change	Proposed Subcritical	Proposed Subcritical	Proposed Mixed Flow			
Home Avenue Channel									Home Ave Channel			
10	82.46	82.32	-0.14	12.80	12.70	-0.10	4.50	1.01	82.32	12.70	4.50	1.01
1	82.36	82.81	0.45	7.90	8.08	0.18	2.97	0.65	80.97	14.76	2.97	1.52
Chollas Creek									Chollas Creek			
4215		98.24			5.85		9.74	0.34	98.24	5.85	9.74	0.34
4139	97.73	95.56	-2.17	14.70	8.02	-6.68	7.26	0.54	95.56	8.02	7.26	0.54
3749.99	96.63	94.17	-2.46	14.80	8.20	-6.60	5.97	0.6	94.17	8.20	5.97	0.6
3743.98	-	94.38	-	-	6.74	-	7.78	0.44	94.38	6.74	7.78	0.44
3652	95.82	94.04	-1.78	14.50	7.06	-7.44	7.47	0.46	94.04	7.06	7.47	0.46
3513	94.65	93.47	-1.18	14.20	7.63	-6.57	6.97	0.52	93.47	7.63	6.97	0.52
3402	93.62	92.91	-0.71	14.80	8.09	-6.71	6.47	0.57	92.91	8.09	6.47	0.57
3298.97	94.24	90.73	-3.51	10.30	12.02	1.72	4.53	1.01	90.73	12.02	4.53	1.01
3292.97	-	90.08	-	-	7.00	-	8.18	0.44	90.08	7.00	8.18	0.44
3267	-	89.98	-	-	7.08	-	8.09	0.45	89.98	7.08	8.09	0.45
3031.27	91.00	89.01	-1.99	14.40	7.71	-6.69	7.24	0.51	89.01	7.71	7.24	0.51
2965.96	91.05	87.92	-3.13	10.30	10.46	0.16	6.19	0.75	87.92	10.46	6.19	0.75
2892.27	89.10	86.37	-2.73	14.10	12.21	-1.89	4.67	1.00	86.37	12.21	4.67	1.00
2886.27	-	86.20	-	-	8.04	-	7.50	0.53	86.20	8.04	7.50	0.53
2861	-	86.01	-	-	8.29	-	7.32	0.55	86.01	8.29	7.32	0.55
2744.11	89.29	84.99	-4.30	7.20	9.52	2.32	6.36	0.67	84.99	9.52	6.36	0.67
2623	-	83.31	-	-	10.34	-	4.71	0.84	83.31	10.34	4.71	0.84
2621	-	83.90	-	-	6.99	-	7.70	0.45	83.90	6.99	7.70	0.45
2585.39 RCB UP				11.80	-	-	-	-				
2585.39 RCB DN				15.70	-	-	-	-				
2375.43	82.36	83.31	0.95	13.70	6.38	-7.32	7.21	0.42	83.31	6.38	7.21	0.42
2253.83	82.58	82.54	-0.04	9.40	10.09	0.69	7.54	0.63	82.54	10.09	7.54	0.63
2073.85	82.26	82.27	0.01	10.00	9.96	-0.04	7.77	0.64	82.27	9.96	7.77	0.64
2073.45 Bridge UP				13.80	13.69	-0.11	-	-	-	13.69	-	-
2073.44	Bridge								Bridge			
2073.45 Bridge DN				13.30	13.54	0.24	-	-	-	13.54	-	-
2072.85	81.38	81.42	0.04	11.40	11.26	-0.14	8.12	0.69	81.42	11.26	8.12	0.69
2014.48	81.11	81.13	0.02	11.80	11.99	0.19	8.43	0.69	81.13	11.99	8.43	0.69
1900	81.10	81.10	0.00	11.00	10.63	-0.37	8.80	0.60	81.10	10.63	8.80	0.60

Drop Structure

4.3 Stone Sizing

The basis for stone sizing in the channel bed, channel banks, and drop structures, is based upon both the ***City of San Diego, Drainage Design Manual, 2107*** (SDDDM) and the methodology found in the ***US Army Corps of Engineers Engineering and Design Manual – Hydraulic Design of Flood Control Channels, EM 1110.2.1601, 1994*** (Corps). We are using the term "stone" instead rock for this project to differentiate between riprap rock and the natural stone we are proposing.

We used the iterative Corps method for stone sizing by checking the factor of safety this analysis produces. We used the SDDDM for determining the stone layer thickness (SDDDM Table 7-6) and for the Manning's roughness coefficients 'n' (SDDDM Table 7- 4) used in the HEC-RAS analysis.

4.3.1 Channel Bottom and North Slope Stone

The stone sizing process begins with obtaining the highest velocity of each cross section within the HEC-RAS model results for the proposed condition. Once the maximum channel velocity is determined for a cross section, calculations are performed using the Corps methodology, and ultimately a minimum stone size is determined, based on a factor of safety greater than 1.1. Once an acceptable stone size was determined, stone size selection was increased by a class, further increasing the factor of safety. See **Appendix F** for calculations.

Table 5: Stone Sizing

Station	Flow Depth (ft)	Max Velocity (by X-Sect.)	W50 Stone Wt. (lbs)	D50 Stone Diameter (ft)	Stone Layer Thickness (ft)	Stone Classification	Safety Factor
4215	9.74	5.85	2,000	2.9	4.3	1 Ton*	17.6
4139	7.26	8.02	200	1.3	2.5	Light	3.4
3750	5.97	8.20	1,000	2.3	3.5	1/2 Ton*	5.4
3744	7.78	6.74	1,000	2.3	3.5	1/2 Ton*	9.4
3652	7.47	7.06	200	1.3	2.5	Light	4.8
3513	6.97	7.63	200	1.3	2.5	Light	3.9
3402	6.47	8.09	200	1.3	2.5	Light	3.3
3299	4.53	12.02	2,000	2.9	4.3	1 Ton*	2.5
3293	8.18	7.00	2,000	2.9	4.3	1 Ton*	11.2
3267	8.09	7.08	200	1.3	2.5	Light	4.8
3031	7.24	7.71	200	1.3	2.5	Light	3.8
2966	6.19	10.46	200	1.3	2.5	Light	1.7
2892	4.67	12.21	2,000	2.9	4.3	1 Ton*	2.4
2886	7.50	8.04	2,000	2.9	4.3	1 Ton*	7.7
2861	7.32	8.29	200	1.3	2.5	Light	3.2
2744	6.36	9.52	200	1.3	2.5	Light	2.2
2623	4.71	10.34	1,000	2.3	3.5	1/2 Ton*	2.8
2621	7.70	6.99	1,000	2.3	3.5	1/2 Ton*	8.5
2375	7.21	6.38	200	1.3	2.5	Light	6.1
2254	7.54	10.09	200	1.3	2.5	Light	2.0

* Drop structure locations

4.3.2 Stone Filter Bedding

A granular filter is proposed underneath the stone layer of the proposed channel. The filter layer will prevent water from removing the underlying channel bed and bank material through voids in the stone layer.

The granular filter was designed using Section 4.4 of ***Design of Riprap Revetment (HEC-11), FHWA, 1989***. This method requires various gradation values for the large stone layer, channel bed/bank material, and the gravel used for the filter. The D_{15} and D_{85} values for the underlying channel material were determined by taking the average of the gradation test results provided in Appendix B of the project's geotechnical report.

Based on the calculations, the project proposes a single-layer granular bedding, 6-inches thick, composed of 2-inch crushed aggregate to be placed under the main channel and north slope.

For stable condition, 2 requirements:

$$1)\quad \frac{D_{15}\text{ (coarse layer)}}{D_{85}\text{ (fine layer)}} = \text{Filter Ratio} < 5$$

$$2)\quad 5 < \frac{D_{15}\text{ (coarse layer)}}{D_{15}\text{ (fine layer)}} < 40$$

Given:

- D_{15} (riprap)	= 0.88 ft	Average for light class stone per USACE EM 1110-2-1601
	= 268 mm	
- D_{85} (channel bank)	= 12 mm	Average values per gradation test results provided in App. B of project's geotechnical report (sample locations B-1, B-2, B-3, and B-5)
- D_{15} (channel bank)	= 0.5 mm	

Check if filter bedding is required:

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (channel bank)}} = \frac{268\text{ mm}}{12\text{ mm}} = 22 > 5 \quad \text{Filter Required}$$

Determine if single layer of gravel can be used:

1st Requirement:

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (gravel)}} = \frac{268\text{ mm}}{60\text{ mm}} = 4.5 < 5 \quad \text{OK}$$

$$\frac{D_{15}\text{ (gravel)}}{D_{85}\text{ (streambank)}} = \frac{8\text{ mm}}{12\text{ mm}} = 0.67 < 5 \quad \text{OK}$$

2nd Requirement:

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (gravel)}} = \frac{268\text{ mm}}{8\text{ mm}} = 34 < 40 \quad \text{OK}$$

$$\frac{D_{15}\text{ (gravel)}}{D_{85}\text{ (channel bank)}} = \frac{8\text{ mm}}{0.5\text{ mm}} = 16 < 40 \quad \text{OK}$$

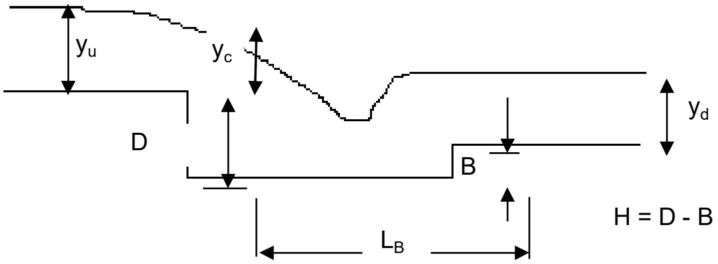
Therefore, use single layer of gravel for filter blanket:

- FILTER BEDDING THICKNESS = 6 inches per HEC-11 for single layer
- Gravel size = 2-inch aggregate

4.3.3 Drop Structure Length

The four drop structures proposed along the channel length were sized to dissipate energy and allow the proposed channel to have a uniform slope along the entire reach. We used the methodology in ***Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998*** (as used by the NRCS) to determine the length of the dissipator landing.

Drop heights range from approximately 1.7 to 4.3-feet. The necessary length of stone energy dissipation for the largest 4.3-foot drop structure (located at approximately Sta 33+00) was determined to be 25-feet. The 25-foot dissipator length was used for the remaining three smaller drop structures for conformity during construction and to provide an extra factor of safety. The Corps method was used to size the drop structure stone based on highest velocities from the HEC-RAS analysis.



Given:

Q_{100} = 3500 cfs

width at crest, b = 61.1 ft.

y_c = 4.53 ft.

D = 4.3 ft.

B = 2.5 ft.

H = D - B = 1.8 ft.

H/y_c = 0.40 < 0.7 (LOW DROP)

From Fig. III-2, L_B/H = 11.4 , then L_B = 20.52 ft

Since y_d = 7.52 ft., then y_d/y_c = 1.66

From Fig. III-3, B_{av}/y_c = 0.18 , so B_{av} = 0.8154

From Fig. III-4,

B_{max}/B_{av} = 1.20 , so B_{max} = 0.97848

B_{min}/B_{av} = 0.79 , so B_{min} = 0.644166

Then, applying safety factor of 1.2:

L_B = 25.0 ft

B = 1.0 ft.

4.3.4 Energy Dissipator

The energy dissipator at the upstream end of the project (Station 42+21) was designed using the ***US Bureau of Reclamation, Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph 25, 1984*** (USBR). Section 2 was used to size the concrete sill and estimate the length of the hydraulic jump. HEC-RAS was used to determine the water depths before and after the energy dissipator, the Froude Number, and velocities for stone sizing in the landing area.

The conclusions for a USBR Type II dissipator (page 26) stated that the height of the chute block or sill can be equal to the depth of flow entering the basin; 1.85 ft in our design.

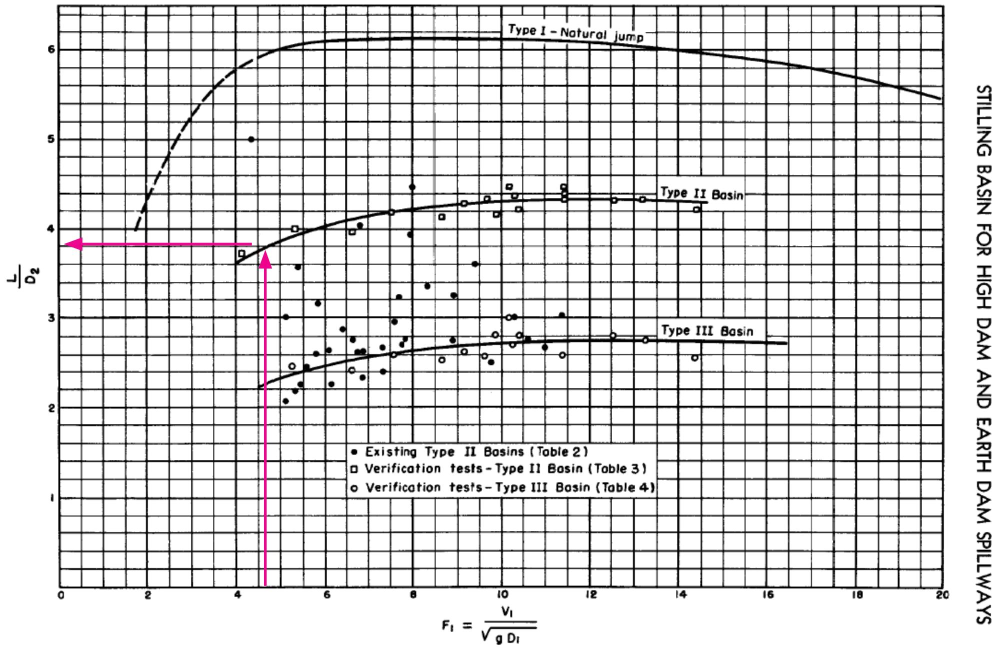


FIGURE 12.—*Length of jump on horizontal floor (Basins I, II, and III).*

From the HEC-RAS analysis:

F_1 (Froude Number) at Station 42+41 = 4.65

D_2 (downstream depth at Station 42+15) = 9.81 ft

From the above graph for a Type II Basin, L/D_2 = 3.8

Therefore, L = (9.81 x 3.8) = 37.3 ft, Use L = 40 ft

This configuration of sill height and dissipator length was verified by multiple HEC-RAS calculations as a good solution.

4.3.5 Storm Drain Outlets

A total of nine existing storm drains will discharge into the proposed channel through headwalls on the north channel bank, or openings in the proposed south side retaining wall. Storm drain sizes range from 18 to 36-inches. Flow will discharge from each storm drain outfall onto the proposed channel bed and banks, which are lined with Light class stone having a D_{50} of 1.3-feet. Thus, energy dissipation and channel armoring at each storm drain outfall will be provided by the proposed stone layer of the channel.

To verify adequate protection at the storm drain outlets, the proposed stone layer in the channel was considered to function approximately as a riprap apron. The D_{50} of the proposed stone layer was then compared against the D_{50} required by Equation 10.4, Section 10.2 Riprap Apron, HEC-14 Hydraulic Design of Energy Dissipators.

The 36-inch existing storm drain was checked first (located on the south side of the channel at approximately Station 28+50). The flow rate was estimated as 61 cfs based on a normal depth calculation, which assumed the pipe to be flowing 75% full at a slope of 1.0%. The flow rate, flow depth, and pipe diameter were then entered into Equations 10.4 and 10.5 to calculate the required D_{50} stone size as 1.1 feet.

Since the D_{50} of the proposed Light class stone (1.3-feet) is greater than the minimum required D_{50}, the design is adequate for the 36-inch storm drain outfall. For the remaining storm drains, the minimum required D_{50} is assumed to be less than 1.1 feet, because all pipes have a diameter less than 36 inches. Therefore, the Light class stone with D_{50} of 1.3 feet provides adequate protection for all storm drain outfalls.

Check required stone size for 36-inch pipe @ ~Sta 28+50:

D =	3 ft	Pipe diameter
Q =	61 ft^3/s	Design discharge (assumed 75% full pipe @ 1% slope)
y =	2.25 ft	Flow depth in pipe (assumed pipe 75% full)
TW =	1.2 ft	Tailwater depth (if unknown use 0.4*D)
D' =	2.625 ft	Adjusted culvert diameter used when flow is supercritical
	$D' = \frac{D + y_n}{2}$	per equation 10.5, HEC-14 Flow is supercritical, therefore use D'
$D_{50} = 0.2\,D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right)$		Equation 10.4
D_{50} =	**1.1 ft**	Required stone size per equation 10.4

D_{50} req'd = 1.1 ft < 1.3 ft = D_{50} of Light Class channel stone => OK

All other storm drain outlets into channel are less than 36", therefore

D_{50} req'd < 1.1 ft < 1.3 ft = D_{50} of Light Class channel stone => OK

4.4 Sediment Transport Analysis

Our sediment transport analysis consists of both qualitative and quantitative studies. In addition to reviewing historic aerial imagery, our qualitative analysis included site visits to evaluate existing conditions and the erosion and deposition mechanics of the natural portions of the creek, including upstream and downstream. Four sediment samples were collected from the upstream creek bed and banks during one of these site visits. We performed our quantitative analysis using the sediment transport model built into HEC-RAS.

Field Sampling

A pebble count was performed at four locations upstream of the project site. After counting the larger stone in the pebble count, bags were filled for a sieve analysis, which is presented in the **Appendix.** A map showing the sampling locations are shown below in **Figure 18**.

Pebble Count

Pebble Count in Field November 19, 2020 Chollas Creek Upstream from Project				
	Location			
Grid Opening	**#1**	**#2**	**#3**	**#4**
128 mm	6	3	2	1
90	9	6	8	6
64	17	20	17	15
45	26	28	23	24
32	11	0	0	0

Figure 18: Sediment Sampling Locations

HEC-RAS Sediment Modeling Methods

We used the hydraulic models that were prepared for the existing and proposed condition hydraulic analyses to also analyze the sediment transport capabilities of Chollas Creek. In the existing condition, Chollas Creek was modeled as a paved open channel with a Manning's n value of 0.015. In the proposed condition, Chollas Creek was modeled as a stone-lined channel with Manning's n values that were determined in **Appendix F**, Stone Sizing Calculations. The analyses were performed without the Home Avenue bridge, as is typical in sediment transport analyses. The bridge does not come into contact with the floodplain except for one pier, which was removed from the models to avoid sediment transport model errors.

The existing and proposed condition HEC-RAS sediment transport file names are listed in **Table 6** below. Each scenario for this study was saved as a plan that is linked to each individual quasi-unsteady flow file and sediment data file.

Table 6

Existing and Proposed HEC-RAS Sediment Transport Model	
File:	FederalBlvdSedTrans.prj
Project:	Federal Blvd Sediment Transport
Plan:	EX-NOLOAD (2, 10, 100-Yr) EX-EQULOAD (2, 10, 100-Yr) PR-NOLOAD (2, 10, 100-Yr) PR-EQULOAD (2, 10, 100-Yr)

Sediment Data

The sediment transport analysis was set up by assigning a grain size distribution, channel stations, and maximum depth of scour to each cross section. We collected sediment samples at four locations upstream of the project site, which represent the natural and deposited material in the channel, as the existing channel for the length of the project is concrete. The grain size distributions from the sieve analysis were used for the Chollas Creek channel cross sections. The sediment channel stations were assigned to the cross section overbank stations. The maximum possible depth of scour was set at ten feet for the proposed rehabilitated reach of Chollas Creek and zero at the drop structures, as they will be armored with engineered stone to avoid scour. Scour was set to 0.00 feet for the existing concrete portions of Chollas Creek West, Chollas Creek downstream of the Home Avenue Bridge, and the impervious Home Avenue Channel.

An existing and proposed gradation curve was created for Chollas Creek, based on the existing condition sieve analysis results, field measurements, and the proposed stone specifications. The existing condition gradation curve includes only the smaller stone from the sieve analysis. Larger sized stone was measured by hand during a site visit; however, this is not reflected in the existing condition gradation curve, which results in conservative output for the existing condition modeling. The proposed condition gradation curve took into account the sieve analysis but removed the sands and increased the largest stone diameter, since the proposed channel will be armored with larger sized stone. A separate gradation curve was created for the Home Avenue Channel, but contains no actual gradation values, since the channel is concrete-lined and supports a mostly urban watershed. This is meant to represent a non-erosive channel with mostly clear flows. Existing and proposed Chollas Creek gradations for this study are shown in **Tables 7 and 8** below.

Table 7: Existing Condition Gradation

Class	Diameter (mm)	% Finer
FS	0.25	1
MS	0.5	20
CS	1	31
FG	8	42
CG	32	90

Table 8: Proposed Condition Gradation

Class	Diameter (mm)	% Finer
FG	8	1
CG	32	10
VCG	64	20
SC	128	30
LC	256	40
SB	512	90
LB	2048	100

Upstream Channel Bed

Initial Conditions

The Transport Function, Sorting Method, and Fall Velocity Method were each selected by running a sensitivity analysis, running various combinations, analyzing the results, and comparing them with the known gradation and channel characteristics. The following methods were ultimately selected for this model:

- Transport Function: Meyer Peter Muller
- Sorting Method: Thomas (EX 5)
- Fall Velocity Method: Ruby

As is most often the case, no bedload sediment sampling is available for the design flows entering the project reach, so we used a qualitative approach to predict sediment loading for the HEC-RAS sediment analysis. The options within HEC-RAS include equilibrium condition or a sediment rating curve.

The equilibrium condition defaults to critical depth upstream, which prevents the upstream-most cross section from scouring and maximizes sediment load downstream.

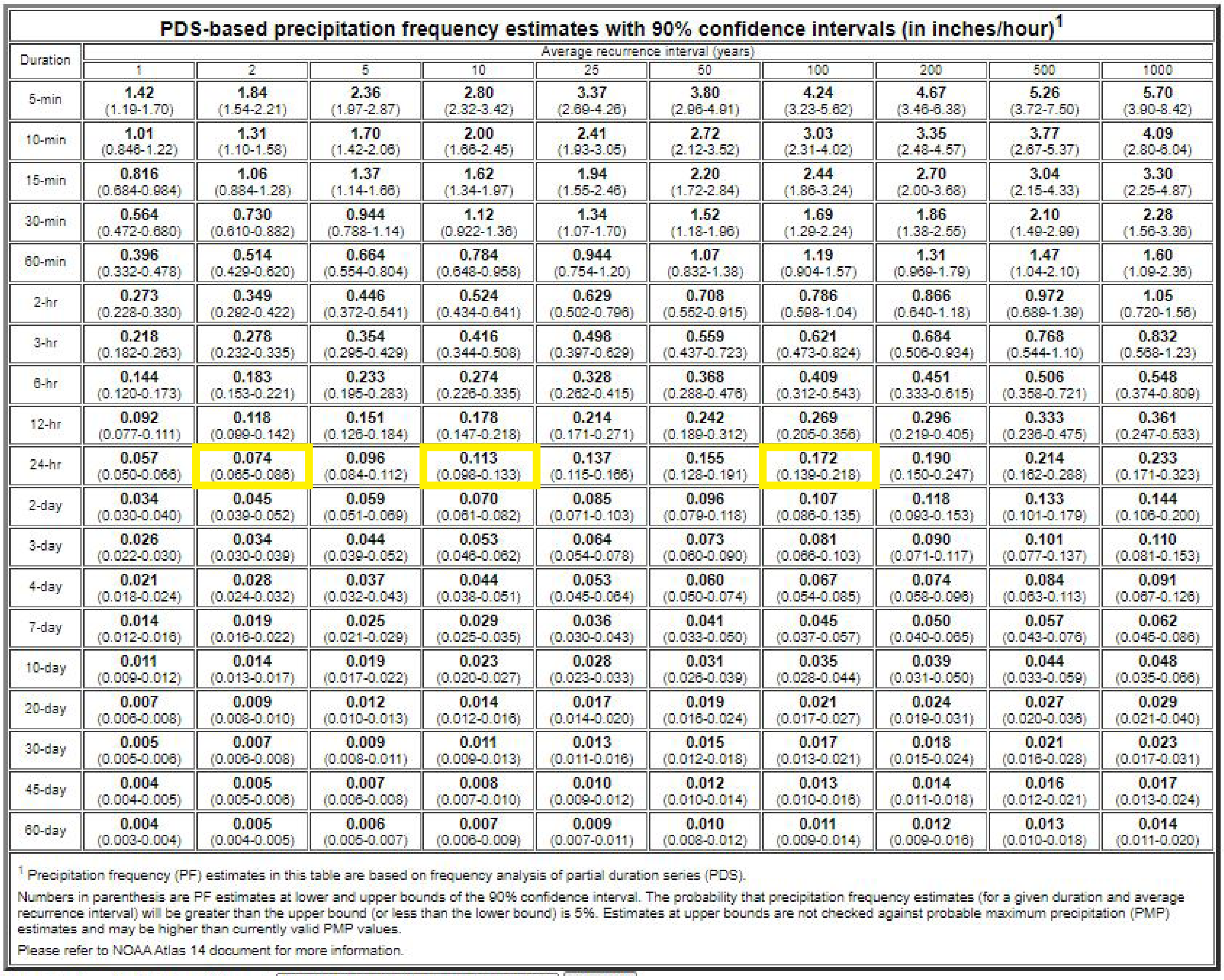
The sediment rating curve option was used with a load of zero, which maximizes scour by assuming that the upstream culvert creates zero load within the runoff. This is because culverts are typically a choke point, which creates deposition upstream of the culvert and very low to no load in the runoff. We therefore ran both the equilibrium condition and the zero-load sediment rating curve boundary conditions for this analysis and compared the two, as the actual sediment transport results for the channel lie somewhere between these two conditions.

Quasi-Unsteady Flow Editor

A synthetic hydrograph was used for both Chollas Creek and Home Avenue, with a computation interval of 0.1 hours. The duration of the model was set to 24 hours.

The 10-year flow rate was taken from the 2019 Flood Insurance Study (FIS) for San Diego, and the 2-year flow rate was estimated by a combination of pro-rating from the 100-year flow rate from the NOAA Atlas 14 precipitation intensity, and comparison with the 10-year FIS flow rate. The 2-year flow rate was pro-rated using the NOAA Atlas 14 point precipitation frequency (pf) estimates for a 24 hour period (**Table 9** below), but then reduced further since the pro-rated flow rate was greater than the 10-year FIS flow rate. The two-year flow rate was pro-rated by 30% of the 100-year storm, as shown in **Table 10**.

Table 9: NOAA 14 Precipitation Frequencies



PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**1.42** (1.19-1.70)	**1.84** (1.54-2.21)	**2.36** (1.97-2.87)	**2.80** (2.32-3.42)	**3.37** (2.69-4.26)	**3.80** (2.96-4.91)	**4.24** (3.23-5.62)	**4.67** (3.46-6.38)	**5.26** (3.72-7.50)	**5.70** (3.90-8.42)
10-min	**1.01** (0.846-1.22)	**1.31** (1.10-1.58)	**1.70** (1.42-2.06)	**2.00** (1.66-2.45)	**2.41** (1.93-3.05)	**2.72** (2.12-3.52)	**3.03** (2.31-4.02)	**3.35** (2.48-4.57)	**3.77** (2.67-5.37)	**4.09** (2.80-6.04)
15-min	**0.816** (0.684-0.984)	**1.06** (0.884-1.28)	**1.37** (1.14-1.66)	**1.62** (1.34-1.97)	**1.94** (1.55-2.46)	**2.20** (1.72-2.84)	**2.44** (1.86-3.24)	**2.70** (2.00-3.68)	**3.04** (2.15-4.33)	**3.30** (2.25-4.87)
30-min	**0.564** (0.472-0.680)	**0.730** (0.610-0.882)	**0.944** (0.788-1.14)	**1.12** (0.922-1.36)	**1.34** (1.07-1.70)	**1.52** (1.18-1.96)	**1.69** (1.29-2.24)	**1.86** (1.38-2.55)	**2.10** (1.49-2.99)	**2.28** (1.56-3.36)
60-min	**0.396** (0.332-0.478)	**0.514** (0.429-0.620)	**0.664** (0.554-0.804)	**0.784** (0.648-0.958)	**0.944** (0.754-1.20)	**1.07** (0.832-1.38)	**1.19** (0.904-1.57)	**1.31** (0.969-1.79)	**1.47** (1.04-2.10)	**1.60** (1.09-2.36)
2-hr	**0.273** (0.228-0.330)	**0.349** (0.292-0.422)	**0.446** (0.372-0.541)	**0.524** (0.434-0.641)	**0.629** (0.502-0.796)	**0.708** (0.552-0.915)	**0.786** (0.598-1.04)	**0.866** (0.640-1.18)	**0.972** (0.689-1.39)	**1.05** (0.720-1.56)
3-hr	**0.218** (0.182-0.263)	**0.278** (0.232-0.335)	**0.354** (0.295-0.429)	**0.416** (0.344-0.508)	**0.498** (0.397-0.629)	**0.559** (0.437-0.723)	**0.621** (0.473-0.824)	**0.684** (0.506-0.934)	**0.768** (0.544-1.10)	**0.832** (0.568-1.23)
6-hr	**0.144** (0.120-0.173)	**0.183** (0.153-0.221)	**0.233** (0.195-0.283)	**0.274** (0.226-0.335)	**0.328** (0.262-0.415)	**0.368** (0.288-0.476)	**0.409** (0.312-0.543)	**0.451** (0.333-0.615)	**0.506** (0.358-0.721)	**0.548** (0.374-0.809)
12-hr	**0.092** (0.077-0.111)	**0.118** (0.099-0.142)	**0.151** (0.126-0.184)	**0.178** (0.147-0.218)	**0.214** (0.171-0.271)	**0.242** (0.189-0.312)	**0.269** (0.205-0.356)	**0.296** (0.219-0.405)	**0.333** (0.236-0.475)	**0.361** (0.247-0.533)
24-hr	**0.057** (0.050-0.066)	**0.074** (0.065-0.086)	**0.096** (0.084-0.112)	**0.113** (0.098-0.133)	**0.137** (0.115-0.166)	**0.155** (0.128-0.191)	**0.172** (0.139-0.218)	**0.190** (0.150-0.247)	**0.214** (0.162-0.288)	**0.233** (0.171-0.323)
2-day	**0.034** (0.030-0.040)	**0.045** (0.039-0.052)	**0.059** (0.051-0.069)	**0.070** (0.061-0.082)	**0.085** (0.071-0.103)	**0.096** (0.079-0.118)	**0.107** (0.086-0.135)	**0.118** (0.093-0.153)	**0.133** (0.101-0.179)	**0.144** (0.106-0.200)
3-day	**0.026** (0.022-0.030)	**0.034** (0.030-0.039)	**0.044** (0.039-0.052)	**0.053** (0.046-0.062)	**0.064** (0.054-0.078)	**0.073** (0.060-0.090)	**0.081** (0.066-0.103)	**0.090** (0.071-0.117)	**0.101** (0.077-0.137)	**0.110** (0.081-0.153)
4-day	**0.021** (0.018-0.024)	**0.028** (0.024-0.032)	**0.037** (0.032-0.043)	**0.044** (0.038-0.051)	**0.053** (0.045-0.064)	**0.060** (0.050-0.074)	**0.067** (0.054-0.085)	**0.074** (0.058-0.096)	**0.084** (0.063-0.113)	**0.091** (0.067-0.126)
7-day	**0.014** (0.012-0.016)	**0.019** (0.016-0.022)	**0.025** (0.021-0.029)	**0.029** (0.025-0.035)	**0.036** (0.030-0.043)	**0.041** (0.033-0.050)	**0.045** (0.037-0.057)	**0.050** (0.040-0.065)	**0.057** (0.043-0.076)	**0.062** (0.045-0.086)
10-day	**0.011** (0.009-0.012)	**0.014** (0.013-0.017)	**0.019** (0.017-0.022)	**0.023** (0.020-0.027)	**0.028** (0.023-0.033)	**0.031** (0.026-0.039)	**0.035** (0.028-0.044)	**0.039** (0.031-0.050)	**0.044** (0.033-0.059)	**0.048** (0.035-0.066)
20-day	**0.007** (0.006-0.008)	**0.009** (0.008-0.010)	**0.012** (0.010-0.013)	**0.014** (0.012-0.016)	**0.017** (0.014-0.020)	**0.019** (0.016-0.024)	**0.021** (0.017-0.027)	**0.024** (0.019-0.031)	**0.027** (0.020-0.036)	**0.029** (0.021-0.040)
30-day	**0.005** (0.005-0.006)	**0.007** (0.006-0.008)	**0.009** (0.008-0.011)	**0.011** (0.009-0.013)	**0.013** (0.011-0.016)	**0.015** (0.012-0.018)	**0.017** (0.013-0.021)	**0.018** (0.015-0.024)	**0.021** (0.016-0.028)	**0.023** (0.017-0.031)
45-day	**0.004** (0.004-0.005)	**0.005** (0.005-0.006)	**0.007** (0.006-0.008)	**0.008** (0.007-0.010)	**0.010** (0.009-0.012)	**0.012** (0.010-0.014)	**0.013** (0.010-0.016)	**0.014** (0.011-0.018)	**0.016** (0.012-0.021)	**0.017** (0.013-0.024)
60-day	**0.004** (0.003-0.004)	**0.005** (0.004-0.005)	**0.006** (0.005-0.007)	**0.007** (0.006-0.009)	**0.009** (0.007-0.011)	**0.010** (0.008-0.012)	**0.011** (0.009-0.014)	**0.012** (0.009-0.016)	**0.013** (0.010-0.018)	**0.014** (0.011-0.020)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

The 2-year flow rates were estimated by reducing the 100-year flow rates by 43%, and the 10-year flow rates were estimated by reducing the 100-year flow rates by 66%, using the ratios of that storm precipitation to the 100-yr number (**Table 10**).

Table 10: Peak Flow Rates

Storm Event	NOAA 14	Percentage of 100-yr Q	Q Chollas	Q Home	Total
2-year	0.074	0.30	1,050	360	1,410
5-year	0.096	0.35	1,225	420	1,645
10-year	0.113		1,500	430	1,930
25-year	0.137	0.60	2,100	720	2,820
50-year	0.155		2,800	950	3,750
100-year	0.172	1.00	3,500	1,200	4,700

The Chollas Creek West downstream boundary condition was set to normal depth instead of a starting water surface elevation. The friction slope was set to 0.007.

Sediment Transport Results

Table 11 includes the results of the sediment analyses showing the cumulative change in bed mass. Profiles of each scenario are included in the **Appendix**. A positive change in bed means that if we look at the channel as a whole, there is deposition. A negative change in bed mass means there is more erosion than deposition in the system.

Table 11: Cumulative Change in Bed Mass over 24 Hours (Tons)

Boundary Condition	Existing Condition			Proposed Condition		
	2-Year	10-Year	100-Year	2-Year	10-Year	100-Year
Equilibrium Load	+ 246	+ 506	+ 1,680	- 15	- 27	- 274
No Load	0	0	0	- 15	- 28	- 280

As can be seen in **Table 11**, in general, the existing condition model shows sediment accumulation along the reach, and no scour. This is expected for a concrete channel where scour is not possible, but if there is load in runoff, there will be deposition along the channel. In the proposed condition, all storms and load assumptions produce some level of degradation.

As mentioned previously, it is expected that the results of these two models (equilibrium and no load) represent the two extremes of scour and deposition, and the true results are expected to lie somewhere in between. The 2-year storm results were nearly the same for both the equilibrium and no-load models, which indicates that this channel is close to equilibrium but would tend to experience minor scour during the 2-year storm. The figures below show a profile of the channel invert during the 2-year storm equilibrium and no load conditions.

These results show that, in the proposed condition, some scour would occur along the channel during all storm events. However, according to the stone sizing calculations for the channel (in **Section 4.3**), it has been sized with stone based on maximum allowable shear stresses and velocities for the shown storm events. Therefore, the proposed channel will not experience scour or deposition, and will remain stable.

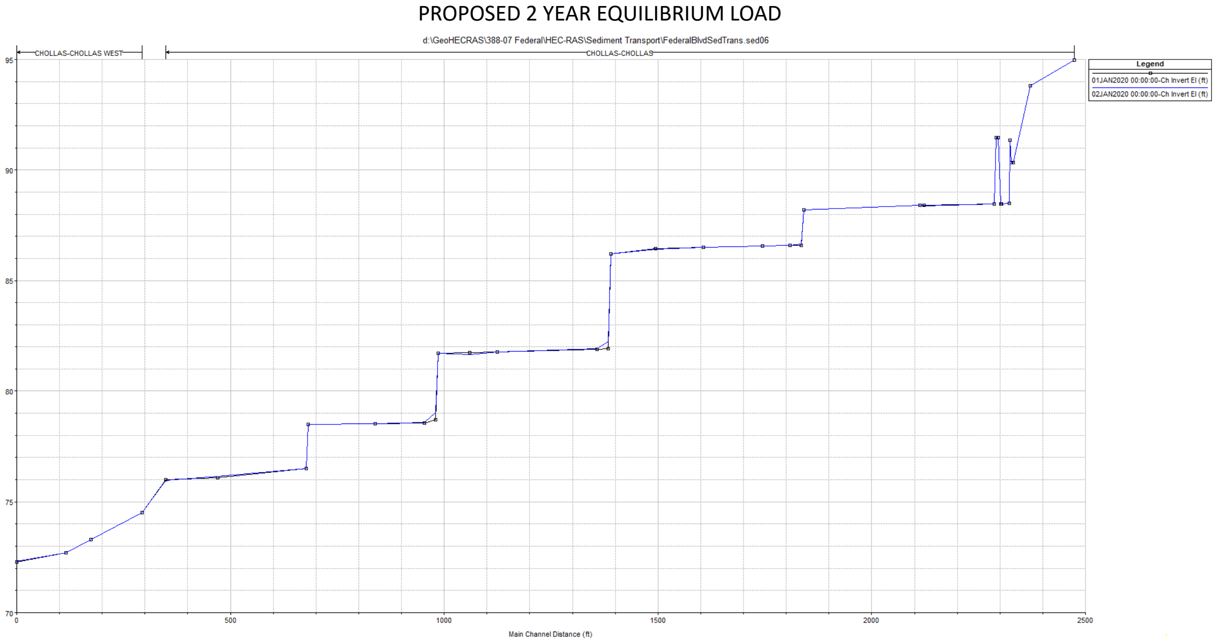


Figure 19: Channel Profile During 2-Year Proposed Equilibrium Condition

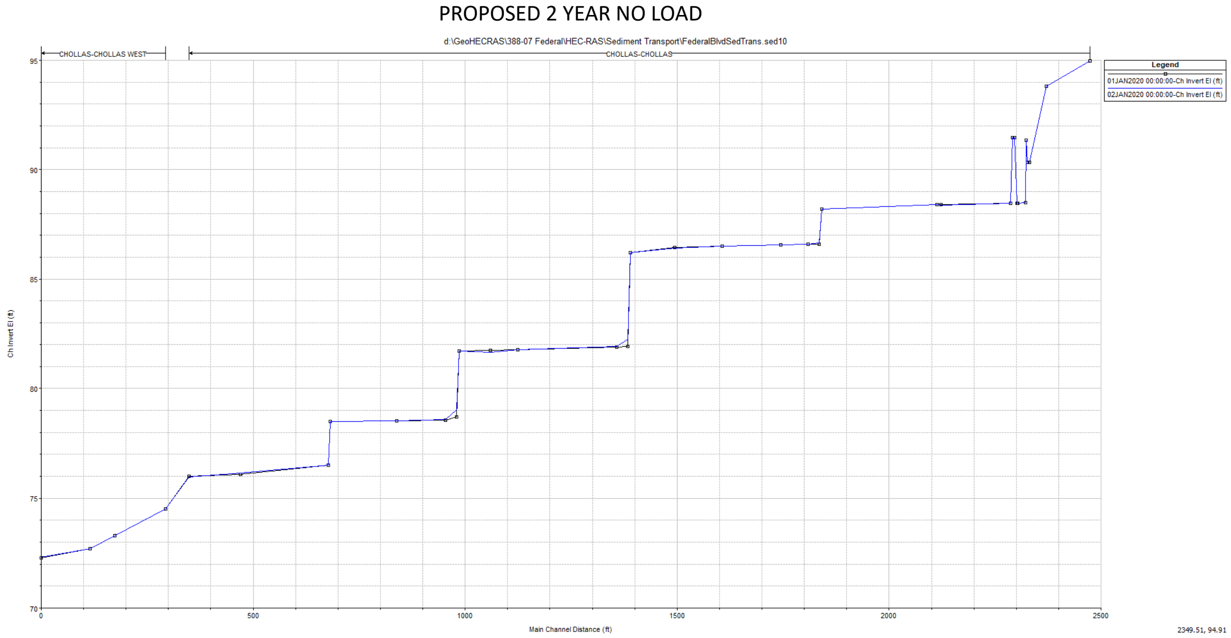


Figure 20: Channel Profile During 2-Year Proposed No Load Condition

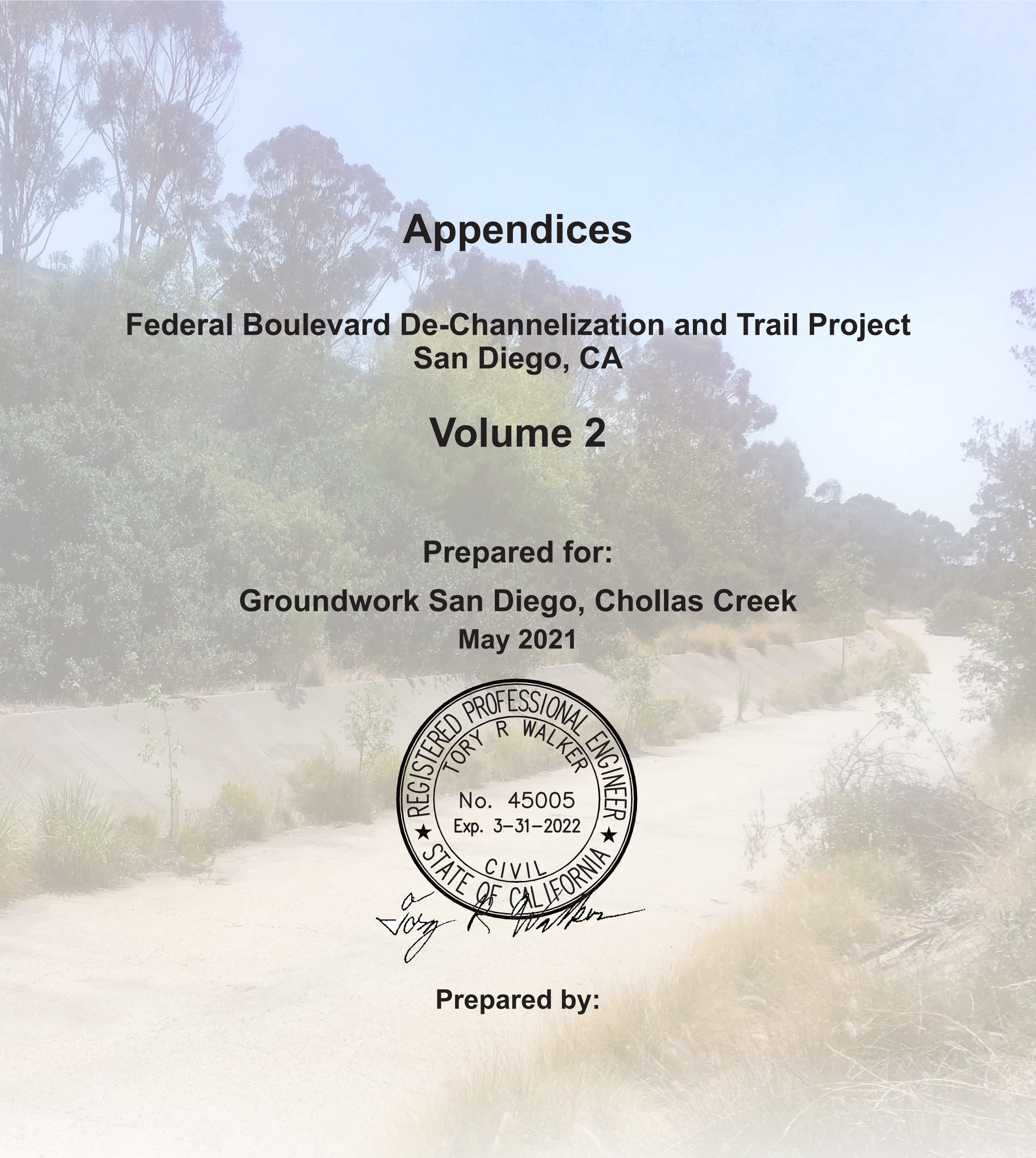
5. Summary

From our hydraulic analyses comparing existing and proposed flow conditions we conclude:

- Water surface elevations are reduced
- Flow velocities work with natural stone
- Aesthetically pleasing wall fits neighborhood vision
- The proposed channel will neither scour nor aggrade
- We have sized the stone with large safety factors to ensure the proposed channel stability

FEMA

We have prepared a detailed hydraulic analysis demonstrating a reduction in flood risk, including the Base Flood (i.e., 100-year) Elevations (BFEs) and the floodplain widths. We will prepare a Conditional Letter of Map Revision (CLOMR) application and submit it to FEMA through the City of San Diego prior to commencement of construction.



Appendices

Federal Boulevard De-Channelization and Trail Project
San Diego, CA

Volume 2

Prepared for:

Groundwork San Diego, Chollas Creek

May 2021

REGISTERED PROFESSIONAL ENGINEER
TORY R WALKER
No. 45005
Exp. 3-31-2022
CIVIL
STATE OF CALIFORNIA

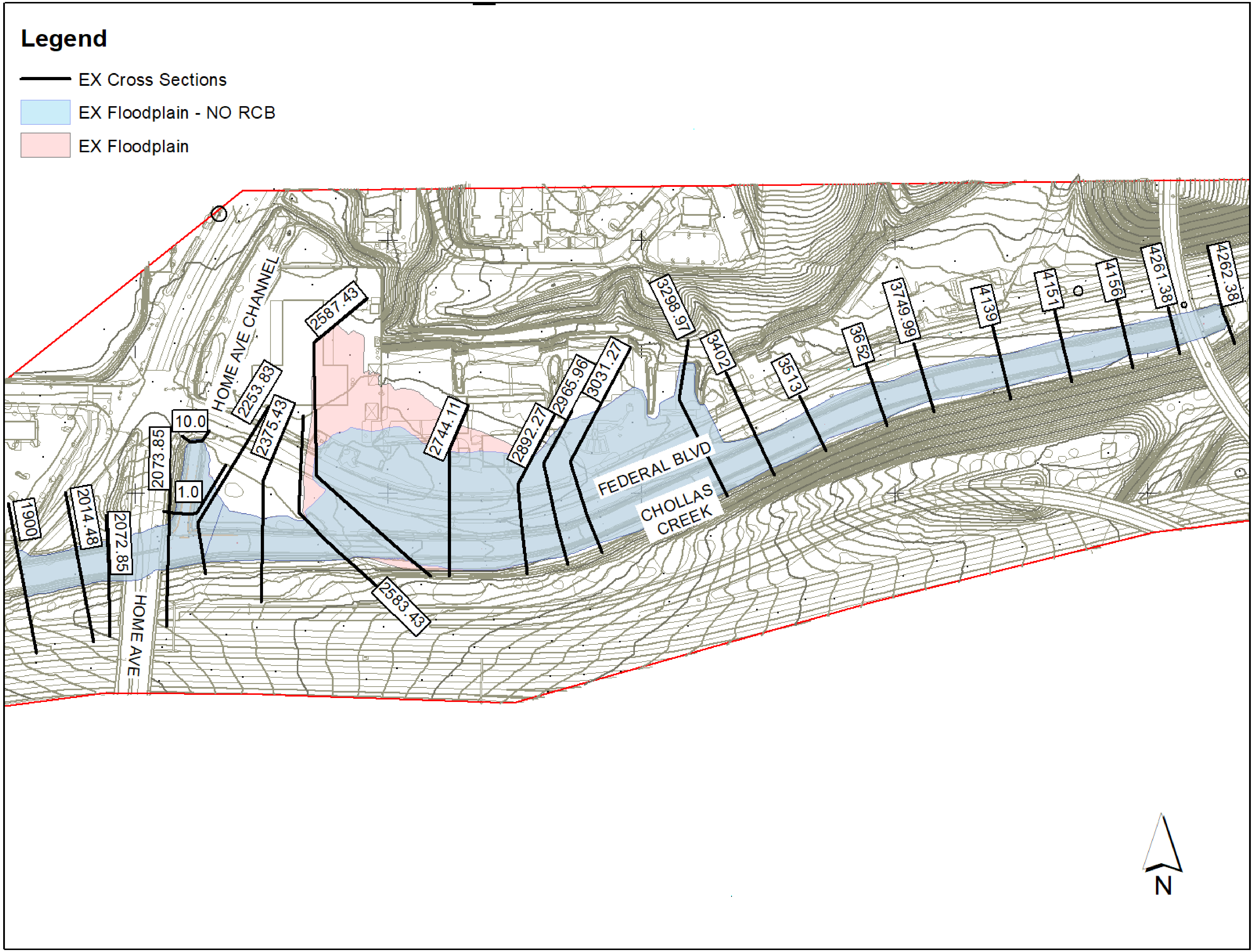
Tory R Walker

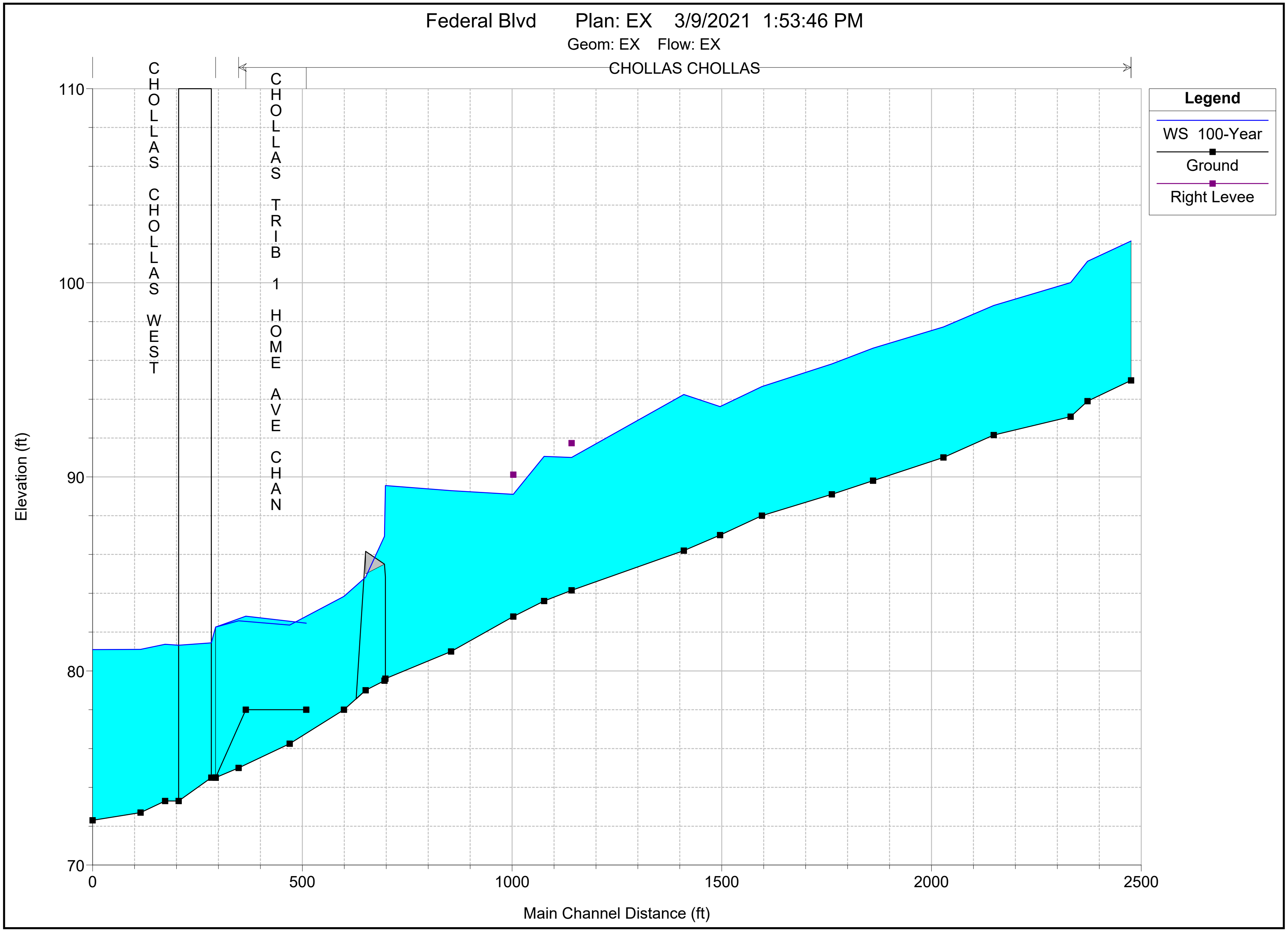
Prepared by:

TORY R. WALKER
ENGINEERING

APPENDICES

A - HEC-RAS Results
Existing Condition


Legend
EX Cross Sections
EX Floodplain - NO RCB
EX Floodplain
HOME AVE CHANNEL
2587.43
2253.83
10.0
2375.43
2073.85
1.0
1900
2014.48
2072.85
HOME AVE
2583.43
2744.11
2892.27
2965.96
3031.27
3298.97
3402
3513
3652
3749.99
4139
4151
4156
4261.38
4262.38
FEDERAL BLVD
CHOLLAS CREEK
N


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
CHOLLAS CHOLLAS
CHOLLAS CHOLLAS WEST
CHOLLAS TRIB 1 HOME AVE CHAN
Legend
WS 100-Year
Ground
Right Levee
Elevation (ft)
Main Channel Distance (ft)
110
100
90
80
70
0
500
1000
1500
2000
2500

HEC-RAS Plan: EX River: CHOLLAS Reach: CHOLLAS

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	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	4262.38	100-Year	3500.00	94.97	102.15	102.15	105.46	0.002359	14.58	240.16	38.73	1.00	7.18
CHOLLAS	4262.38	50-Year	2800.00	94.97	101.21	101.21	104.09	0.002401	13.61	205.66	36.04	1.00	6.24
CHOLLAS	4262.38	25-Year	2100.00	94.97	100.18	100.18	102.58	0.002428	12.43	168.96	35.28	1.00	5.21
CHOLLAS	4262.38	10-Year	1500.00	94.97	99.17	99.17	101.12	0.002499	11.20	133.90	34.34	1.00	4.20
CHOLLAS	4262.38	5-Year	1225.00	94.97	98.65	98.65	100.38	0.002584	10.56	115.98	33.82	1.01	3.68
CHOLLAS	4262.38	2-Year	1050.00	94.97	98.30	98.30	99.87	0.002627	10.06	104.36	33.49	1.00	3.33
CHOLLAS	4261.38	100-Year	3500.00	93.90	101.11	101.11	103.71	0.001992	12.95	273.98	58.32	0.99	7.21
CHOLLAS	4261.38	50-Year	2800.00	93.90	100.29	100.29	102.61	0.002133	12.23	229.12	51.18	1.00	6.39
CHOLLAS	4261.38	25-Year	2100.00	93.90	99.38	99.38	101.38	0.002235	11.34	185.25	46.63	1.00	5.48
CHOLLAS	4261.38	10-Year	1500.00	93.90	98.48	98.48	100.15	0.002363	10.38	144.47	43.57	1.01	4.58
CHOLLAS	4261.38	5-Year	1225.00	93.90	98.01	98.01	99.52	0.002448	9.84	124.50	41.97	1.01	4.11
CHOLLAS	4261.38	2-Year	1050.00	93.90	97.69	97.69	99.08	0.002514	9.43	111.30	40.89	1.01	3.79
CHOLLAS	4156	100-Year	3500.00	93.10	100.01	100.01	102.51	0.002160	12.70	275.68	55.79	1.01	6.91
CHOLLAS	4156	50-Year	2800.00	93.10	99.16	99.16	101.45	0.002194	12.12	231.01	50.62	1.00	6.06
CHOLLAS	4156	25-Year	2100.00	93.10	98.17	98.17	100.21	0.002281	11.44	183.49	45.07	1.00	5.07
CHOLLAS	4156	10-Year	1500.00	93.10	97.22	97.22	98.94	0.002400	10.52	142.61	41.49	1.00	4.12
CHOLLAS	4156	5-Year	1225.00	93.10	96.73	96.73	98.28	0.002509	10.01	122.39	39.79	1.01	3.63
CHOLLAS	4156	2-Year	1050.00	93.10	96.39	96.39	97.83	0.002572	9.60	109.37	38.65	1.01	3.29
CHOLLAS	4151	100-Year	3500.00	92.15	98.83	98.83	101.45	0.002033	13.01	275.12	65.01	0.98	6.68
CHOLLAS	4151	50-Year	2800.00	92.15	97.97	97.97	100.34	0.002265	12.34	226.92	48.25	1.00	5.82
CHOLLAS	4151	25-Year	2100.00	92.15	97.03	97.03	99.08	0.002372	11.48	182.96	45.04	1.00	4.88
CHOLLAS	4151	10-Year	1500.00	92.15	96.11	96.11	97.82	0.002500	10.50	142.80	41.94	1.00	3.95
CHOLLAS	4151	5-Year	1225.00	92.15	95.63	95.63	97.16	0.002586	9.95	123.11	40.30	1.00	3.48
CHOLLAS	4151	2-Year	1050.00	92.15	95.30	95.30	96.71	0.002650	9.54	110.09	39.18	1.00	3.15
CHOLLAS	4139	100-Year	3500.00	91.00	97.73	97.73	100.34	0.002016	13.00	277.19	60.24	0.99	6.73
CHOLLAS	4139	50-Year	2800.00	91.00	96.87	96.87	99.23	0.002140	12.35	228.83	52.53	0.99	5.87
CHOLLAS	4139	25-Year	2100.00	91.00	95.91	95.91	97.97	0.002303	11.50	182.65	44.79	1.00	4.91
CHOLLAS	4139	10-Year	1500.00	91.00	94.99	94.99	96.70	0.002393	10.49	143.01	41.65	1.00	3.99
CHOLLAS	4139	5-Year	1225.00	91.00	94.50	94.50	96.05	0.002503	9.97	122.90	40.12	1.00	3.50
CHOLLAS	4139	2-Year	1050.00	91.00	94.19	94.19	95.59	0.002530	9.50	110.48	39.15	1.00	3.19
CHOLLAS	3749.99	100-Year	3500.00	89.80	96.63	96.63	99.31	0.001985	13.15	270.93	64.29	0.98	6.83
CHOLLAS	3749.99	50-Year	2800.00	89.80	95.73	95.73	98.17	0.002194	12.52	223.57	46.20	1.00	5.93
CHOLLAS	3749.99	25-Year	2100.00	89.80	94.75	94.75	96.87	0.002288	11.68	179.79	42.83	1.01	4.95
CHOLLAS	3749.99	10-Year	1500.00	89.80	93.79	93.79	95.57	0.002400	10.69	140.31	39.91	1.01	3.99
CHOLLAS	3749.99	5-Year	1225.00	89.80	93.32	93.32	94.90	0.002462	10.08	121.55	38.75	1.00	3.52
CHOLLAS	3749.99	2-Year	1050.00	89.80	92.99	92.99	94.43	0.002523	9.64	108.90	37.96	1.00	3.19

HEC-RAS Plan: EX River: CHOLLAS Reach: CHOLLAS (Continued)

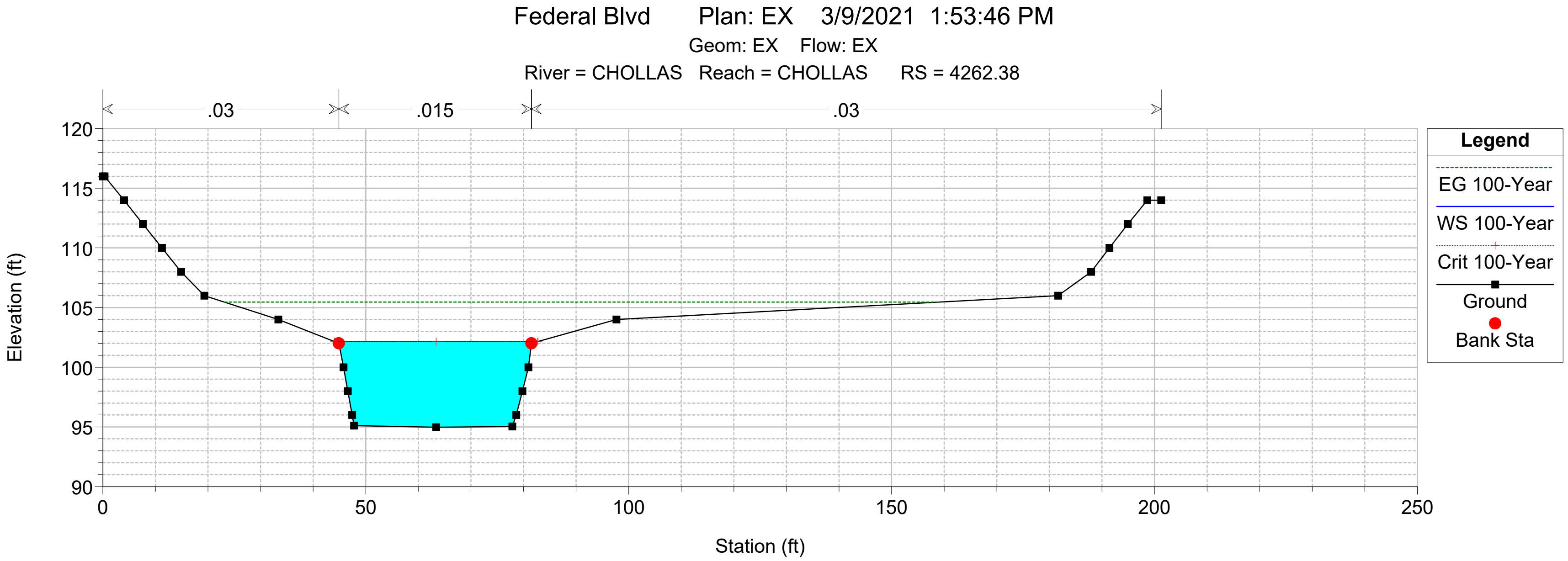
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	3652	100-Year	3500.00	89.10	95.82	95.82	98.43	0.001817	13.04	292.09	75.24	0.95	6.72
CHOLLAS	3652	50-Year	2800.00	89.10	94.92	94.92	97.32	0.002064	12.44	231.17	59.86	0.98	5.82
CHOLLAS	3652	25-Year	2100.00	89.10	93.98	93.98	96.04	0.002322	11.51	182.53	44.95	1.01	4.88
CHOLLAS	3652	10-Year	1500.00	89.10	93.06	93.06	94.78	0.002441	10.52	142.60	41.88	1.00	3.96
CHOLLAS	3652	5-Year	1225.00	89.10	92.59	92.59	94.13	0.002520	9.95	123.17	40.45	1.00	3.49
CHOLLAS	3652	2-Year	1050.00	89.10	92.27	92.27	93.68	0.002584	9.53	110.21	39.45	1.00	3.17
CHOLLAS	3513	100-Year	3500.00	88.00	94.65	94.65	97.18	0.001820	12.85	296.23	78.00	0.96	6.65
CHOLLAS	3513	50-Year	2800.00	88.00	93.81	93.81	96.11	0.001990	12.20	239.49	59.87	0.98	5.81
CHOLLAS	3513	25-Year	2100.00	88.00	92.84	92.84	94.86	0.002192	11.43	185.80	50.62	1.00	4.84
CHOLLAS	3513	10-Year	1500.00	88.00	91.93	91.93	93.62	0.002364	10.44	143.68	42.72	1.00	3.93
CHOLLAS	3513	5-Year	1225.00	88.00	91.46	91.46	92.98	0.002436	9.87	124.07	41.20	1.00	3.46
CHOLLAS	3513	2-Year	1050.00	88.00	91.14	91.14	92.53	0.002497	9.46	111.00	40.18	1.00	3.14
CHOLLAS	3402	100-Year	3500.00	87.00	93.62	93.62	96.34	0.001978	13.28	281.46	71.84	0.98	6.62
CHOLLAS	3402	50-Year	2800.00	87.00	92.87	92.87	95.23	0.002065	12.34	231.97	59.36	0.98	5.87
CHOLLAS	3402	25-Year	2100.00	87.00	91.93	91.93	93.97	0.002310	11.45	183.45	45.27	1.00	4.93
CHOLLAS	3402	10-Year	1500.00	87.00	90.99	90.99	92.71	0.002438	10.51	142.66	41.82	1.00	3.99
CHOLLAS	3402	5-Year	1225.00	87.00	90.51	90.51	92.05	0.002514	9.95	123.12	40.25	1.00	3.51
CHOLLAS	3402	2-Year	1050.00	87.00	90.18	90.18	91.60	0.002588	9.55	109.95	39.16	1.00	3.18
CHOLLAS	3298.97	100-Year	3500.00	86.20	94.24	94.24	95.39	0.000753	9.16	546.28	276.31	0.62	8.04
CHOLLAS	3298.97	50-Year	2800.00	86.20	92.11	92.11	94.42	0.002200	12.21	230.90	64.42	0.99	5.91
CHOLLAS	3298.97	25-Year	2100.00	86.20	91.10	91.10	93.16	0.002365	11.52	182.35	44.61	1.00	4.90
CHOLLAS	3298.97	10-Year	1500.00	86.20	90.16	90.16	91.89	0.002493	10.54	142.25	41.48	1.00	3.96
CHOLLAS	3298.97	5-Year	1225.00	86.20	89.68	89.68	91.23	0.002576	9.99	122.66	39.86	1.00	3.48
CHOLLAS	3298.97	2-Year	1050.00	86.20	89.35	89.35	90.78	0.002642	9.58	109.65	38.75	1.00	3.15
CHOLLAS	3031.27	100-Year	3500.00	84.15	91.00	91.00	93.51	0.001877	12.74	283.79	70.45	0.94	6.85
CHOLLAS	3031.27	50-Year	2800.00	84.15	90.06	90.06	92.41	0.002230	12.30	227.71	48.93	1.00	5.91
CHOLLAS	3031.27	25-Year	2100.00	84.15	89.09	89.09	91.14	0.002336	11.50	182.61	44.49	1.00	4.94
CHOLLAS	3031.27	10-Year	1500.00	84.15	88.15	88.15	89.87	0.002462	10.53	142.43	41.37	1.00	4.00
CHOLLAS	3031.27	5-Year	1225.00	84.15	87.66	87.66	89.21	0.002545	9.98	122.74	39.71	1.00	3.51
CHOLLAS	3031.27	2-Year	1050.00	84.15	87.33	87.33	88.76	0.002612	9.58	109.65	38.55	1.00	3.18
CHOLLAS	2965.96	100-Year	3500.00	83.60	91.05	91.05	92.07	0.000847	9.06	561.85	280.80	0.66	7.45
CHOLLAS	2965.96	50-Year	2800.00	83.60	90.68	90.68	91.63	0.000800	8.44	461.92	263.67	0.63	7.08
CHOLLAS	2965.96	25-Year	2100.00	83.60	88.69	88.69	90.72	0.002217	11.43	184.50	47.32	1.00	5.09
CHOLLAS	2965.96	10-Year	1500.00	83.60	87.73	87.73	89.46	0.002389	10.55	142.11	41.53	1.01	4.13
CHOLLAS	2965.96	5-Year	1225.00	83.60	87.25	87.25	88.80	0.002460	9.99	122.56	39.88	1.01	3.65
CHOLLAS	2965.96	2-Year	1050.00	83.60	86.92	86.92	88.35	0.002520	9.59	109.52	38.73	1.01	3.32

HEC-RAS Plan: EX   River: CHOLLAS   Reach: CHOLLAS (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	2892.27	100-Year	3500.00	82.80	89.10	89.10	91.42	0.002062	12.23	290.12	68.29	0.99	6.30
CHOLLAS	2892.27	50-Year	2800.00	82.80	88.34	88.34	90.44	0.002186	11.62	241.31	59.63	1.00	5.54
CHOLLAS	2892.27	25-Year	2100.00	82.80	87.48	87.48	89.31	0.002300	10.85	193.60	52.95	1.00	4.68
CHOLLAS	2892.27	10-Year	1500.00	82.80	86.61	86.61	88.17	0.002420	10.01	149.83	48.02	1.00	3.81
CHOLLAS	2892.27	5-Year	1225.00	82.80	86.15	86.15	87.57	0.002511	9.54	128.37	45.46	1.00	3.35
CHOLLAS	2892.27	2-Year	1050.00	82.80	85.85	85.85	87.15	0.002566	9.16	114.61	43.88	1.00	3.05
CHOLLAS	2744.11	100-Year	3500.00	81.00	89.29		89.77	0.000347	6.35	780.87	292.20	0.43	8.29
CHOLLAS	2744.11	50-Year	2800.00	81.00	86.72	86.57	88.68	0.002058	11.24	250.00	63.85	0.97	5.72
CHOLLAS	2744.11	25-Year	2100.00	81.00	85.72	85.72	87.57	0.002325	10.92	192.25	52.74	1.01	4.72
CHOLLAS	2744.11	10-Year	1500.00	81.00	84.85	84.85	86.43	0.002430	10.08	148.74	47.57	1.01	3.85
CHOLLAS	2744.11	5-Year	1225.00	81.00	84.39	84.39	85.82	0.002507	9.61	127.46	44.85	1.01	3.39
CHOLLAS	2744.11	2-Year	1050.00	81.00	84.07	84.07	85.40	0.002572	9.26	113.39	43.02	1.01	3.07
CHOLLAS	2587.43	100-Year	3500.00	79.60	89.55	84.07	89.63	0.000047	2.74	2019.18	596.78	0.16	9.95
CHOLLAS	2587.43	50-Year	2800.00	79.60	87.95	83.46	88.10	0.000096	3.39	1170.57	395.71	0.23	8.35
CHOLLAS	2587.43	25-Year	2100.00	79.60	86.09	82.81	86.39	0.000238	4.37	512.59	315.87	0.34	6.49
CHOLLAS	2587.43	10-Year	1500.00	79.60	84.57	82.18	84.86	0.000297	4.32	347.04	80.00	0.37	4.97
CHOLLAS	2587.43	5-Year	1225.00	79.60	83.84	81.87	84.12	0.000331	4.22	290.60	75.63	0.38	4.24
CHOLLAS	2587.43	2-Year	1050.00	79.60	83.34	81.65	83.61	0.000373	4.15	253.19	74.02	0.40	3.74
CHOLLAS	2585.39		Bridge										
CHOLLAS	2583.43	100-Year	3500.00	78.00	83.84	83.84	86.00	0.001847	11.91	311.87	83.37	0.94	5.84
CHOLLAS	2583.43	50-Year	2800.00	78.00	83.09	83.09	85.09	0.002025	11.36	253.07	72.83	0.96	5.09
CHOLLAS	2583.43	25-Year	2100.00	78.00	82.21	82.21	84.00	0.002347	10.74	195.74	56.96	1.00	4.21
CHOLLAS	2583.43	10-Year	1500.00	78.00	81.43	81.43	82.91	0.002449	9.77	153.51	52.33	1.01	3.43
CHOLLAS	2583.43	5-Year	1225.00	78.00	81.02	81.02	82.35	0.002514	9.23	132.74	50.71	1.01	3.02
CHOLLAS	2583.43	2-Year	1050.00	78.00	80.75	80.75	81.96	0.002584	8.82	119.00	49.74	1.01	2.75
CHOLLAS	2375.43	100-Year	3500.00	76.25	82.36	82.36	84.53	0.003205	11.81	298.73	80.34	0.98	6.11
CHOLLAS	2375.43	50-Year	2800.00	76.25	81.64	81.64	83.61	0.003345	11.26	248.70	63.47	1.00	5.39
CHOLLAS	2375.43	25-Year	2100.00	76.25	80.76	80.76	82.54	0.003119	10.70	196.22	55.47	1.00	4.51
CHOLLAS	2375.43	10-Year	1500.00	76.25	79.84	79.84	81.41	0.002807	10.06	149.04	47.92	1.01	3.59
CHOLLAS	2375.43	5-Year	1225.00	76.25	79.40	79.40	80.81	0.002656	9.53	128.58	45.96	1.00	3.15
CHOLLAS	2375.43	2-Year	1050.00	76.25	79.10	79.10	80.40	0.002685	9.14	114.88	44.63	1.00	2.85
CHOLLAS	2253.83	100-Year	3500.00	75.00	82.58		83.57	0.000643	8.03	463.60	148.63	0.61	7.58
CHOLLAS	2253.83	50-Year	2800.00	75.00	81.46		82.50	0.000822	8.18	342.28	76.22	0.68	6.46
CHOLLAS	2253.83	25-Year	2100.00	75.00	80.59		81.46	0.000824	7.48	280.57	66.23	0.64	5.59
CHOLLAS	2253.83	10-Year	1500.00	75.00	79.31		80.16	0.001081	7.39	203.08	56.63	0.69	4.31
CHOLLAS	2253.83	5-Year	1225.00	75.00	78.90		79.62	0.001018	6.79	180.47	54.67	0.66	3.90

HEC-RAS Plan: EX   River: CHOLLAS   Reach: CHOLLAS (Continued)

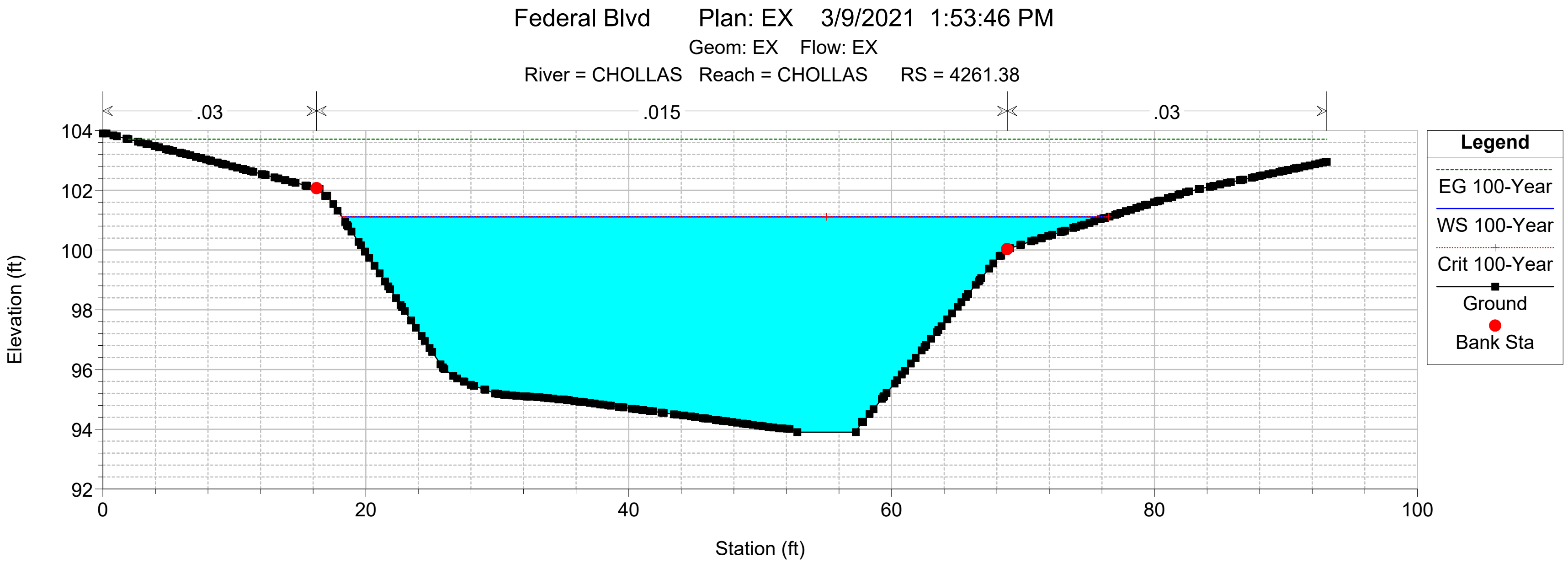
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	2253.83	2-Year	1050.00	75.00	78.50		79.18	0.001085	6.60	159.00	52.73	0.67	3.50



Federal Blvd Plan: EX 3/9/2021 1:53:46 PM

Geom: EX Flow: EX

River = CHOLLAS Reach = CHOLLAS RS = 4262.38

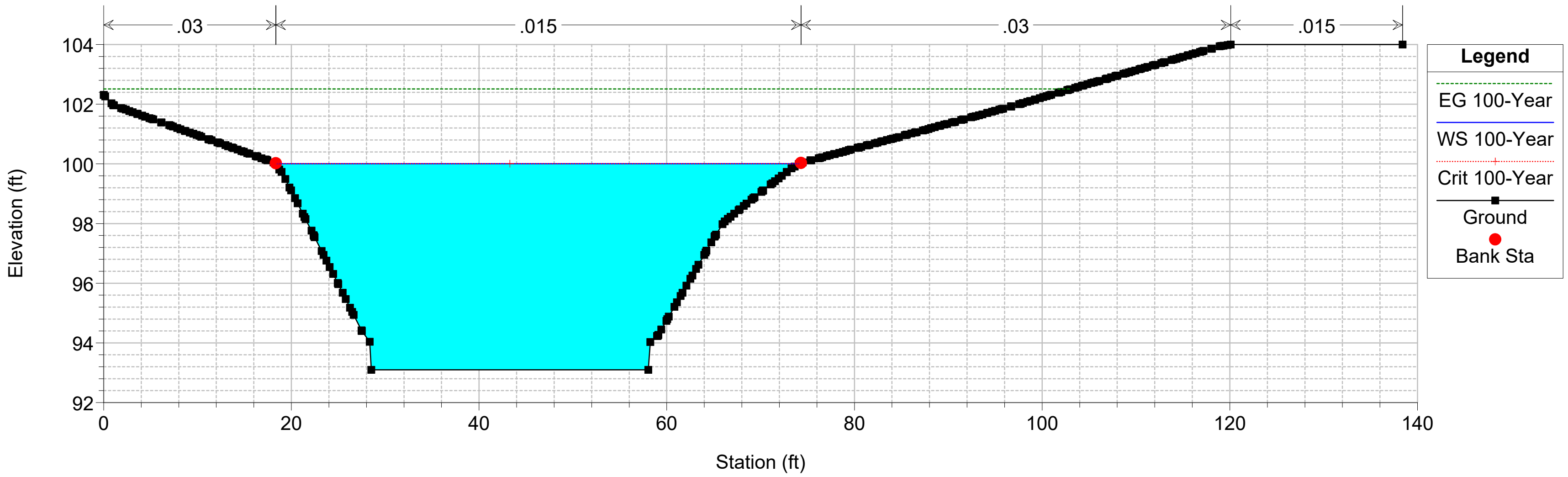


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM

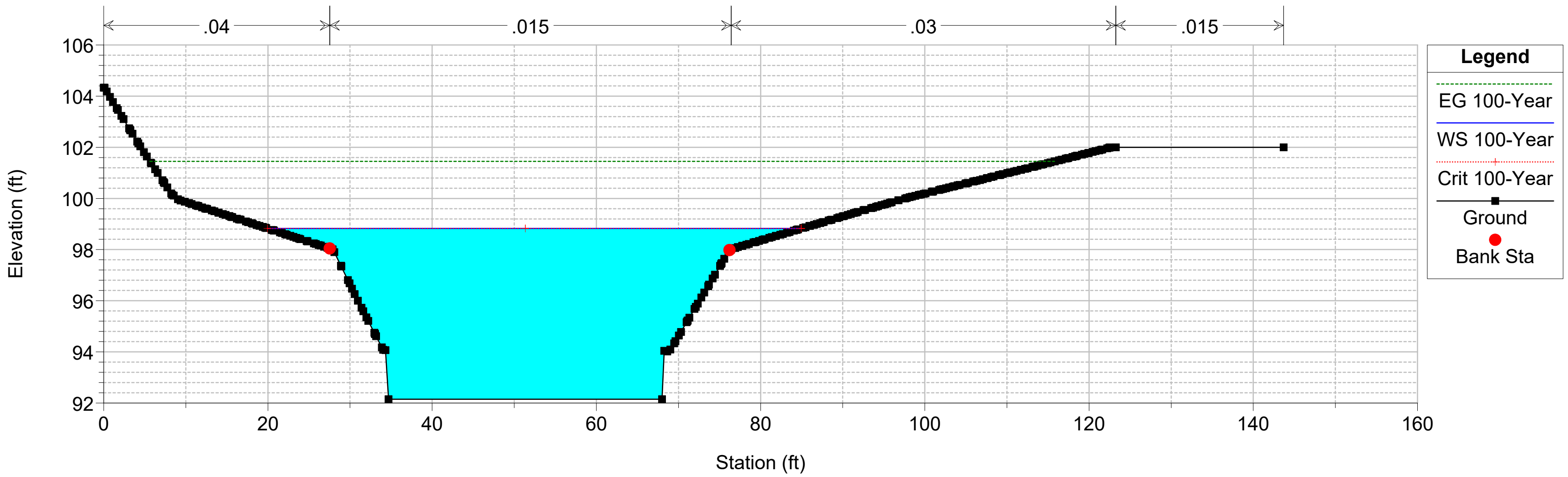
Geom: EX Flow: EX

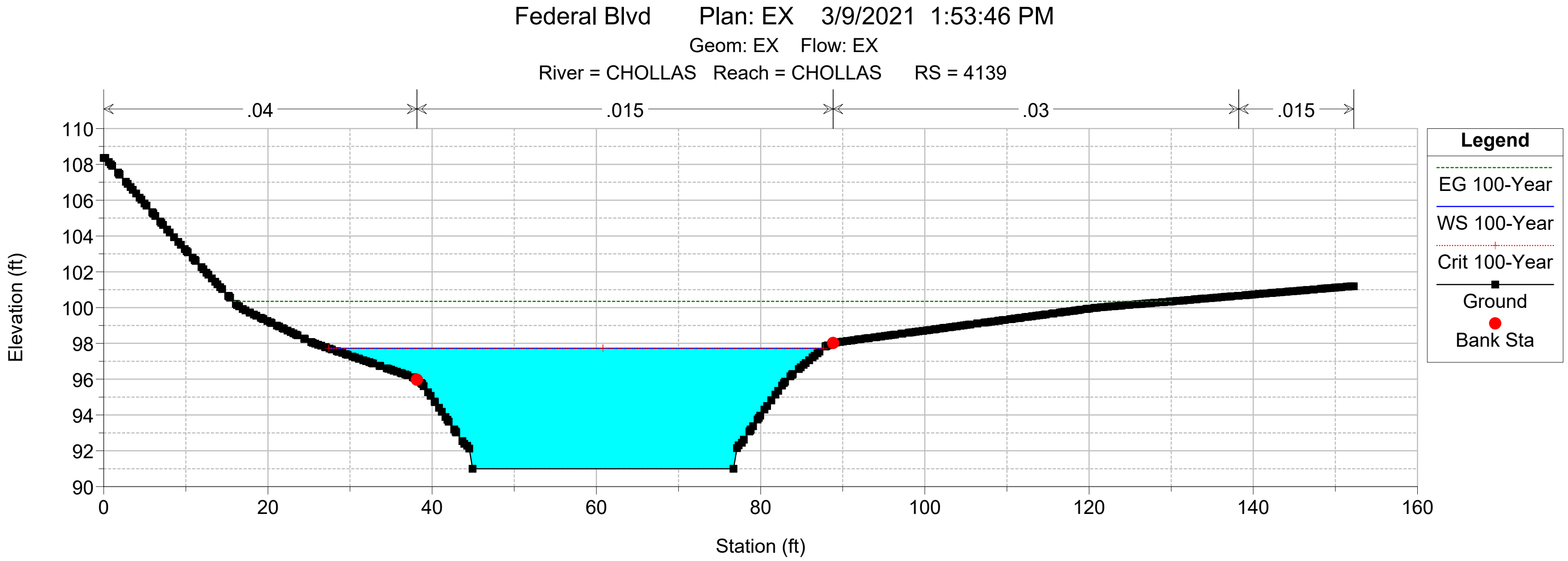
River = CHOLLAS Reach = CHOLLAS RS = 4261.38

Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 4156

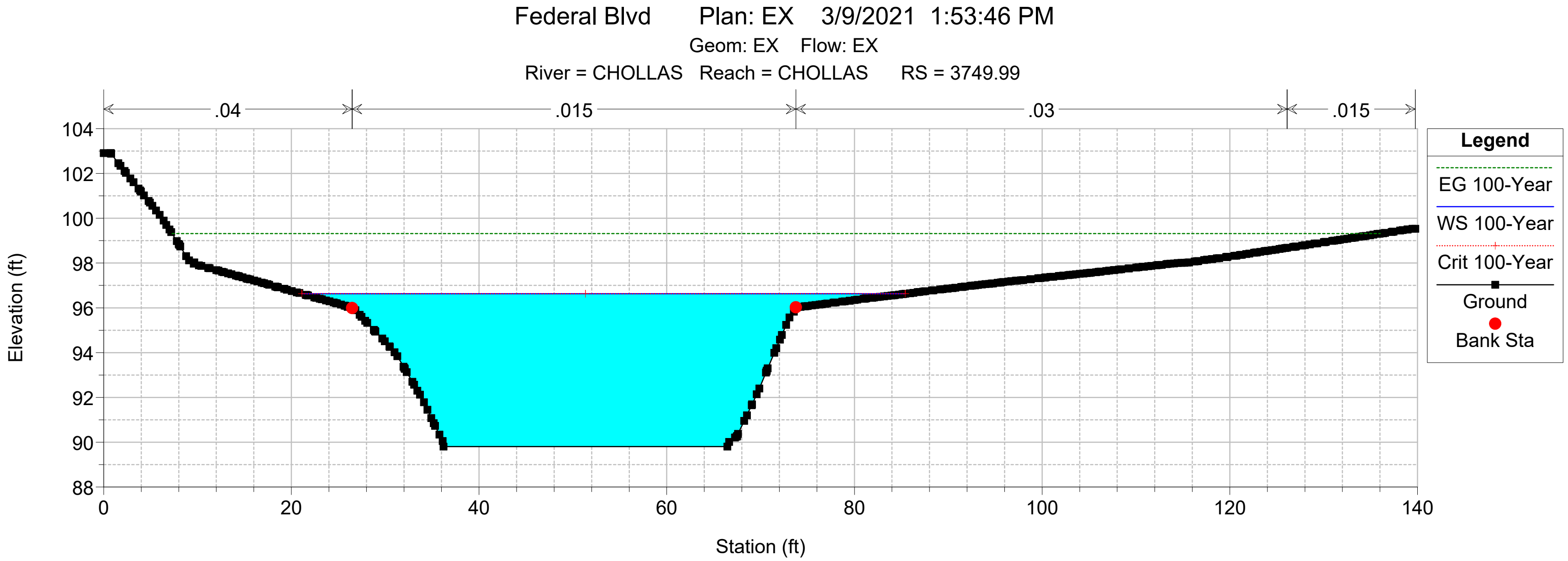


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 4151





Federal Blvd   Plan: EX   3/9/2021 1:53:46 PM
Geom: EX   Flow: EX
River = CHOLLAS   Reach = CHOLLAS   RS = 4139



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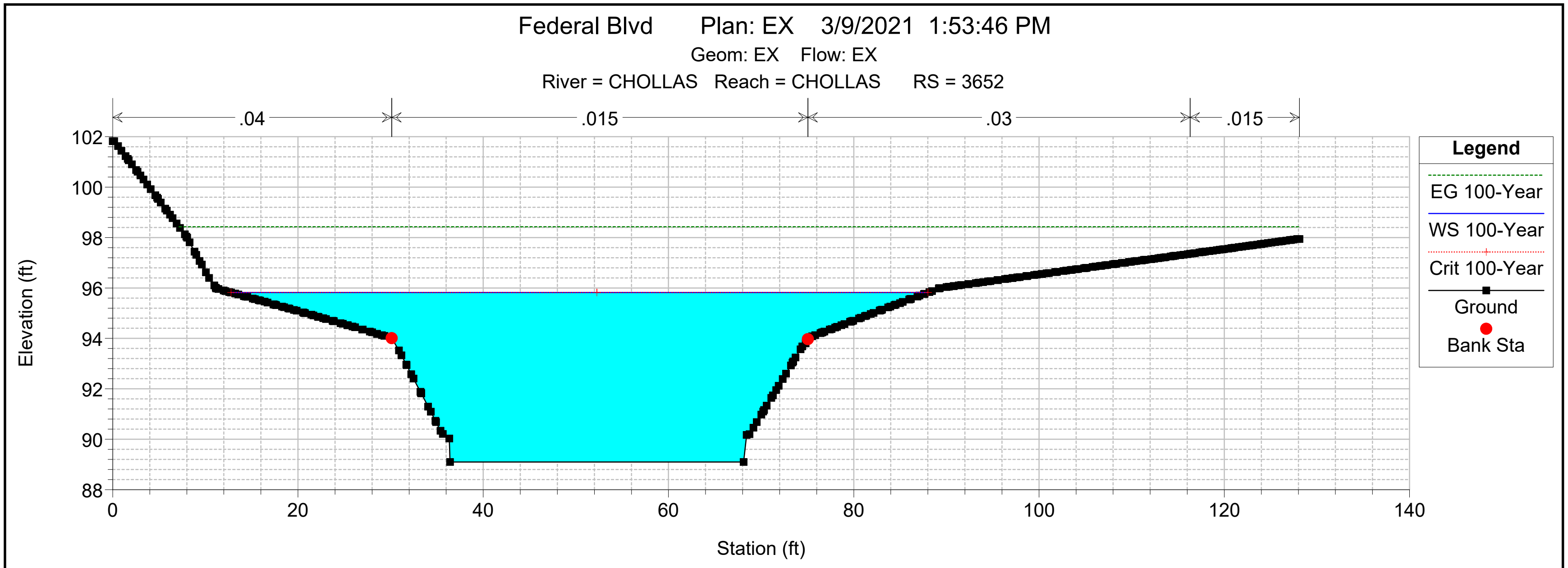
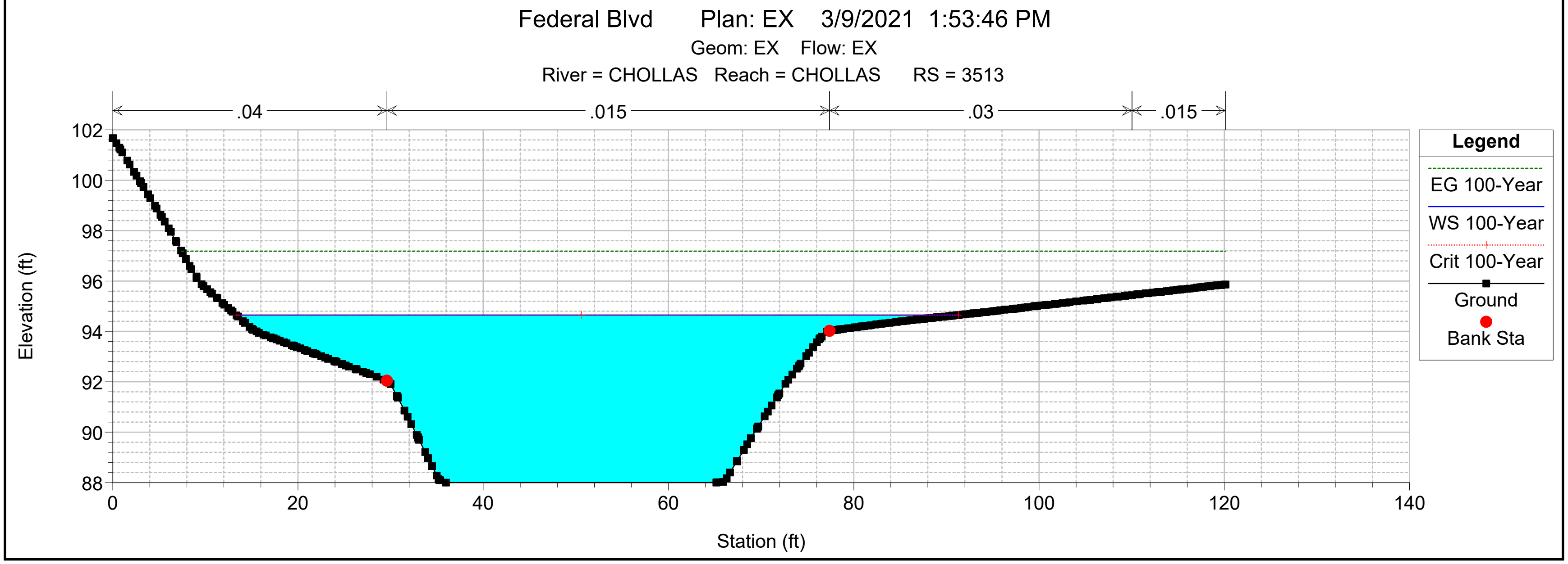
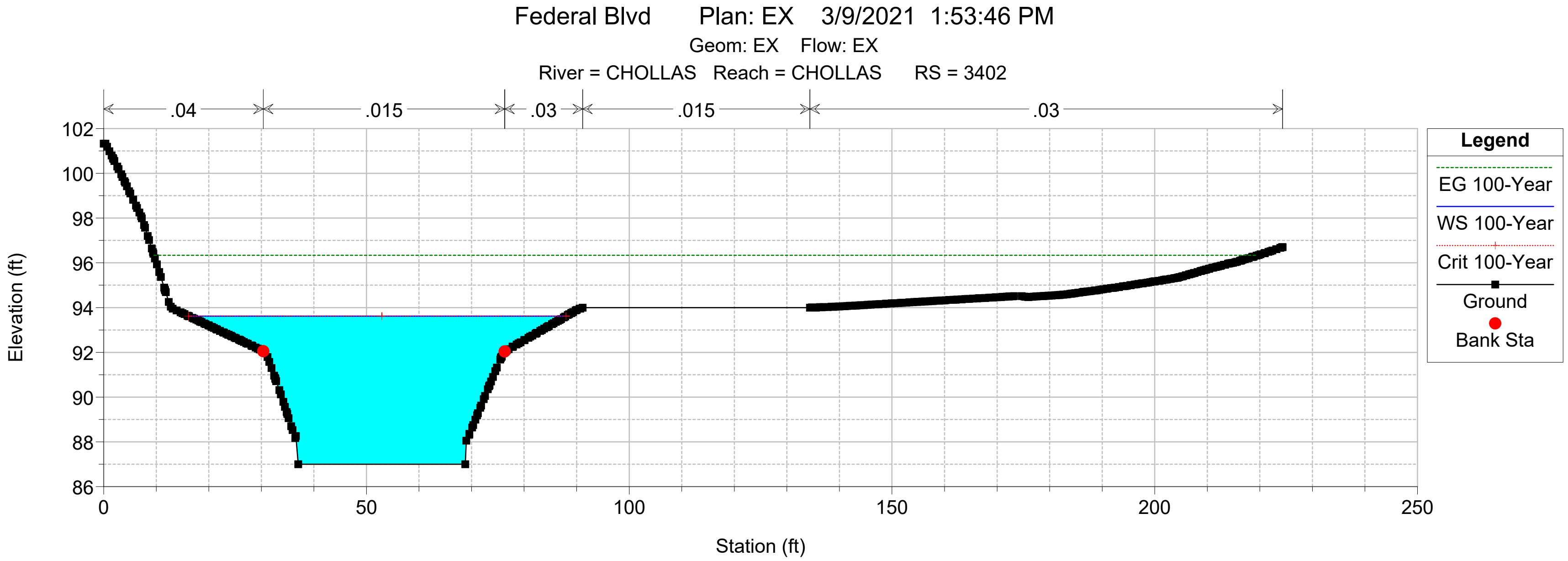
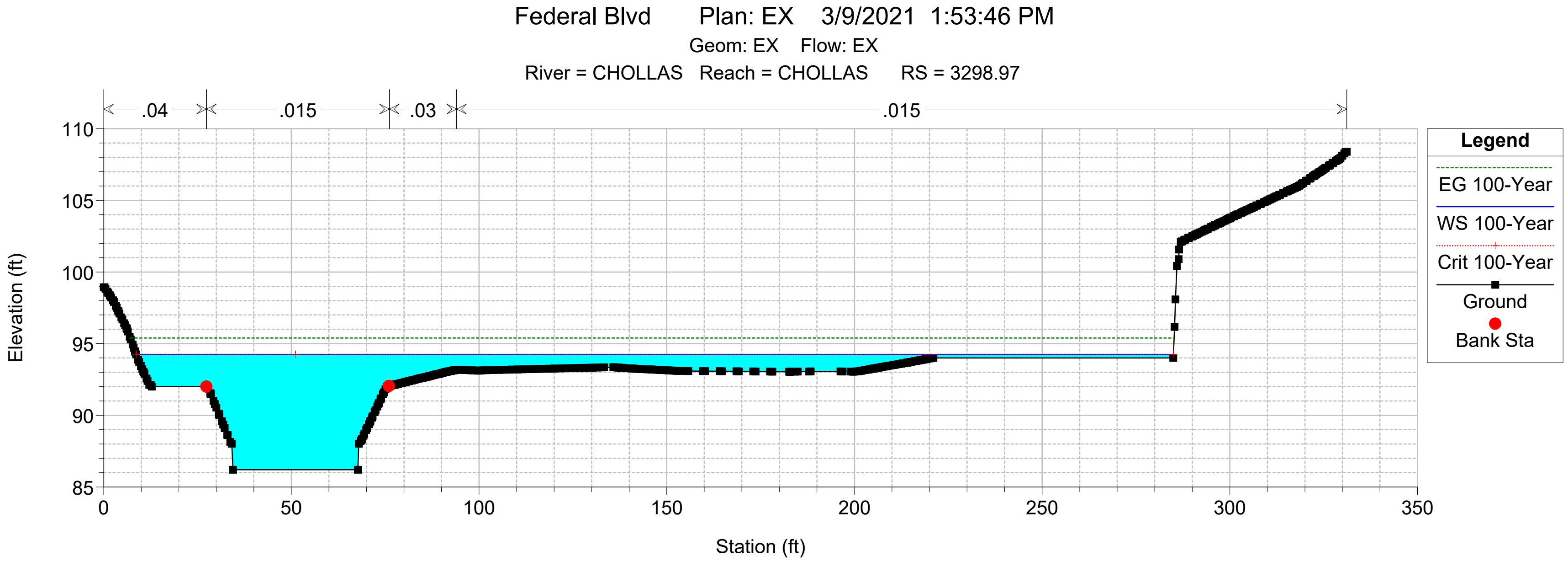
Geom: EX   Flow: EX
River = CHOLLAS   Reach = CHOLLAS   RS = 3749.99


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 3652
.04
.015
.03
.015
Elevation (ft)
102
100
98
96
94
92
90
88
0
20
40
60
80
100
120
140
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 3513
.04
.015
.03
.015
Elevation (ft)
102
100
98
96
94
92
90
88
0
20
40
60
80
100
120
140
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 3402
.04
.015
.03
.015
.03
Elevation (ft)
102
100
98
96
94
92
90
88
86
0
50
100
150
200
250
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta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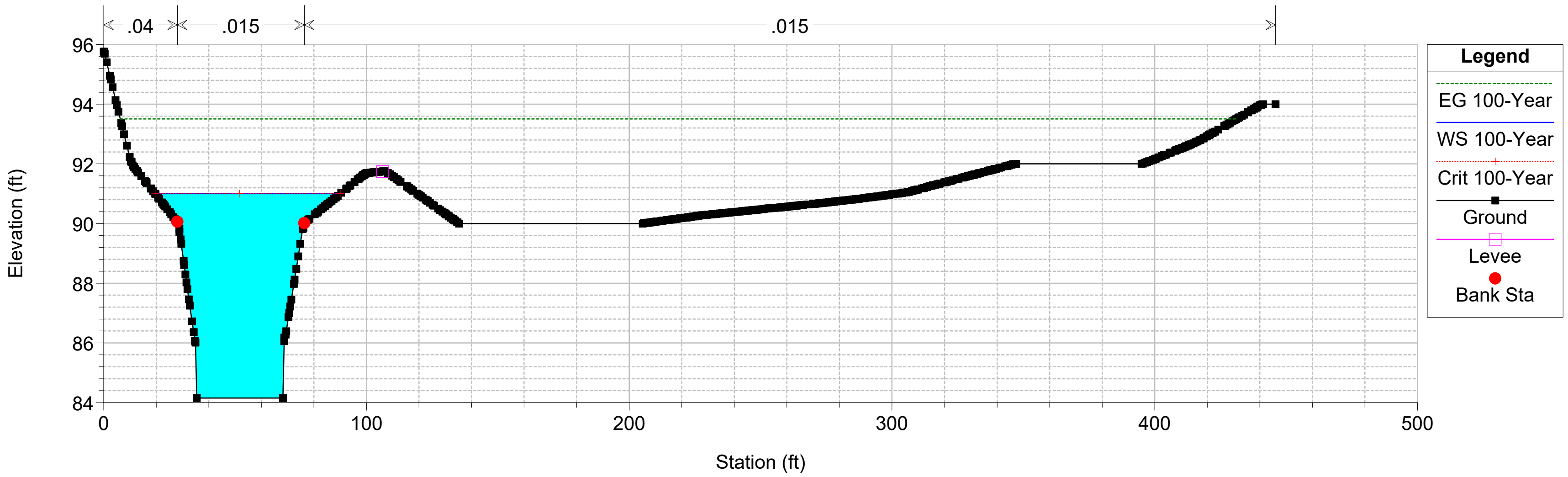
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 3298.97
.04
.015
.03
.015
Elevation (ft)
110
105
100
95
90
85
0
50
100
150
200
250
300
350
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta



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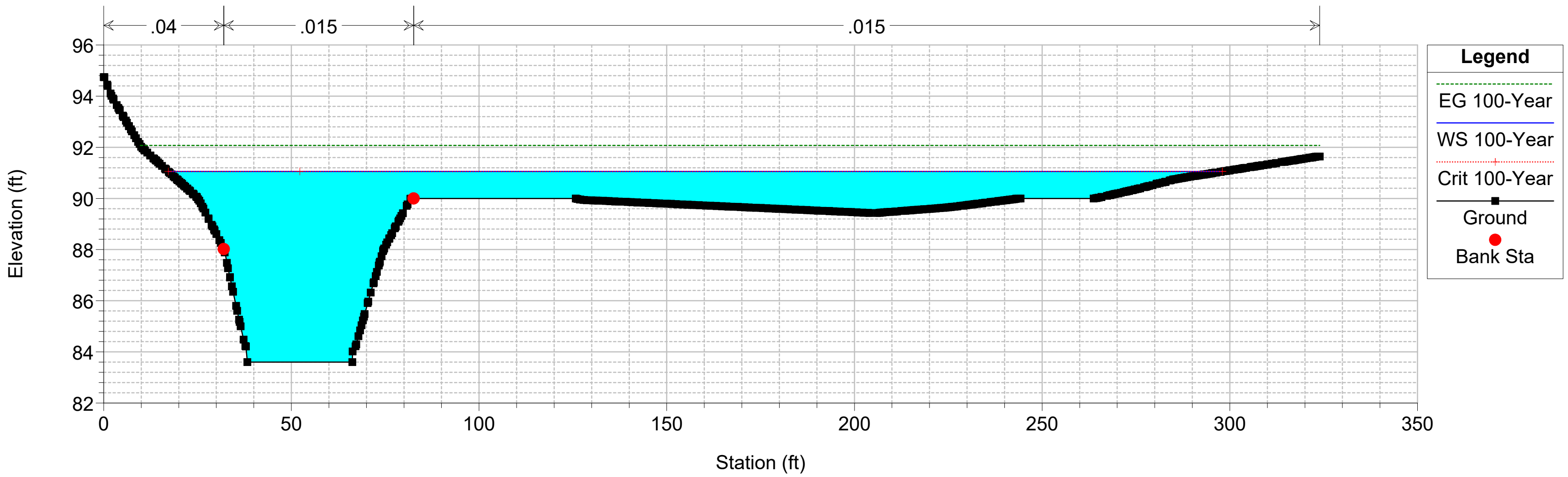
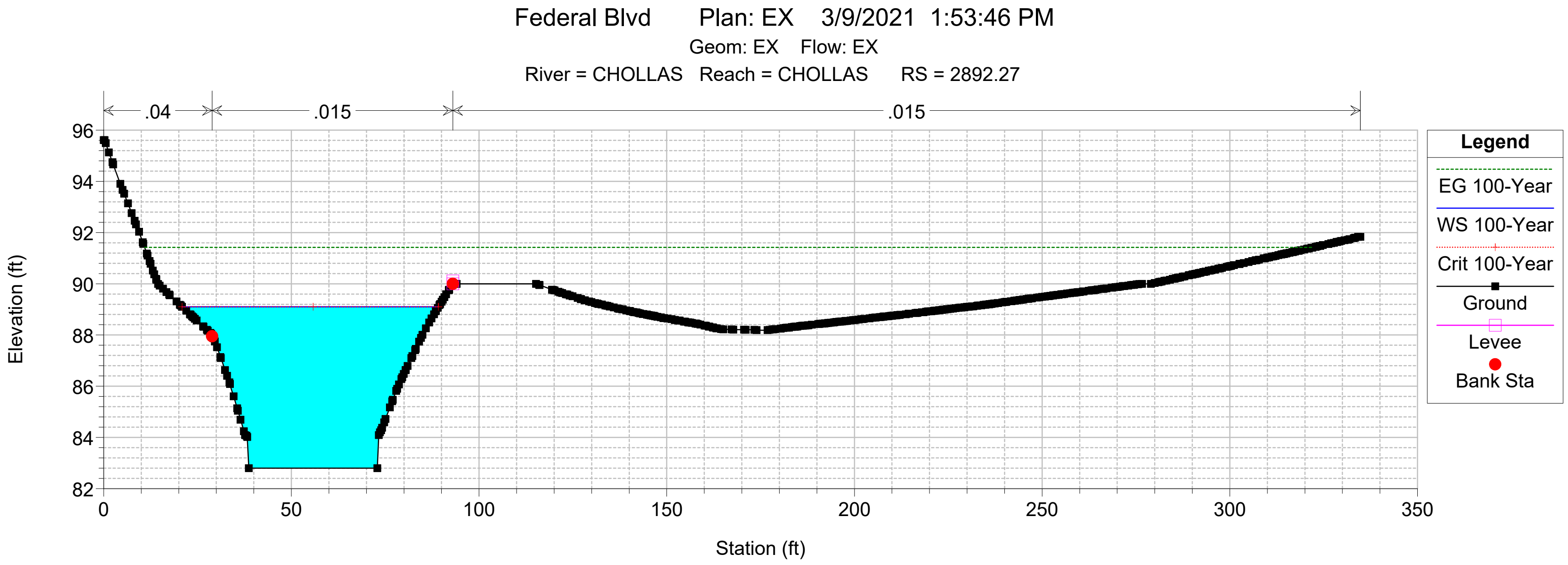
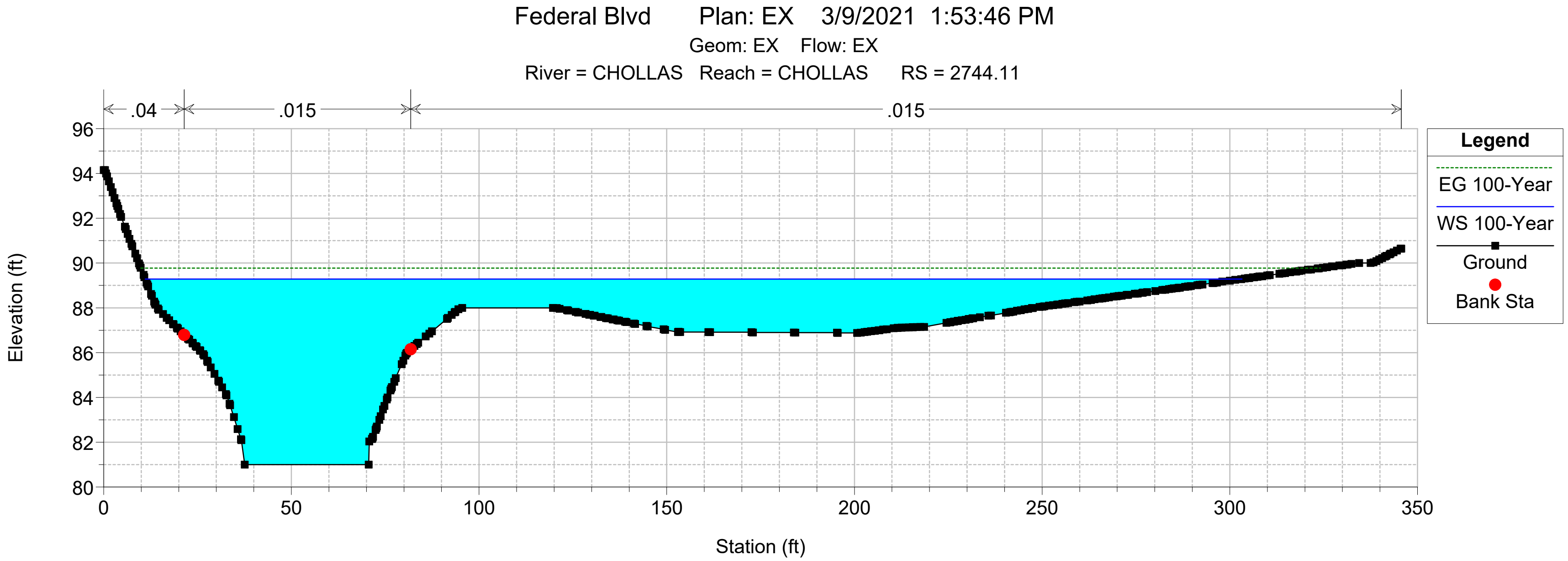
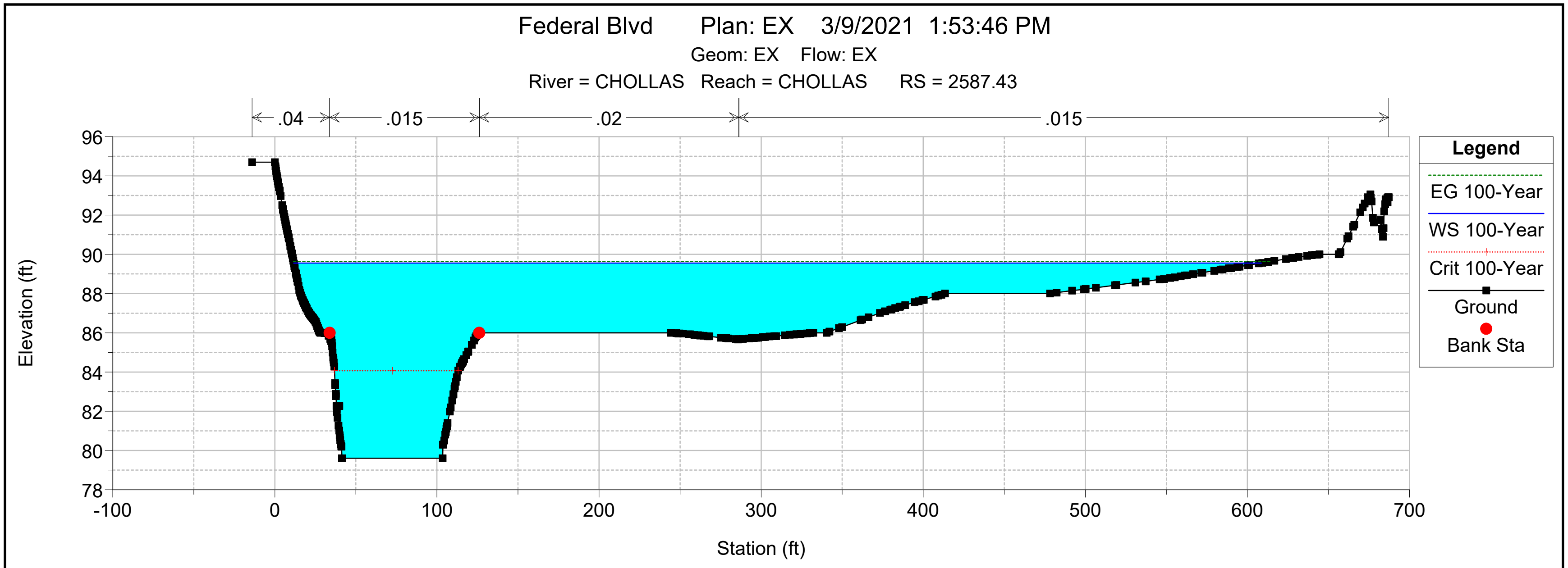
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 3031.27

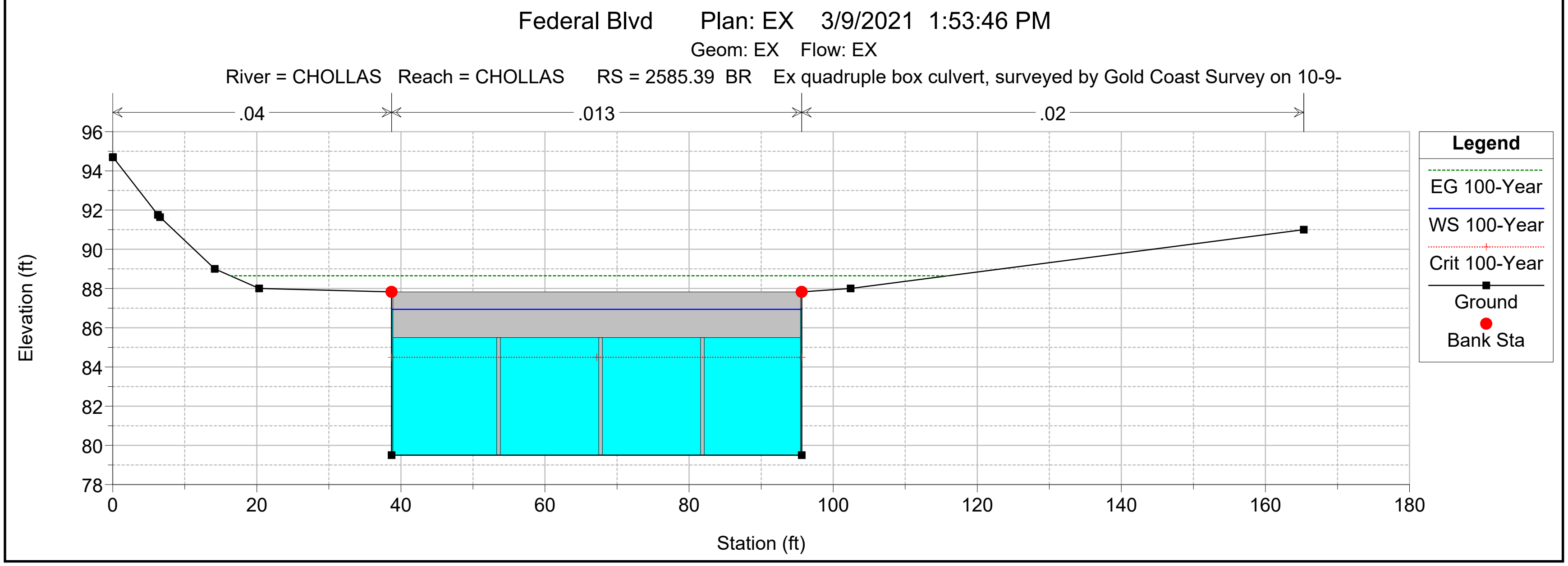


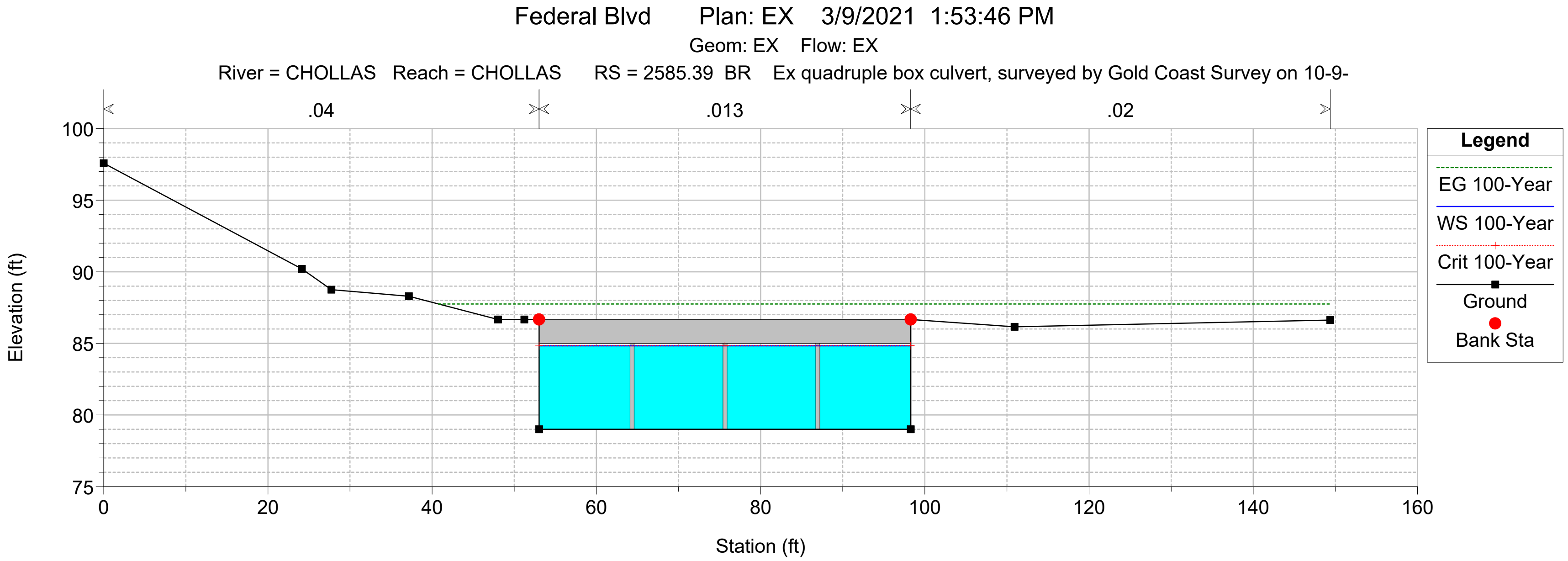
Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2965.96

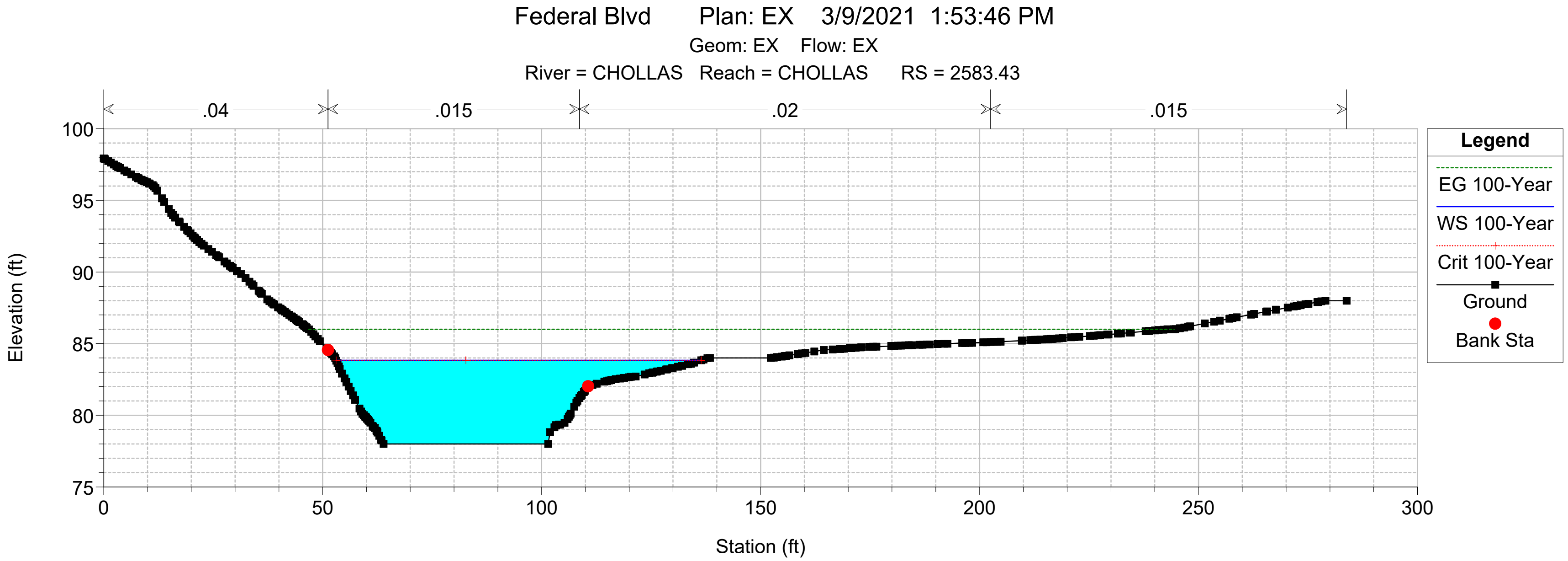

Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2892.27
.04
.015
.015
Elevation (ft)
96
94
92
90
88
86
84
82
0
50
100
150
200
250
300
350
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Levee
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2744.11
.04
.015
.015
Elevation (ft)
96
94
92
90
88
86
84
82
80
0
50
100
150
200
250
300
350
Station (ft)
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta

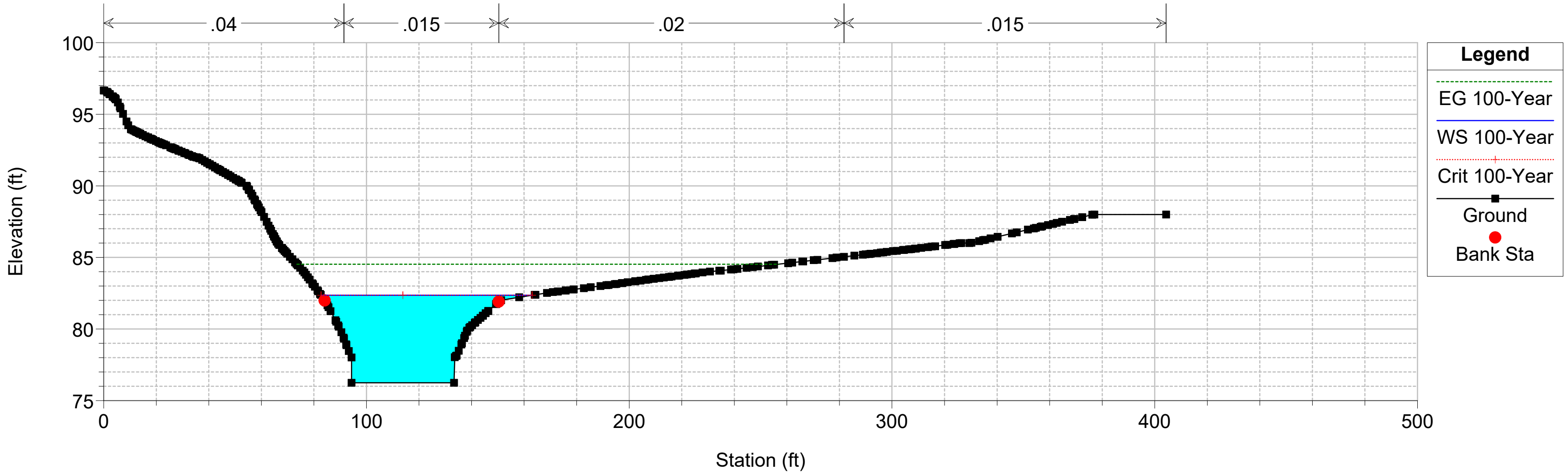

Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2587.43
.04
.015
.02
.015
Elevation (ft)
96
94
92
90
88
86
84
82
80
78
-100
0
100
200
300
400
500
600
700
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2585.39 BR Ex quadruple box culvert, surveyed by Gold Coast Survey on 10-9-
.04
.013
.02
Elevation (ft)
96
94
92
90
88
86
84
82
80
78
0
20
40
60
80
100
120
140
160
180
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2585.39 BR Ex quadruple box culvert, surveyed by Gold Coast Survey on 10-9-
.04
.013
.02
Elevation (ft)
100
95
90
85
80
75
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2583.43
.04
.015
.02
.015
Elevation (ft)
100
95
90
85
80
75
0
50
100
150
200
250
300
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta

Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2375.43



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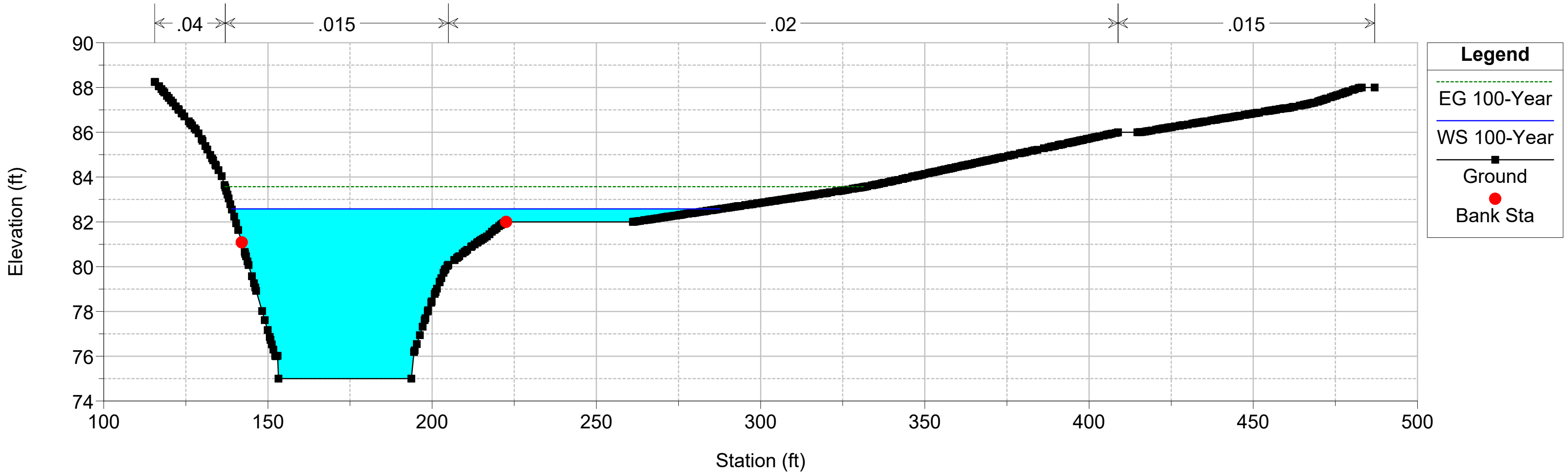
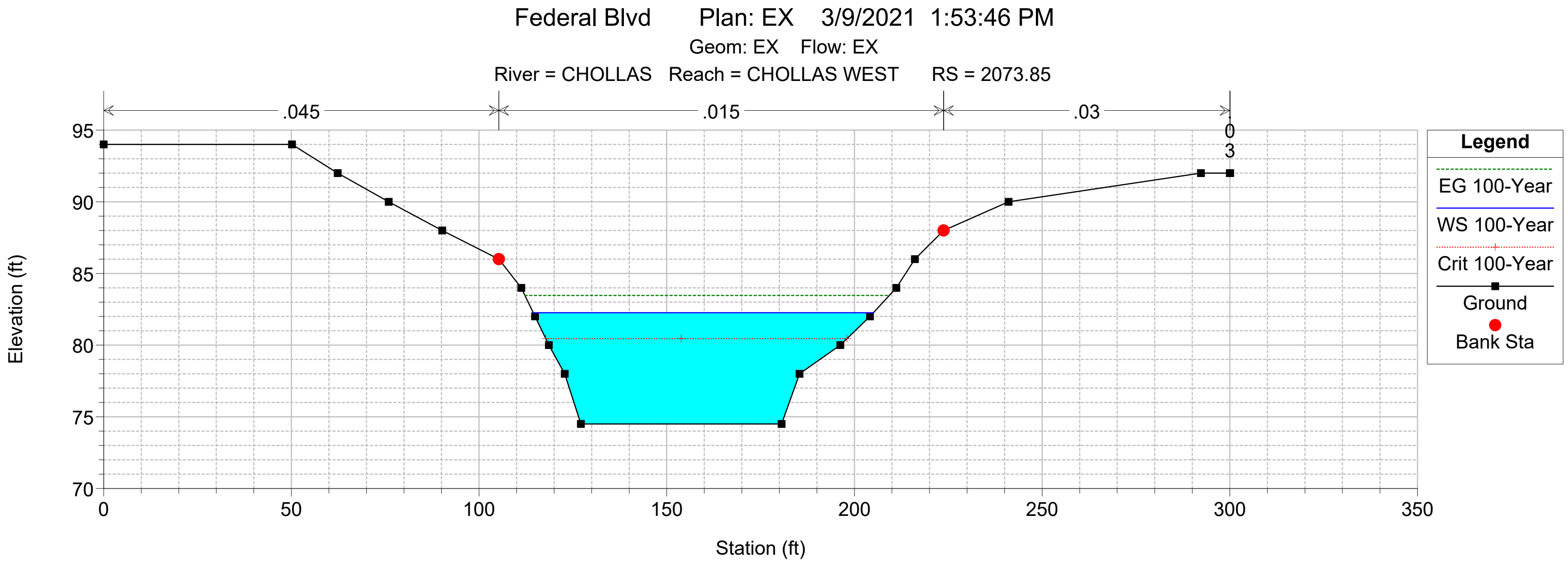
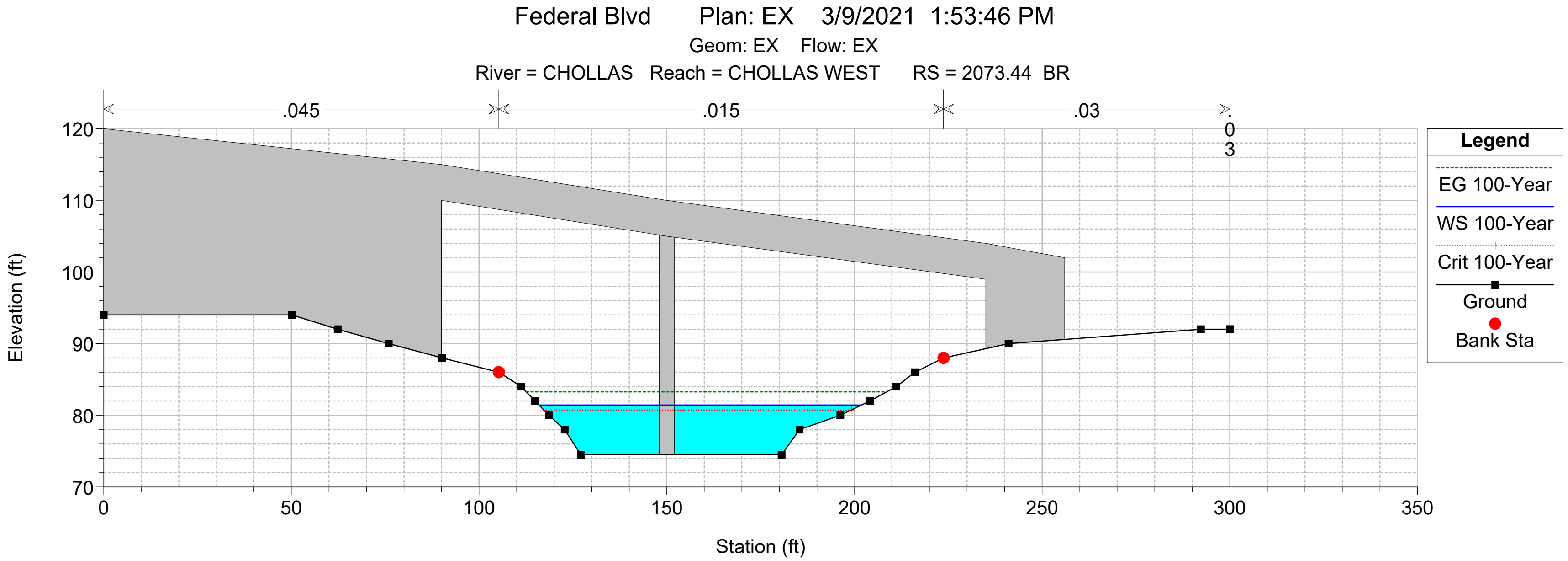
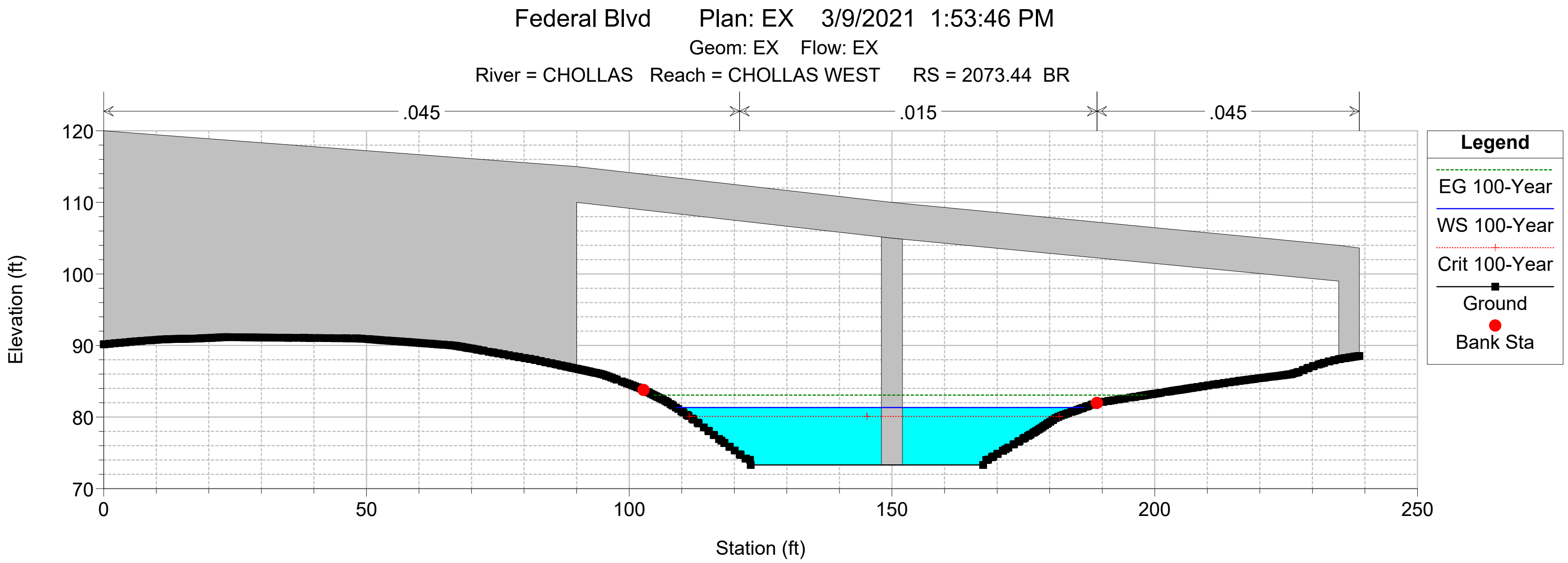
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS RS = 2253.83




Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.85
.045
.015
.03
0
3
Elevation (ft)
95
90
85
80
75
70
0
50
100
150
200
250
300
350
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.44 BR
.045
.015
.03
0
3
Elevation (ft)
120
110
100
90
80
70
0
50
100
150
200
250
300
350
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta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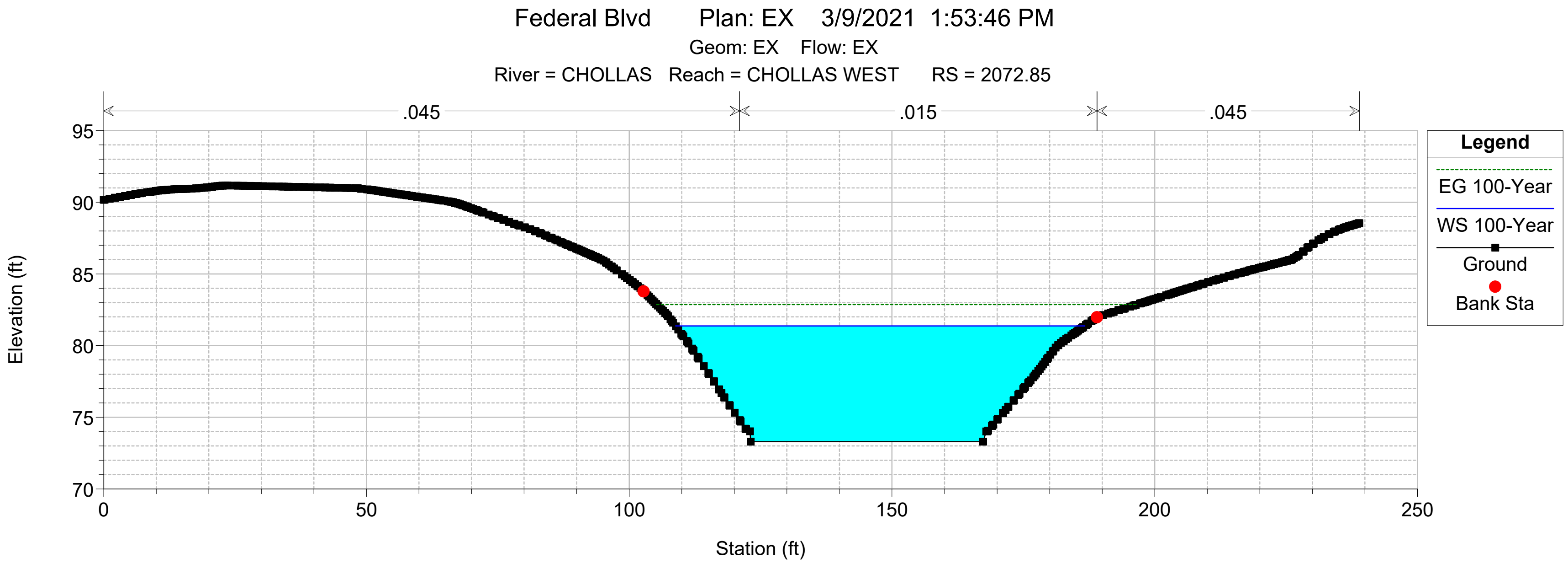
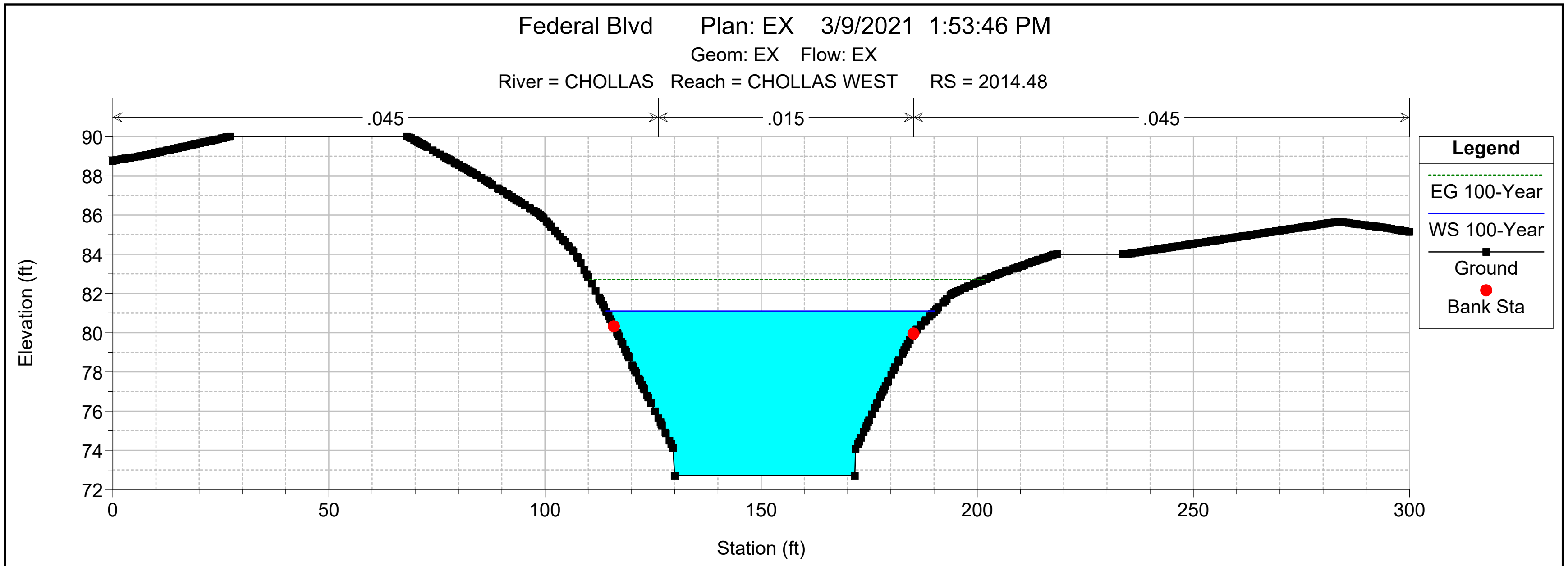
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.44 BR
.045
.015
.045
120
110
100
90
80
70
Elevation (ft)
0
50
100
150
200
250
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS WEST RS = 2072.85
.045
.015
.045
95
90
85
80
75
70
Elevation (ft)
0
50
100
150
200
250
Station (ft)
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta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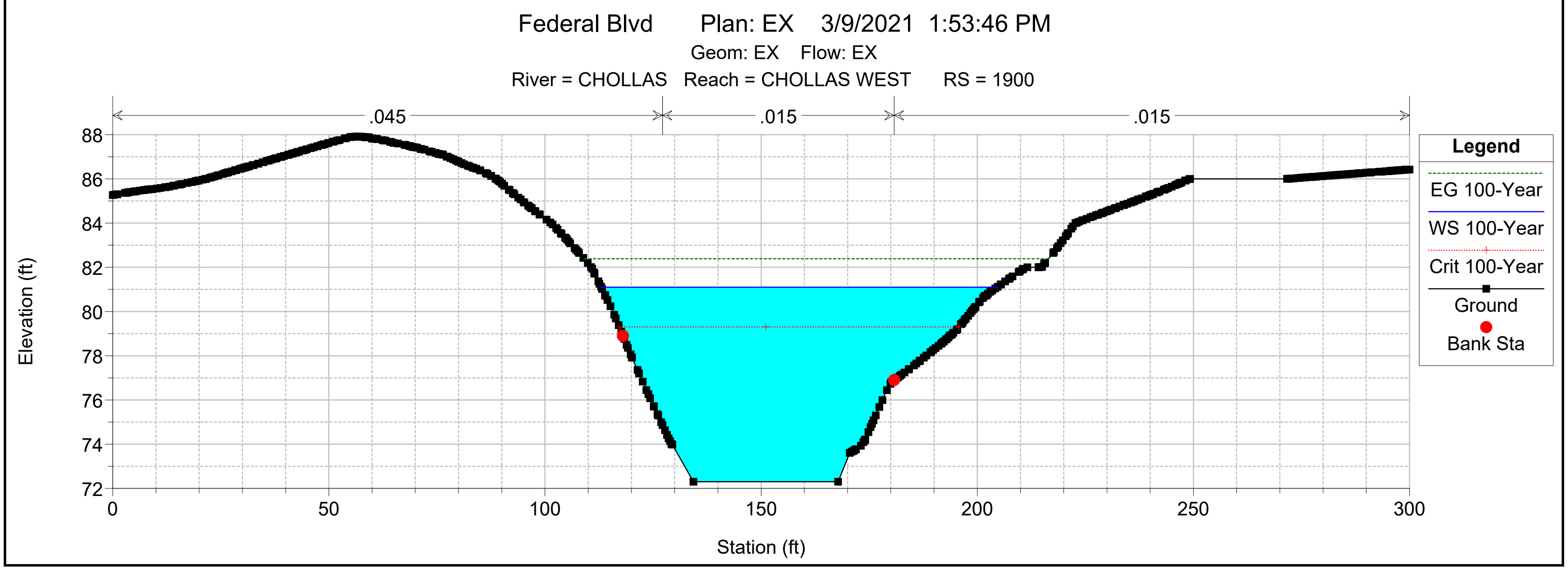
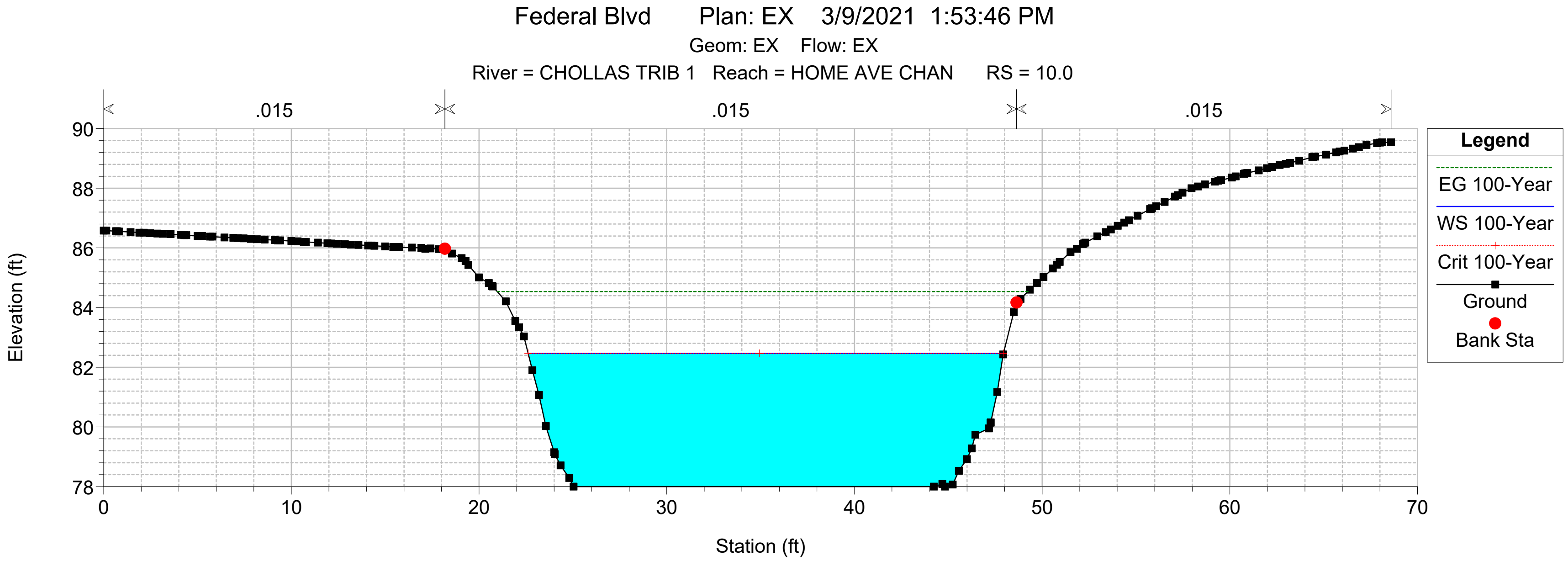
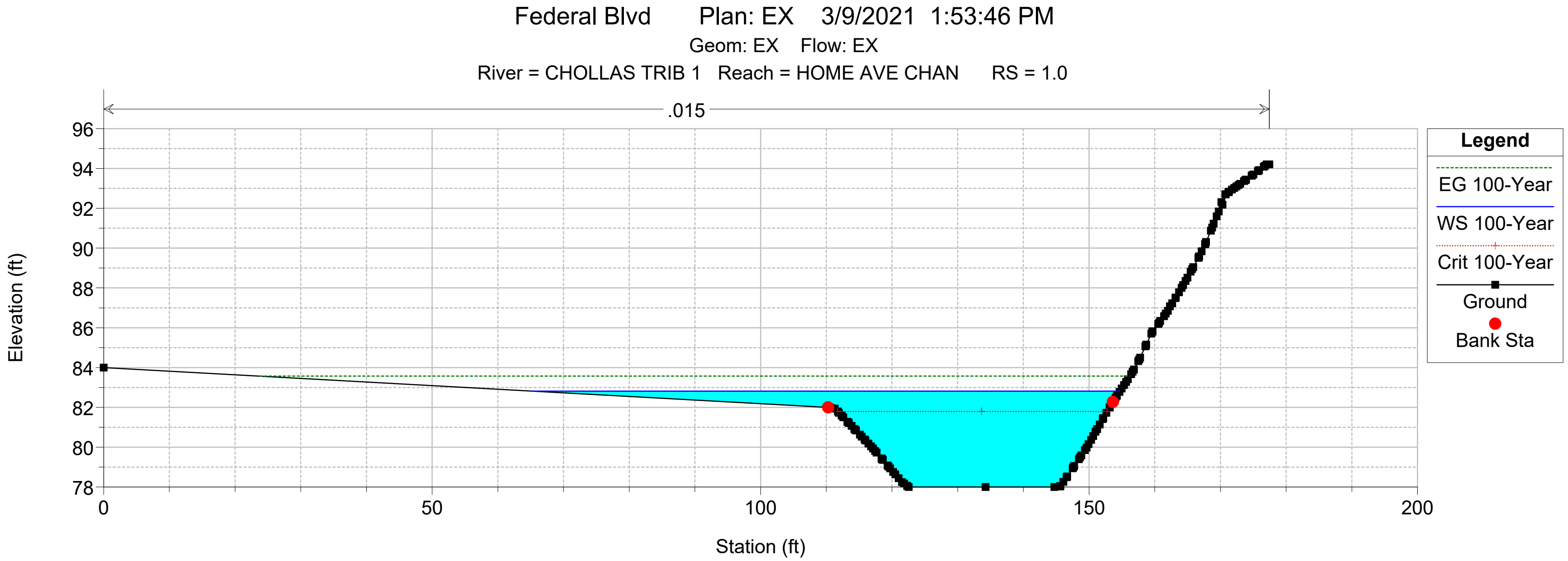
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS WEST RS = 2014.48
.045
.015
.045
Elevation (ft)
90
88
86
84
82
80
78
76
74
72
0
50
100
150
200
250
300
Station (ft)
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta


Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS Reach = CHOLLAS WEST RS = 1900
.045
.015
.015
Elevation (ft)
88
86
84
82
80
78
76
74
72
0
50
100
150
200
250
300
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta

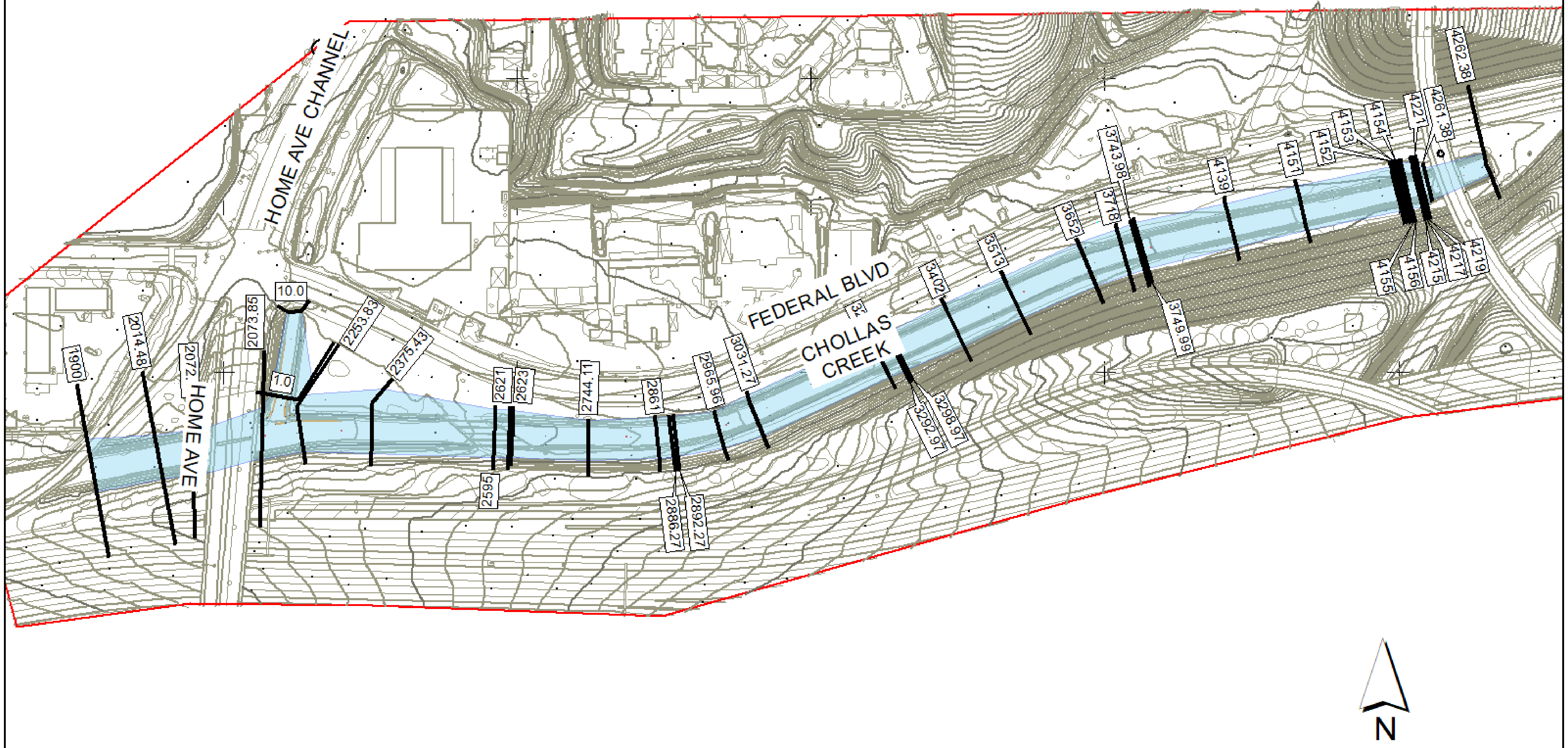

Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS TRIB 1 Reach = HOME AVE CHAN RS = 10.0
.015
.015
.015
Elevation (ft)
90
88
86
84
82
80
78
0
10
20
30
40
50
60
70
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta

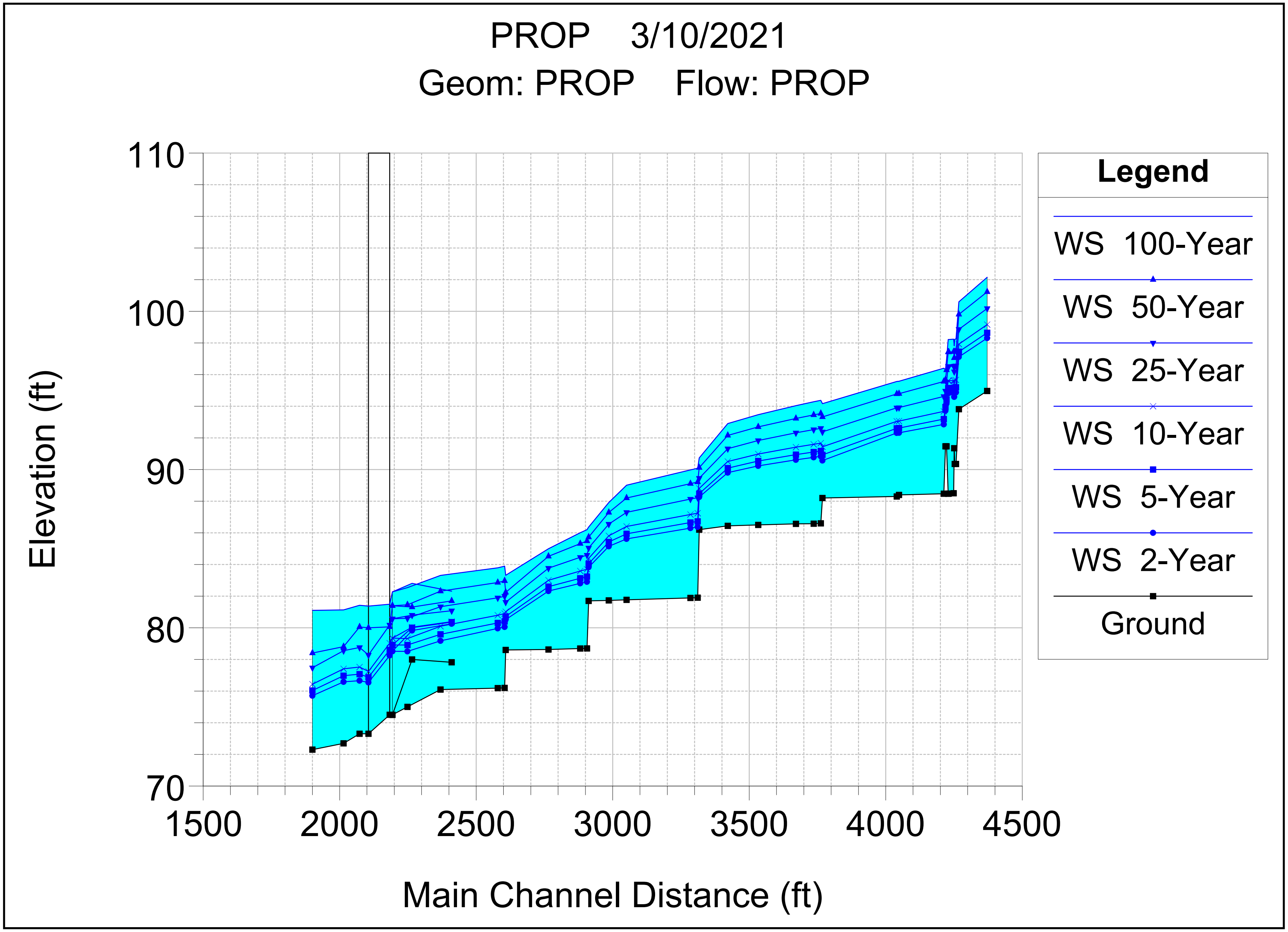

Federal Blvd Plan: EX 3/9/2021 1:53:46 PM
Geom: EX Flow: EX
River = CHOLLAS TRIB 1 Reach = HOME AVE CHAN RS = 1.0
.015
Elevation (ft)
96
94
92
90
88
86
84
82
80
78
0
50
100
150
200
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta

B - HEC-RAS Results
Proposed
Subcritical Flow (Floodplain)

Legend

🟦 PR Floodplain - Subcritical Flow




PROP 3/10/2021
Geom: PROP Flow: PROP
Elevation (ft)
110
100
90
80
70
1500
2000
2500
3000
3500
4000
4500
Main Channel Distance (ft)
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
Ground

HEC-RAS Plan: PROP

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	100-Year	1200.00	77.82	82.32	82.32	84.40	0.002691	11.57	103.71	25.22	1.01	4.50
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	50-Year	950.00	77.82	81.70	81.70	83.50	0.002722	10.76	88.30	24.82	1.01	3.88
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	25-Year	720.00	77.82	81.08	81.08	82.59	0.002774	9.86	72.99	24.39	1.01	3.26
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	10-Year	430.00	77.82	80.39	80.18	81.29	0.002188	7.64	56.31	23.91	0.88	2.57
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	5-Year	420.00	77.82	80.36	80.14	81.24	0.002152	7.53	55.75	23.89	0.87	2.54
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	2-Year	360.00	77.82	80.25	79.93	80.97	0.001837	6.78	53.11	23.81	0.80	2.43
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	100-Year	1200.00	78.00	82.81	81.81	83.57	0.000937	7.13	183.39	92.07	0.65	4.81
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	50-Year	950.00	78.00	81.31	81.31	82.66	0.002516	9.33	101.87	38.19	1.01	3.31
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	25-Year	720.00	78.00	80.80	80.80	81.97	0.002625	8.67	83.00	35.94	1.01	2.80
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	10-Year	430.00	78.00	80.04	80.04	80.92	0.002851	7.55	56.96	32.55	1.01	2.04
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	5-Year	420.00	78.00	80.01	80.01	80.88	0.002856	7.49	56.04	32.43	1.01	2.01
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	2-Year	360.00	78.00	79.83	79.83	80.63	0.002932	7.18	50.13	31.60	1.01	1.83
CHOLLAS	CHOLLAS	4262.38	100-Year	3500.00	94.97	102.15	102.15	105.46	0.002359	14.58	240.16	38.73	1.00	7.18
CHOLLAS	CHOLLAS	4262.38	50-Year	2800.00	94.97	101.23	101.23	104.09	0.002378	13.57	206.32	36.06	1.00	6.26
CHOLLAS	CHOLLAS	4262.38	25-Year	2100.00	94.97	100.18	100.18	102.58	0.002425	12.42	169.03	35.28	1.00	5.21
CHOLLAS	CHOLLAS	4262.38	10-Year	1500.00	94.97	99.16	99.16	101.12	0.002526	11.24	133.42	34.32	1.01	4.19
CHOLLAS	CHOLLAS	4262.38	5-Year	1225.00	94.97	98.65	98.65	100.38	0.002581	10.56	116.03	33.82	1.00	3.68
CHOLLAS	CHOLLAS	4262.38	2-Year	1050.00	94.97	98.30	98.30	99.87	0.002617	10.05	104.49	33.49	1.00	3.33
CHOLLAS	CHOLLAS	4261.38	100-Year	3500.00	93.81	100.60	100.60	103.31	0.002029	13.20	266.95	55.04	1.00	6.79
CHOLLAS	CHOLLAS	4261.38	50-Year	2800.00	93.81	99.81	99.81	102.18	0.002152	12.36	226.49	48.06	1.00	6.00
CHOLLAS	CHOLLAS	4261.38	25-Year	2100.00	93.81	98.86	98.86	100.92	0.002248	11.51	182.45	44.80	1.01	5.05
CHOLLAS	CHOLLAS	4261.38	10-Year	1500.00	93.81	97.93	97.93	99.66	0.002361	10.55	142.24	41.61	1.01	4.12
CHOLLAS	CHOLLAS	4261.38	5-Year	1225.00	93.81	97.45	97.45	99.00	0.002433	9.99	122.61	39.96	1.01	3.64
CHOLLAS	CHOLLAS	4261.38	2-Year	1050.00	93.81	97.12	97.12	98.54	0.002492	9.58	109.58	38.82	1.01	3.31
CHOLLAS	CHOLLAS	4221	100-Year	3500.00	90.35	98.25		98.97	0.003810	6.76	518.13	78.17	0.46	7.90
CHOLLAS	CHOLLAS	4221	50-Year	2800.00	90.35	97.47		98.05	0.003660	6.12	457.54	76.01	0.44	7.12
CHOLLAS	CHOLLAS	4221	25-Year	2100.00	90.35	96.56		97.01	0.003327	5.38	390.06	73.03	0.41	6.21
CHOLLAS	CHOLLAS	4221	10-Year	1500.00	90.35	95.66		95.99	0.002937	4.61	325.59	70.05	0.38	5.31
CHOLLAS	CHOLLAS	4221	5-Year	1225.00	90.35	95.20		95.47	0.002688	4.17	293.59	68.53	0.36	4.85
CHOLLAS	CHOLLAS	4221	2-Year	1050.00	90.35	94.88		95.11	0.002505	3.86	271.75	67.47	0.34	4.53
CHOLLAS	CHOLLAS	4219	100-Year	3500.00	90.35	98.23		98.95	0.003852	6.79	516.35	78.11	0.46	7.88
CHOLLAS	CHOLLAS	4219	50-Year	2800.00	90.35	97.45		98.03	0.003700	6.14	455.90	75.94	0.44	7.10
CHOLLAS	CHOLLAS	4219	25-Year	2100.00	90.35	96.54		97.00	0.003363	5.40	388.66	72.96	0.41	6.19
CHOLLAS	CHOLLAS	4219	10-Year	1500.00	90.35	95.65		95.98	0.002969	4.62	324.44	70.00	0.38	5.30
CHOLLAS	CHOLLAS	4219	5-Year	1225.00	90.35	95.19		95.46	0.002717	4.19	292.57	68.48	0.36	4.84
CHOLLAS	CHOLLAS	4219	2-Year	1050.00	90.35	94.87		95.10	0.002531	3.88	270.83	67.43	0.34	4.52
CHOLLAS	CHOLLAS	4217	100-Year	3500.00	91.35	97.82		98.90	0.007577	8.34	419.65	76.91	0.63	6.47
CHOLLAS	CHOLLAS	4217	50-Year	2800.00	91.35	97.06		97.99	0.007686	7.73	362.25	74.36	0.62	5.71
CHOLLAS	CHOLLAS	4217	25-Year	2100.00	91.35	96.19		96.96	0.007732	7.02	299.00	71.03	0.60	4.84
CHOLLAS	CHOLLAS	4217	10-Year	1500.00	91.35	95.33		95.94	0.007795	6.27	239.38	67.75	0.59	3.98
CHOLLAS	CHOLLAS	4217	5-Year	1225.00	91.35	94.90		95.42	0.007751	5.82	210.35	66.09	0.58	3.55
CHOLLAS	CHOLLAS	4217	2-Year	1050.00	91.35	94.60		95.07	0.007734	5.51	190.61	64.94	0.57	3.25

HEC-RAS Plan: PROP (Continued)

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	4215	100-Year	3500.00	88.50	98.24		98.71	0.001958	5.51	636.32	78.16	0.34	9.74
CHOLLAS	CHOLLAS	4215	50-Year	2800.00	88.50	97.45		97.81	0.001740	4.87	575.19	76.07	0.31	8.95
CHOLLAS	CHOLLAS	4215	25-Year	2100.00	88.50	96.53		96.80	0.001429	4.14	506.94	73.67	0.28	8.03
CHOLLAS	CHOLLAS	4215	10-Year	1500.00	88.50	95.63		95.81	0.001108	3.40	441.22	71.29	0.24	7.13
CHOLLAS	CHOLLAS	4215	5-Year	1225.00	88.50	95.16		95.30	0.000934	3.00	408.45	70.07	0.22	6.66
CHOLLAS	CHOLLAS	4215	2-Year	1050.00	88.50	94.84		94.96	0.000815	2.72	386.01	69.22	0.20	6.34
CHOLLAS	CHOLLAS	4156	100-Year	3500.00	88.48	98.22		98.67	0.001797	5.36	652.47	81.44	0.33	9.74
CHOLLAS	CHOLLAS	4156	50-Year	2800.00	88.48	97.43		97.78	0.001558	4.76	588.76	79.08	0.31	8.95
CHOLLAS	CHOLLAS	4156	25-Year	2100.00	88.48	96.52		96.77	0.001282	4.05	518.04	76.38	0.27	8.04
CHOLLAS	CHOLLAS	4156	10-Year	1500.00	88.48	95.61		95.79	0.000995	3.33	450.19	73.70	0.24	7.13
CHOLLAS	CHOLLAS	4156	5-Year	1225.00	88.48	95.15		95.29	0.000839	2.94	416.47	72.33	0.22	6.67
CHOLLAS	CHOLLAS	4156	2-Year	1050.00	88.48	94.83		94.94	0.000733	2.67	393.40	71.38	0.20	6.35
CHOLLAS	CHOLLAS	4155	100-Year	3500.00	88.47	98.22		98.66	0.001793	5.36	653.02	81.46	0.33	9.75
CHOLLAS	CHOLLAS	4155	50-Year	2800.00	88.47	97.42		97.77	0.001554	4.75	589.33	79.10	0.31	8.95
CHOLLAS	CHOLLAS	4155	25-Year	2100.00	88.47	96.51		96.77	0.001277	4.05	518.63	76.41	0.27	8.04
CHOLLAS	CHOLLAS	4155	10-Year	1500.00	88.47	95.61		95.78	0.000991	3.33	450.81	73.72	0.24	7.14
CHOLLAS	CHOLLAS	4155	5-Year	1225.00	88.47	95.15		95.28	0.000836	2.94	417.09	72.35	0.22	6.68
CHOLLAS	CHOLLAS	4155	2-Year	1050.00	88.47	94.83		94.94	0.000729	2.66	394.03	71.40	0.20	6.36
CHOLLAS	CHOLLAS	4154	100-Year	3500.00	91.47	96.95	96.32	98.53	0.012709	10.08	347.23	74.22	0.82	5.48
CHOLLAS	CHOLLAS	4154	50-Year	2800.00	91.47	96.29	95.67	97.65	0.012723	9.35	299.51	71.63	0.81	4.82
CHOLLAS	CHOLLAS	4154	25-Year	2100.00	91.47	95.53	94.97	96.66	0.013065	8.54	245.93	68.61	0.80	4.06
CHOLLAS	CHOLLAS	4154	10-Year	1500.00	91.47	94.78	94.29	95.69	0.013529	7.67	195.54	65.63	0.78	3.31
CHOLLAS	CHOLLAS	4154	5-Year	1225.00	91.47	94.42	93.95	95.21	0.013454	7.12	172.00	64.20	0.77	2.95
CHOLLAS	CHOLLAS	4154	2-Year	1050.00	91.47	94.16	93.71	94.87	0.013496	6.74	155.71	63.19	0.76	2.69
CHOLLAS	CHOLLAS	4153	100-Year	3500.00	91.47	96.32	96.32	98.42	0.019587	11.63	300.98	71.71	1.00	4.85
CHOLLAS	CHOLLAS	4153	50-Year	2800.00	91.47	95.67	95.67	97.54	0.020688	10.96	255.40	69.15	1.01	4.20
CHOLLAS	CHOLLAS	4153	25-Year	2100.00	91.47	94.97	94.97	96.55	0.021894	10.10	208.01	66.38	1.01	3.50
CHOLLAS	CHOLLAS	4153	10-Year	1500.00	91.47	94.29	94.29	95.59	0.023424	9.15	163.97	63.70	1.01	2.82
CHOLLAS	CHOLLAS	4153	5-Year	1225.00	91.47	93.95	93.95	95.10	0.024410	8.61	142.24	62.34	1.01	2.48
CHOLLAS	CHOLLAS	4153	2-Year	1050.00	91.47	93.71	93.71	94.76	0.025199	8.22	127.71	61.41	1.01	2.24
CHOLLAS	CHOLLAS	4152	100-Year	3500.00	88.47	96.41		97.14	0.003722	6.86	510.40	76.09	0.47	7.94
CHOLLAS	CHOLLAS	4152	50-Year	2800.00	88.47	95.57		96.18	0.003531	6.26	447.54	73.59	0.45	7.10
CHOLLAS	CHOLLAS	4152	25-Year	2100.00	88.47	94.62		95.10	0.003279	5.54	379.08	70.78	0.42	6.15
CHOLLAS	CHOLLAS	4152	10-Year	1500.00	88.47	93.68		94.03	0.002976	4.78	313.81	67.99	0.39	5.21
CHOLLAS	CHOLLAS	4152	5-Year	1225.00	88.47	93.19		93.48	0.002789	4.36	280.95	66.54	0.37	4.72
CHOLLAS	CHOLLAS	4152	2-Year	1050.00	88.47	92.85		93.11	0.002640	4.06	258.79	65.54	0.36	4.38
CHOLLAS	CHOLLAS	4151	100-Year	3500.00	88.40	95.58		96.49	0.003966	7.65	457.32	74.87	0.55	7.18
CHOLLAS	CHOLLAS	4151	50-Year	2800.00	88.40	94.80		95.56	0.003811	7.01	399.56	72.43	0.53	6.40
CHOLLAS	CHOLLAS	4151	25-Year	2100.00	88.40	93.92		94.52	0.003587	6.23	337.23	69.70	0.50	5.52
CHOLLAS	CHOLLAS	4151	10-Year	1500.00	88.40	93.06		93.51	0.003287	5.38	278.57	67.03	0.47	4.66
CHOLLAS	CHOLLAS	4151	5-Year	1225.00	88.40	92.62		93.00	0.003082	4.91	249.48	65.66	0.44	4.22

HEC-RAS Plan: PROP (Continued)

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	4151	2-Year	1050.00	88.40	92.33		92.65	0.002908	4.56	230.16	64.74	0.43	3.93
CHOLLAS	CHOLLAS	4139	100-Year	3500.00	88.30	95.56		96.45	0.003818	7.56	462.85	74.92	0.54	7.26
CHOLLAS	CHOLLAS	4139	50-Year	2800.00	88.30	94.78		95.52	0.003650	6.91	405.07	72.51	0.52	6.48
CHOLLAS	CHOLLAS	4139	25-Year	2100.00	88.30	93.90		94.49	0.003409	6.13	342.72	69.81	0.49	5.60
CHOLLAS	CHOLLAS	4139	10-Year	1500.00	88.30	93.05		93.48	0.003091	5.28	284.03	67.16	0.45	4.75
CHOLLAS	CHOLLAS	4139	5-Year	1225.00	88.30	92.61		92.97	0.002878	4.81	254.94	65.81	0.43	4.31
CHOLLAS	CHOLLAS	4139	2-Year	1050.00	88.30	92.31		92.62	0.002700	4.46	235.61	64.90	0.41	4.01
CHOLLAS	CHOLLAS	3749.99	100-Year	3500.00	88.20	94.17		95.15	0.006100	7.94	440.88	81.99	0.60	5.97
CHOLLAS	CHOLLAS	3749.99	50-Year	2800.00	88.20	93.33		94.20	0.006560	7.50	373.16	79.72	0.61	5.13
CHOLLAS	CHOLLAS	3749.99	25-Year	2100.00	88.20	92.38		93.15	0.007402	7.02	298.97	77.15	0.63	4.18
CHOLLAS	CHOLLAS	3749.99	10-Year	1500.00	88.20	91.44		92.11	0.009031	6.60	227.13	74.58	0.67	3.24
CHOLLAS	CHOLLAS	3749.99	5-Year	1225.00	88.20	90.93		91.58	0.010730	6.46	189.61	73.20	0.71	2.73
CHOLLAS	CHOLLAS	3749.99	2-Year	1050.00	88.20	90.57		91.21	0.012649	6.42	163.68	72.24	0.75	2.37
CHOLLAS	CHOLLAS	3743.98	100-Year	3500.00	86.60	94.38		95.02	0.002961	6.43	544.38	80.20	0.44	7.78
CHOLLAS	CHOLLAS	3743.98	50-Year	2800.00	86.60	93.54		94.08	0.002808	5.85	478.43	78.01	0.42	6.94
CHOLLAS	CHOLLAS	3743.98	25-Year	2100.00	86.60	92.60		93.02	0.002610	5.17	406.24	75.54	0.39	6.00
CHOLLAS	CHOLLAS	3743.98	10-Year	1500.00	86.60	91.67		91.98	0.002382	4.46	336.67	73.09	0.37	5.07
CHOLLAS	CHOLLAS	3743.98	5-Year	1225.00	86.60	91.18		91.43	0.002250	4.07	301.14	71.80	0.35	4.58
CHOLLAS	CHOLLAS	3743.98	2-Year	1050.00	86.60	90.84		91.06	0.002150	3.79	276.88	70.91	0.34	4.24
CHOLLAS	CHOLLAS	3718	100-Year	3500.00	86.58	94.28		94.94	0.003061	6.50	538.39	79.97	0.44	7.70
CHOLLAS	CHOLLAS	3718	50-Year	2800.00	86.58	93.46		94.00	0.002905	5.92	473.13	77.80	0.42	6.88
CHOLLAS	CHOLLAS	3718	25-Year	2100.00	86.58	92.53		92.95	0.002699	5.23	401.80	75.37	0.40	5.95
CHOLLAS	CHOLLAS	3718	10-Year	1500.00	86.58	91.60		91.91	0.002465	4.50	332.98	72.94	0.37	5.02
CHOLLAS	CHOLLAS	3718	5-Year	1225.00	86.58	91.11		91.37	0.002328	4.11	297.86	71.66	0.36	4.53
CHOLLAS	CHOLLAS	3718	2-Year	1050.00	86.58	90.77		91.00	0.002225	3.83	273.88	70.78	0.34	4.19
CHOLLAS	CHOLLAS	3652	100-Year	3500.00	86.57	94.04		94.74	0.002846	6.73	519.82	79.38	0.46	7.47
CHOLLAS	CHOLLAS	3652	50-Year	2800.00	86.57	93.23		93.82	0.002706	6.13	456.54	77.26	0.44	6.66
CHOLLAS	CHOLLAS	3652	25-Year	2100.00	86.57	92.32		92.78	0.002524	5.42	387.25	74.87	0.42	5.75
CHOLLAS	CHOLLAS	3652	10-Year	1500.00	86.57	91.41		91.76	0.002316	4.68	320.49	72.50	0.39	4.84
CHOLLAS	CHOLLAS	3652	5-Year	1225.00	86.57	90.94		91.23	0.002192	4.28	286.50	71.26	0.38	4.37
CHOLLAS	CHOLLAS	3652	2-Year	1050.00	86.57	90.61		90.86	0.002099	3.99	263.27	70.40	0.36	4.04
CHOLLAS	CHOLLAS	3513	100-Year	3500.00	86.50	93.47		94.29	0.003627	7.29	480.03	78.03	0.52	6.97
CHOLLAS	CHOLLAS	3513	50-Year	2800.00	86.50	92.70		93.38	0.003474	6.65	420.83	76.02	0.50	6.20
CHOLLAS	CHOLLAS	3513	25-Year	2100.00	86.50	91.83		92.37	0.003267	5.89	356.24	73.76	0.47	5.33
CHOLLAS	CHOLLAS	3513	10-Year	1500.00	86.50	90.98		91.39	0.003021	5.10	294.32	71.53	0.44	4.48
CHOLLAS	CHOLLAS	3513	5-Year	1225.00	86.50	90.54		90.88	0.002872	4.66	262.86	70.37	0.43	4.04
CHOLLAS	CHOLLAS	3513	2-Year	1050.00	86.50	90.23		90.53	0.002758	4.35	241.41	69.57	0.41	3.73
CHOLLAS	CHOLLAS	3402	100-Year	3500.00	86.44	92.91		93.84	0.004376	7.74	452.24	80.08	0.57	6.47
CHOLLAS	CHOLLAS	3402	50-Year	2800.00	86.44	92.15		92.94	0.004314	7.13	392.92	77.72	0.56	5.71
CHOLLAS	CHOLLAS	3402	25-Year	2100.00	86.44	91.32		91.95	0.004196	6.38	329.24	75.11	0.54	4.88
CHOLLAS	CHOLLAS	3402	10-Year	1500.00	86.44	90.51		90.99	0.004013	5.57	269.26	72.56	0.51	4.07

HEC-RAS Plan: PROP (Continued)

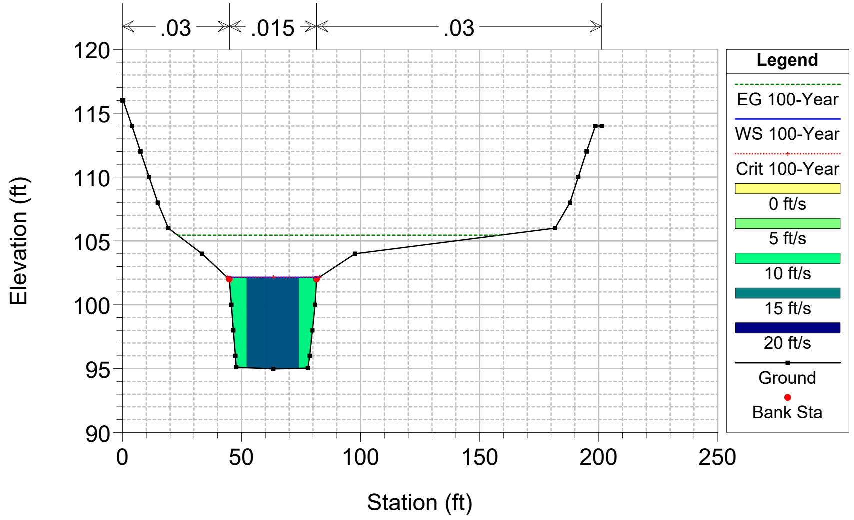
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	3402	5-Year	1225.00	86.44	90.09		90.50	0.003883	5.12	239.23	71.25	0.49	3.65
CHOLLAS	CHOLLAS	3402	2-Year	1050.00	86.44	89.80		90.16	0.003775	4.80	218.92	70.35	0.48	3.36
CHOLLAS	CHOLLAS	3298.97	100-Year	3500.00	86.20	90.73	90.73	92.87	0.020053	11.72	298.65	70.67	1.01	4.53
CHOLLAS	CHOLLAS	3298.97	50-Year	2800.00	86.20	90.12	90.12	91.98	0.020985	10.94	255.83	69.38	1.00	3.92
CHOLLAS	CHOLLAS	3298.97	25-Year	2100.00	86.20	89.45	89.45	91.01	0.022276	10.01	209.73	67.96	1.00	3.25
CHOLLAS	CHOLLAS	3298.97	10-Year	1500.00	86.20	88.81	88.81	90.07	0.023908	9.01	166.47	66.60	1.00	2.61
CHOLLAS	CHOLLAS	3298.97	5-Year	1225.00	86.20	88.48	88.48	89.59	0.024957	8.45	144.94	65.92	1.00	2.28
CHOLLAS	CHOLLAS	3298.97	2-Year	1050.00	86.20	88.26	88.26	89.27	0.025788	8.05	130.48	65.45	1.00	2.06
CHOLLAS	CHOLLAS	3292.97	100-Year	3500.00	81.90	90.08		90.76	0.003291	6.63	527.71	74.61	0.44	8.18
CHOLLAS	CHOLLAS	3292.97	50-Year	2800.00	81.90	89.21		89.78	0.003114	6.04	463.71	72.46	0.42	7.31
CHOLLAS	CHOLLAS	3292.97	25-Year	2100.00	81.90	88.22		88.67	0.002890	5.34	393.42	70.02	0.40	6.32
CHOLLAS	CHOLLAS	3292.97	10-Year	1500.00	81.90	87.24		87.57	0.002631	4.60	325.91	67.60	0.37	5.34
CHOLLAS	CHOLLAS	3292.97	5-Year	1225.00	81.90	86.73		87.00	0.002482	4.20	291.43	66.33	0.35	4.83
CHOLLAS	CHOLLAS	3292.97	2-Year	1050.00	81.90	86.37		86.61	0.002370	3.92	267.89	65.44	0.34	4.47
CHOLLAS	CHOLLAS	3267	100-Year	3500.00	81.89	89.98		90.68	0.003423	6.72	521.16	74.51	0.45	8.09
CHOLLAS	CHOLLAS	3267	50-Year	2800.00	81.89	89.11		89.69	0.003243	6.12	457.76	72.36	0.43	7.22
CHOLLAS	CHOLLAS	3267	25-Year	2100.00	81.89	88.14		88.59	0.003014	5.41	388.24	69.93	0.40	6.25
CHOLLAS	CHOLLAS	3267	10-Year	1500.00	81.89	87.16		87.50	0.002749	4.67	321.45	67.52	0.38	5.27
CHOLLAS	CHOLLAS	3267	5-Year	1225.00	81.89	86.65		86.94	0.002595	4.26	287.36	66.25	0.36	4.76
CHOLLAS	CHOLLAS	3267	2-Year	1050.00	81.89	86.30		86.55	0.002480	3.98	264.10	65.37	0.35	4.41
CHOLLAS	CHOLLAS	3031.27	100-Year	3500.00	81.77	89.01		89.85	0.003533	7.34	476.55	75.13	0.51	7.24
CHOLLAS	CHOLLAS	3031.27	50-Year	2800.00	81.77	88.20		88.90	0.003404	6.72	416.67	73.05	0.50	6.43
CHOLLAS	CHOLLAS	3031.27	25-Year	2100.00	81.77	87.30		87.85	0.003232	5.98	351.43	70.71	0.47	5.53
CHOLLAS	CHOLLAS	3031.27	10-Year	1500.00	81.77	86.40		86.82	0.003010	5.18	289.43	68.42	0.44	4.63
CHOLLAS	CHOLLAS	3031.27	5-Year	1225.00	81.77	85.94		86.29	0.002876	4.75	257.98	67.23	0.43	4.17
CHOLLAS	CHOLLAS	3031.27	2-Year	1050.00	81.77	85.62		85.93	0.002769	4.44	236.68	66.41	0.41	3.85
CHOLLAS	CHOLLAS	2965.96	100-Year	3500.00	81.73	87.92	86.87	89.45	0.007970	9.91	353.01	64.76	0.75	6.19
CHOLLAS	CHOLLAS	2965.96	50-Year	2800.00	81.73	87.29	86.18	88.53	0.007396	8.96	312.52	63.18	0.71	5.56
CHOLLAS	CHOLLAS	2965.96	25-Year	2100.00	81.73	86.55		87.52	0.006761	7.87	266.82	61.35	0.67	4.82
CHOLLAS	CHOLLAS	2965.96	10-Year	1500.00	81.73	85.81		86.52	0.006096	6.76	222.04	59.50	0.62	4.08
CHOLLAS	CHOLLAS	2965.96	5-Year	1225.00	81.73	85.42		86.01	0.005729	6.16	198.93	58.52	0.59	3.69
CHOLLAS	CHOLLAS	2965.96	2-Year	1050.00	81.73	85.15		85.66	0.005449	5.73	183.20	57.84	0.57	3.42
CHOLLAS	CHOLLAS	2892.27	100-Year	3500.00	81.70	86.37	86.37	88.51	0.019874	11.73	298.36	69.81	1.00	4.67
CHOLLAS	CHOLLAS	2892.27	50-Year	2800.00	81.70	85.73	85.73	87.61	0.020942	11.00	254.52	68.20	1.00	4.03
CHOLLAS	CHOLLAS	2892.27	25-Year	2100.00	81.70	85.05	85.05	86.63	0.022189	10.08	208.31	66.47	1.00	3.35
CHOLLAS	CHOLLAS	2892.27	10-Year	1500.00	81.70	84.39	84.39	85.67	0.023769	9.09	165.06	64.80	1.00	2.69
CHOLLAS	CHOLLAS	2892.27	5-Year	1225.00	81.70	84.05	84.05	85.19	0.024789	8.53	143.59	63.96	1.00	2.35
CHOLLAS	CHOLLAS	2892.27	2-Year	1050.00	81.70	83.83	83.83	84.86	0.025598	8.13	129.18	63.38	1.00	2.13
CHOLLAS	CHOLLAS	2886.27	100-Year	3500.00	78.70	86.20		87.11	0.004867	7.62	459.24	70.60	0.53	7.50
CHOLLAS	CHOLLAS	2886.27	50-Year	2800.00	78.70	85.49		86.21	0.004415	6.84	409.24	68.81	0.49	6.79
CHOLLAS	CHOLLAS	2886.27	25-Year	2100.00	78.70	84.59		85.16	0.004039	6.02	348.87	66.57	0.46	5.89

HEC-RAS Plan: PROP (Continued)

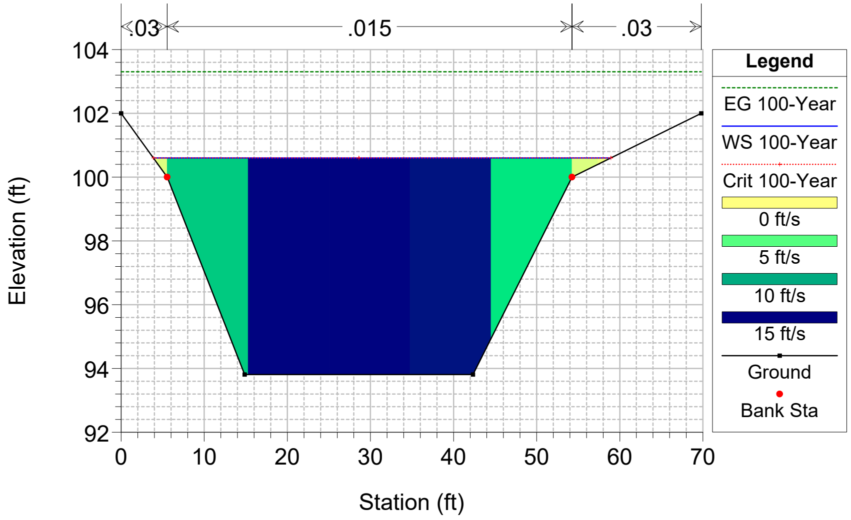
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	2886.27	10-Year	1500.00	78.70	83.70		84.12	0.003614	5.16	290.62	64.34	0.43	5.00
CHOLLAS	CHOLLAS	2886.27	5-Year	1225.00	78.70	83.24		83.58	0.003373	4.70	260.76	63.17	0.41	4.54
CHOLLAS	CHOLLAS	2886.27	2-Year	1050.00	78.70	82.91		83.21	0.003197	4.37	240.26	62.35	0.39	4.21
CHOLLAS	CHOLLAS	2861	100-Year	3500.00	78.69	86.01		86.97	0.005334	7.88	444.41	69.63	0.55	7.32
CHOLLAS	CHOLLAS	2861	50-Year	2800.00	78.69	85.32		86.09	0.004803	7.05	397.13	67.95	0.51	6.63
CHOLLAS	CHOLLAS	2861	25-Year	2100.00	78.69	84.46		85.05	0.004375	6.19	339.18	65.85	0.48	5.77
CHOLLAS	CHOLLAS	2861	10-Year	1500.00	78.69	83.59		84.02	0.003907	5.30	282.87	63.73	0.44	4.90
CHOLLAS	CHOLLAS	2861	5-Year	1225.00	78.69	83.13		83.49	0.003642	4.82	253.97	62.62	0.42	4.44
CHOLLAS	CHOLLAS	2861	2-Year	1050.00	78.69	82.81		83.12	0.003450	4.49	234.10	61.84	0.41	4.12
CHOLLAS	CHOLLAS	2744.11	100-Year	3500.00	78.63	84.99		86.27	0.006322	9.06	386.50	68.69	0.67	6.36
CHOLLAS	CHOLLAS	2744.11	50-Year	2800.00	78.63	84.52		85.49	0.005292	7.91	354.03	67.50	0.61	5.89
CHOLLAS	CHOLLAS	2744.11	25-Year	2100.00	78.63	83.76		84.51	0.004756	6.91	304.03	65.62	0.57	5.13
CHOLLAS	CHOLLAS	2744.11	10-Year	1500.00	78.63	83.00		83.54	0.004198	5.89	254.81	63.72	0.52	4.37
CHOLLAS	CHOLLAS	2744.11	5-Year	1225.00	78.63	82.60		83.04	0.003889	5.34	229.37	62.72	0.49	3.97
CHOLLAS	CHOLLAS	2744.11	2-Year	1050.00	78.63	82.32		82.70	0.003669	4.96	211.80	62.02	0.47	3.69
CHOLLAS	CHOLLAS	2623	100-Year	3500.00	78.60	83.31		84.87	0.012911	10.00	350.12	80.22	0.84	4.71
CHOLLAS	CHOLLAS	2623	50-Year	2800.00	78.60	82.24	82.24	83.97	0.019869	10.55	265.33	77.50	1.01	3.64
CHOLLAS	CHOLLAS	2623	25-Year	2100.00	78.60	81.62	81.62	83.06	0.021080	9.65	217.51	75.93	1.01	3.02
CHOLLAS	CHOLLAS	2623	10-Year	1500.00	78.60	81.02	81.02	82.19	0.022587	8.69	172.68	74.42	1.01	2.42
CHOLLAS	CHOLLAS	2623	5-Year	1225.00	78.60	80.72	80.72	81.75	0.023580	8.15	150.33	73.66	1.01	2.12
CHOLLAS	CHOLLAS	2623	2-Year	1050.00	78.60	80.51	80.51	81.45	0.024353	7.76	135.34	73.14	1.01	1.91
CHOLLAS	CHOLLAS	2621	100-Year	3500.00	76.20	83.90		84.58	0.003224	6.66	525.40	77.23	0.45	7.70
CHOLLAS	CHOLLAS	2621	50-Year	2800.00	76.20	82.96		83.55	0.003216	6.16	454.40	75.06	0.44	6.76
CHOLLAS	CHOLLAS	2621	25-Year	2100.00	76.20	81.99		82.46	0.003076	5.49	382.55	72.80	0.42	5.79
CHOLLAS	CHOLLAS	2621	10-Year	1500.00	76.20	80.90		81.27	0.003204	4.93	304.19	70.25	0.42	4.70
CHOLLAS	CHOLLAS	2621	5-Year	1225.00	76.20	80.40		80.72	0.003107	4.54	270.02	69.11	0.40	4.20
CHOLLAS	CHOLLAS	2621	2-Year	1050.00	76.20	80.06		80.34	0.003060	4.27	246.05	68.30	0.40	3.86
CHOLLAS	CHOLLAS	2595	100-Year	3500.00	76.19	83.79		84.50	0.003362	6.75	518.20	77.02	0.46	7.60
CHOLLAS	CHOLLAS	2595	50-Year	2800.00	76.19	82.86		83.47	0.003372	6.26	447.47	74.85	0.45	6.67
CHOLLAS	CHOLLAS	2595	25-Year	2100.00	76.19	81.90		82.38	0.003233	5.58	376.44	72.60	0.43	5.71
CHOLLAS	CHOLLAS	2595	10-Year	1500.00	76.19	80.80		81.19	0.003420	5.03	297.93	70.04	0.43	4.61
CHOLLAS	CHOLLAS	2595	5-Year	1225.00	76.19	80.31		80.64	0.003328	4.64	264.19	68.91	0.42	4.12
CHOLLAS	CHOLLAS	2595	2-Year	1050.00	76.19	79.96		80.26	0.003295	4.37	240.35	68.10	0.41	3.77
CHOLLAS	CHOLLAS	2375.43	100-Year	3500.00	76.10	83.31		83.88	0.002307	6.08	583.42	115.54	0.42	7.21
CHOLLAS	CHOLLAS	2375.43	50-Year	2800.00	76.10	82.31		82.83	0.002550	5.77	485.44	86.10	0.43	6.21
CHOLLAS	CHOLLAS	2375.43	25-Year	2100.00	76.10	81.34		81.76	0.002568	5.21	402.70	83.60	0.42	5.24
CHOLLAS	CHOLLAS	2375.43	10-Year	1500.00	76.10	80.10		80.49	0.003265	4.98	301.34	80.44	0.45	4.00
CHOLLAS	CHOLLAS	2375.43	5-Year	1225.00	76.10	79.59		79.93	0.003471	4.71	260.23	79.12	0.46	3.49
CHOLLAS	CHOLLAS	2375.43	2-Year	1050.00	76.10	79.18		79.51	0.003888	4.60	228.03	78.07	0.47	3.08
CHOLLAS	CHOLLAS	2253.83	100-Year	3500.00	75.00	82.54		83.58	0.001895	8.21	429.49	100.39	0.63	7.54
CHOLLAS	CHOLLAS	2253.83	50-Year	2800.00	75.00	81.46		82.50	0.002029	8.20	341.56	74.35	0.67	6.46

HEC-RAS Plan: PROP (Continued)

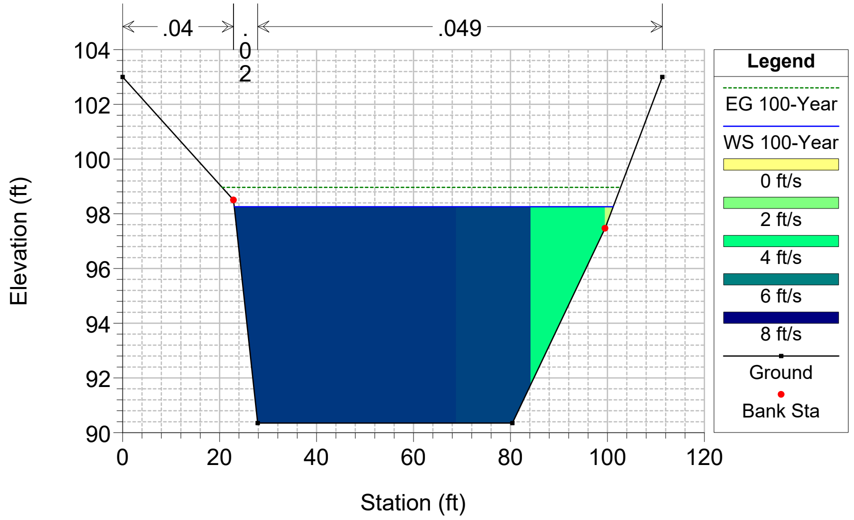
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	2253.83	25-Year	2100.00	75.00	80.60		81.47	0.001676	7.46	281.56	66.19	0.64	5.60
CHOLLAS	CHOLLAS	2253.83	10-Year	1500.00	75.00	79.32		80.16	0.001717	7.36	203.71	56.68	0.68	4.32
CHOLLAS	CHOLLAS	2253.83	5-Year	1225.00	75.00	78.91		79.62	0.001561	6.77	180.99	54.72	0.66	3.91
CHOLLAS	CHOLLAS	2253.83	2-Year	1050.00	75.00	78.51		79.18	0.001598	6.59	159.45	52.77	0.67	3.51
CHOLLAS	CHOLLAS WEST	2073.85	100-Year	4700.00	74.50	82.27	80.45	83.47	0.000783	8.79	534.52	90.69	0.64	7.77
CHOLLAS	CHOLLAS WEST	2073.85	50-Year	3750.00	74.50	81.39	79.69	82.44	0.000777	8.20	457.20	85.73	0.63	6.89
CHOLLAS	CHOLLAS WEST	2073.85	25-Year	2820.00	74.50	80.57	78.81	81.39	0.000698	7.26	388.57	80.96	0.58	6.07
CHOLLAS	CHOLLAS WEST	2073.85	10-Year	1930.00	74.50	79.35	77.82	80.02	0.000714	6.55	294.47	72.76	0.57	4.85
CHOLLAS	CHOLLAS WEST	2073.85	5-Year	1645.00	74.50	78.91	77.50	79.52	0.000709	6.25	263.15	69.44	0.57	4.41
CHOLLAS	CHOLLAS WEST	2073.85	2-Year	1410.00	74.50	78.52	77.21	79.07	0.000701	5.96	236.48	66.48	0.56	4.02
CHOLLAS	CHOLLAS WEST	2073.45		Bridge										
CHOLLAS	CHOLLAS WEST	2072.85	100-Year	4700.00	73.30	81.42		82.89	0.001855	9.71	484.13	78.16	0.69	8.12
CHOLLAS	CHOLLAS WEST	2072.85	50-Year	3750.00	73.30	80.06		81.55	0.002079	9.80	382.75	70.29	0.74	6.76
CHOLLAS	CHOLLAS WEST	2072.85	25-Year	2820.00	73.30	78.76		80.18	0.002278	9.56	294.95	65.07	0.79	5.46
CHOLLAS	CHOLLAS WEST	2072.85	10-Year	1930.00	73.30	77.52		78.74	0.002341	8.87	217.55	60.18	0.82	4.22
CHOLLAS	CHOLLAS WEST	2072.85	5-Year	1645.00	73.30	77.07		78.23	0.002395	8.62	190.79	58.32	0.84	3.77
CHOLLAS	CHOLLAS WEST	2072.85	2-Year	1410.00	73.30	76.66	76.35	77.77	0.002485	8.43	167.33	56.65	0.86	3.36
CHOLLAS	CHOLLAS WEST	2014.48	100-Year	4700.00	72.70	81.13		82.73	0.001985	10.16	466.79	76.25	0.69	8.43
CHOLLAS	CHOLLAS WEST	2014.48	50-Year	3750.00	72.70	78.81	78.71	81.13	0.004148	12.23	306.55	63.17	0.98	6.11
CHOLLAS	CHOLLAS WEST	2014.48	25-Year	2820.00	72.70	78.55	77.76	80.02	0.002683	9.71	290.52	62.00	0.79	5.85
CHOLLAS	CHOLLAS WEST	2014.48	10-Year	1930.00	72.70	77.41	76.70	78.58	0.002442	8.67	222.60	56.82	0.77	4.71
CHOLLAS	CHOLLAS WEST	2014.48	5-Year	1645.00	72.70	76.97	76.31	78.04	0.002371	8.30	198.22	54.87	0.77	4.27
CHOLLAS	CHOLLAS WEST	2014.48	2-Year	1410.00	72.70	76.58	75.97	77.57	0.002310	7.96	177.04	53.11	0.77	3.88
CHOLLAS	CHOLLAS WEST	1900	100-Year	4700.00	72.30	81.10	79.29	82.44	0.001009	9.52	530.17	91.57	0.60	8.80
CHOLLAS	CHOLLAS WEST	1900	50-Year	3750.00	72.30	78.40	78.40	80.74	0.002977	12.31	310.56	71.65	0.96	6.10
CHOLLAS	CHOLLAS WEST	1900	25-Year	2820.00	72.30	77.48	77.48	79.50	0.003350	11.42	247.85	63.63	0.99	5.18
CHOLLAS	CHOLLAS WEST	1900	10-Year	1930.00	72.30	76.44	76.44	78.10	0.003195	10.35	186.41	55.60	1.00	4.14
CHOLLAS	CHOLLAS WEST	1900	5-Year	1645.00	72.30	76.04	76.04	77.59	0.003123	9.99	164.64	53.76	1.01	3.74
CHOLLAS	CHOLLAS WEST	1900	2-Year	1410.00	72.30	75.71	75.71	77.14	0.003004	9.58	147.14	52.25	1.01	3.41



PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4262.38



PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4261.38



PROP 3/8/2021
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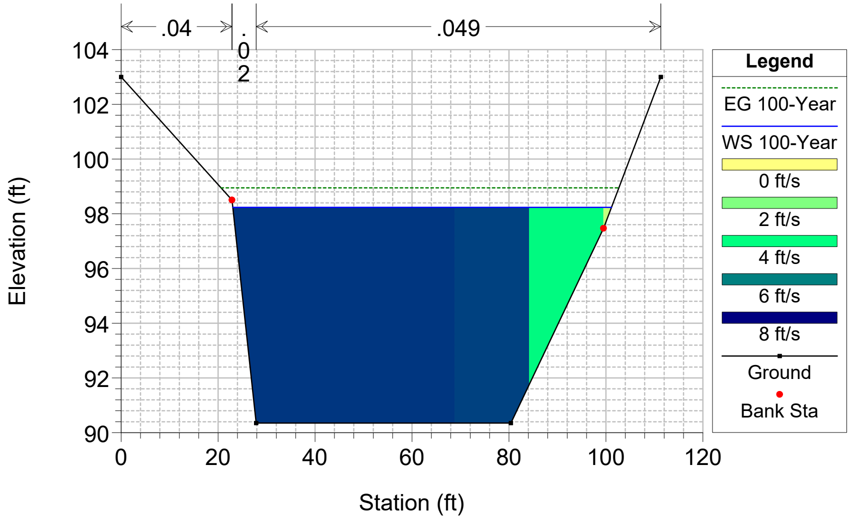
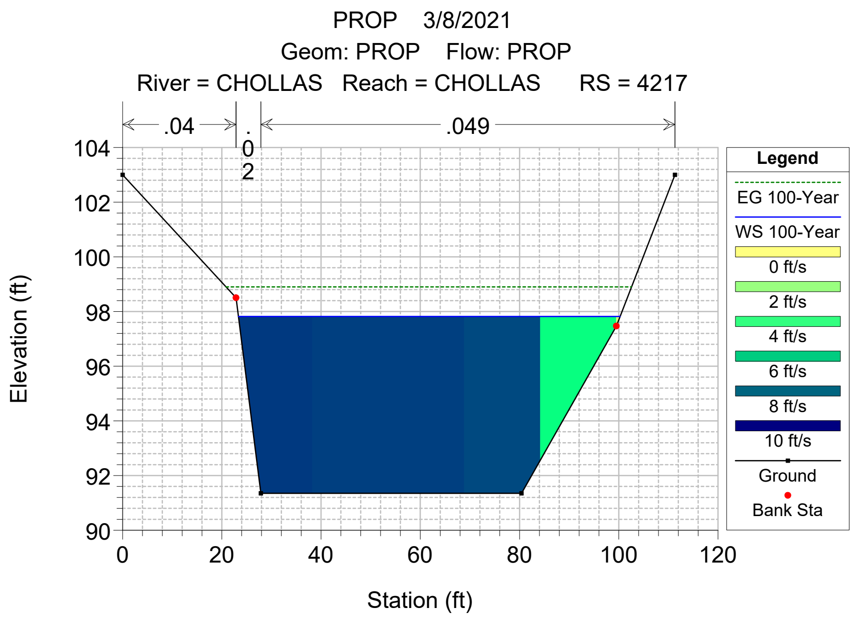
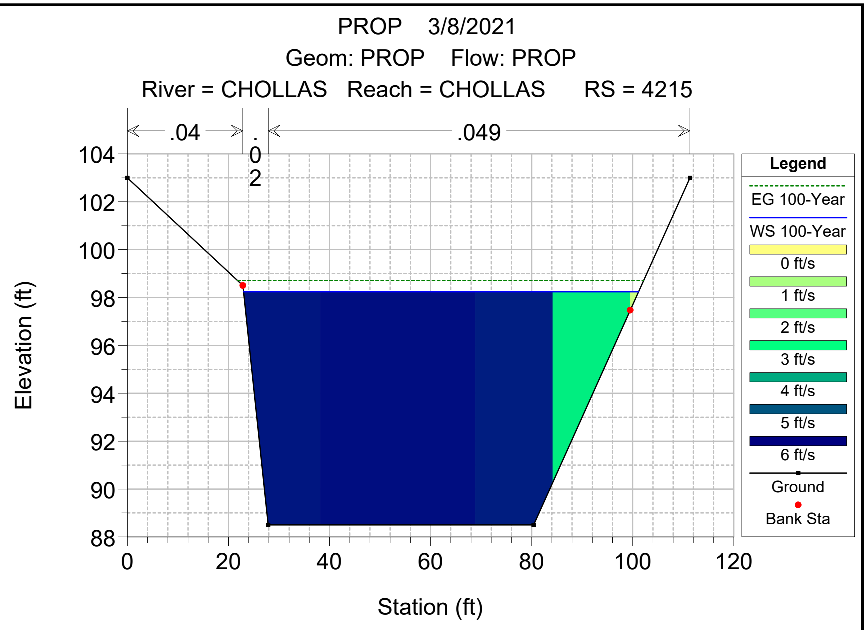
River = CHOLLAS Reach = CHOLLAS RS = 4221



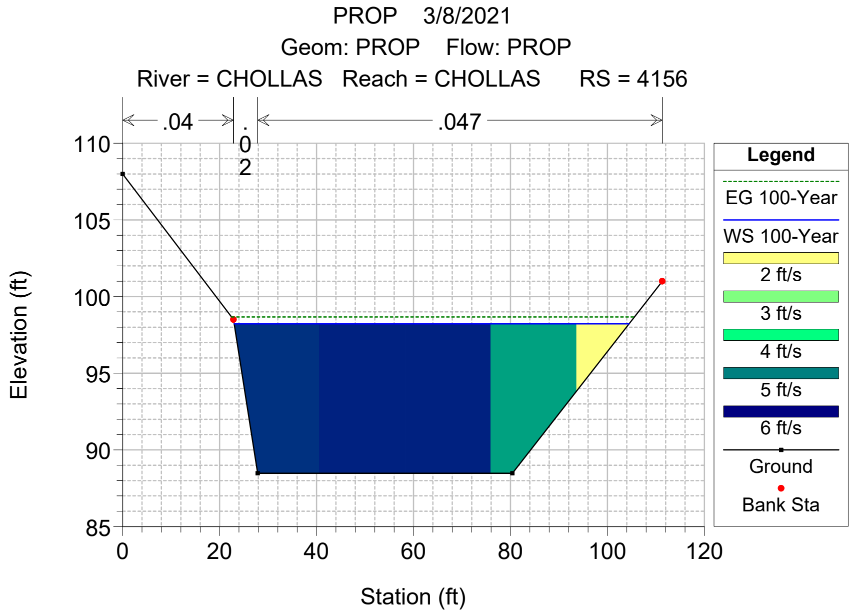
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4219



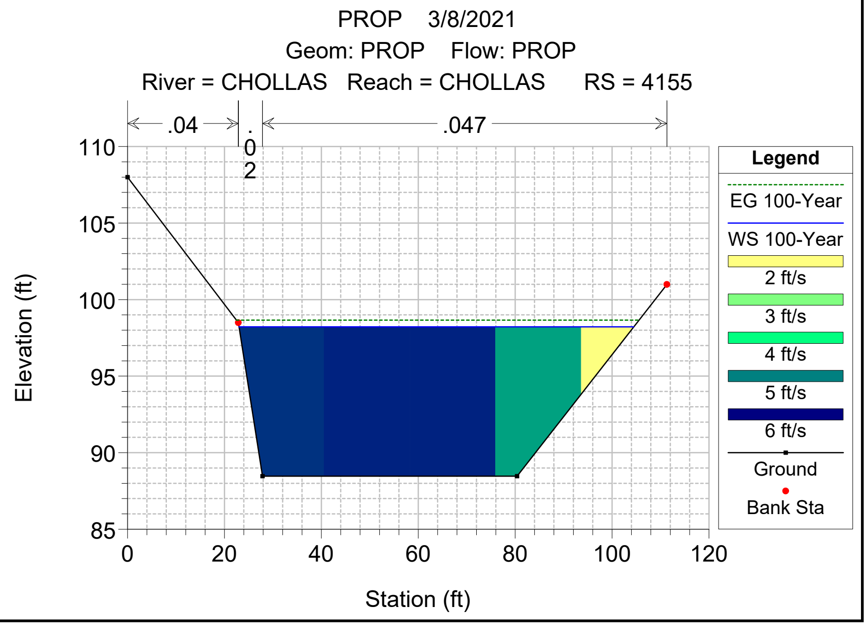
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4217



PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4215

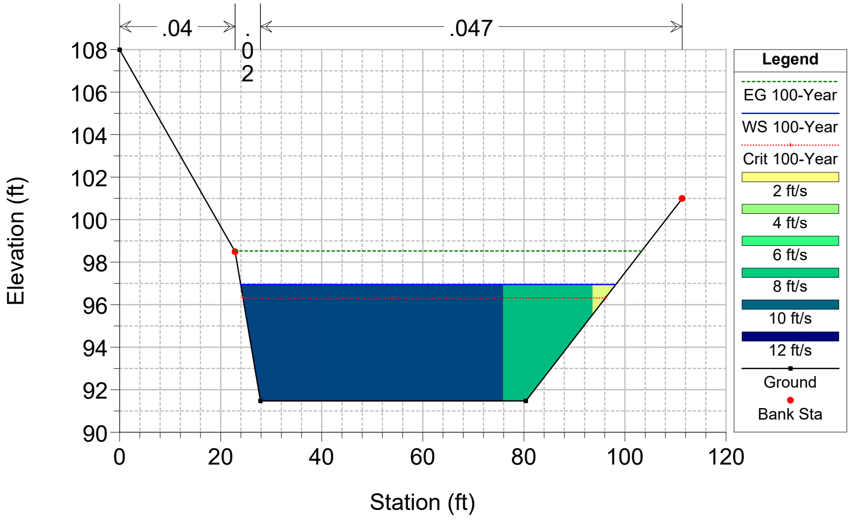


PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4156

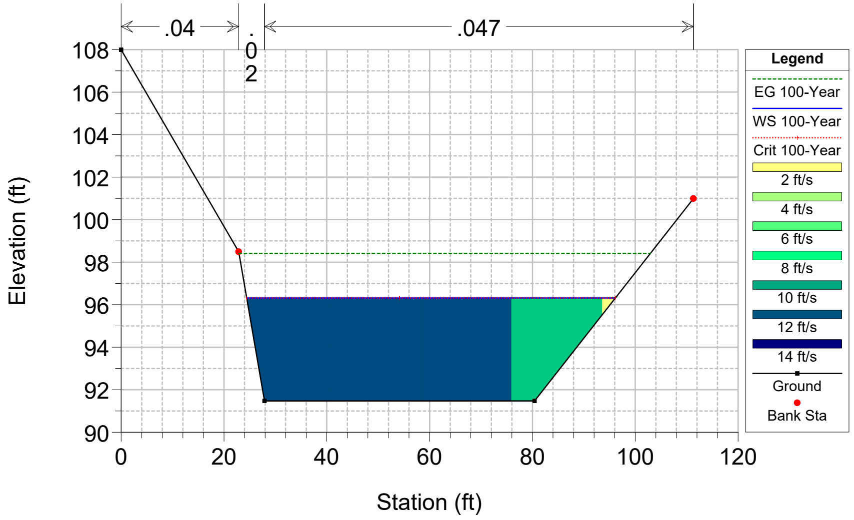


PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4155

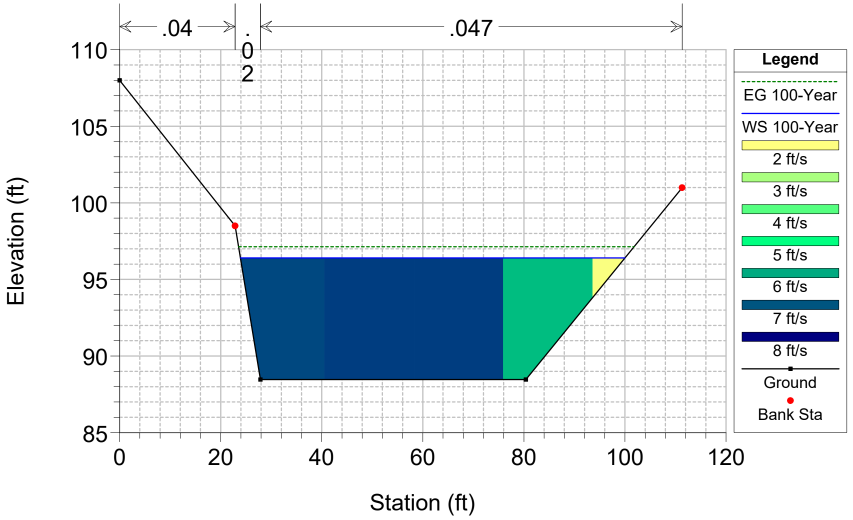
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4154



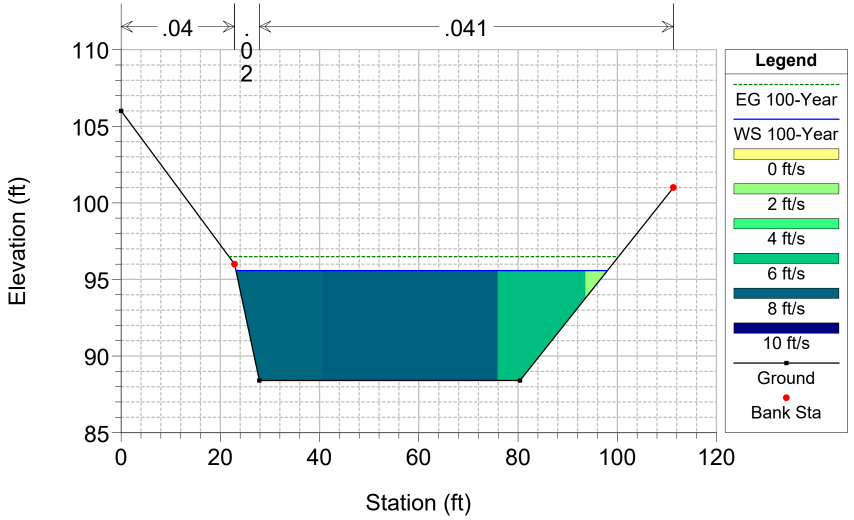
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4153

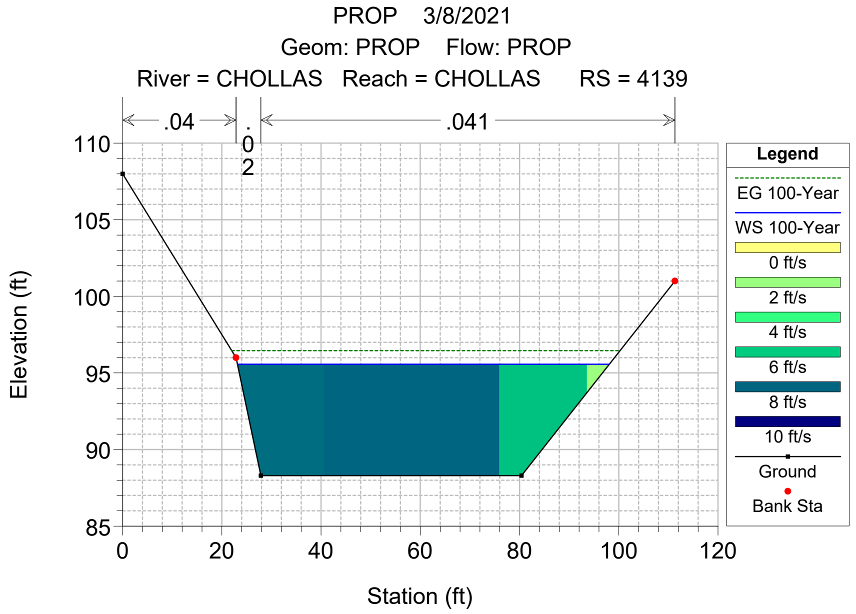


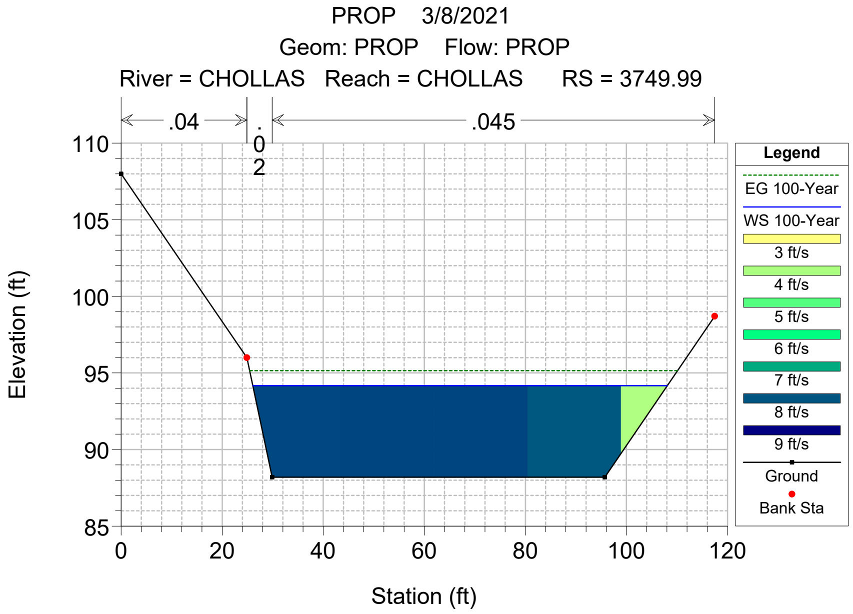
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4152

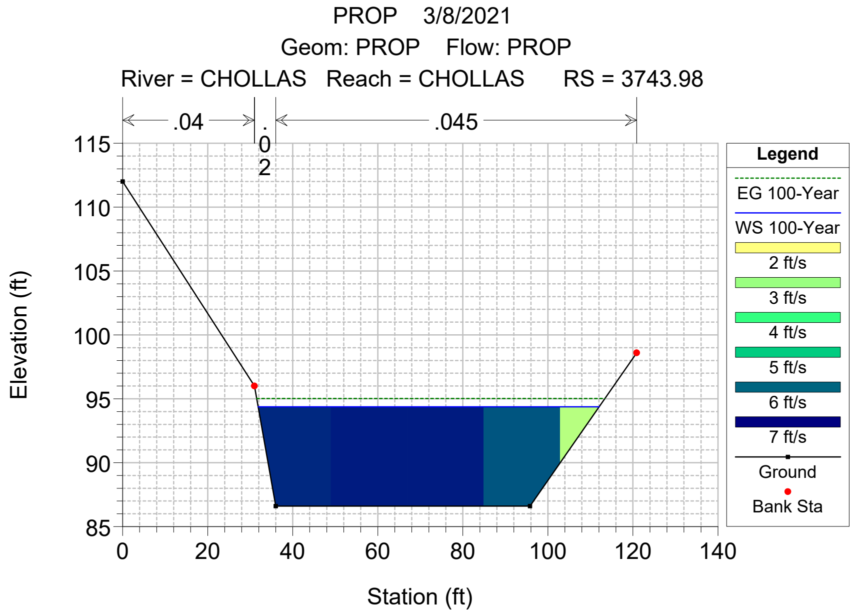


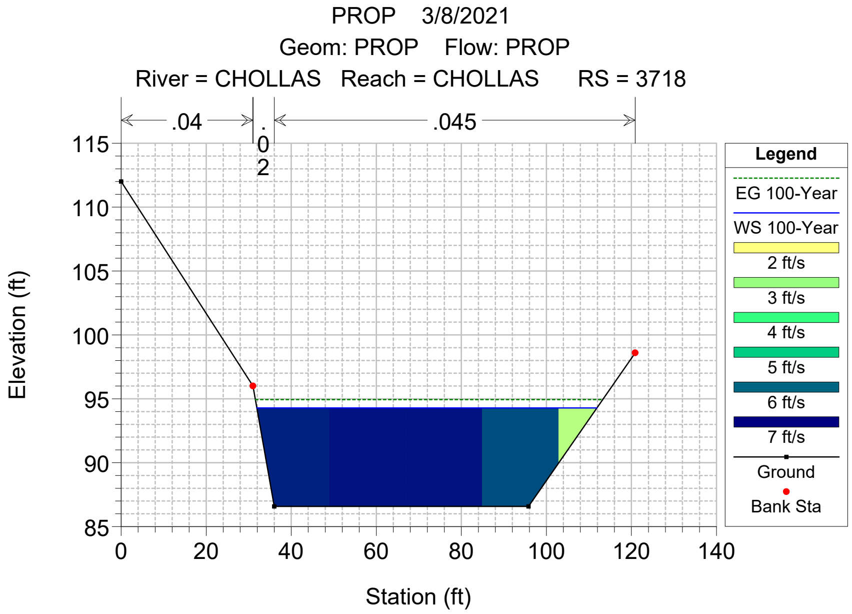
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4151



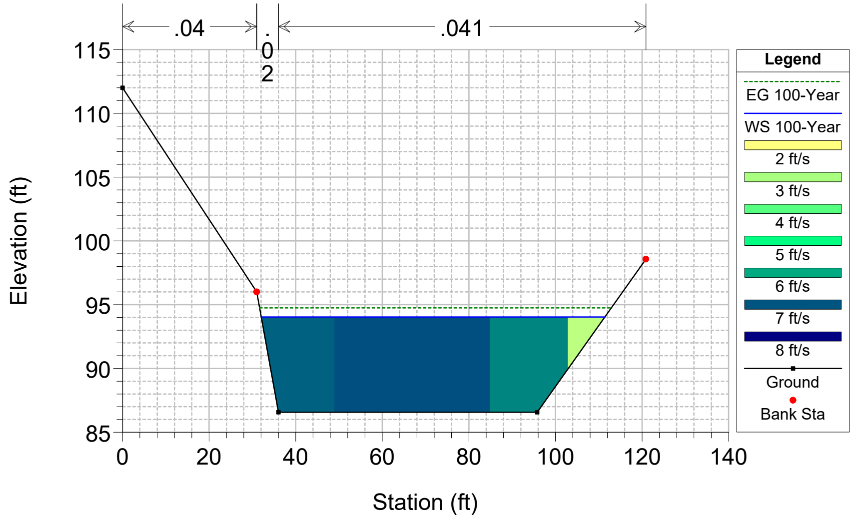

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4139
.04
.02
.041
Elevation (ft)
Station (ft)
110
105
100
95
90
85
0
20
40
60
80
100
120
Legend
EG 100-Year
WS 100-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta


PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3749.99
.04
.02
.045
Elevation (ft)
Station (ft)
110
105
100
95
90
85
0
20
40
60
80
100
120
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta

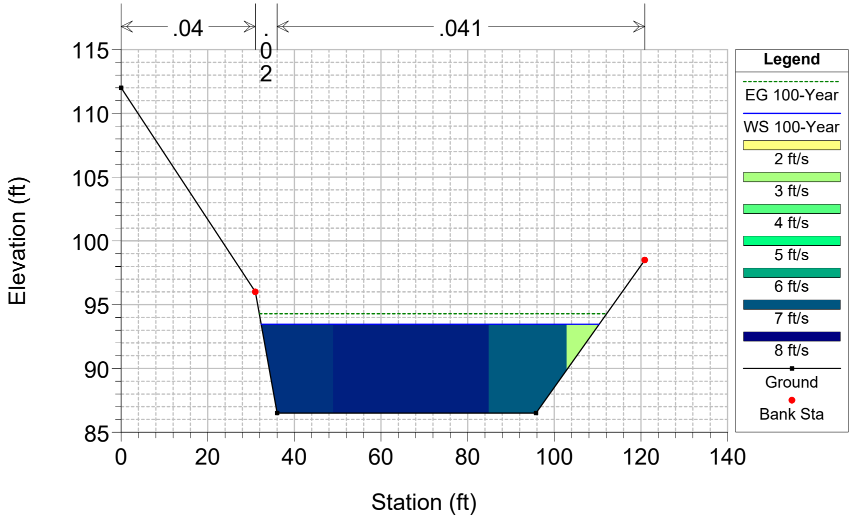

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3743.98
.04
.02
.045
Elevation (ft)
Station (ft)
115
110
105
100
95
90
85
0
20
40
60
80
100
120
140
Legend
EG 100-Year
WS 100-Year
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta


PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3718
.04
.02
.045
Elevation (ft)
Station (ft)
115
110
105
100
95
90
85
0
20
40
60
80
100
120
140
Legend
EG 100-Year
WS 100-Year
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta

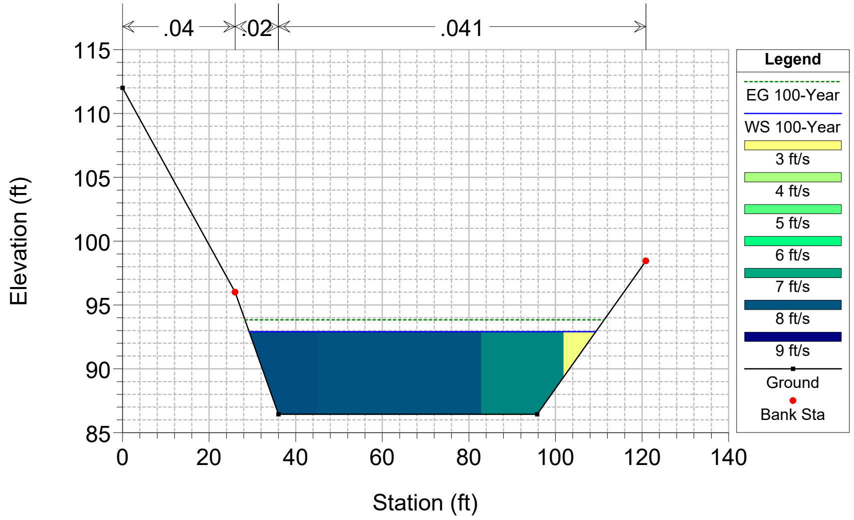
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3652



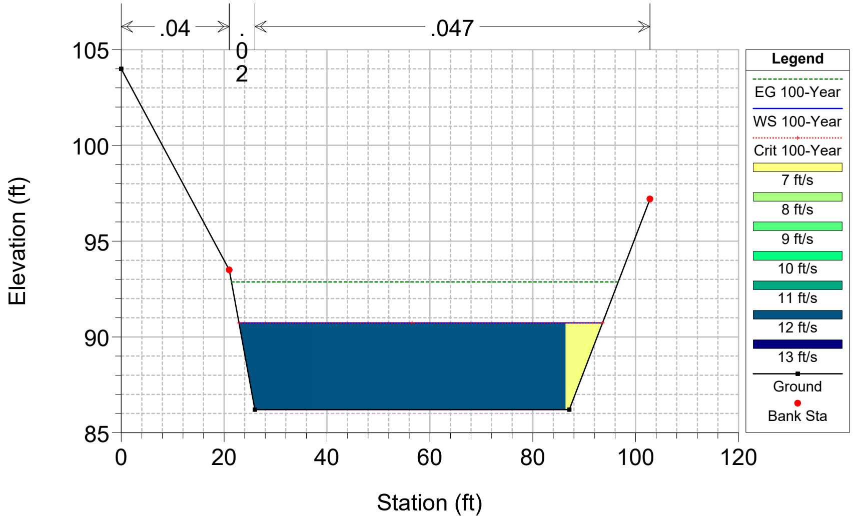
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3513

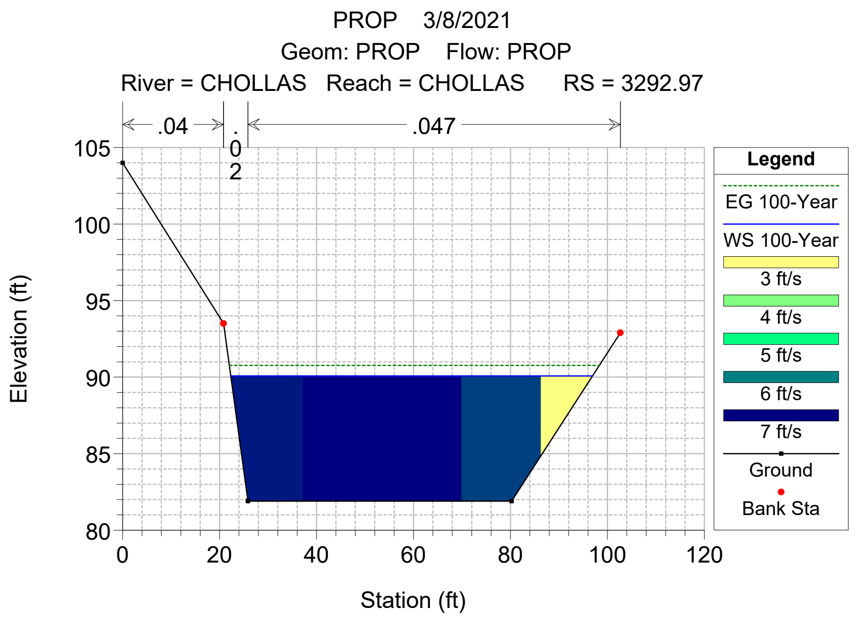


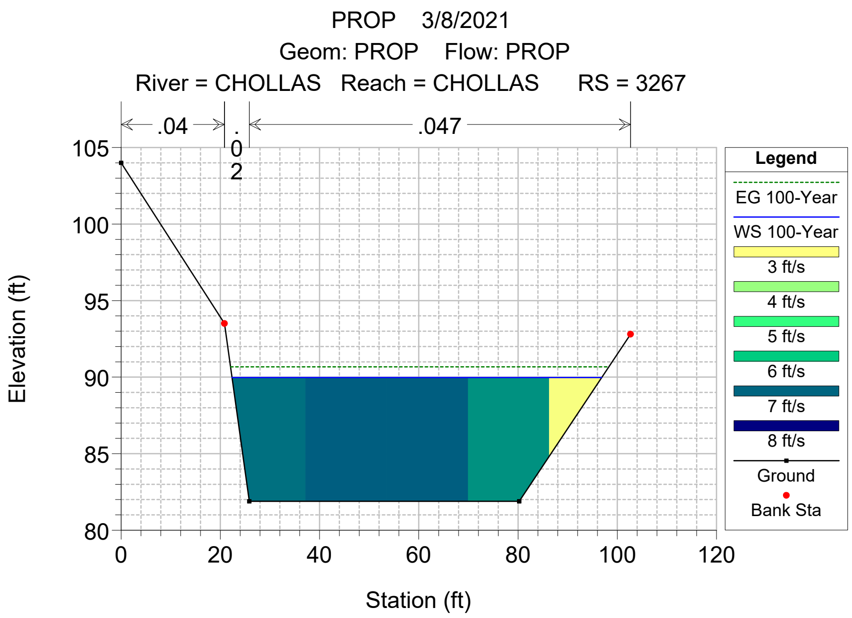
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3402

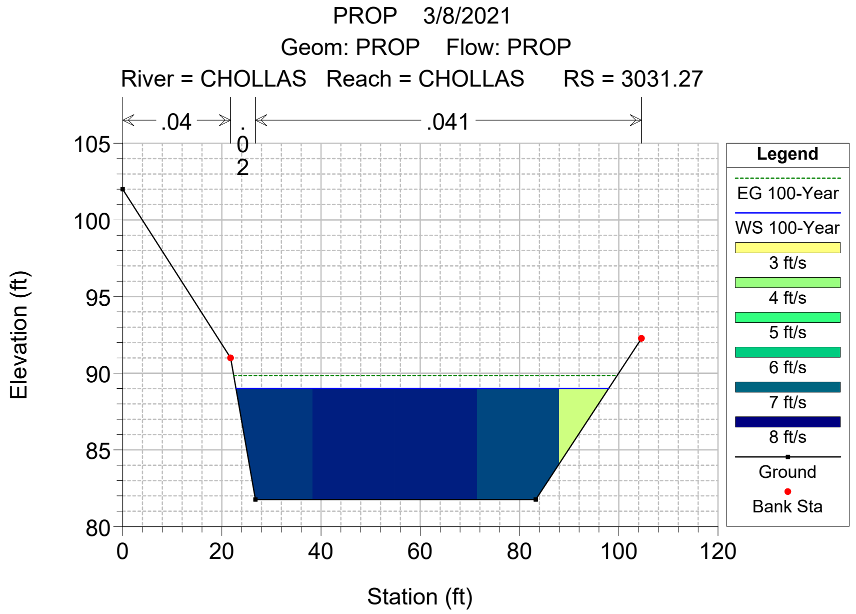


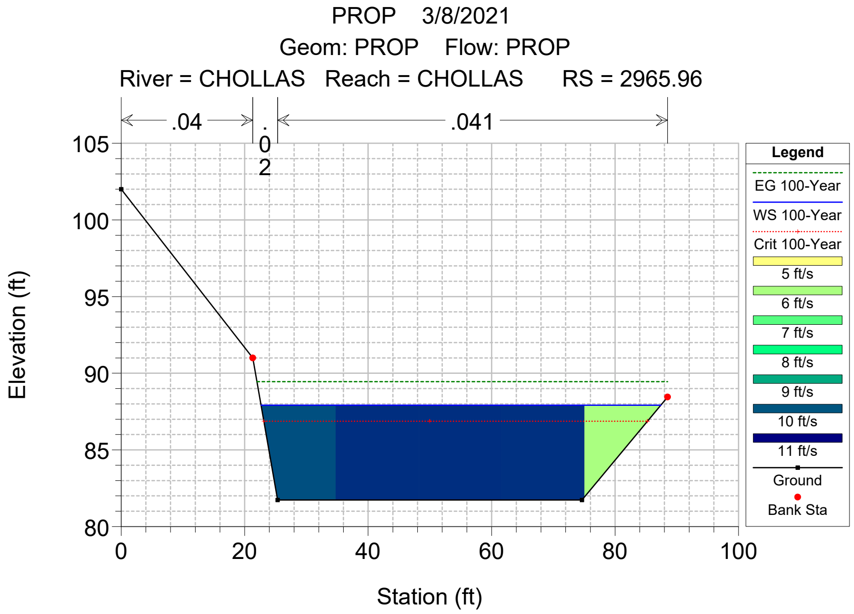
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3298.97

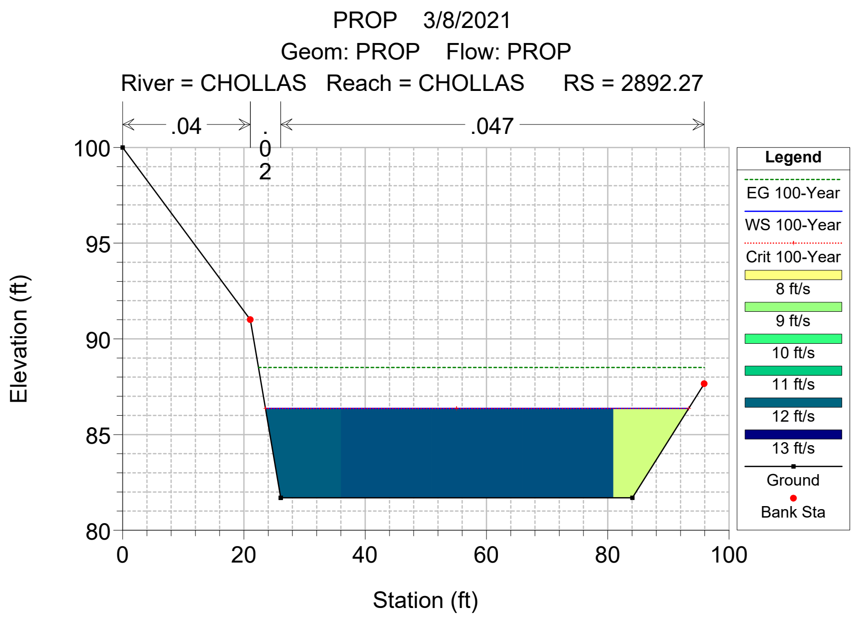


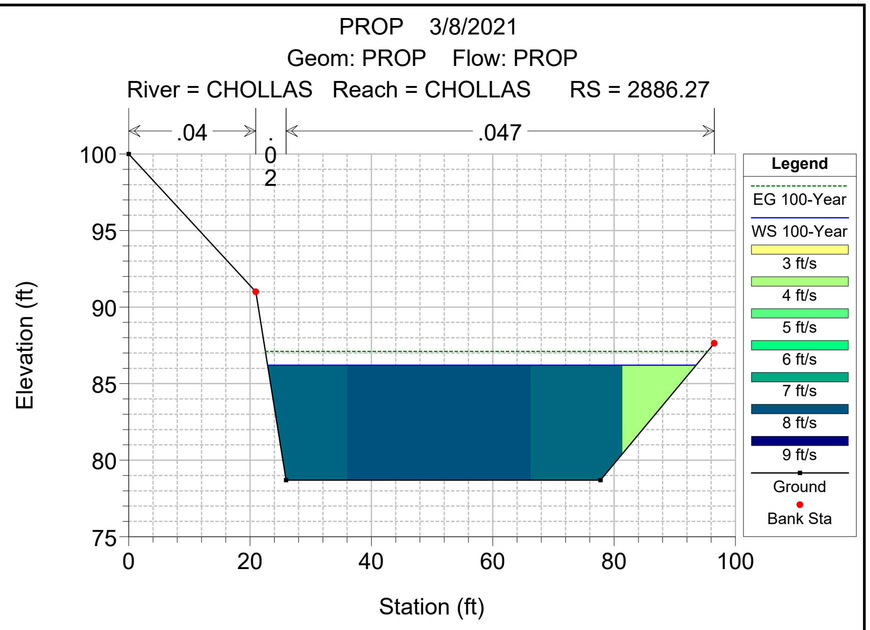

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3292.97
.04
.02
.047
Elevation (ft)
105
100
95
90
85
80
0
20
40
60
80
100
120
Station (ft)
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta

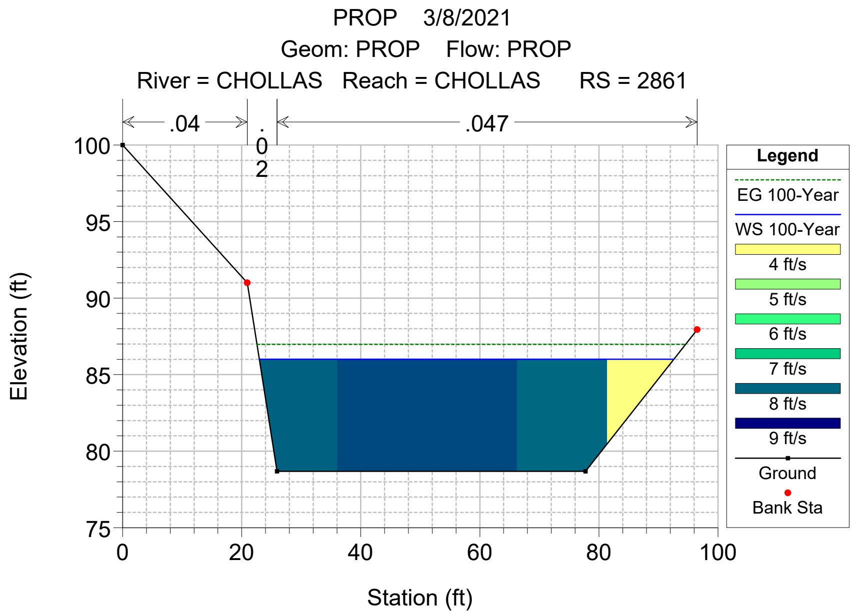

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3267
.04
.02
.047
Elevation (ft)
105
100
95
90
85
80
0
20
40
60
80
100
120
Station (ft)
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta

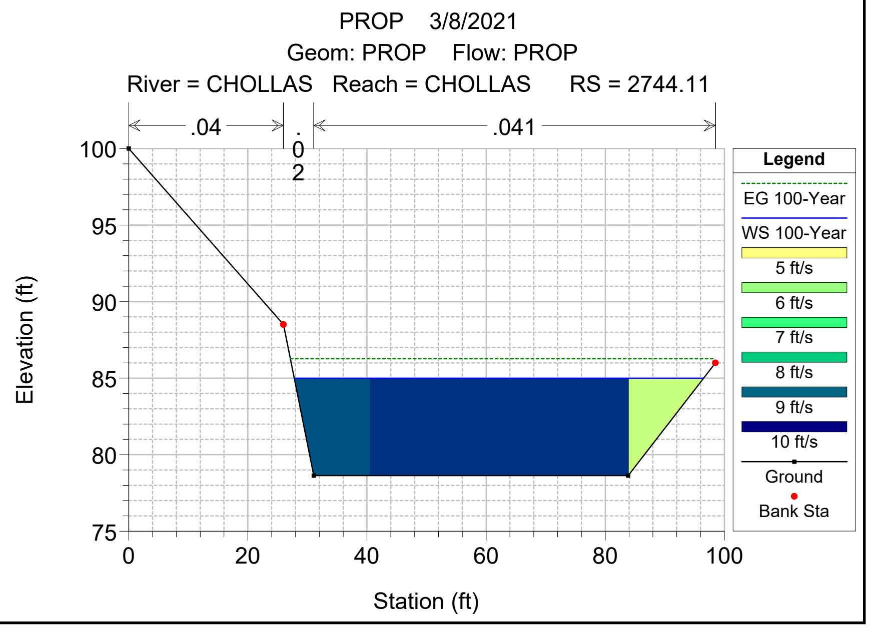

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3031.27
.04
.02
.041
Elevation (ft)
105
100
95
90
85
80
0
20
40
60
80
100
120
Station (ft)
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta

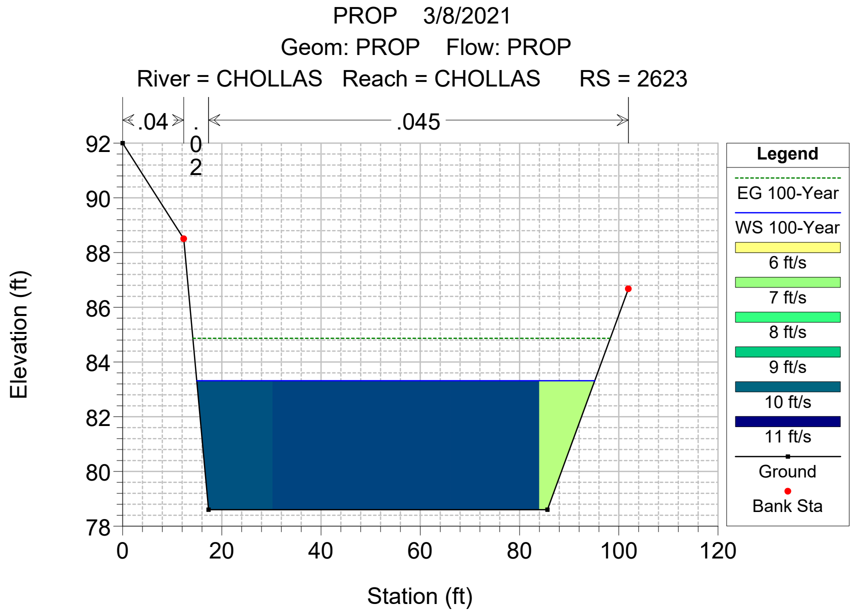

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2965.96
.04
.02
.041
Elevation (ft)
105
100
95
90
85
80
0
20
40
60
80
100
Station (ft)
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
Ground
Bank Sta

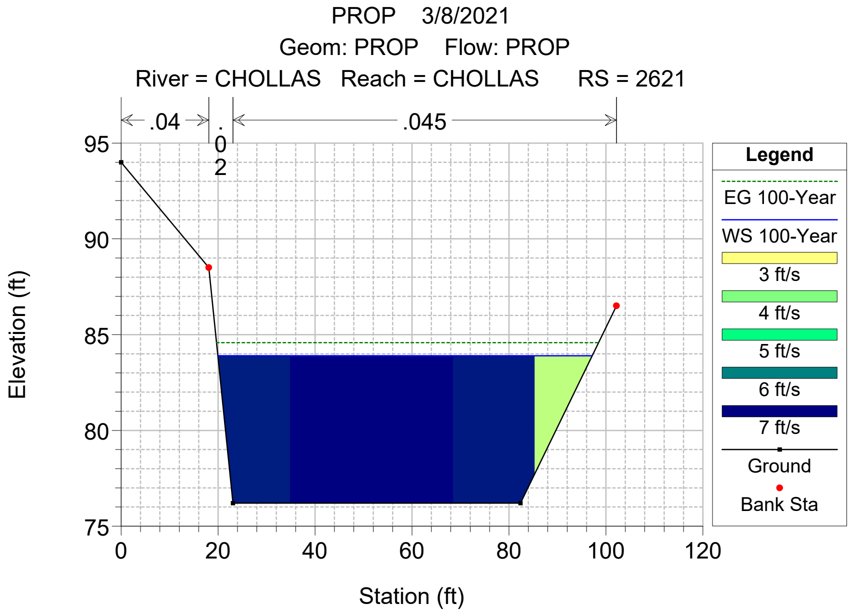

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2892.27
.04
.02
.047
Elevation (ft)
100
95
90
85
80
Station (ft)
0
20
40
60
80
100
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
Ground
Bank Sta

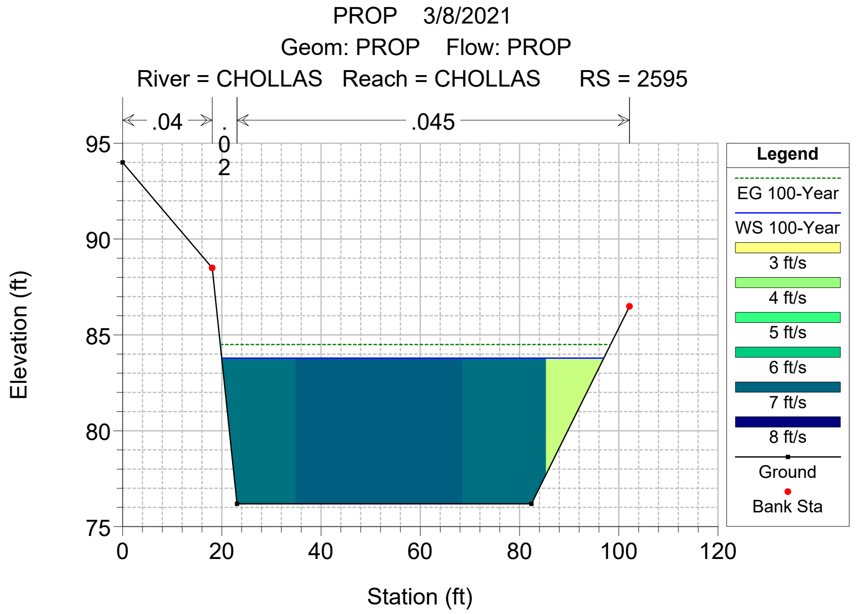

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2886.27
.04
.02
.047
Elevation (ft)
100
95
90
85
80
75
Station (ft)
0
20
40
60
80
100
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta

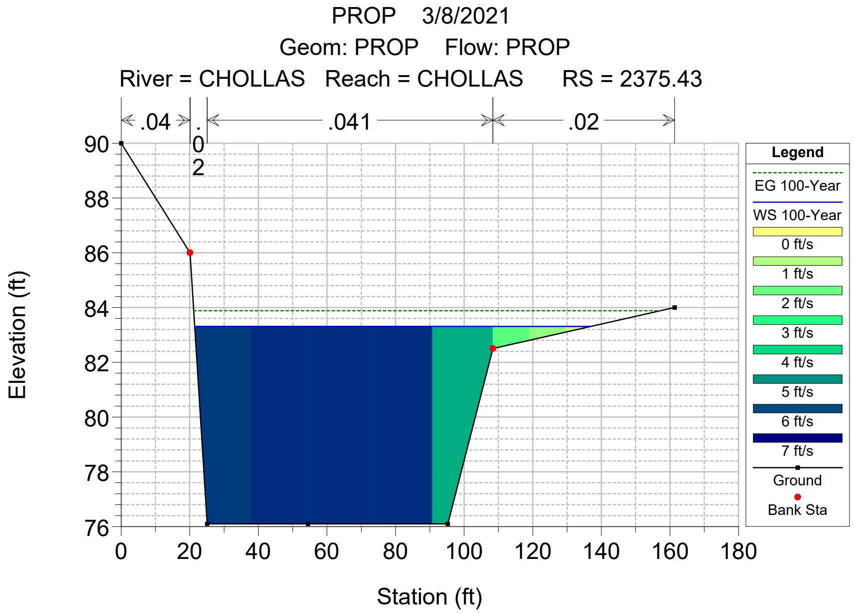

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2861
.04
.02
.047
Elevation (ft)
100
95
90
85
80
75
Station (ft)
0
20
40
60
80
100
Legend
EG 100-Year
WS 100-Year
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta

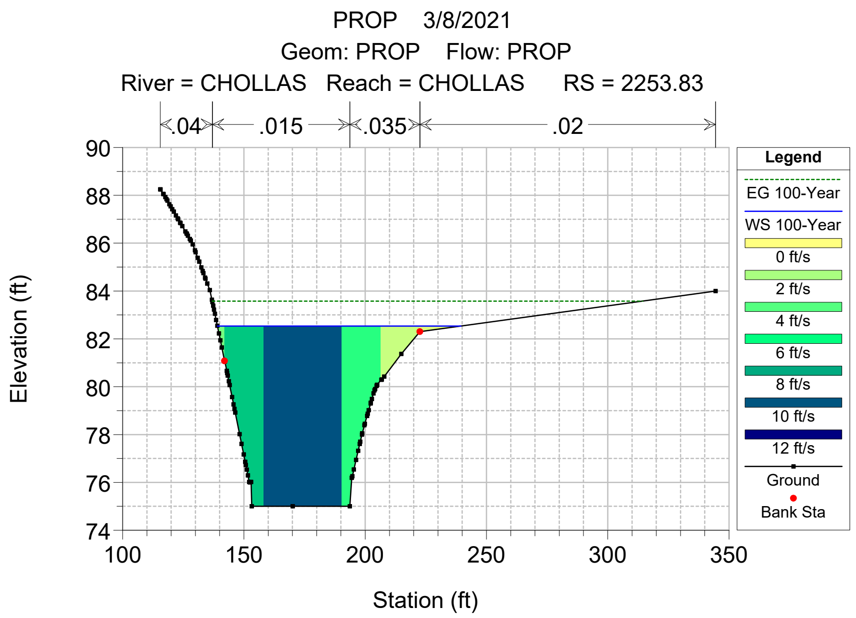

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2744.11
.04
.02
.041
Elevation (ft)
100
95
90
85
80
75
Station (ft)
0
20
40
60
80
100
Legend
EG 100-Year
WS 100-Year
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
Ground
Bank Sta

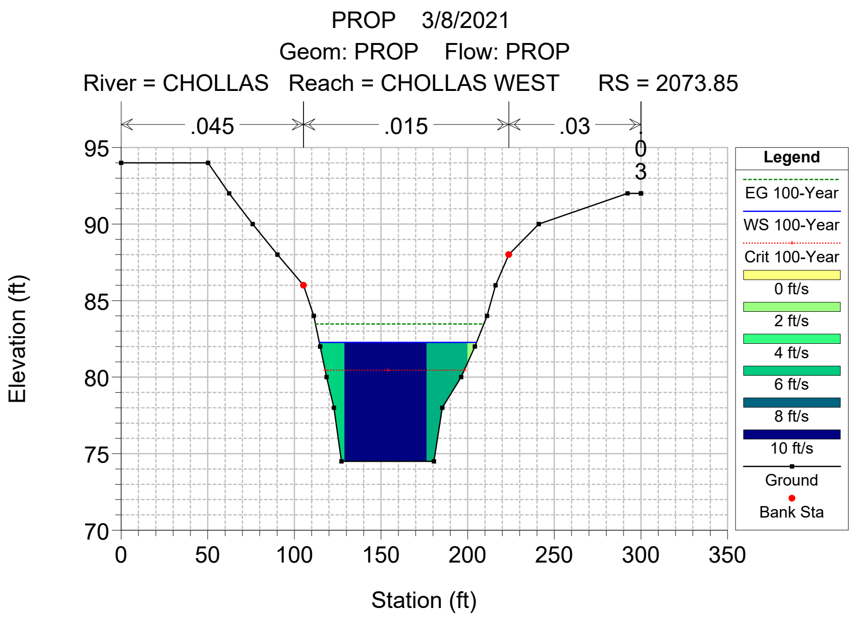

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2623
.04
.02
.045
Elevation (ft)
92
90
88
86
84
82
80
78
0
20
40
60
80
100
120
Station (ft)
Legend
EG 100-Year
WS 100-Year
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
Ground
Bank Sta

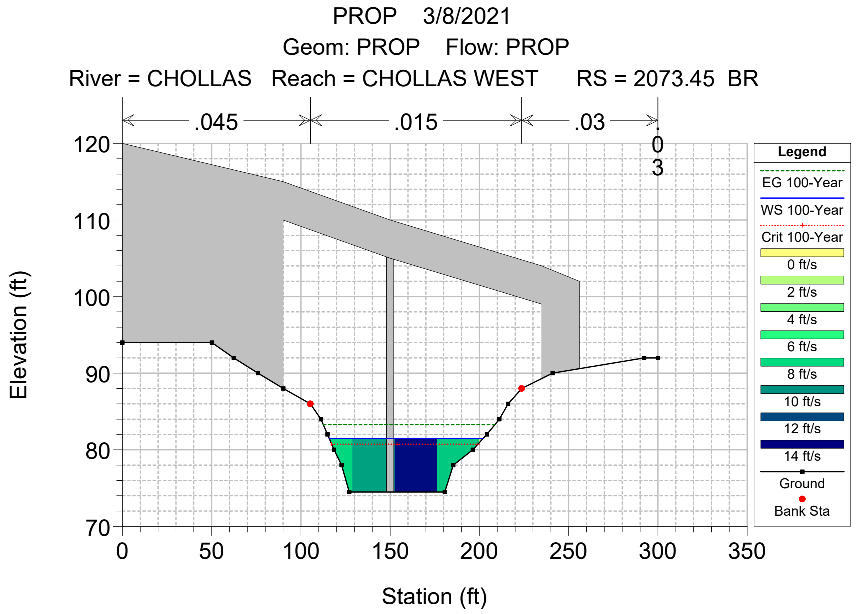

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2621
.04
.02
.045
Elevation (ft)
95
90
85
80
75
0
20
40
60
80
100
120
Station (ft)
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta

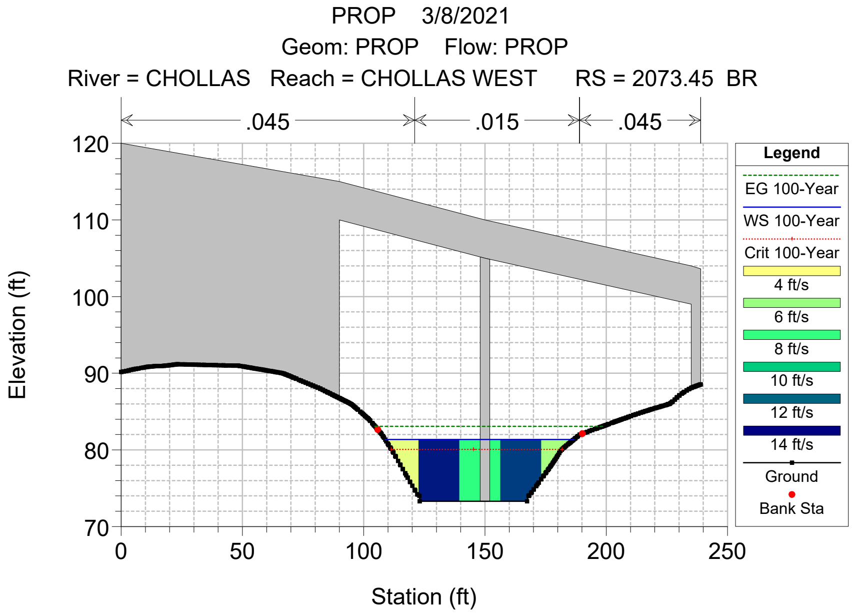

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2595
.04
.02
.045
Elevation (ft)
95
90
85
80
75
0
20
40
60
80
100
120
Station (ft)
Legend
EG 100-Year
WS 100-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta

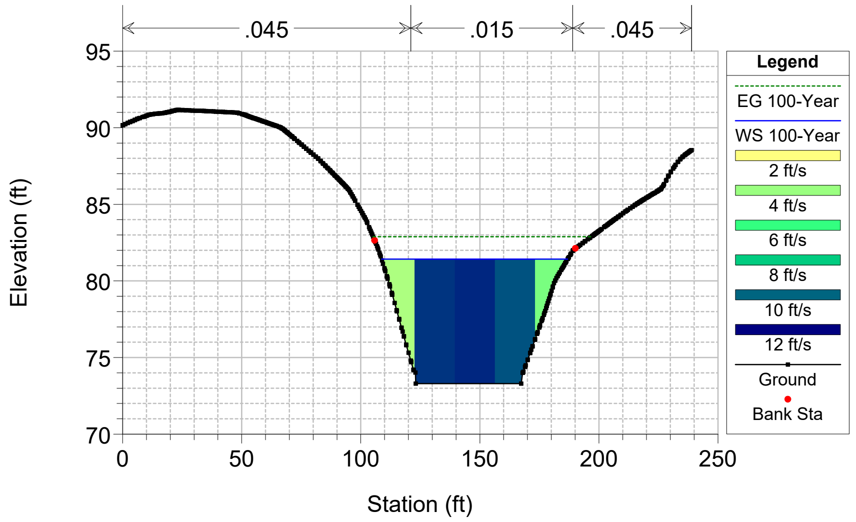

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2375.43
.04
.02
.041
.02
Elevation (ft)
90
88
86
84
82
80
78
76
0
20
40
60
80
100
120
140
160
180
Station (ft)
Legend
EG 100-Year
WS 100-Year
0 ft/s
1 ft/s
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta


PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2253.83
.04
.015
.035
.02
Elevation (ft)
90
88
86
84
82
80
78
76
74
Station (ft)
100
150
200
250
300
350
Legend
EG 100-Year
WS 100-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta

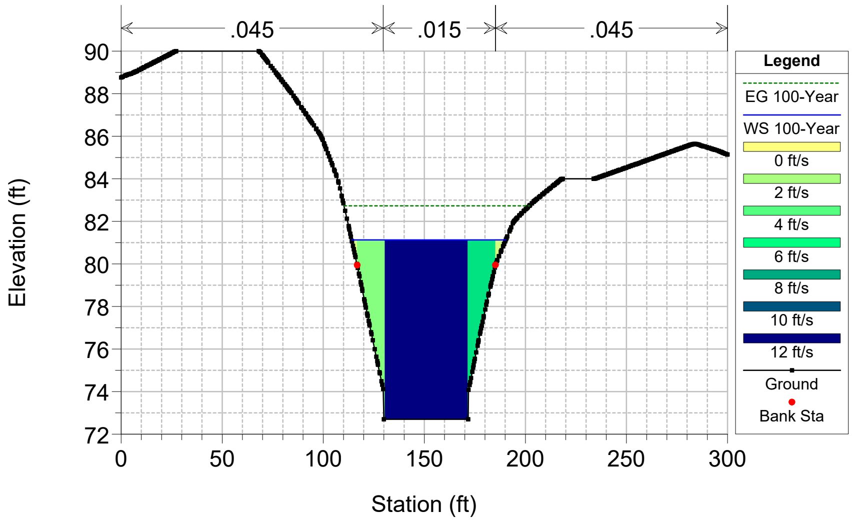

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.85
.045
.015
.03
0
3
Elevation (ft)
95
90
85
80
75
70
Station (ft)
0
50
100
150
200
250
300
350
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta


PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.45 BR
.045
.015
.03
0
3
Elevation (ft)
120
110
100
90
80
70
Station (ft)
0
50
100
150
200
250
300
350
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta

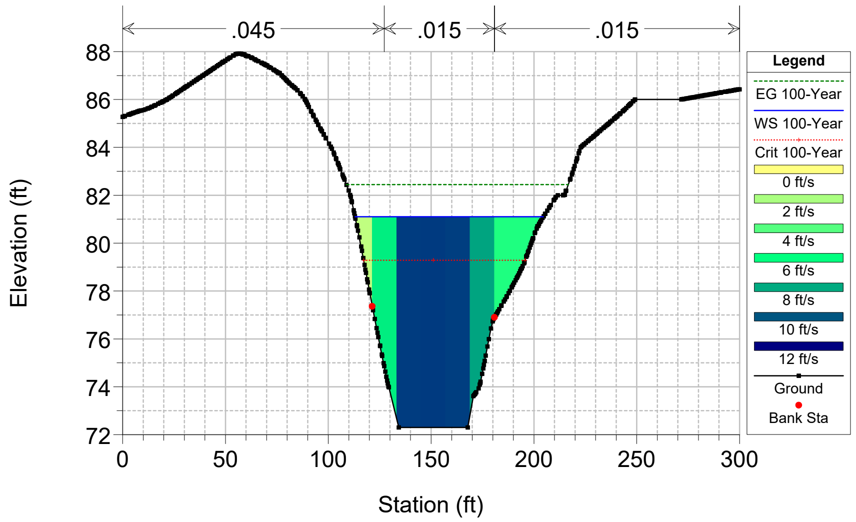

PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.45 BR
.045
.015
.045
Elevation (ft)
120
110
100
90
80
70
Station (ft)
0
50
100
150
200
250
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta



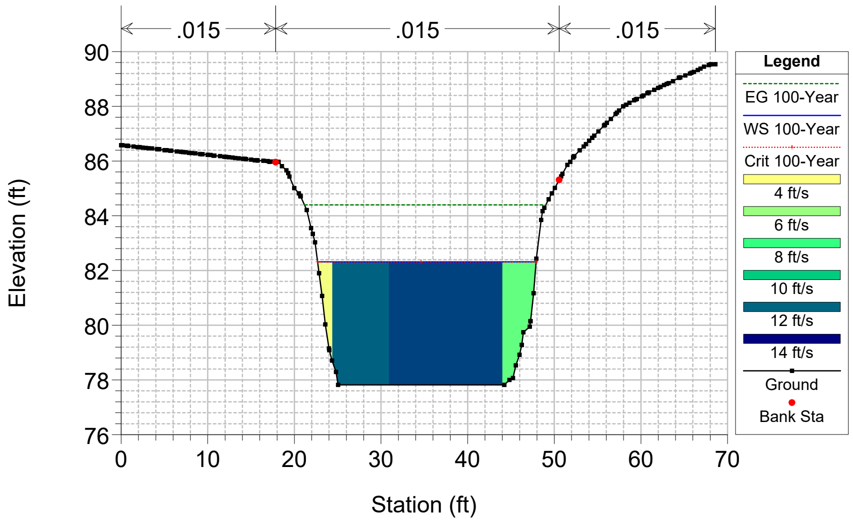
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2072.85



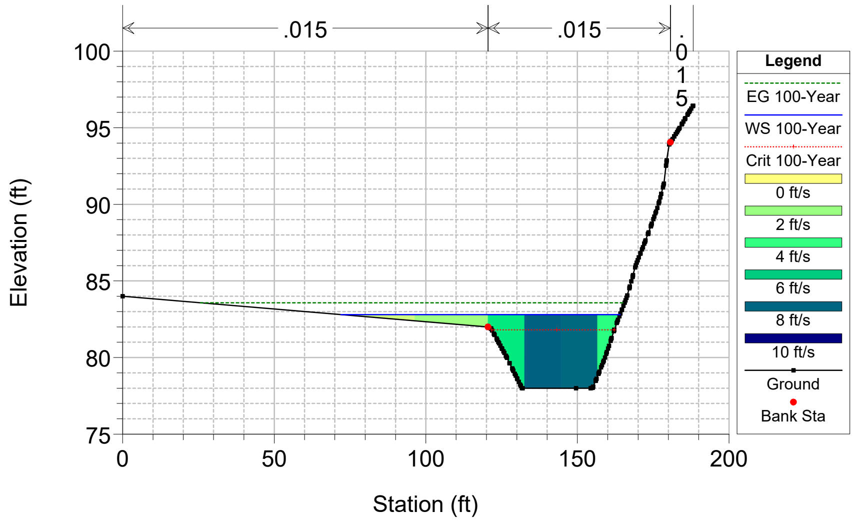
PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2014.48



PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 1900



PROP 3/8/2021
Geom: PROP Flow: PROP
River = CHOLLAS TRIB 1 Reach = HOME AVE CHAN RS = 10.0

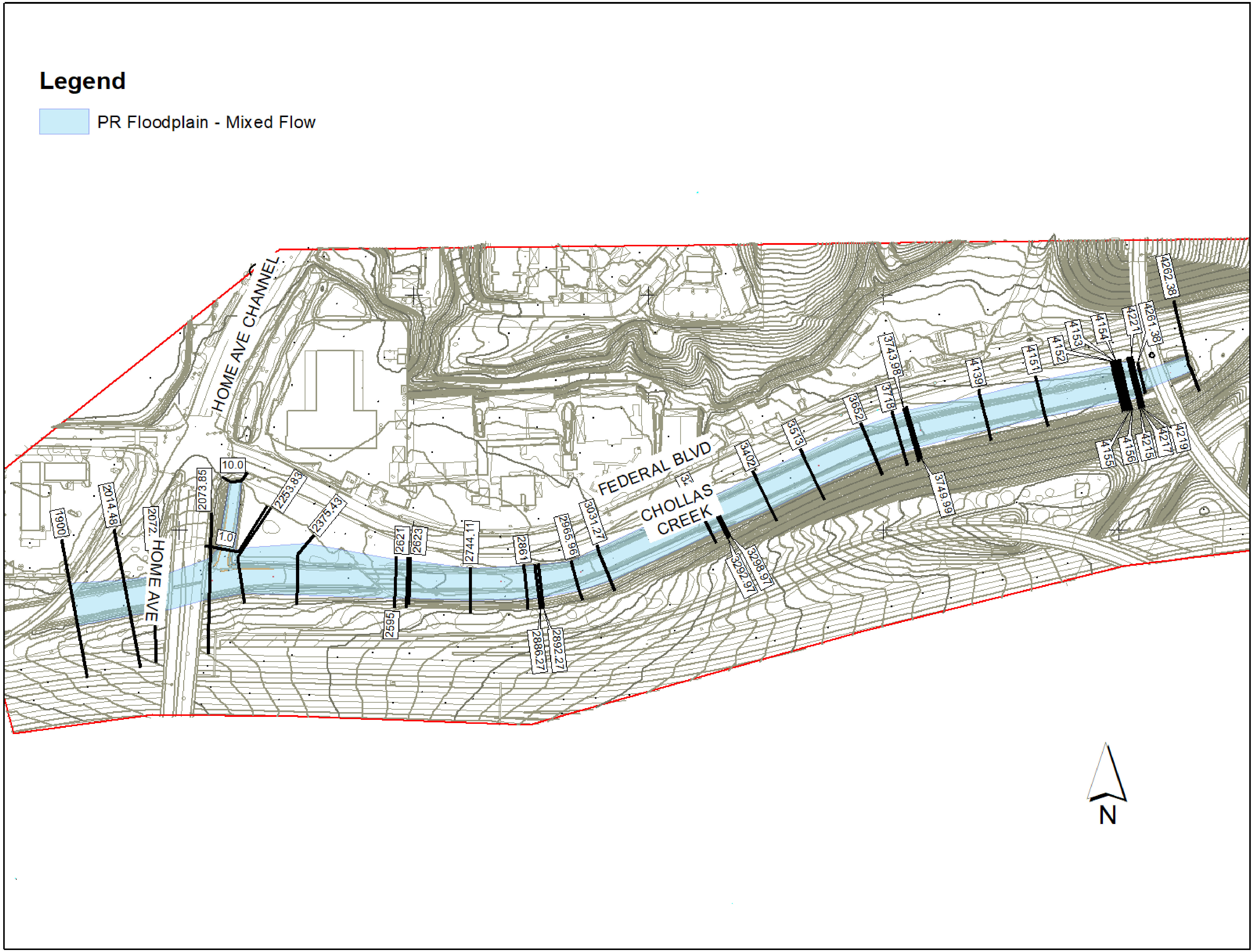


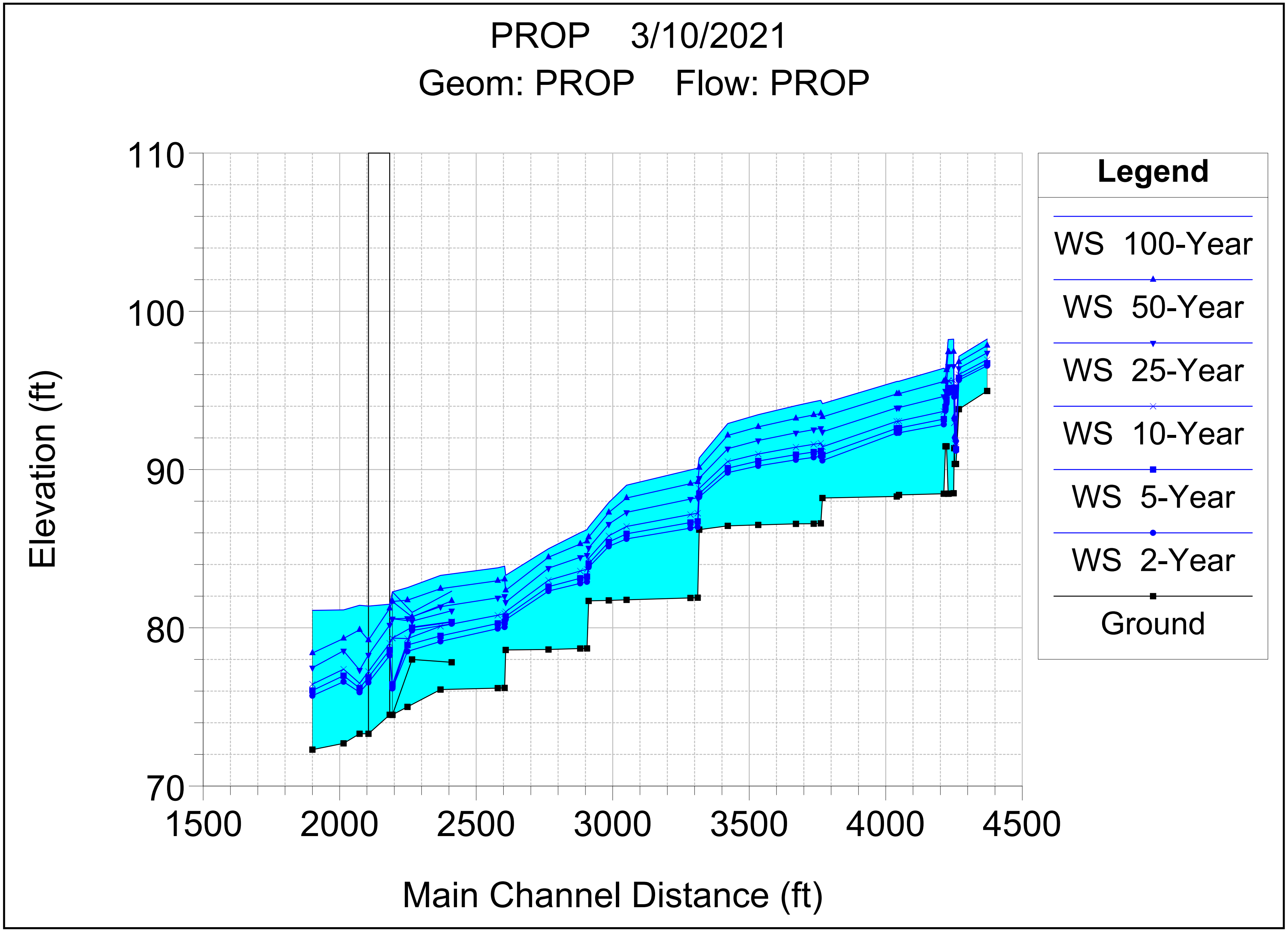
PROP 3/8/2021

Geom: PROP Flow: PROP

River = CHOLLAS TRIB 1 Reach = HOME AVE CHAN RS = 1.0

C - HEC-RAS Results
Proposed
Mixed Flow (Stone Sizing)


Legend
🟦 PR Floodplain - Mixed Flow
HOME AVE CHANNEL
HOME AVE
FEDERAL BLVD
CHOLLAS CREEK
1900
2014.48
2072.
2073.85
10.0
1.0
2253.83
2375.43
2595
2621
2623
2744.11
2861
2886.27
2892.27
2965.96
3031.27
3292.97
3298.97
3402
3513
3652
3718
3743.98
3749.99
4139
4151
4152
4153
4154
4155
4156
4215
4217
4219
4221
4261.38
4262.38
N


PROP 3/10/2021
Geom: PROP Flow: PROP
Elevation (ft)
110
100
90
80
70
1500
2000
2500
3000
3500
4000
4500
Main Channel Distance (ft)
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
Ground

HEC-RAS Plan: PROP

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	100-Year	1200.00	77.82	82.32	82.33	84.40	0.002691	11.57	103.71	25.22	1.01	4.50
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	50-Year	950.00	77.82	81.70	81.70	83.50	0.002724	10.76	88.28	24.81	1.01	3.88
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	25-Year	720.00	77.82	81.08	81.08	82.59	0.002774	9.86	72.99	24.39	1.01	3.26
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	10-Year	430.00	77.82	80.39	80.18	81.29	0.002189	7.64	56.30	23.91	0.88	2.57
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	5-Year	420.00	77.82	80.36	80.14	81.24	0.002152	7.53	55.75	23.89	0.87	2.54
CHOLLAS TRIB 1	HOME AVE CHAN	10.0	2-Year	360.00	77.82	80.25	79.93	80.97	0.001836	6.78	53.12	23.81	0.80	2.43
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	100-Year	1200.00	78.00	80.97	81.81	83.77	0.005860	13.42	89.42	36.70	1.52	2.97
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	50-Year	950.00	78.00	80.69	81.31	82.93	0.005258	12.01	79.13	35.47	1.42	2.69
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	25-Year	720.00	78.00	80.42	80.80	82.08	0.004396	10.34	69.65	34.24	1.28	2.42
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	10-Year	430.00	78.00	80.04	80.04	80.92	0.002831	7.53	57.10	32.57	1.00	2.04
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	5-Year	420.00	78.00	80.01	80.01	80.88	0.002861	7.50	56.01	32.43	1.01	2.01
CHOLLAS TRIB 1	HOME AVE CHAN	1.0	2-Year	360.00	78.00	79.82	79.82	80.63	0.002936	7.18	50.11	31.60	1.01	1.82
CHOLLAS	CHOLLAS	4262.38	100-Year	3500.00	94.97	98.25	102.15	116.35	0.030812	34.13	102.55	33.43	3.44	3.28
CHOLLAS	CHOLLAS	4262.38	50-Year	2800.00	94.97	97.83	101.23	113.28	0.030812	31.53	88.80	33.03	3.39	2.86
CHOLLAS	CHOLLAS	4262.38	25-Year	2100.00	94.97	97.38	100.18	109.93	0.030811	28.42	73.88	32.58	3.33	2.41
CHOLLAS	CHOLLAS	4262.38	10-Year	1500.00	94.97	96.94	99.16	106.75	0.030809	25.12	59.70	32.15	3.25	1.97
CHOLLAS	CHOLLAS	4262.38	5-Year	1225.00	94.97	96.72	98.65	105.16	0.030808	23.30	52.56	31.93	3.20	1.75
CHOLLAS	CHOLLAS	4262.38	2-Year	1050.00	94.97	96.56	98.30	104.09	0.030861	22.01	47.70	31.78	3.17	1.59
CHOLLAS	CHOLLAS	4261.38	100-Year	3500.00	93.81	97.15	100.62	112.58	0.026591	31.51	111.09	38.96	3.29	3.34
CHOLLAS	CHOLLAS	4261.38	50-Year	2800.00	93.81	96.80	99.81	109.62	0.025087	28.72	97.50	37.74	3.15	2.99
CHOLLAS	CHOLLAS	4261.38	25-Year	2100.00	93.81	96.40	98.86	106.42	0.023131	25.40	82.69	36.37	2.97	2.59
CHOLLAS	CHOLLAS	4261.38	10-Year	1500.00	93.81	96.01	97.93	103.43	0.020778	21.86	68.61	35.01	2.75	2.20
CHOLLAS	CHOLLAS	4261.38	5-Year	1225.00	93.81	95.80	97.45	101.98	0.019407	19.94	61.45	34.31	2.63	1.99
CHOLLAS	CHOLLAS	4261.38	2-Year	1050.00	93.81	95.65	97.12	101.01	0.018414	18.57	56.54	33.81	2.53	1.84
CHOLLAS	CHOLLAS	4221	100-Year	3500.00	90.35	92.17	95.24	110.84	0.628080	34.66	100.98	58.53	4.65	1.82
CHOLLAS	CHOLLAS	4221	50-Year	2800.00	90.35	91.93	94.60	107.93	0.642433	32.08	87.27	57.75	4.60	1.58
CHOLLAS	CHOLLAS	4221	25-Year	2100.00	90.35	91.67	93.87	104.80	0.665109	29.06	72.26	56.89	4.55	1.32
CHOLLAS	CHOLLAS	4221	10-Year	1500.00	90.35	91.41	93.19	101.89	0.701130	25.96	57.79	56.04	4.51	1.06
CHOLLAS	CHOLLAS	4221	5-Year	1225.00	90.35	91.28	92.84	100.47	0.731119	24.31	50.38	55.60	4.50	0.93
CHOLLAS	CHOLLAS	4221	2-Year	1050.00	90.35	91.19	92.60	99.54	0.760212	23.18	45.30	55.30	4.51	0.84
CHOLLAS	CHOLLAS	4219	100-Year	3500.00	90.35	92.37	95.25	107.39	0.443596	31.10	112.56	59.18	3.97	2.02
CHOLLAS	CHOLLAS	4219	50-Year	2800.00	90.35	92.14	94.60	104.52	0.425583	28.23	99.20	58.43	3.82	1.79
CHOLLAS	CHOLLAS	4219	25-Year	2100.00	90.35	91.89	93.88	101.45	0.398953	24.81	84.64	57.60	3.61	1.54
CHOLLAS	CHOLLAS	4219	10-Year	1500.00	90.35	91.64	93.19	98.64	0.364058	21.21	70.70	56.80	3.35	1.29
CHOLLAS	CHOLLAS	4219	5-Year	1225.00	90.35	95.19	92.84	95.46	0.002717	4.19	292.57	68.48	0.36	4.84
CHOLLAS	CHOLLAS	4219	2-Year	1050.00	90.35	94.87	92.60	95.10	0.002531	3.88	270.83	67.43	0.34	4.52
CHOLLAS	CHOLLAS	4217	100-Year	3500.00	91.35	93.55	96.20	105.81	0.326887	28.09	124.61	60.93	3.46	2.20
CHOLLAS	CHOLLAS	4217	50-Year	2800.00	91.35	93.34	95.56	103.01	0.291503	24.94	112.26	60.15	3.22	1.99
CHOLLAS	CHOLLAS	4217	25-Year	2100.00	91.35	93.13	94.86	100.06	0.241319	21.12	99.45	59.33	2.88	1.78
CHOLLAS	CHOLLAS	4217	10-Year	1500.00	91.35	92.95	94.18	97.38	0.176645	16.88	88.85	58.64	2.42	1.60
CHOLLAS	CHOLLAS	4217	5-Year	1225.00	91.35	94.90		95.42	0.007751	5.82	210.35	66.09	0.58	3.55
CHOLLAS	CHOLLAS	4217	2-Year	1050.00	91.35	94.60		95.07	0.007734	5.51	190.61	64.94	0.57	3.25

HEC-RAS Plan: PROP (Continued)

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	4215	100-Year	3500.00	88.50	98.24	93.43	98.71	0.001958	5.51	636.32	78.16	0.34	9.74
CHOLLAS	CHOLLAS	4215	50-Year	2800.00	88.50	97.45	92.78	97.81	0.001740	4.87	575.19	76.07	0.31	8.95
CHOLLAS	CHOLLAS	4215	25-Year	2100.00	88.50	96.53	92.05	96.80	0.001429	4.14	506.94	73.67	0.28	8.03
CHOLLAS	CHOLLAS	4215	10-Year	1500.00	88.50	95.63	91.36	95.81	0.001108	3.40	441.22	71.29	0.24	7.13
CHOLLAS	CHOLLAS	4215	5-Year	1225.00	88.50	95.16		95.30	0.000934	3.00	408.45	70.07	0.22	6.66
CHOLLAS	CHOLLAS	4215	2-Year	1050.00	88.50	94.84		94.96	0.000815	2.72	386.01	69.22	0.20	6.34
CHOLLAS	CHOLLAS	4156	100-Year	3500.00	88.48	98.22		98.67	0.001797	5.36	652.47	81.44	0.33	9.74
CHOLLAS	CHOLLAS	4156	50-Year	2800.00	88.48	97.43		97.78	0.001558	4.76	588.76	79.08	0.31	8.95
CHOLLAS	CHOLLAS	4156	25-Year	2100.00	88.48	96.52		96.77	0.001282	4.05	518.04	76.38	0.27	8.04
CHOLLAS	CHOLLAS	4156	10-Year	1500.00	88.48	95.61		95.79	0.000995	3.33	450.19	73.70	0.24	7.13
CHOLLAS	CHOLLAS	4156	5-Year	1225.00	88.48	95.15		95.29	0.000839	2.94	416.47	72.33	0.22	6.67
CHOLLAS	CHOLLAS	4156	2-Year	1050.00	88.48	94.83		94.94	0.000733	2.67	393.40	71.38	0.20	6.35
CHOLLAS	CHOLLAS	4155	100-Year	3500.00	88.47	98.22		98.66	0.001793	5.36	653.02	81.46	0.33	9.75
CHOLLAS	CHOLLAS	4155	50-Year	2800.00	88.47	97.42		97.77	0.001554	4.75	589.33	79.10	0.31	8.95
CHOLLAS	CHOLLAS	4155	25-Year	2100.00	88.47	96.51		96.77	0.001277	4.05	518.63	76.41	0.27	8.04
CHOLLAS	CHOLLAS	4155	10-Year	1500.00	88.47	95.61		95.78	0.000991	3.33	450.81	73.72	0.24	7.14
CHOLLAS	CHOLLAS	4155	5-Year	1225.00	88.47	95.15		95.28	0.000836	2.94	417.09	72.35	0.22	6.68
CHOLLAS	CHOLLAS	4155	2-Year	1050.00	88.47	94.83		94.94	0.000729	2.66	394.03	71.40	0.20	6.36
CHOLLAS	CHOLLAS	4154	100-Year	3500.00	91.47	96.95	96.32	98.53	0.012709	10.08	347.23	74.22	0.82	5.48
CHOLLAS	CHOLLAS	4154	50-Year	2800.00	91.47	96.29	95.67	97.65	0.012723	9.35	299.52	71.63	0.81	4.82
CHOLLAS	CHOLLAS	4154	25-Year	2100.00	91.47	95.53	94.97	96.66	0.013065	8.54	245.93	68.61	0.80	4.06
CHOLLAS	CHOLLAS	4154	10-Year	1500.00	91.47	94.78	94.29	95.69	0.013529	7.67	195.54	65.63	0.78	3.31
CHOLLAS	CHOLLAS	4154	5-Year	1225.00	91.47	94.42	93.95	95.21	0.013454	7.12	172.00	64.20	0.77	2.95
CHOLLAS	CHOLLAS	4154	2-Year	1050.00	91.47	94.16	93.71	94.87	0.013496	6.74	155.71	63.18	0.76	2.69
CHOLLAS	CHOLLAS	4153	100-Year	3500.00	91.47	96.32	96.32	98.42	0.019587	11.63	300.98	71.71	1.00	4.85
CHOLLAS	CHOLLAS	4153	50-Year	2800.00	91.47	95.67	95.67	97.54	0.020688	10.96	255.39	69.15	1.01	4.20
CHOLLAS	CHOLLAS	4153	25-Year	2100.00	91.47	94.97	94.97	96.55	0.021894	10.10	208.01	66.38	1.01	3.50
CHOLLAS	CHOLLAS	4153	10-Year	1500.00	91.47	94.29	94.29	95.59	0.023424	9.15	163.97	63.70	1.01	2.82
CHOLLAS	CHOLLAS	4153	5-Year	1225.00	91.47	93.95	93.95	95.10	0.024412	8.61	142.24	62.34	1.01	2.48
CHOLLAS	CHOLLAS	4153	2-Year	1050.00	91.47	93.71	93.71	94.76	0.025197	8.22	127.72	61.41	1.01	2.24
CHOLLAS	CHOLLAS	4152	100-Year	3500.00	88.47	96.41	93.38	97.14	0.003722	6.86	510.40	76.09	0.47	7.94
CHOLLAS	CHOLLAS	4152	50-Year	2800.00	88.47	95.57	92.73	96.18	0.003531	6.26	447.54	73.59	0.45	7.10
CHOLLAS	CHOLLAS	4152	25-Year	2100.00	88.47	94.62	92.01	95.10	0.003279	5.54	379.08	70.78	0.42	6.15
CHOLLAS	CHOLLAS	4152	10-Year	1500.00	88.47	93.68	91.32	94.03	0.002976	4.78	313.81	67.99	0.39	5.21
CHOLLAS	CHOLLAS	4152	5-Year	1225.00	88.47	93.19	90.97	93.48	0.002789	4.36	280.95	66.54	0.37	4.72
CHOLLAS	CHOLLAS	4152	2-Year	1050.00	88.47	92.85	90.73	93.11	0.002640	4.06	258.79	65.54	0.36	4.38
CHOLLAS	CHOLLAS	4151	100-Year	3500.00	88.40	95.58		96.49	0.003966	7.65	457.32	74.87	0.55	7.18
CHOLLAS	CHOLLAS	4151	50-Year	2800.00	88.40	94.80		95.56	0.003811	7.01	399.56	72.43	0.53	6.40
CHOLLAS	CHOLLAS	4151	25-Year	2100.00	88.40	93.92		94.52	0.003587	6.23	337.23	69.70	0.50	5.52
CHOLLAS	CHOLLAS	4151	10-Year	1500.00	88.40	93.06		93.51	0.003287	5.38	278.57	67.03	0.47	4.66
CHOLLAS	CHOLLAS	4151	5-Year	1225.00	88.40	92.62		93.00	0.003082	4.91	249.48	65.66	0.44	4.22

HEC-RAS Plan: PROP (Continued)

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	4151	2-Year	1050.00	88.40	92.33		92.65	0.002908	4.56	230.16	64.74	0.43	3.93
CHOLLAS	CHOLLAS	4139	100-Year	3500.00	88.30	95.56		96.45	0.003818	7.56	462.85	74.92	0.54	7.26
CHOLLAS	CHOLLAS	4139	50-Year	2800.00	88.30	94.78		95.52	0.003650	6.91	405.07	72.51	0.52	6.48
CHOLLAS	CHOLLAS	4139	25-Year	2100.00	88.30	93.90		94.49	0.003409	6.13	342.72	69.81	0.49	5.60
CHOLLAS	CHOLLAS	4139	10-Year	1500.00	88.30	93.05		93.48	0.003091	5.28	284.03	67.16	0.45	4.75
CHOLLAS	CHOLLAS	4139	5-Year	1225.00	88.30	92.61		92.97	0.002878	4.81	254.94	65.81	0.43	4.31
CHOLLAS	CHOLLAS	4139	2-Year	1050.00	88.30	92.31		92.62	0.002700	4.46	235.61	64.90	0.41	4.01
CHOLLAS	CHOLLAS	3749.99	100-Year	3500.00	88.20	94.17		95.15	0.006100	7.94	440.88	81.99	0.60	5.97
CHOLLAS	CHOLLAS	3749.99	50-Year	2800.00	88.20	93.33		94.20	0.006560	7.50	373.16	79.72	0.61	5.13
CHOLLAS	CHOLLAS	3749.99	25-Year	2100.00	88.20	92.38		93.15	0.007402	7.02	298.97	77.15	0.63	4.18
CHOLLAS	CHOLLAS	3749.99	10-Year	1500.00	88.20	91.44		92.11	0.009031	6.60	227.13	74.58	0.67	3.24
CHOLLAS	CHOLLAS	3749.99	5-Year	1225.00	88.20	90.93		91.58	0.010730	6.46	189.61	73.20	0.71	2.73
CHOLLAS	CHOLLAS	3749.99	2-Year	1050.00	88.20	90.57		91.21	0.012649	6.42	163.68	72.24	0.75	2.37
CHOLLAS	CHOLLAS	3743.98	100-Year	3500.00	86.60	94.38		95.02	0.002961	6.43	544.38	80.20	0.44	7.78
CHOLLAS	CHOLLAS	3743.98	50-Year	2800.00	86.60	93.54		94.08	0.002808	5.85	478.43	78.01	0.42	6.94
CHOLLAS	CHOLLAS	3743.98	25-Year	2100.00	86.60	92.60		93.02	0.002610	5.17	406.24	75.54	0.39	6.00
CHOLLAS	CHOLLAS	3743.98	10-Year	1500.00	86.60	91.67		91.98	0.002382	4.46	336.67	73.09	0.37	5.07
CHOLLAS	CHOLLAS	3743.98	5-Year	1225.00	86.60	91.18		91.43	0.002250	4.07	301.14	71.80	0.35	4.58
CHOLLAS	CHOLLAS	3743.98	2-Year	1050.00	86.60	90.84		91.06	0.002150	3.79	276.88	70.91	0.34	4.24
CHOLLAS	CHOLLAS	3718	100-Year	3500.00	86.58	94.28		94.94	0.003061	6.50	538.39	79.97	0.44	7.70
CHOLLAS	CHOLLAS	3718	50-Year	2800.00	86.58	93.46		94.00	0.002905	5.92	473.13	77.80	0.42	6.88
CHOLLAS	CHOLLAS	3718	25-Year	2100.00	86.58	92.53		92.95	0.002699	5.23	401.80	75.37	0.40	5.95
CHOLLAS	CHOLLAS	3718	10-Year	1500.00	86.58	91.60		91.91	0.002465	4.50	332.98	72.94	0.37	5.02
CHOLLAS	CHOLLAS	3718	5-Year	1225.00	86.58	91.11		91.37	0.002328	4.11	297.86	71.66	0.36	4.53
CHOLLAS	CHOLLAS	3718	2-Year	1050.00	86.58	90.77		91.00	0.002225	3.83	273.88	70.78	0.34	4.19
CHOLLAS	CHOLLAS	3652	100-Year	3500.00	86.57	94.04		94.74	0.002846	6.73	519.82	79.38	0.46	7.47
CHOLLAS	CHOLLAS	3652	50-Year	2800.00	86.57	93.23		93.82	0.002706	6.13	456.54	77.26	0.44	6.66
CHOLLAS	CHOLLAS	3652	25-Year	2100.00	86.57	92.32		92.78	0.002524	5.42	387.25	74.87	0.42	5.75
CHOLLAS	CHOLLAS	3652	10-Year	1500.00	86.57	91.41		91.76	0.002316	4.68	320.49	72.50	0.39	4.84
CHOLLAS	CHOLLAS	3652	5-Year	1225.00	86.57	90.94		91.23	0.002192	4.28	286.50	71.26	0.38	4.37
CHOLLAS	CHOLLAS	3652	2-Year	1050.00	86.57	90.61		90.86	0.002099	3.99	263.27	70.40	0.36	4.04
CHOLLAS	CHOLLAS	3513	100-Year	3500.00	86.50	93.47		94.29	0.003627	7.29	480.03	78.03	0.52	6.97
CHOLLAS	CHOLLAS	3513	50-Year	2800.00	86.50	92.70		93.38	0.003474	6.65	420.83	76.02	0.50	6.20
CHOLLAS	CHOLLAS	3513	25-Year	2100.00	86.50	91.83		92.37	0.003267	5.89	356.24	73.76	0.47	5.33
CHOLLAS	CHOLLAS	3513	10-Year	1500.00	86.50	90.98		91.39	0.003021	5.10	294.32	71.53	0.44	4.48
CHOLLAS	CHOLLAS	3513	5-Year	1225.00	86.50	90.54		90.88	0.002872	4.66	262.86	70.37	0.43	4.04
CHOLLAS	CHOLLAS	3513	2-Year	1050.00	86.50	90.23		90.53	0.002758	4.35	241.41	69.57	0.41	3.73
CHOLLAS	CHOLLAS	3402	100-Year	3500.00	86.44	92.91		93.84	0.004376	7.74	452.24	80.08	0.57	6.47
CHOLLAS	CHOLLAS	3402	50-Year	2800.00	86.44	92.15		92.94	0.004314	7.13	392.92	77.72	0.56	5.71
CHOLLAS	CHOLLAS	3402	25-Year	2100.00	86.44	91.32		91.95	0.004196	6.38	329.24	75.11	0.54	4.88
CHOLLAS	CHOLLAS	3402	10-Year	1500.00	86.44	90.51		90.99	0.004013	5.57	269.26	72.56	0.51	4.07

HEC-RAS Plan: PROP (Continued)

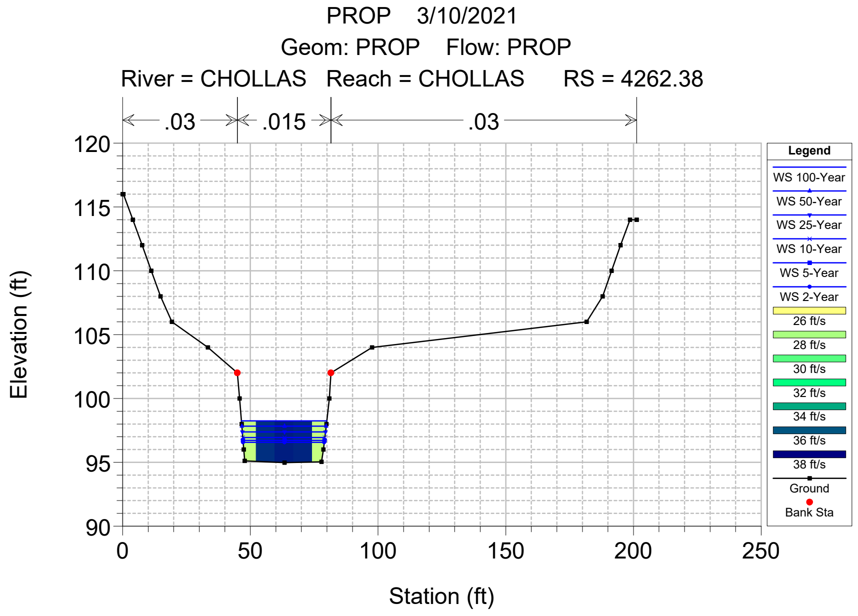
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	3402	5-Year	1225.00	86.44	90.09		90.50	0.003883	5.12	239.22	71.25	0.49	3.65
CHOLLAS	CHOLLAS	3402	2-Year	1050.00	86.44	89.80		90.16	0.003775	4.80	218.93	70.35	0.48	3.36
CHOLLAS	CHOLLAS	3298.97	100-Year	3500.00	86.20	90.73	90.73	92.87	0.020053	11.72	298.65	70.67	1.01	4.53
CHOLLAS	CHOLLAS	3298.97	50-Year	2800.00	86.20	90.12	90.12	91.98	0.020986	10.95	255.82	69.38	1.00	3.92
CHOLLAS	CHOLLAS	3298.97	25-Year	2100.00	86.20	89.45	89.45	91.01	0.022276	10.01	209.73	67.96	1.00	3.25
CHOLLAS	CHOLLAS	3298.97	10-Year	1500.00	86.20	88.81	88.81	90.07	0.023908	9.01	166.47	66.60	1.00	2.61
CHOLLAS	CHOLLAS	3298.97	5-Year	1225.00	86.20	88.48	88.48	89.59	0.024954	8.45	144.94	65.92	1.00	2.28
CHOLLAS	CHOLLAS	3298.97	2-Year	1050.00	86.20	88.26	88.26	89.27	0.025789	8.05	130.48	65.45	1.00	2.06
CHOLLAS	CHOLLAS	3292.97	100-Year	3500.00	81.90	90.08	86.76	90.76	0.003291	6.63	527.71	74.61	0.44	8.18
CHOLLAS	CHOLLAS	3292.97	50-Year	2800.00	81.90	89.21	86.09	89.78	0.003114	6.04	463.71	72.46	0.42	7.31
CHOLLAS	CHOLLAS	3292.97	25-Year	2100.00	81.90	88.22	85.38	88.67	0.002890	5.34	393.42	70.02	0.40	6.32
CHOLLAS	CHOLLAS	3292.97	10-Year	1500.00	81.90	87.24	84.70	87.57	0.002631	4.60	325.91	67.60	0.37	5.34
CHOLLAS	CHOLLAS	3292.97	5-Year	1225.00	81.90	86.73	84.35	87.00	0.002482	4.20	291.43	66.33	0.35	4.83
CHOLLAS	CHOLLAS	3292.97	2-Year	1050.00	81.90	86.37	84.12	86.61	0.002370	3.92	267.89	65.44	0.34	4.47
CHOLLAS	CHOLLAS	3267	100-Year	3500.00	81.89	89.98		90.68	0.003423	6.72	521.16	74.51	0.45	8.09
CHOLLAS	CHOLLAS	3267	50-Year	2800.00	81.89	89.11		89.69	0.003243	6.12	457.76	72.36	0.43	7.22
CHOLLAS	CHOLLAS	3267	25-Year	2100.00	81.89	88.14		88.59	0.003014	5.41	388.24	69.93	0.40	6.25
CHOLLAS	CHOLLAS	3267	10-Year	1500.00	81.89	87.16		87.50	0.002749	4.67	321.45	67.52	0.38	5.27
CHOLLAS	CHOLLAS	3267	5-Year	1225.00	81.89	86.65		86.94	0.002595	4.26	287.36	66.25	0.36	4.76
CHOLLAS	CHOLLAS	3267	2-Year	1050.00	81.89	86.30		86.55	0.002480	3.98	264.10	65.37	0.35	4.41
CHOLLAS	CHOLLAS	3031.27	100-Year	3500.00	81.77	89.01		89.85	0.003533	7.34	476.55	75.13	0.51	7.24
CHOLLAS	CHOLLAS	3031.27	50-Year	2800.00	81.77	88.20		88.90	0.003405	6.72	416.67	73.05	0.50	6.43
CHOLLAS	CHOLLAS	3031.27	25-Year	2100.00	81.77	87.30		87.85	0.003232	5.98	351.43	70.71	0.47	5.53
CHOLLAS	CHOLLAS	3031.27	10-Year	1500.00	81.77	86.40		86.82	0.003010	5.18	289.43	68.42	0.44	4.63
CHOLLAS	CHOLLAS	3031.27	5-Year	1225.00	81.77	85.94		86.29	0.002876	4.75	257.98	67.23	0.43	4.17
CHOLLAS	CHOLLAS	3031.27	2-Year	1050.00	81.77	85.62		85.93	0.002769	4.44	236.68	66.41	0.41	3.85
CHOLLAS	CHOLLAS	2965.96	100-Year	3500.00	81.73	87.92	86.87	89.45	0.007970	9.91	353.01	64.76	0.75	6.19
CHOLLAS	CHOLLAS	2965.96	50-Year	2800.00	81.73	87.29	86.19	88.53	0.007396	8.96	312.51	63.18	0.71	5.56
CHOLLAS	CHOLLAS	2965.96	25-Year	2100.00	81.73	86.55		87.52	0.006761	7.87	266.82	61.35	0.67	4.82
CHOLLAS	CHOLLAS	2965.96	10-Year	1500.00	81.73	85.81		86.52	0.006096	6.76	222.04	59.50	0.62	4.08
CHOLLAS	CHOLLAS	2965.96	5-Year	1225.00	81.73	85.42		86.01	0.005729	6.16	198.93	58.52	0.59	3.69
CHOLLAS	CHOLLAS	2965.96	2-Year	1050.00	81.73	85.15		85.66	0.005449	5.73	183.20	57.84	0.57	3.42
CHOLLAS	CHOLLAS	2892.27	100-Year	3500.00	81.70	86.37	86.37	88.51	0.019874	11.73	298.36	69.81	1.00	4.67
CHOLLAS	CHOLLAS	2892.27	50-Year	2800.00	81.70	85.73	85.73	87.61	0.020941	11.00	254.52	68.20	1.00	4.03
CHOLLAS	CHOLLAS	2892.27	25-Year	2100.00	81.70	85.05	85.05	86.63	0.022189	10.08	208.31	66.47	1.00	3.35
CHOLLAS	CHOLLAS	2892.27	10-Year	1500.00	81.70	84.39	84.39	85.67	0.023769	9.09	165.06	64.80	1.00	2.69
CHOLLAS	CHOLLAS	2892.27	5-Year	1225.00	81.70	84.05	84.05	85.19	0.024789	8.53	143.58	63.96	1.00	2.35
CHOLLAS	CHOLLAS	2892.27	2-Year	1050.00	81.70	83.83	83.83	84.86	0.025600	8.13	129.17	63.38	1.00	2.13
CHOLLAS	CHOLLAS	2886.27	100-Year	3500.00	78.70	86.20	83.70	87.11	0.004867	7.62	459.24	70.60	0.53	7.50
CHOLLAS	CHOLLAS	2886.27	50-Year	2800.00	78.70	85.46	83.02	86.19	0.004471	6.87	407.53	68.75	0.50	6.76
CHOLLAS	CHOLLAS	2886.27	25-Year	2100.00	78.70	84.59	82.29	85.16	0.004039	6.02	348.87	66.57	0.46	5.89

HEC-RAS Plan: PROP (Continued)

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	2886.27	10-Year	1500.00	78.70	83.70	81.58	84.12	0.003614	5.16	290.62	64.34	0.43	5.00
CHOLLAS	CHOLLAS	2886.27	5-Year	1225.00	78.70	83.24	81.23	83.58	0.003373	4.70	260.74	63.17	0.41	4.54
CHOLLAS	CHOLLAS	2886.27	2-Year	1050.00	78.70	82.91	80.99	83.21	0.003197	4.37	240.25	62.35	0.39	4.21
CHOLLAS	CHOLLAS	2861	100-Year	3500.00	78.69	86.01		86.97	0.005334	7.88	444.41	69.63	0.55	7.32
CHOLLAS	CHOLLAS	2861	50-Year	2800.00	78.69	85.29		86.07	0.004873	7.08	395.24	67.89	0.52	6.60
CHOLLAS	CHOLLAS	2861	25-Year	2100.00	78.69	84.46		85.05	0.004375	6.19	339.18	65.85	0.48	5.77
CHOLLAS	CHOLLAS	2861	10-Year	1500.00	78.69	83.59		84.02	0.003907	5.30	282.87	63.73	0.44	4.90
CHOLLAS	CHOLLAS	2861	5-Year	1225.00	78.69	83.13		83.49	0.003642	4.82	253.95	62.62	0.42	4.44
CHOLLAS	CHOLLAS	2861	2-Year	1050.00	78.69	82.81		83.12	0.003450	4.49	234.10	61.84	0.41	4.12
CHOLLAS	CHOLLAS	2744.11	100-Year	3500.00	78.63	84.99		86.27	0.006322	9.06	386.50	68.69	0.67	6.36
CHOLLAS	CHOLLAS	2744.11	50-Year	2800.00	78.63	84.46		85.45	0.005475	8.00	350.13	67.36	0.62	5.83
CHOLLAS	CHOLLAS	2744.11	25-Year	2100.00	78.63	83.76		84.51	0.004756	6.91	304.03	65.62	0.57	5.13
CHOLLAS	CHOLLAS	2744.11	10-Year	1500.00	78.63	83.00		83.54	0.004198	5.89	254.81	63.72	0.52	4.37
CHOLLAS	CHOLLAS	2744.11	5-Year	1225.00	78.63	82.60		83.04	0.003891	5.34	229.34	62.72	0.49	3.97
CHOLLAS	CHOLLAS	2744.11	2-Year	1050.00	78.63	82.32		82.70	0.003669	4.96	211.80	62.02	0.47	3.69
CHOLLAS	CHOLLAS	2623	100-Year	3500.00	78.60	83.31		84.87	0.012911	10.00	350.12	80.22	0.84	4.71
CHOLLAS	CHOLLAS	2623	50-Year	2800.00	78.60	82.37	82.24	83.98	0.017631	10.16	275.50	77.83	0.95	3.77
CHOLLAS	CHOLLAS	2623	25-Year	2100.00	78.60	81.62	81.62	83.06	0.021080	9.65	217.51	75.93	1.01	3.02
CHOLLAS	CHOLLAS	2623	10-Year	1500.00	78.60	81.02	81.02	82.19	0.022587	8.69	172.68	74.42	1.01	2.42
CHOLLAS	CHOLLAS	2623	5-Year	1225.00	78.60	80.72	80.72	81.75	0.023557	8.15	150.37	73.66	1.01	2.12
CHOLLAS	CHOLLAS	2623	2-Year	1050.00	78.60	80.51	80.51	81.45	0.024355	7.76	135.33	73.14	1.01	1.91
CHOLLAS	CHOLLAS	2621	100-Year	3500.00	76.20	83.90		84.58	0.003224	6.66	525.40	77.23	0.45	7.70
CHOLLAS	CHOLLAS	2621	50-Year	2800.00	76.20	83.06		83.64	0.003056	6.06	462.05	75.30	0.43	6.86
CHOLLAS	CHOLLAS	2621	25-Year	2100.00	76.20	81.99	79.51	82.46	0.003076	5.49	382.55	72.80	0.42	5.79
CHOLLAS	CHOLLAS	2621	10-Year	1500.00	76.20	80.90	78.85	81.27	0.003204	4.93	304.19	70.25	0.42	4.70
CHOLLAS	CHOLLAS	2621	5-Year	1225.00	76.20	80.37	78.52	80.70	0.003184	4.57	267.93	69.04	0.41	4.17
CHOLLAS	CHOLLAS	2621	2-Year	1050.00	76.20	80.05	78.30	80.33	0.003089	4.28	245.32	68.27	0.40	3.85
CHOLLAS	CHOLLAS	2595	100-Year	3500.00	76.19	83.79		84.50	0.003362	6.75	518.20	77.02	0.46	7.60
CHOLLAS	CHOLLAS	2595	50-Year	2800.00	76.19	82.97		83.56	0.003187	6.14	455.78	75.11	0.44	6.78
CHOLLAS	CHOLLAS	2595	25-Year	2100.00	76.19	81.90		82.38	0.003233	5.58	376.44	72.60	0.43	5.71
CHOLLAS	CHOLLAS	2595	10-Year	1500.00	76.19	80.80		81.19	0.003420	5.03	297.93	70.04	0.43	4.61
CHOLLAS	CHOLLAS	2595	5-Year	1225.00	76.19	80.28		80.62	0.003422	4.68	261.87	68.83	0.42	4.09
CHOLLAS	CHOLLAS	2595	2-Year	1050.00	76.19	79.95		80.25	0.003331	4.38	239.54	68.07	0.41	3.76
CHOLLAS	CHOLLAS	2375.43	100-Year	3500.00	76.10	83.31		83.88	0.002307	6.08	583.42	115.54	0.42	7.21
CHOLLAS	CHOLLAS	2375.43	50-Year	2800.00	76.10	82.47		82.96	0.002341	5.61	499.02	86.50	0.41	6.37
CHOLLAS	CHOLLAS	2375.43	25-Year	2100.00	76.10	81.34		81.76	0.002568	5.21	402.70	83.60	0.42	5.24
CHOLLAS	CHOLLAS	2375.43	10-Year	1500.00	76.10	80.10		80.49	0.003265	4.98	301.34	80.44	0.45	4.00
CHOLLAS	CHOLLAS	2375.43	5-Year	1225.00	76.10	79.49		79.86	0.003800	4.84	252.93	78.88	0.48	3.39
CHOLLAS	CHOLLAS	2375.43	2-Year	1050.00	76.10	79.13		79.47	0.004068	4.67	224.82	77.96	0.48	3.03
CHOLLAS	CHOLLAS	2253.83	100-Year	3500.00	75.00	82.54		83.58	0.001895	8.21	429.49	100.39	0.63	7.54
CHOLLAS	CHOLLAS	2253.83	50-Year	2800.00	75.00	81.74		82.67	0.001793	7.71	363.31	77.29	0.62	6.74

HEC-RAS Plan: PROP (Continued)

River	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	Max Chl Dpth
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)
CHOLLAS	CHOLLAS	2253.83	25-Year	2100.00	75.00	80.60		81.47	0.001676	7.46	281.56	66.19	0.64	5.60
CHOLLAS	CHOLLAS	2253.83	10-Year	1500.00	75.00	79.32		80.16	0.001717	7.36	203.71	56.68	0.68	4.32
CHOLLAS	CHOLLAS	2253.83	5-Year	1225.00	75.00	78.91		79.62	0.001561	6.77	180.99	54.72	0.66	3.91
CHOLLAS	CHOLLAS	2253.83	2-Year	1050.00	75.00	78.51		79.18	0.001598	6.59	159.45	52.77	0.67	3.51
CHOLLAS	CHOLLAS WEST	2073.85	100-Year	4700.00	74.50	82.27	80.47	83.47	0.000783	8.79	534.52	90.69	0.64	7.77
CHOLLAS	CHOLLAS WEST	2073.85	50-Year	3750.00	74.50	81.66	79.70	82.61	0.000676	7.81	480.11	87.27	0.59	7.16
CHOLLAS	CHOLLAS WEST	2073.85	25-Year	2820.00	74.50	80.57	78.81	81.39	0.000698	7.26	388.57	80.96	0.58	6.07
CHOLLAS	CHOLLAS WEST	2073.85	10-Year	1930.00	74.50	79.35	77.83	80.02	0.000714	6.55	294.47	72.76	0.57	4.85
CHOLLAS	CHOLLAS WEST	2073.85	5-Year	1645.00	74.50	76.42	77.50	80.06	0.010879	15.29	107.59	58.46	1.99	1.92
CHOLLAS	CHOLLAS WEST	2073.85	2-Year	1410.00	74.50	76.17	77.21	79.74	0.012699	15.14	93.13	57.82	2.10	1.67
CHOLLAS	CHOLLAS WEST	2073.45		Bridge										
CHOLLAS	CHOLLAS WEST	2072.85	100-Year	4700.00	73.30	81.42		82.89	0.001855	9.71	484.13	78.16	0.69	8.12
CHOLLAS	CHOLLAS WEST	2072.85	50-Year	3750.00	73.30	79.88		81.47	0.002257	10.13	370.13	69.38	0.77	6.58
CHOLLAS	CHOLLAS WEST	2072.85	25-Year	2820.00	73.30	77.34	78.02	80.24	0.005725	13.66	206.47	59.41	1.29	4.04
CHOLLAS	CHOLLAS WEST	2072.85	10-Year	1930.00	73.30	76.49	77.03	78.82	0.005442	12.23	157.76	55.96	1.28	3.19
CHOLLAS	CHOLLAS WEST	2072.85	5-Year	1645.00	73.30	76.19	76.67	78.30	0.005325	11.66	141.09	54.74	1.28	2.89
CHOLLAS	CHOLLAS WEST	2072.85	2-Year	1410.00	73.30	75.93	76.36	77.85	0.005201	11.11	126.89	53.67	1.27	2.63
CHOLLAS	CHOLLAS WEST	2014.48	100-Year	4700.00	72.70	81.13		82.73	0.001985	10.16	466.79	76.25	0.69	8.43
CHOLLAS	CHOLLAS WEST	2014.48	50-Year	3750.00	72.70	79.33	78.71	81.22	0.003202	11.03	339.96	65.54	0.85	6.63
CHOLLAS	CHOLLAS WEST	2014.48	25-Year	2820.00	72.70	78.55	77.76	80.01	0.002694	9.72	290.06	61.97	0.79	5.85
CHOLLAS	CHOLLAS WEST	2014.48	10-Year	1930.00	72.70	77.39	76.69	78.57	0.002475	8.72	221.40	56.72	0.78	4.69
CHOLLAS	CHOLLAS WEST	2014.48	5-Year	1645.00	72.70	76.97	76.31	78.04	0.002372	8.30	198.21	54.87	0.77	4.27
CHOLLAS	CHOLLAS WEST	2014.48	2-Year	1410.00	72.70	76.59	75.97	77.57	0.002287	7.93	177.75	53.17	0.76	3.89
CHOLLAS	CHOLLAS WEST	1900	100-Year	4700.00	72.30	81.10	79.29	82.44	0.001009	9.52	530.17	91.57	0.60	8.80
CHOLLAS	CHOLLAS WEST	1900	50-Year	3750.00	72.30	78.40	78.40	80.74	0.002977	12.31	310.56	71.65	0.96	6.10
CHOLLAS	CHOLLAS WEST	1900	25-Year	2820.00	72.30	77.48	77.48	79.50	0.003350	11.42	247.85	63.63	0.99	5.18
CHOLLAS	CHOLLAS WEST	1900	10-Year	1930.00	72.30	76.44	76.44	78.10	0.003195	10.35	186.41	55.60	1.00	4.14
CHOLLAS	CHOLLAS WEST	1900	5-Year	1645.00	72.30	76.04	76.04	77.59	0.003123	9.99	164.64	53.76	1.01	3.74
CHOLLAS	CHOLLAS WEST	1900	2-Year	1410.00	72.30	75.71	75.71	77.14	0.002999	9.58	147.23	52.25	1.01	3.41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.015
.03
Elevation (ft)
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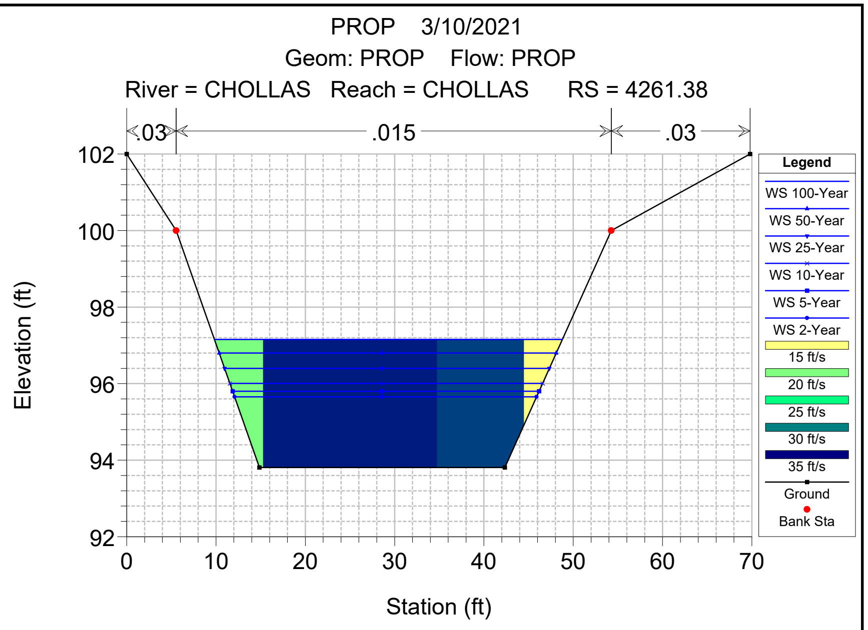
115
110
105
100
95
90
Station (ft)
0
50
100
150
200
250
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
26 ft/s
28 ft/s
30 ft/s
32 ft/s
34 ft/s
36 ft/s
38 ft/s
Ground
Bank Sta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.03
.015
.03
Elevation (ft)
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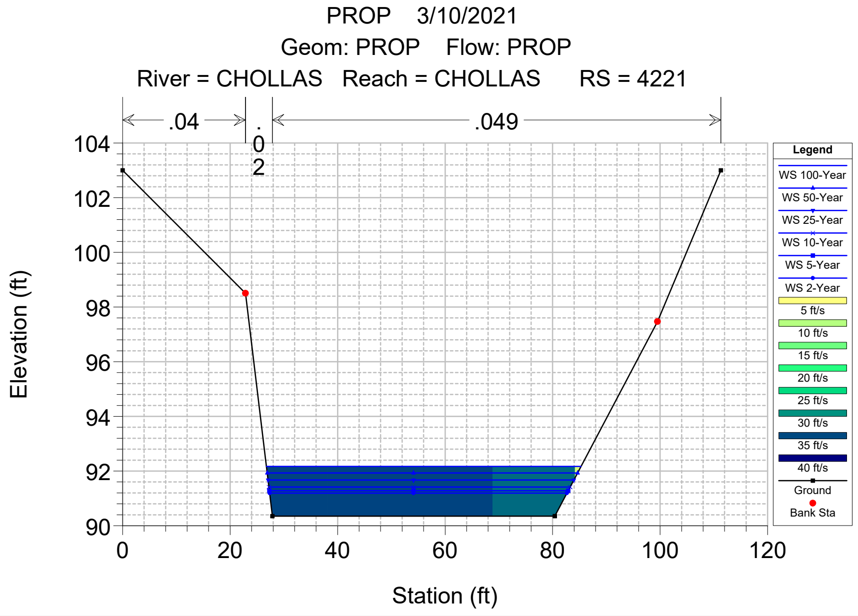
100
98
96
94
92
Station (ft)
0
10
20
30
40
50
60
70
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
15 ft/s
20 ft/s
25 ft/s
30 ft/s
35 ft/s
Ground
Bank Sta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.04
.02
.049
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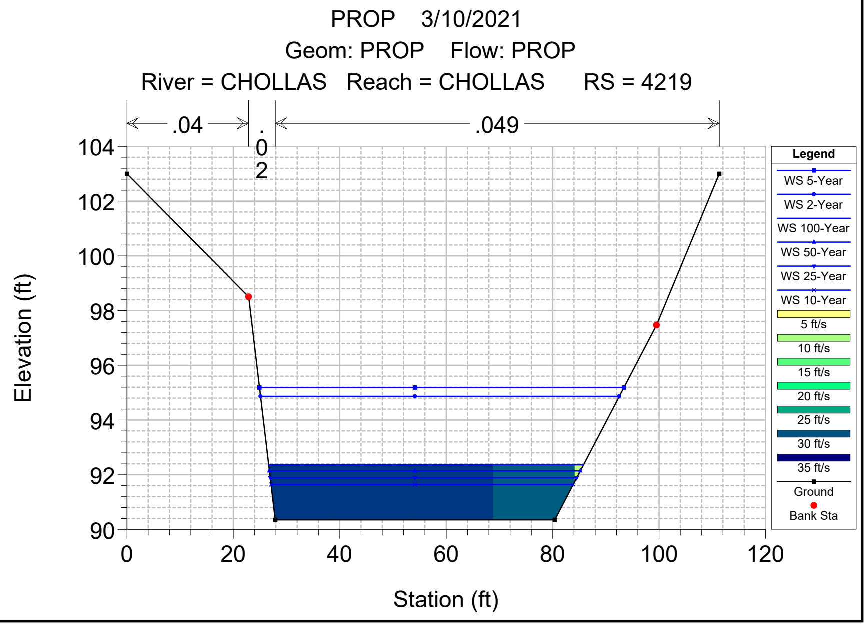
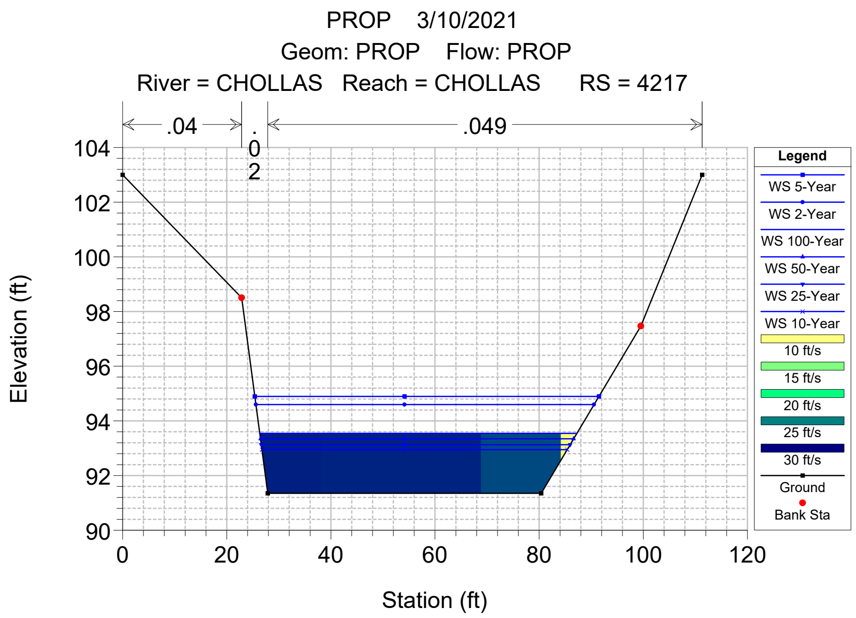
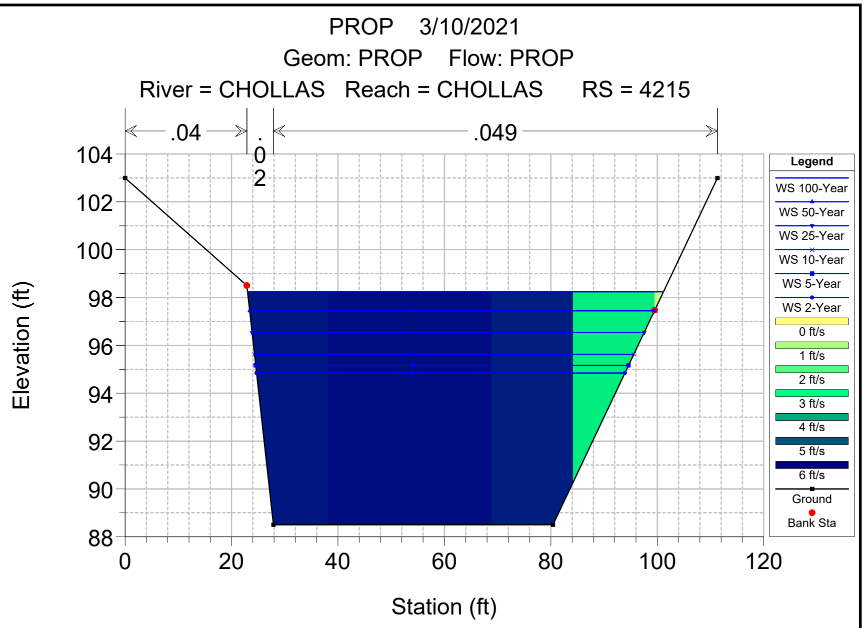
102
100
98
96
94
92
90
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
5 ft/s
10 ft/s
15 ft/s
20 ft/s
25 ft/s
30 ft/s
35 ft/s
40 ft/s
Ground
Bank Sta

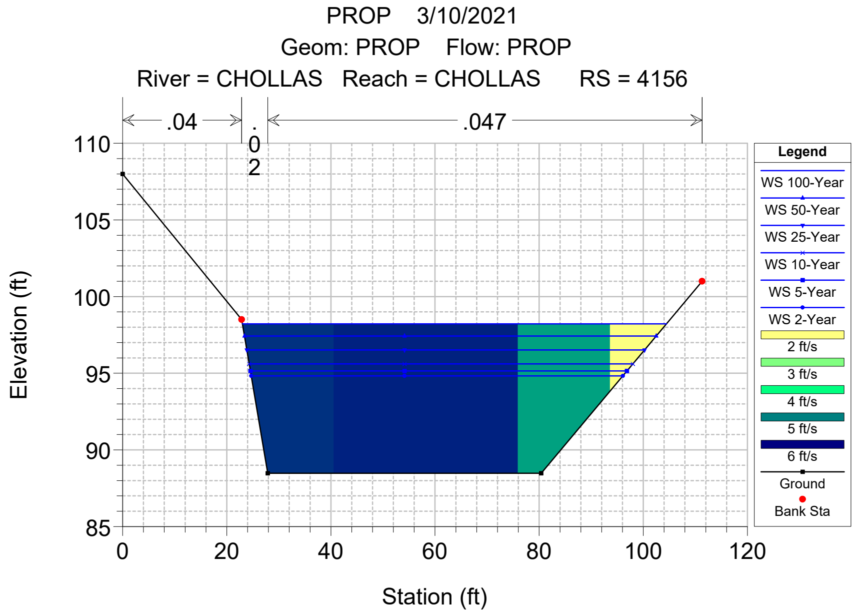

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4219
.04
.02
.049
Elevation (ft)
104
102
100
98
96
94
92
90
Station (ft)
0
20
40
60
80
100
120
Legend
WS 5-Year
WS 2-Year
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
5 ft/s
10 ft/s
15 ft/s
20 ft/s
25 ft/s
30 ft/s
35 ft/s
Ground
Bank Sta



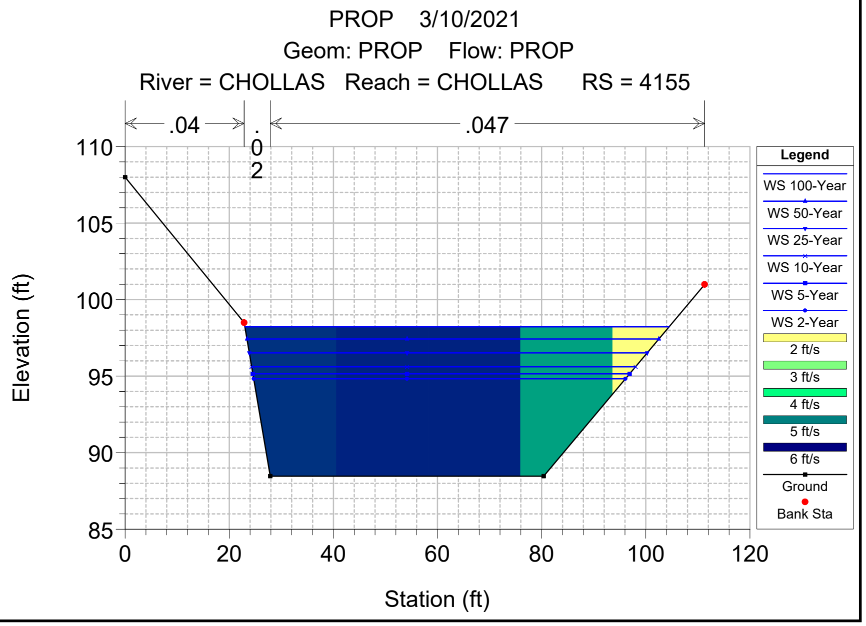
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4217



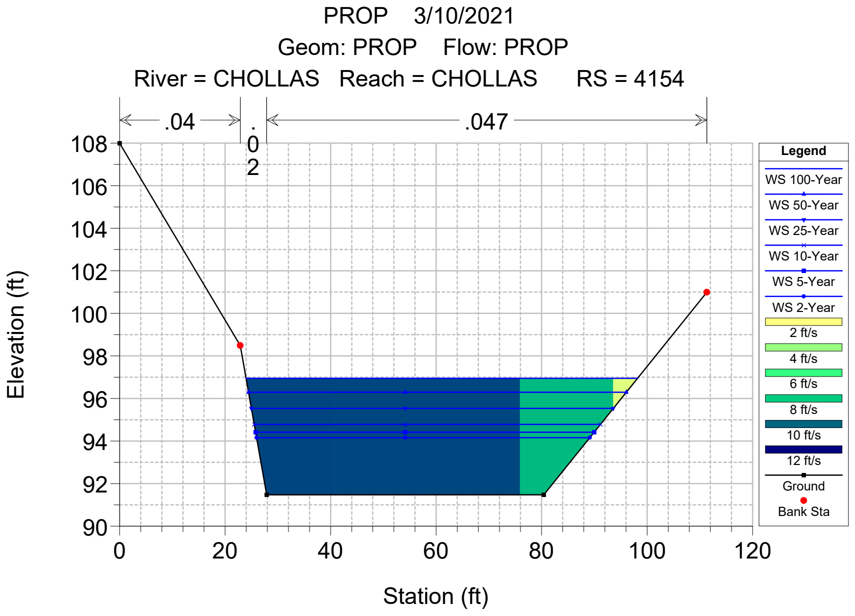
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4215

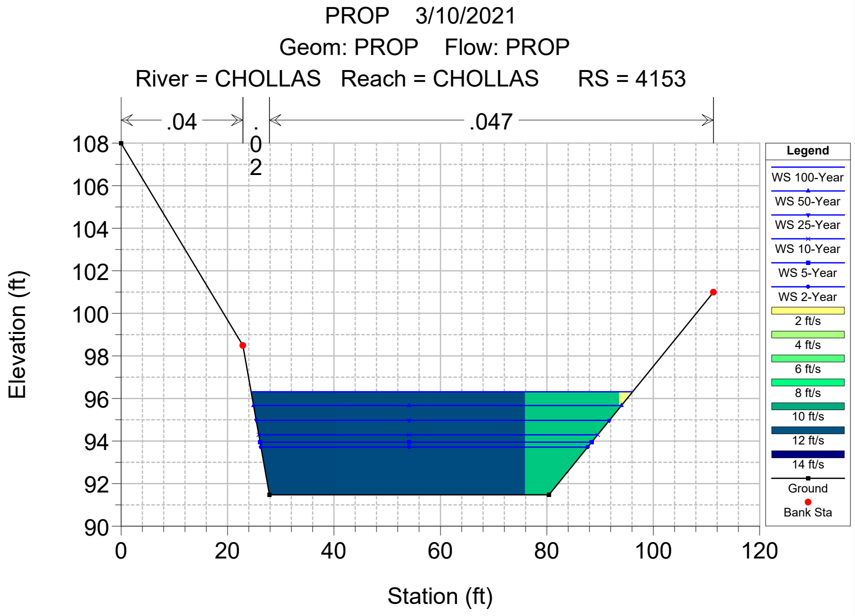


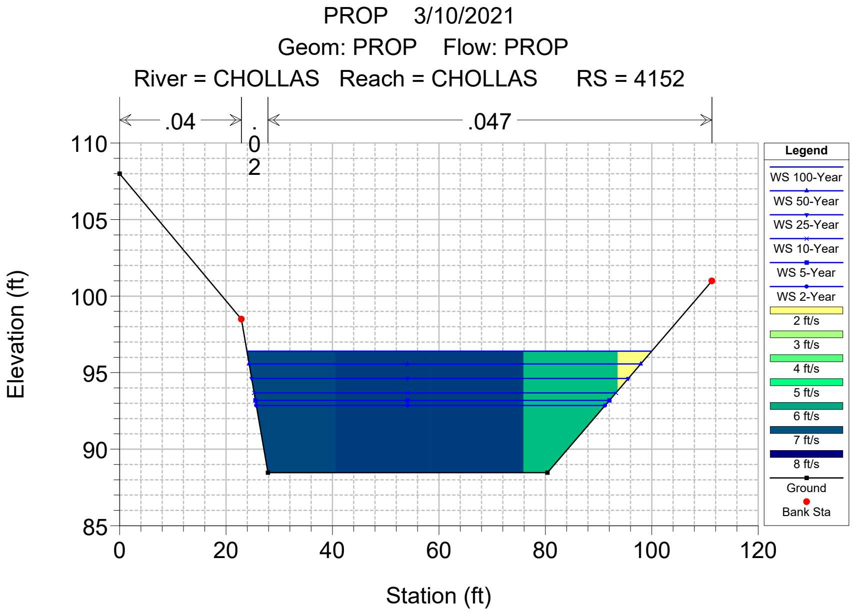
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4156

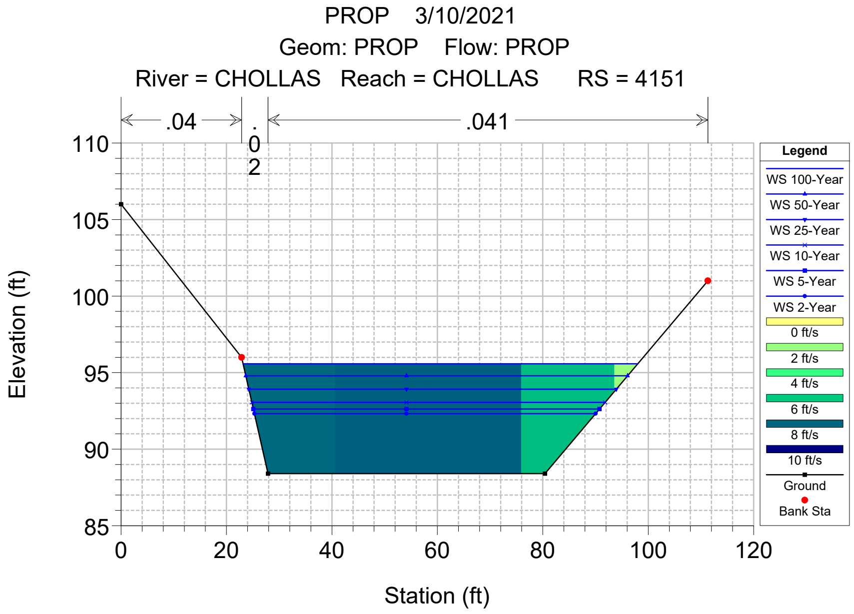


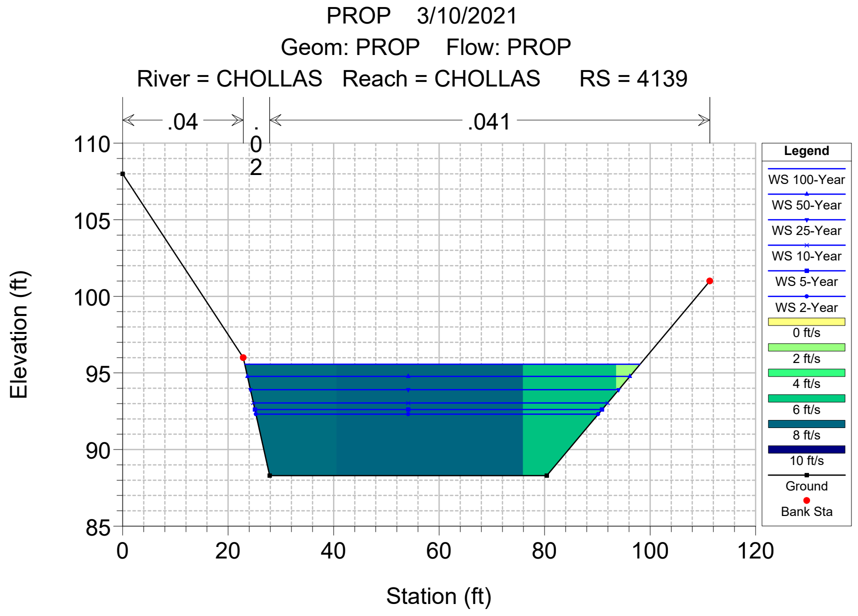
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4155

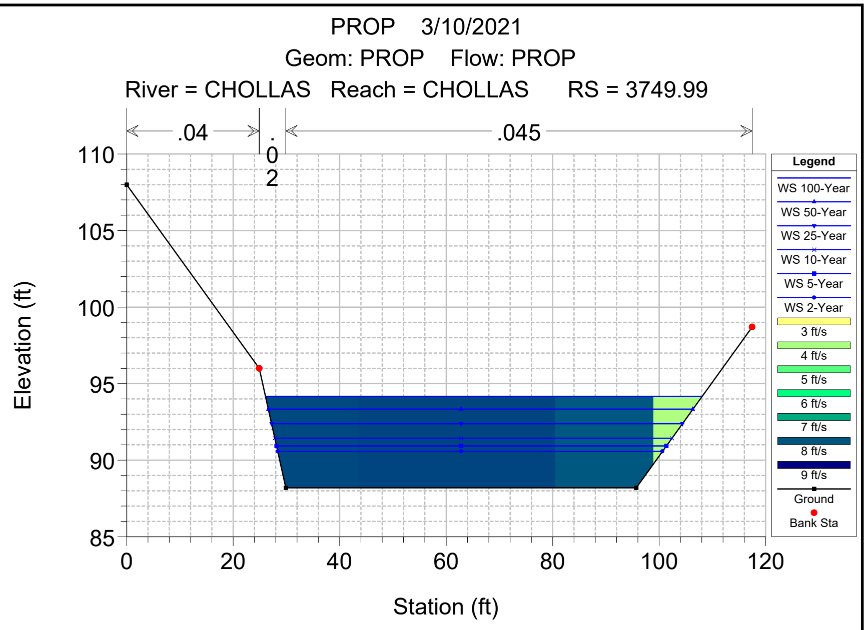

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4154
.04
.02
.047
Elevation (ft)
108
106
104
102
100
98
96
94
92
90
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta

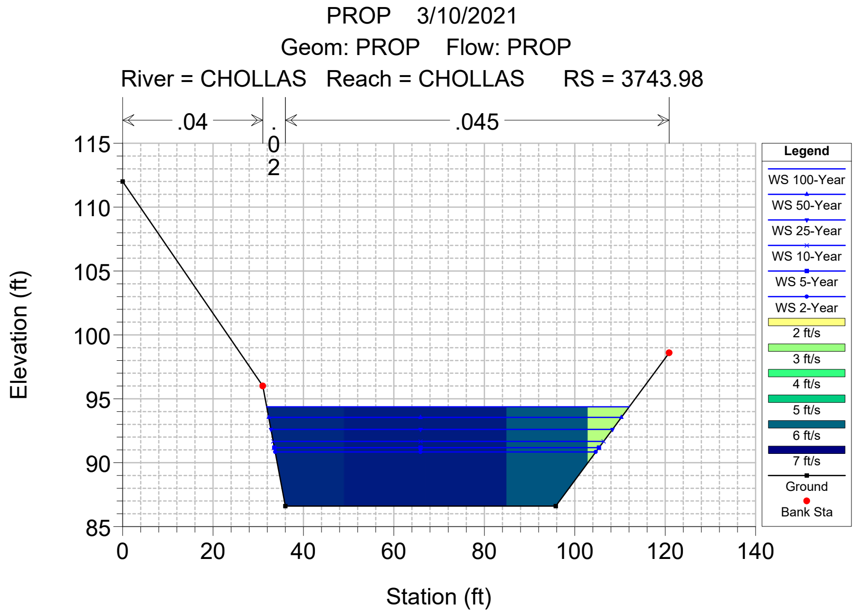

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4153
.04
.02
.047
Elevation (ft)
108
106
104
102
100
98
96
94
92
90
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta

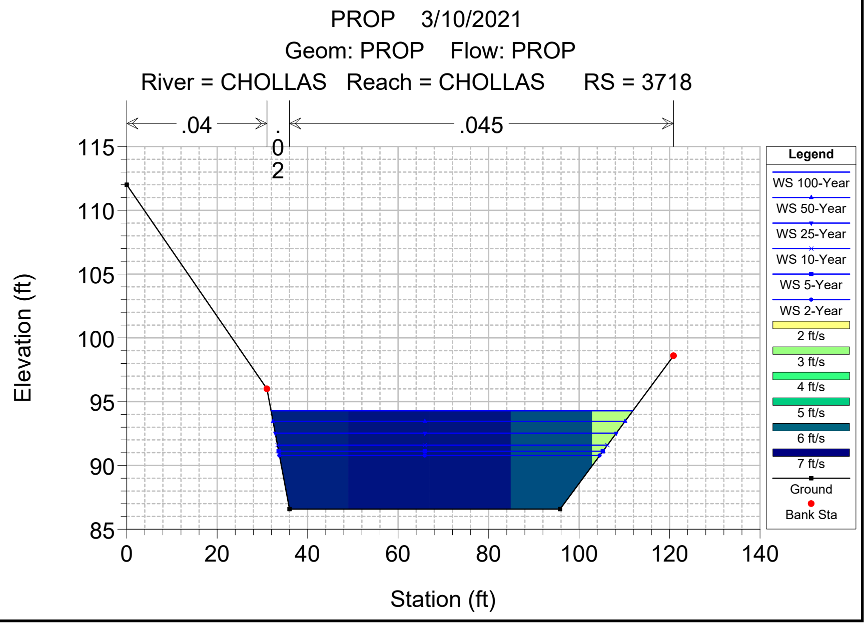

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4152
.04
.02
.047
Elevation (ft)
110
105
100
95
90
85
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4151
.04
.02
.041
Elevation (ft)
110
105
100
95
90
85
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta

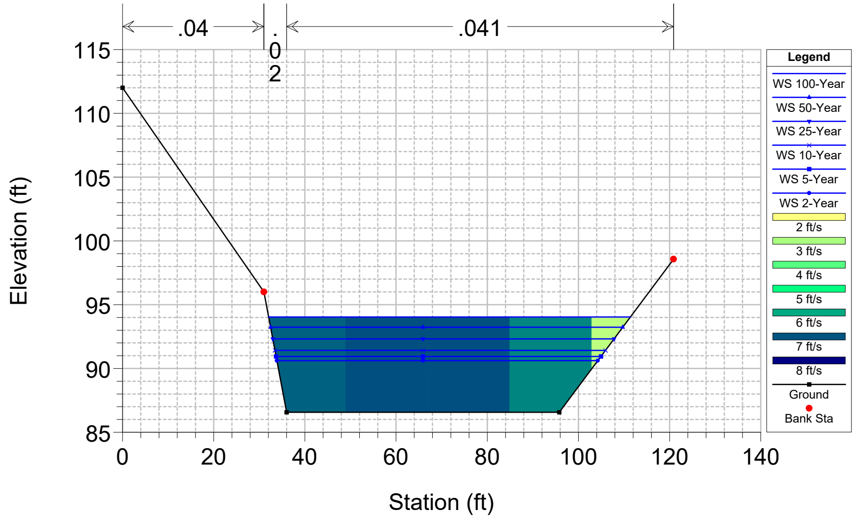

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 4139
.04
.02
.041
Elevation (ft)
Station (ft)
110
105
100
95
90
85
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3749.99
.04
.02
.045
Elevation (ft)
Station (ft)
110
105
100
95
90
85
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta

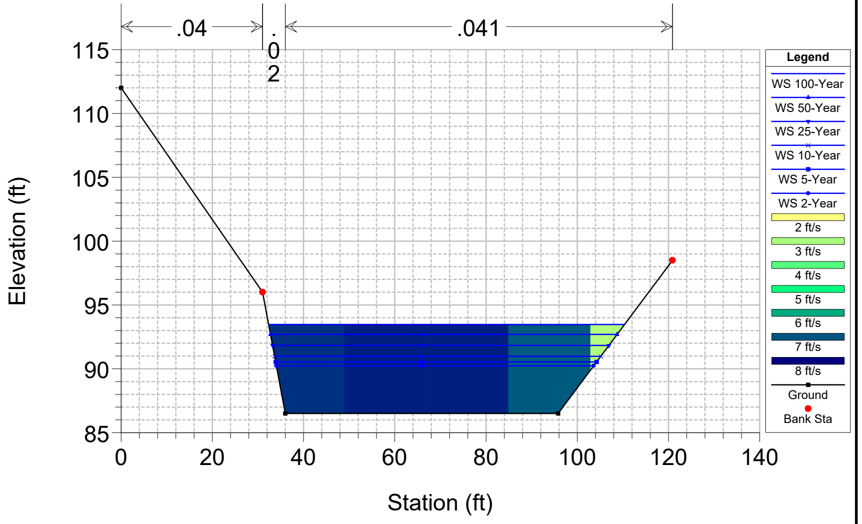

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3743.98
.04
.02
.045
Elevation (ft)
Station (ft)
115
110
105
100
95
90
85
0
20
40
60
80
100
120
140
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3718
.04
.02
.045
Elevation (ft)
Station (ft)
115
110
105
100
95
90
85
0
20
40
60
80
100
120
140
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta

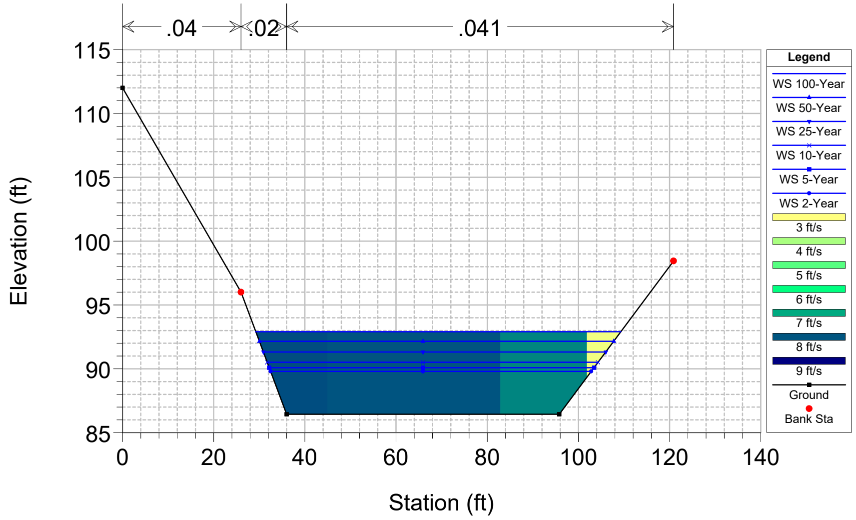
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3652



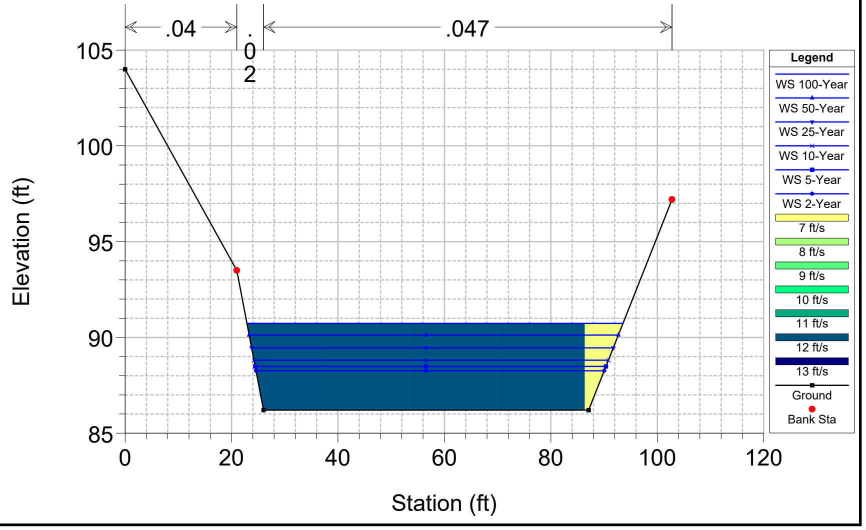
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3513

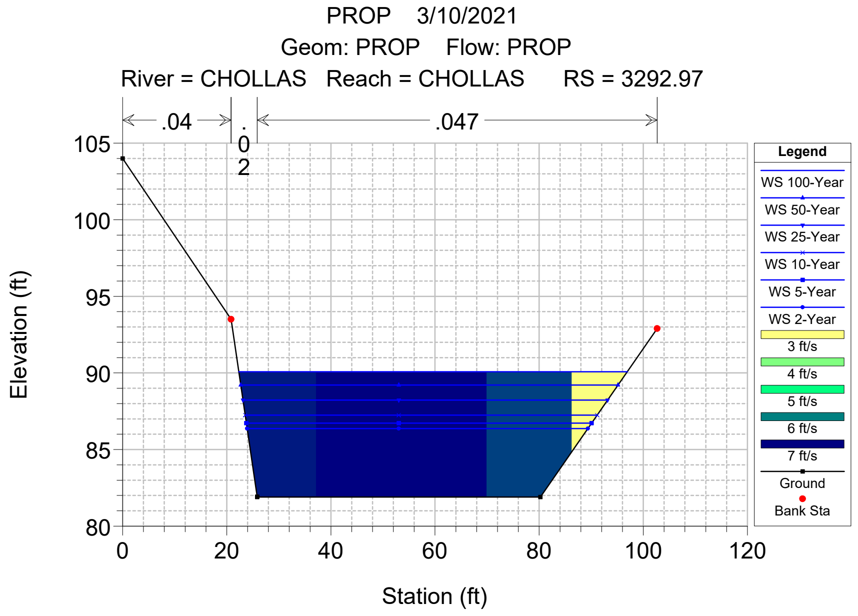


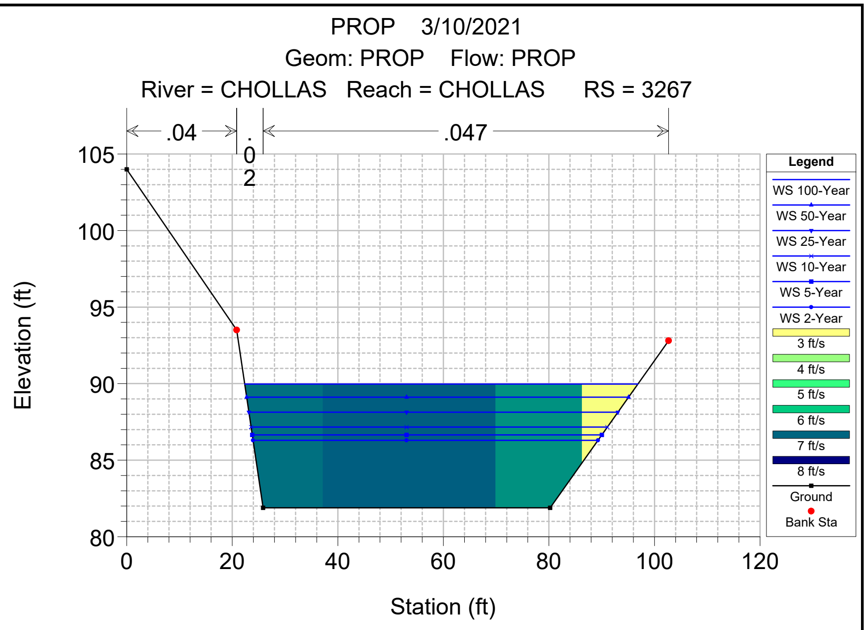
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3402

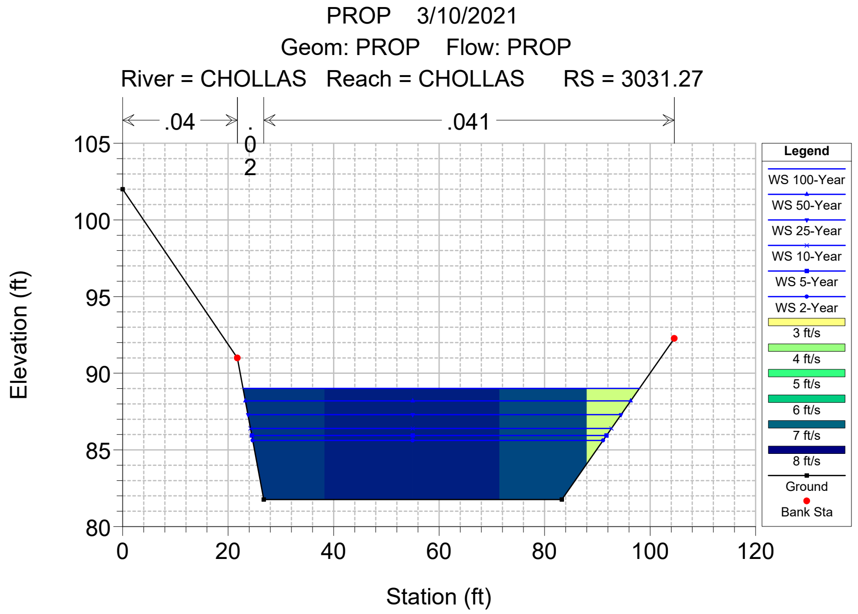


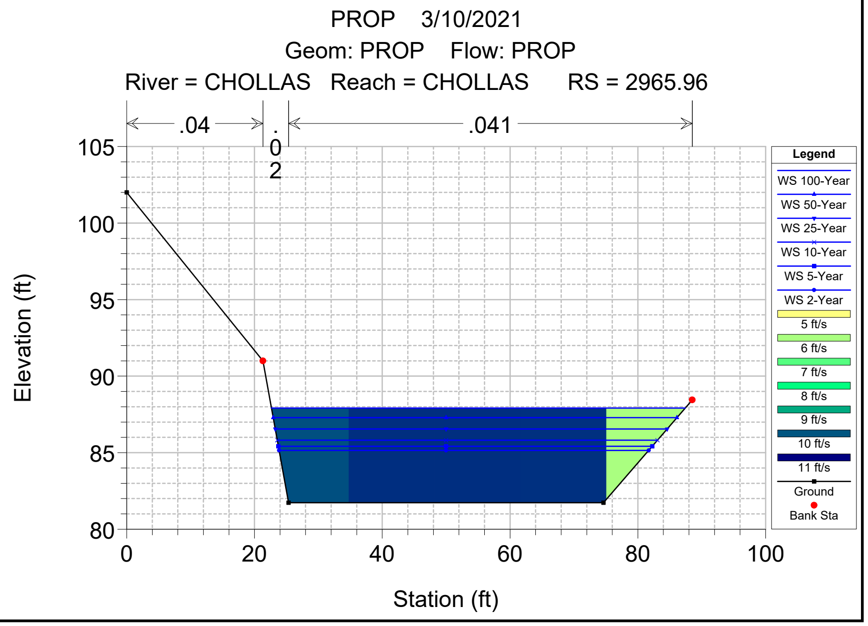
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3298.97



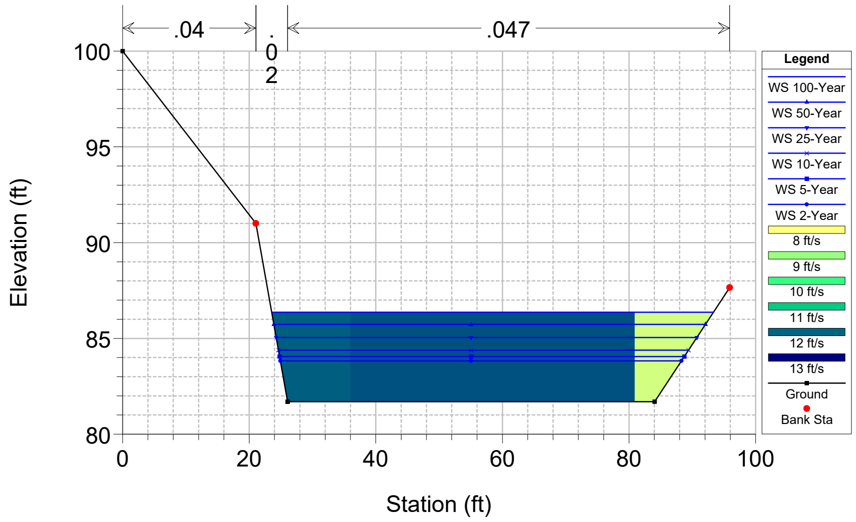

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3292.97
.04
.02
.047
Elevation (ft)
105
100
95
90
85
80
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3267
.04
.02
.047
Elevation (ft)
105
100
95
90
85
80
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta

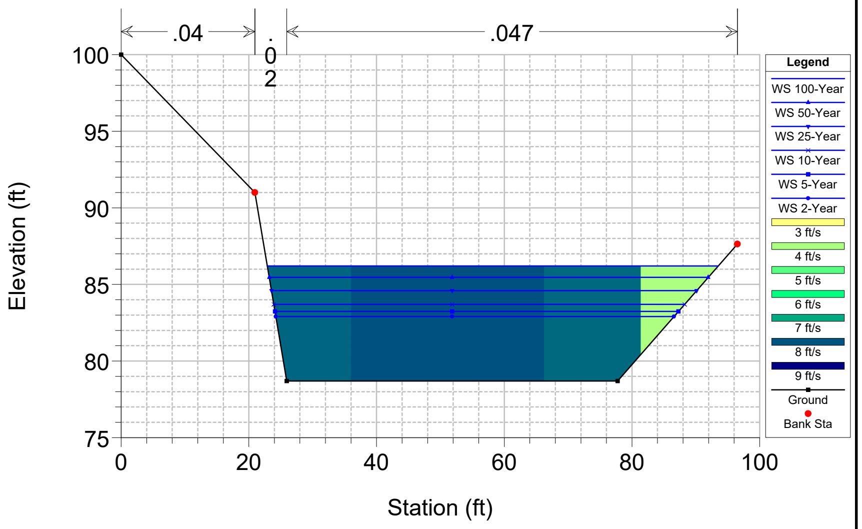

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 3031.27
.04
.02
.041
Elevation (ft)
105
100
95
90
85
80
Station (ft)
0
20
40
60
80
100
120
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2965.96
.04
.02
.041
Elevation (ft)
105
100
95
90
85
80
Station (ft)
0
20
40
60
80
100
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
Ground
Bank Sta

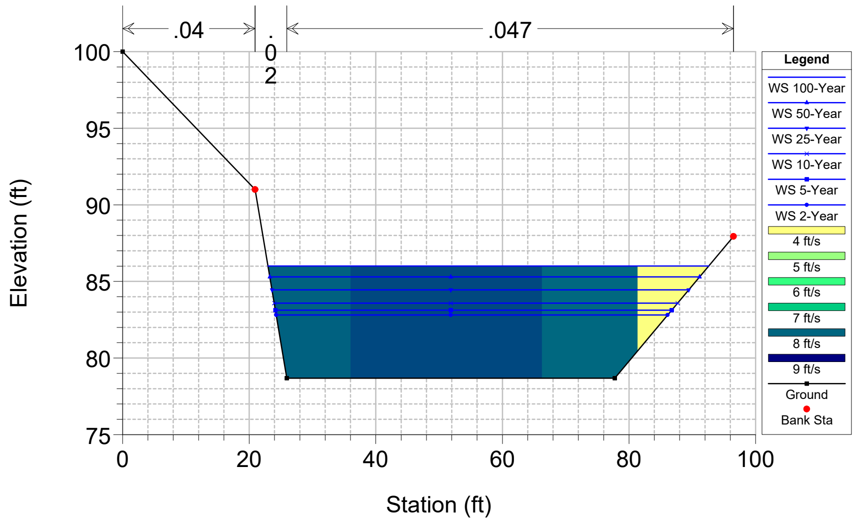
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2892.27



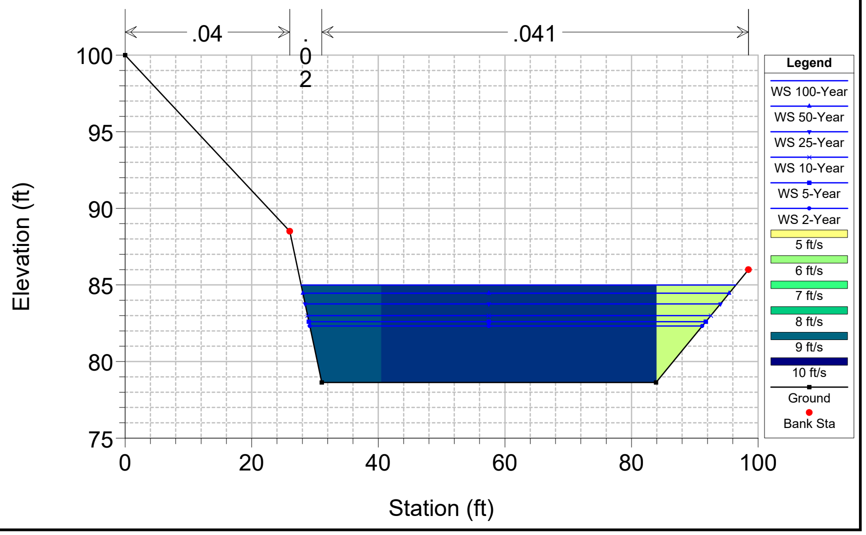
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2886.27



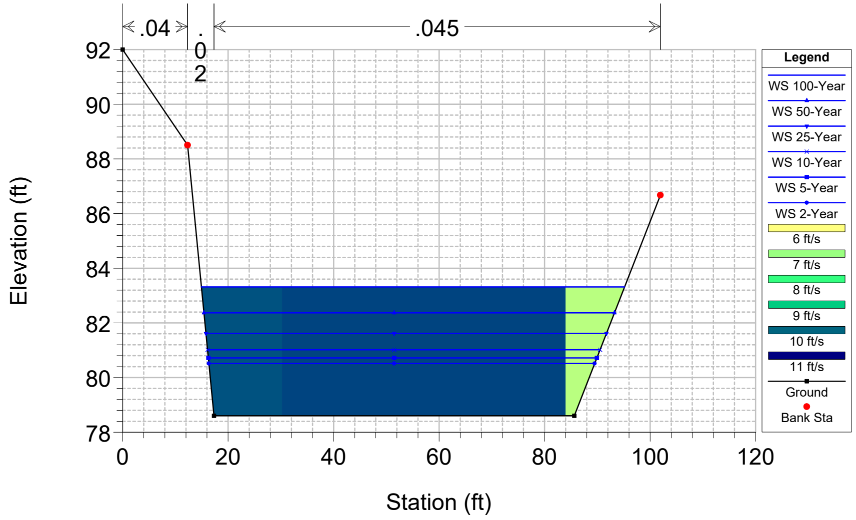
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2861



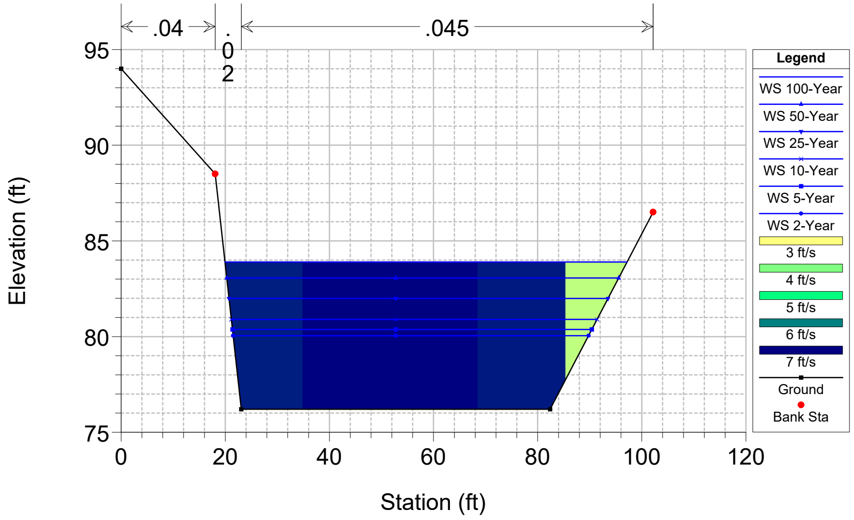
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2744.11



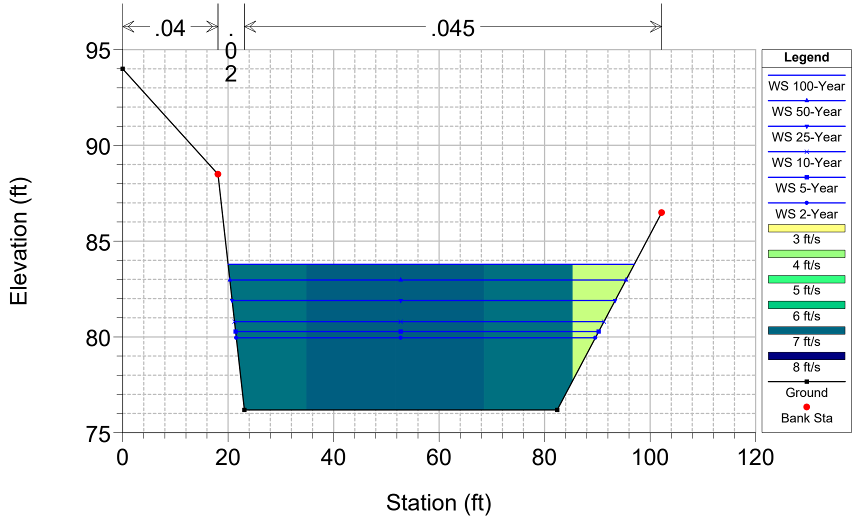
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2623



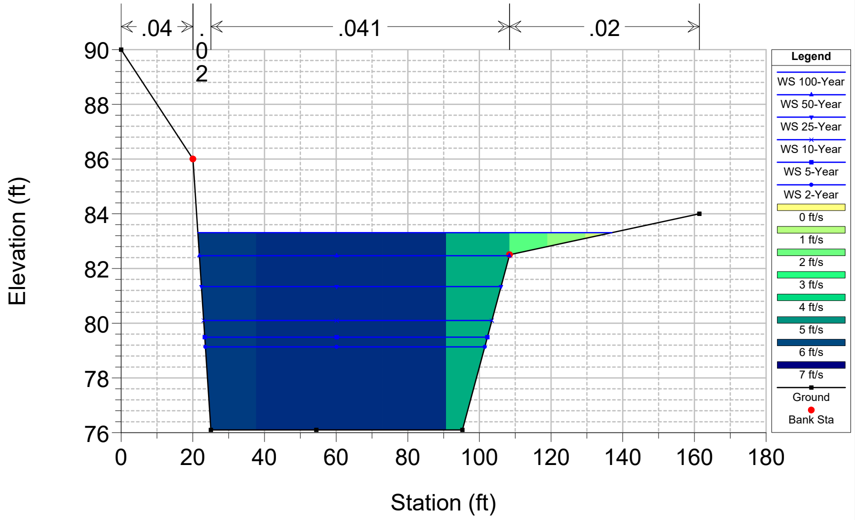
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2621

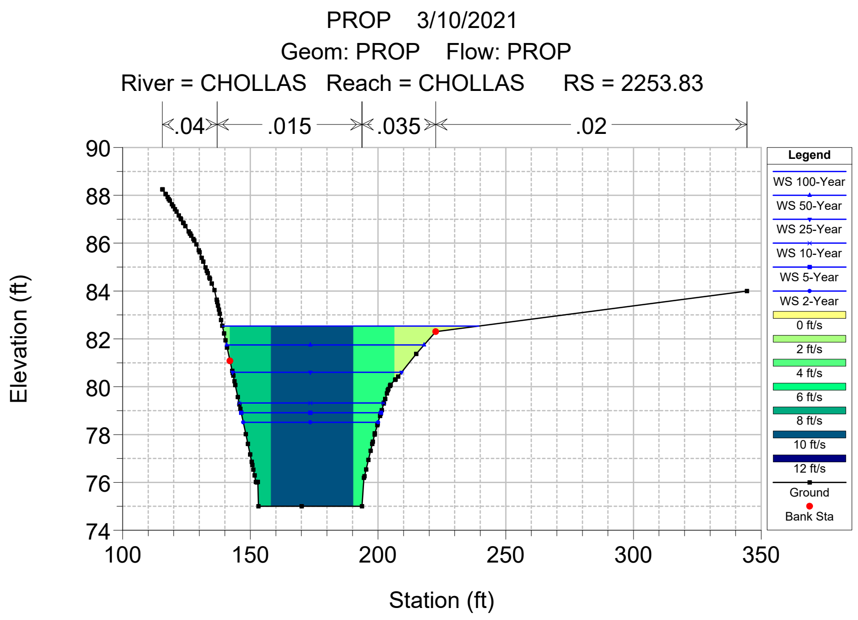


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2595

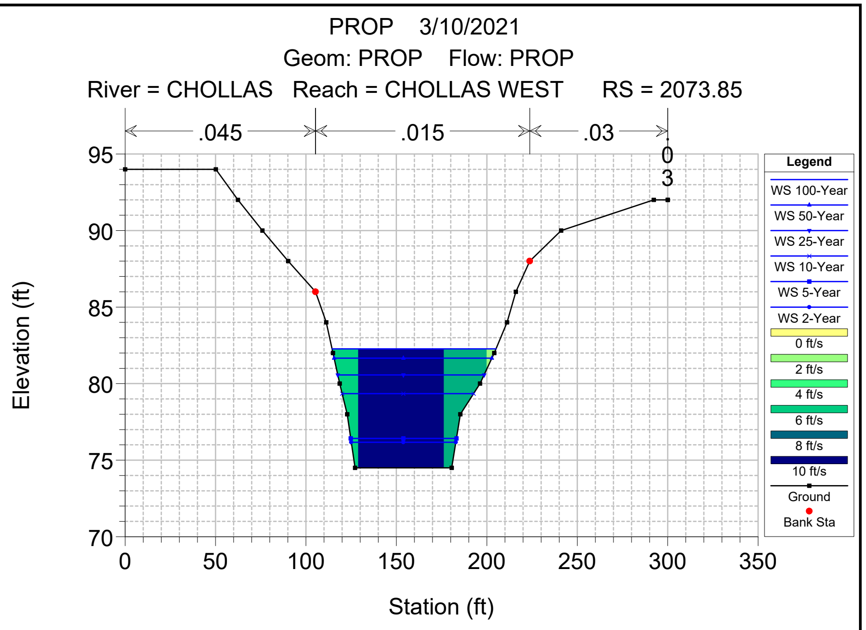


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2375.43

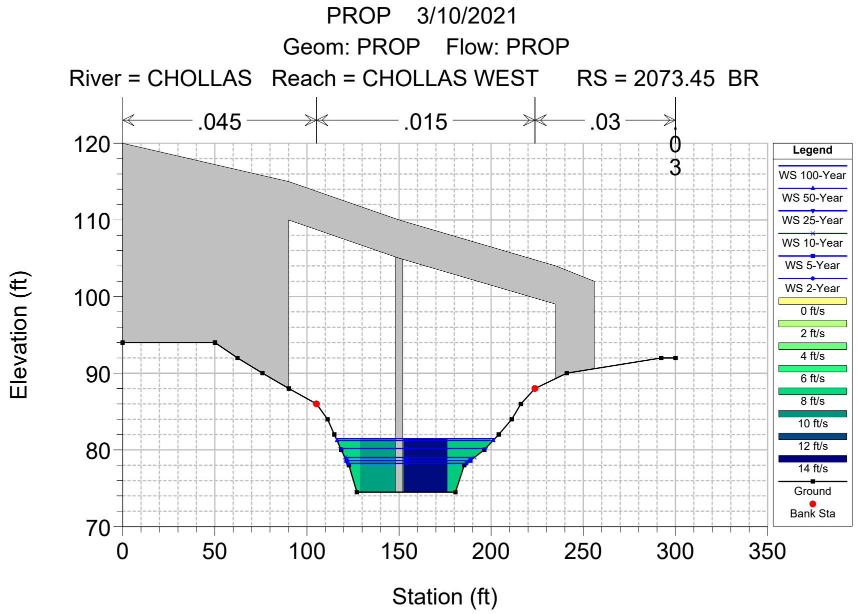




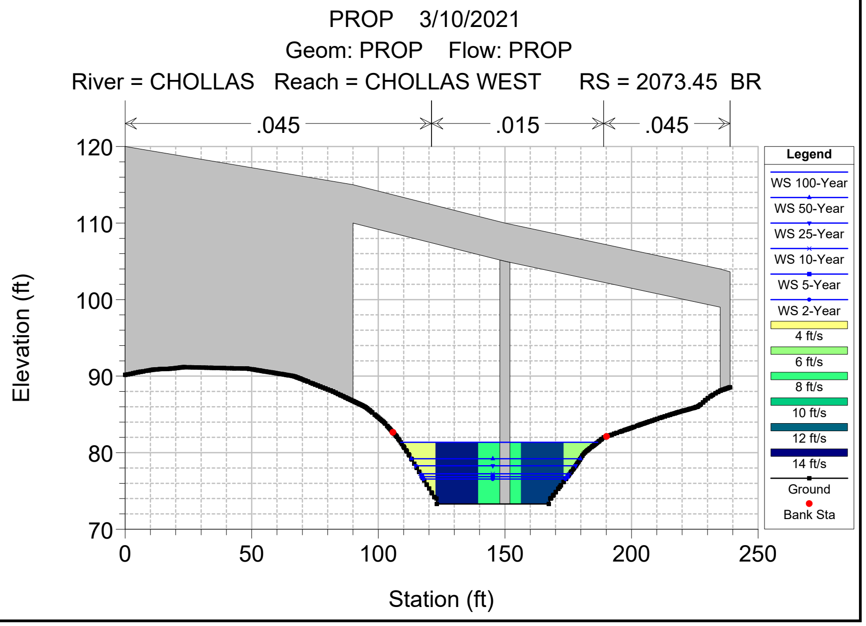
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS RS = 2253.83



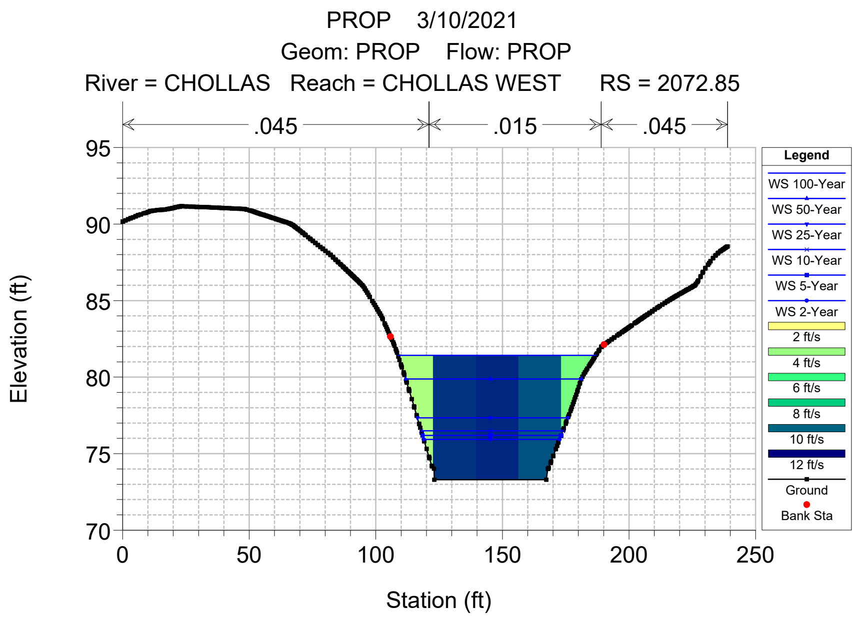
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.85

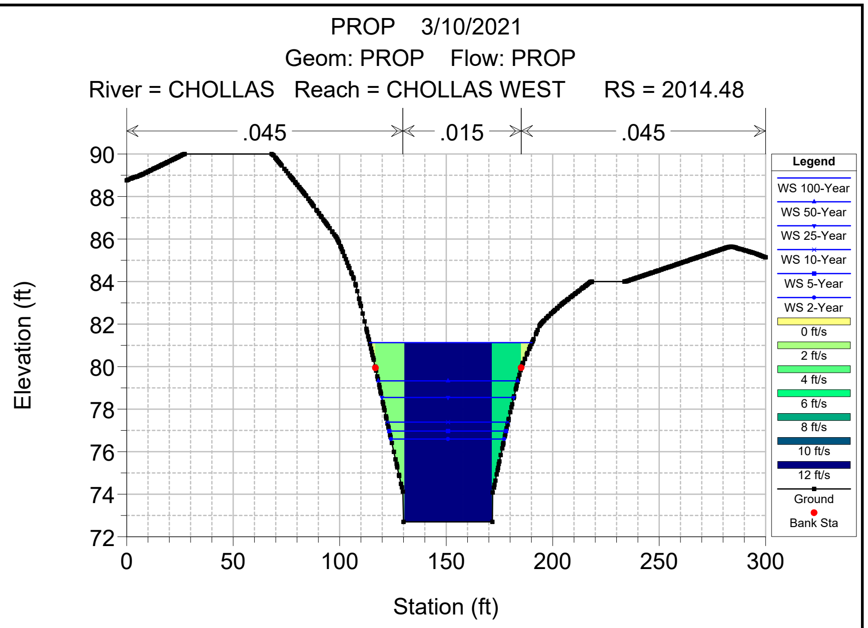


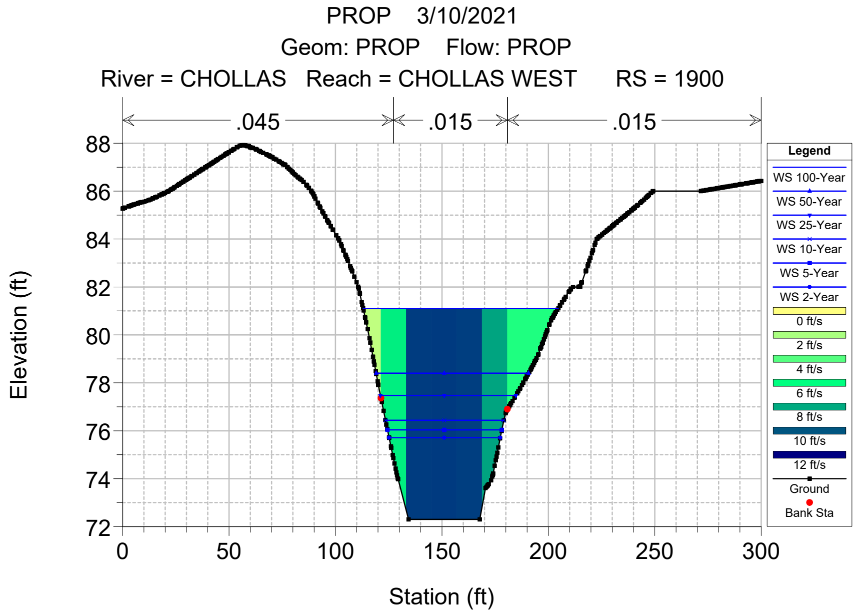
PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.45 BR

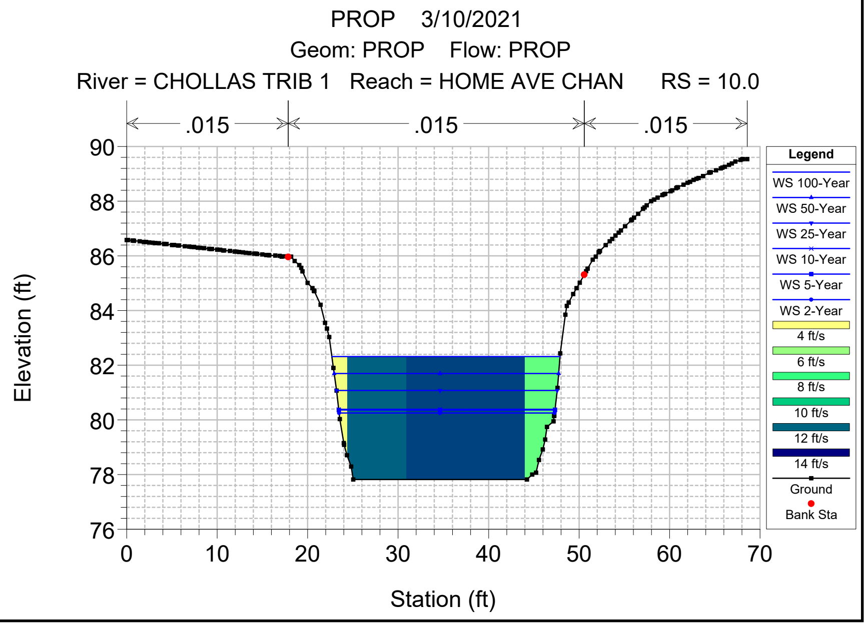


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2073.45 BR

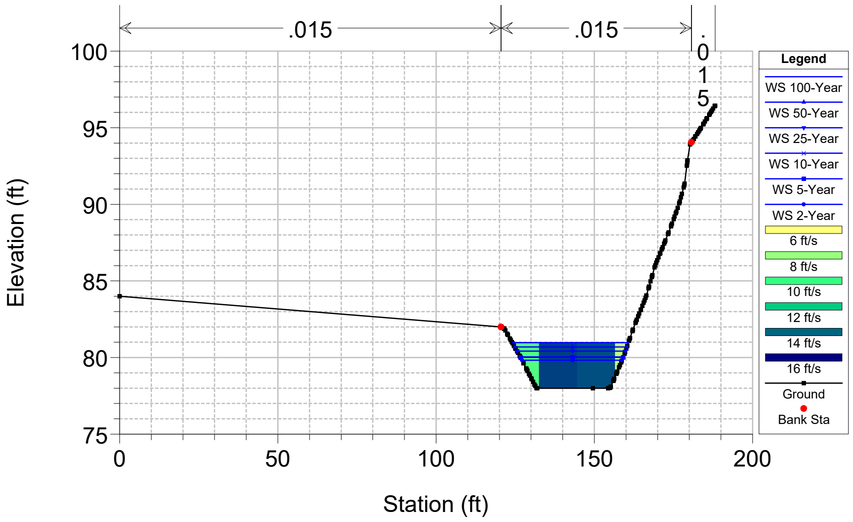

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2072.85
.045
.015
.045
Elevation (ft)
95
90
85
80
75
70
Station (ft)
0
50
100
150
200
250
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 2014.48
.045
.015
.045
Elevation (ft)
90
88
86
84
82
80
78
76
74
72
Station (ft)
0
50
100
150
200
250
300
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta

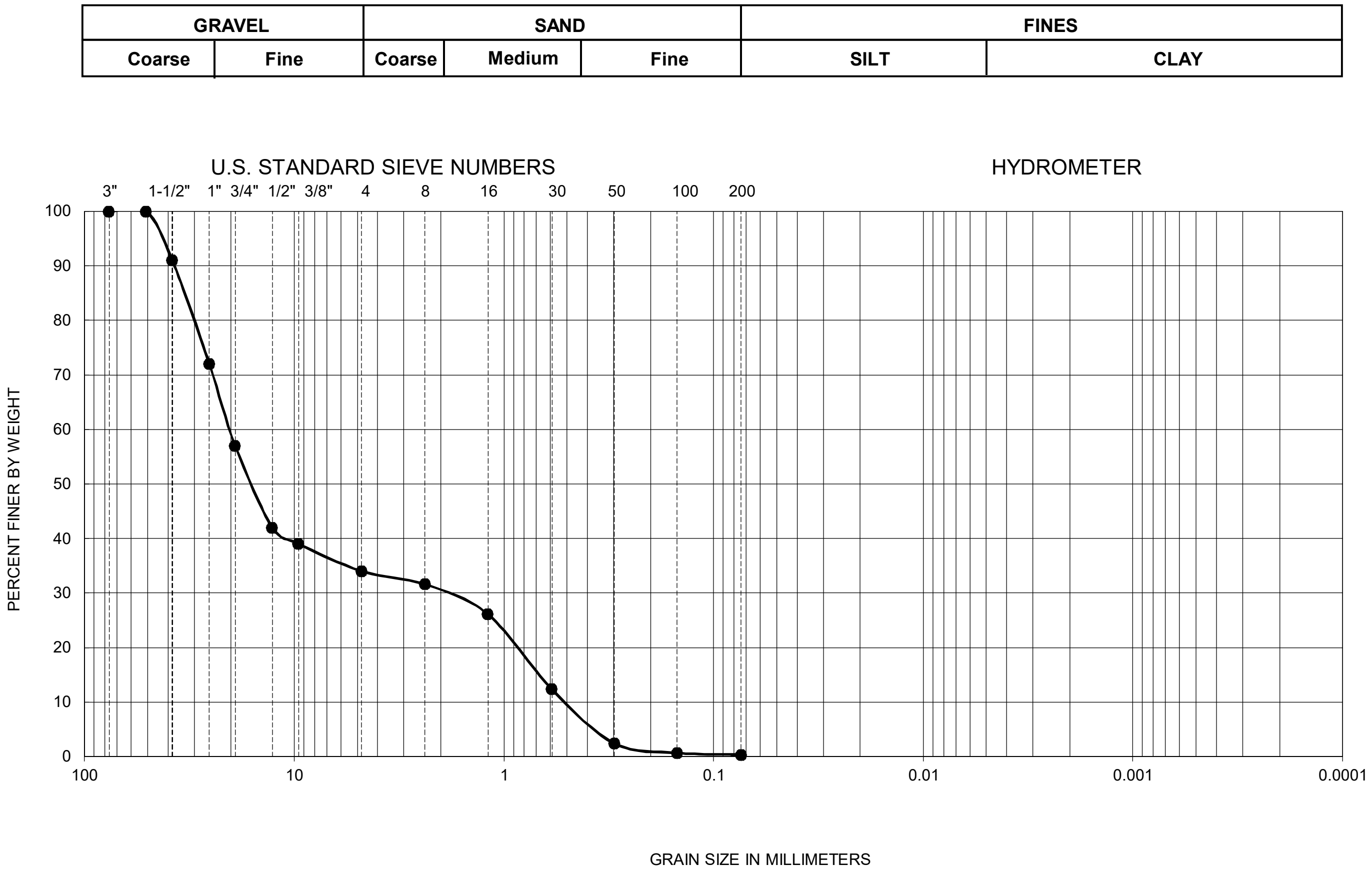

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS Reach = CHOLLAS WEST RS = 1900
.045
.015
.015
Elevation (ft)
88
86
84
82
80
78
76
74
72
Station (ft)
0
50
100
150
200
250
300
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS TRIB 1 Reach = HOME AVE CHAN RS = 10.0
.015
.015
.015
Elevation (ft)
90
88
86
84
82
80
78
76
Station (ft)
0
10
20
30
40
50
60
70
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta

PROP 3/10/2021
Geom: PROP Flow: PROP
River = CHOLLAS TRIB 1 Reach = HOME AVE CHAN RS = 1.0



D - Upstream Sieve Analysis



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	125813	-	--	--	--	0.40	1.80	21.00	52.5	0.4	0	GP

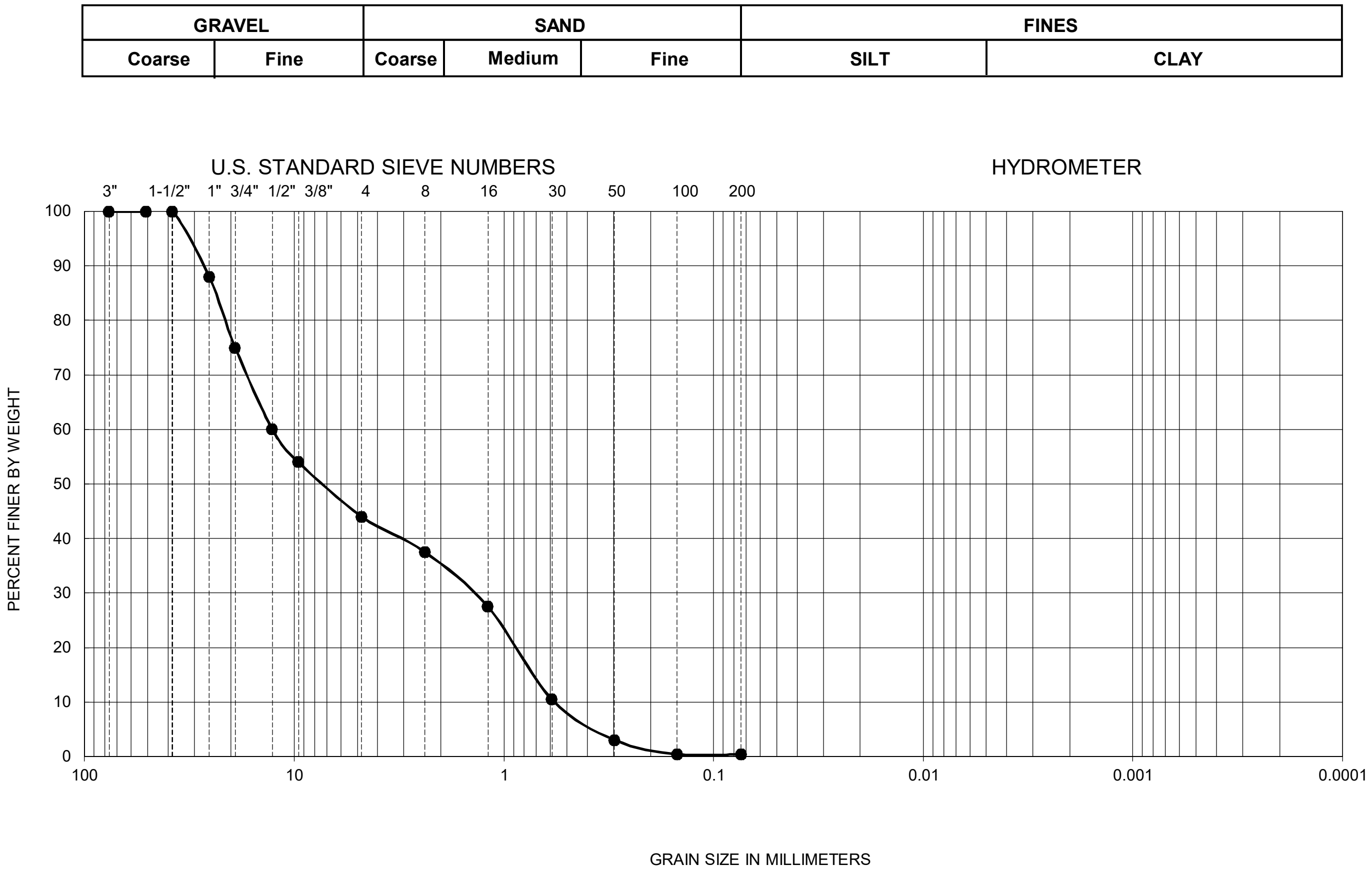
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE 1

GRADATION TEST RESULTS

FEDERAL BOULEVARD DECHANNELIZATION AND TRAIL PROJECT
SAN DIEGO, CALIFORNIA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	125814	-	--	--	--	0.60	1.30	12.70	21.2	0.2	0	GP

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

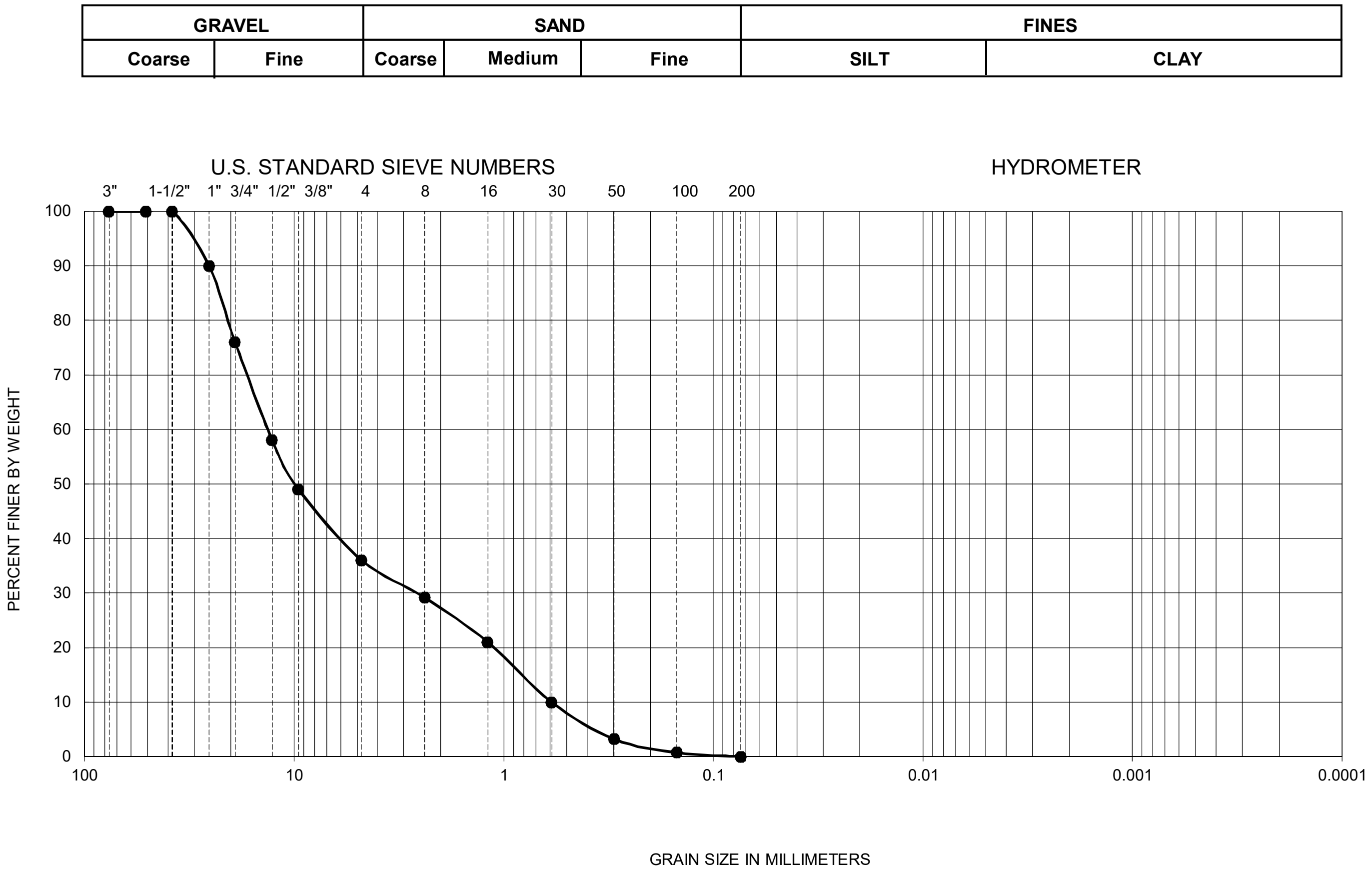
FIGURE 2

GRADATION TEST RESULTS

FEDERAL BOULEVARD DECHANNELIZATION AND TRAIL PROJECT
SAN DIEGO, CALIFORNIA

109052002 11/20

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	125815	-	--	--	--	0.60	2.38	13.00	21.7	0.7	0	GP

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE 3

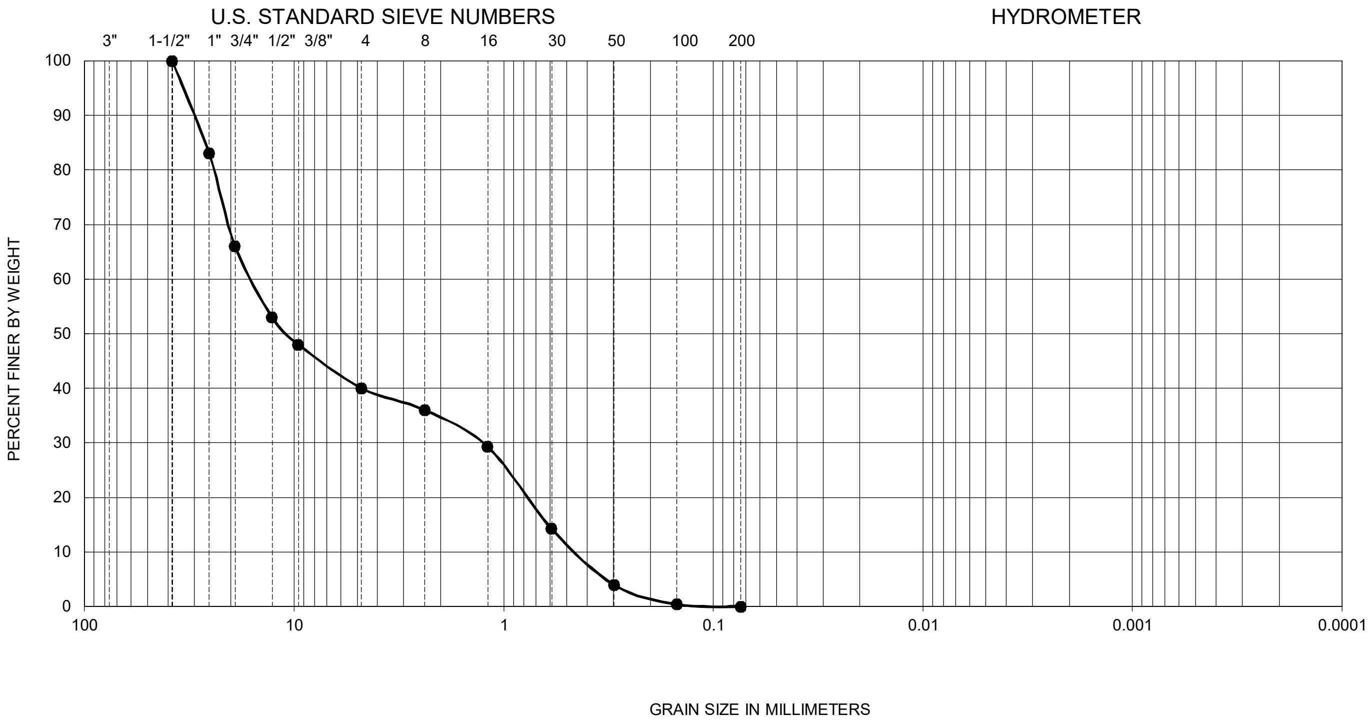
GRADATION TEST RESULTS

FEDERAL BOULEVARD DECHANNELIZATION AND TRAIL PROJECT
SAN DIEGO, CALIFORNIA

109052002 11/20

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	125816	-	--	--	--	0.46	1.19	16.00	34.8	0.2	0	GP

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE 4

GRADATION TEST RESULTS

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

FEDERAL BOULEVARD DECHANNELIZATION AND TRAIL PROJECT
SAN DIEGO, CALIFORNIA

109052002 11/20

125816 SPLITSIEVE

E - Sediment Transport Results

HEC-RAS Sediment Transport Results

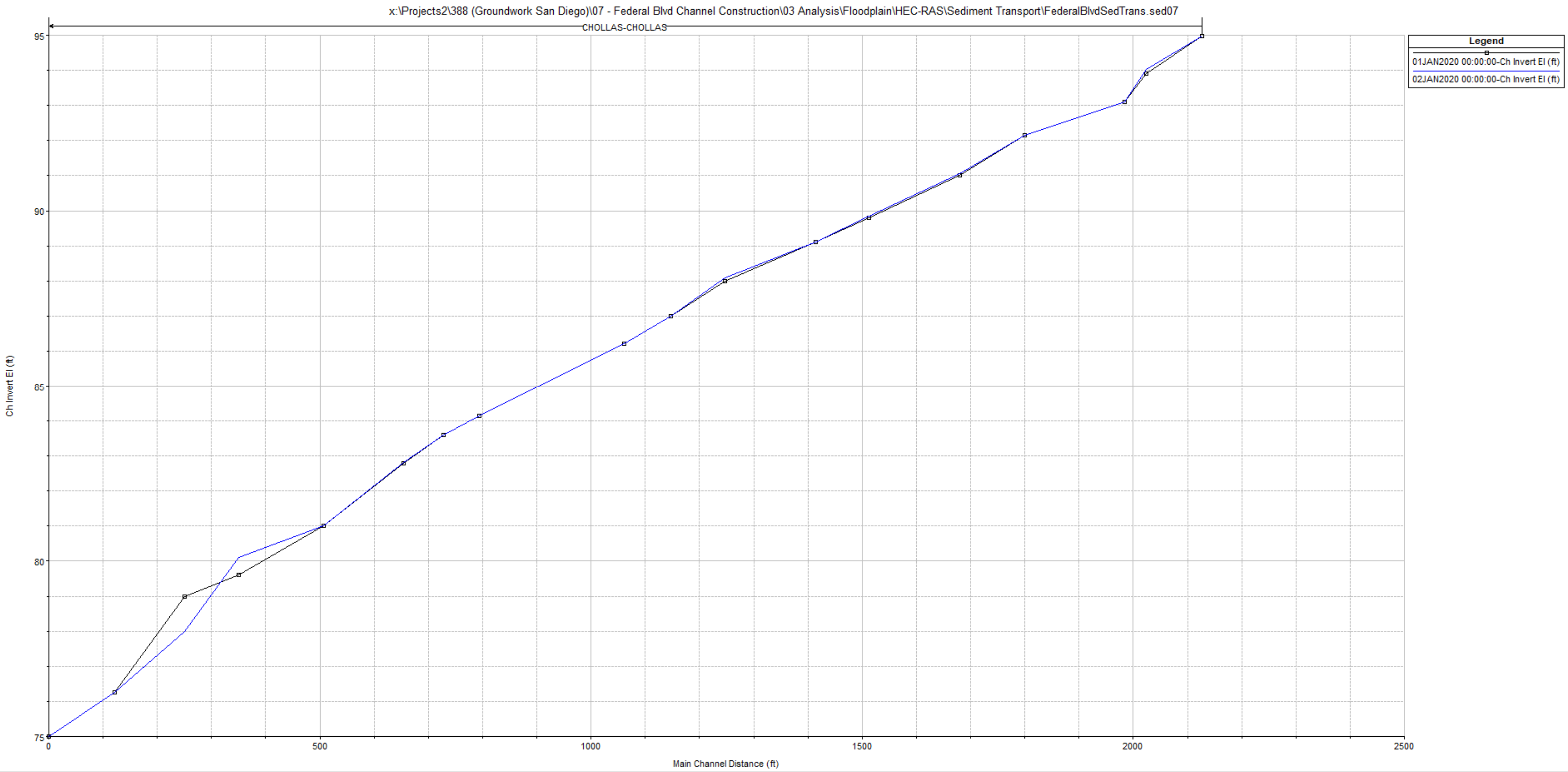
EXISTING MASS BED CHANGE (TONS)						
EQU Load				NO LOAD		
2 yr	10YR	100 YR		2YR	10YR	100YR
0	0	0		0	0	0
16.7	37.5	82.6		0	0	0
0.7	1.0	1.1		0	0	0
0.8	0.3	0.2		0	0	0
11.1	7.1	-1.1		0	0	0
12.0	9.6	-0.9		0	0	0
0.3	1.3	1.1		0	0	0
21.8	34.3	13.0		0	0	0
0.0	0.0	0.4		0	0	0
0.0	0.0	38.3		0	0	0
0.1	0.0	420.9		0	0	0
0.0	0.6	82.1		0	0	0
0.8	1.7	112.5		0	0	0
2.6	2.6	294.4		0	0	0
177.3	408.2	-27.5		0	0	0
0.6	0.5	-26.7		0	0	0
0.5	0.5	611.1		0	0	0
0.8	1.1	78.9		0	0	0
TOTAL						
246.0	**506.2**	**1680.4**		**0**	**0**	**0**

PROPOSED MASS BED CHANGE (TONS)						
EQU LOAD				NO LOAD		
2 YR	10 YR	100 YR		2 YR	10 YR	100 YR
0	0	0		0	0	0
0.1	0.1	0.6		0.0	0.0	0.0
0.1	0.1	0.1		0.0	0.0	0.0
0.0	0.0	0.0		0.0	0.0	0.0
0.0	0.0	0.0		0.0	0.0	0.0
0.2	0.8	0.9		0.0	0.0	0.0
0.0	0.0	0.3		0.0	0.0	0.0
0.0	0.0	0.1		0.0	0.0	0.0
0.0	0.0	0.0		0.0	0.0	0.0
0.0	0.0	0.0		0.0	0.0	0.0
0.0	0.0	0.0		0.0	0.0	0.0
-8.3	-18.9	-78.6		-8.4	-19.1	-80.4
-5.7	-21.1	-104.3		-5.7	-21.1	-105.0
0.0	0.2	1.7		0.0	0.2	1.7
3.5	0.3	48.1		3.5	0.3	48.2
1.6	0.6	23.8		1.6	0.6	23.6
3.3	7.5	-30.6		3.3	7.5	-30.8
-6.7	-8.7	-57.5		-6.7	-8.7	-57.6
-13.9	-16.1	-57.1		-13.9	-16.1	-57.3
0.0	0.1	0.2		0.0	0.1	0.2
17.5	38.3	43.6		17.5	38.3	43.6
0.5	3.0	1.6		0.5	3.0	1.6
-9.4	-22.6	-66.6		-9.4	-22.7	-66.8
-19.2	-38.2	-87.8		-19.2	-38.2	-87.9
0.1	0.1	0.3		0.1	0.1	0.3
15.4	18.4	26.1		15.4	18.4	26.1
1.6	2.0	0.1		1.6	2.0	-0.1
-15.1	-29.8	-112.2		-15.1	-29.8	-112.2
0.1	0.3	1.7		0.1	0.3	1.8
2.3	8.5	161.1		2.3	8.5	161.1
20.3	57.4	16.4		20.3	57.4	16.0
-6.7	-11.6	-27.7		-6.7	-11.6	-27.8
2.2	0.5	18.9		2.2	0.5	18.8
0.6	0.8	-0.5		0.6	0.9	-0.5
0.5	0.6	1.6		0.5	0.7	1.6
0.4	0.4	1.5		0.4	0.5	1.4
Total						
-14.8	**-27.1**	**-274.1**		**-15.5**	**-28.1**	**-280.1**

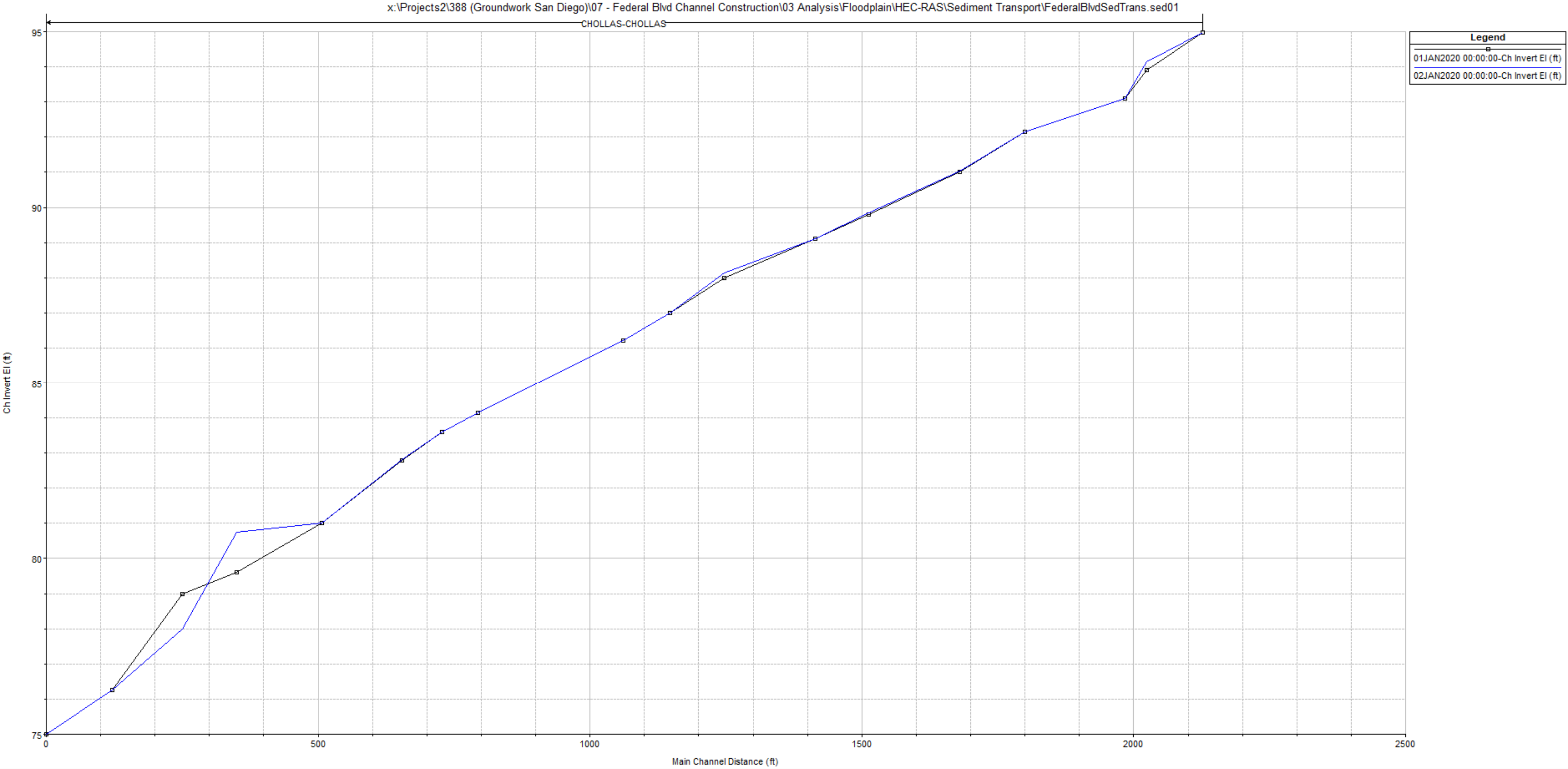
EXISTING CONDITION

EQUILIBRIUM LOAD

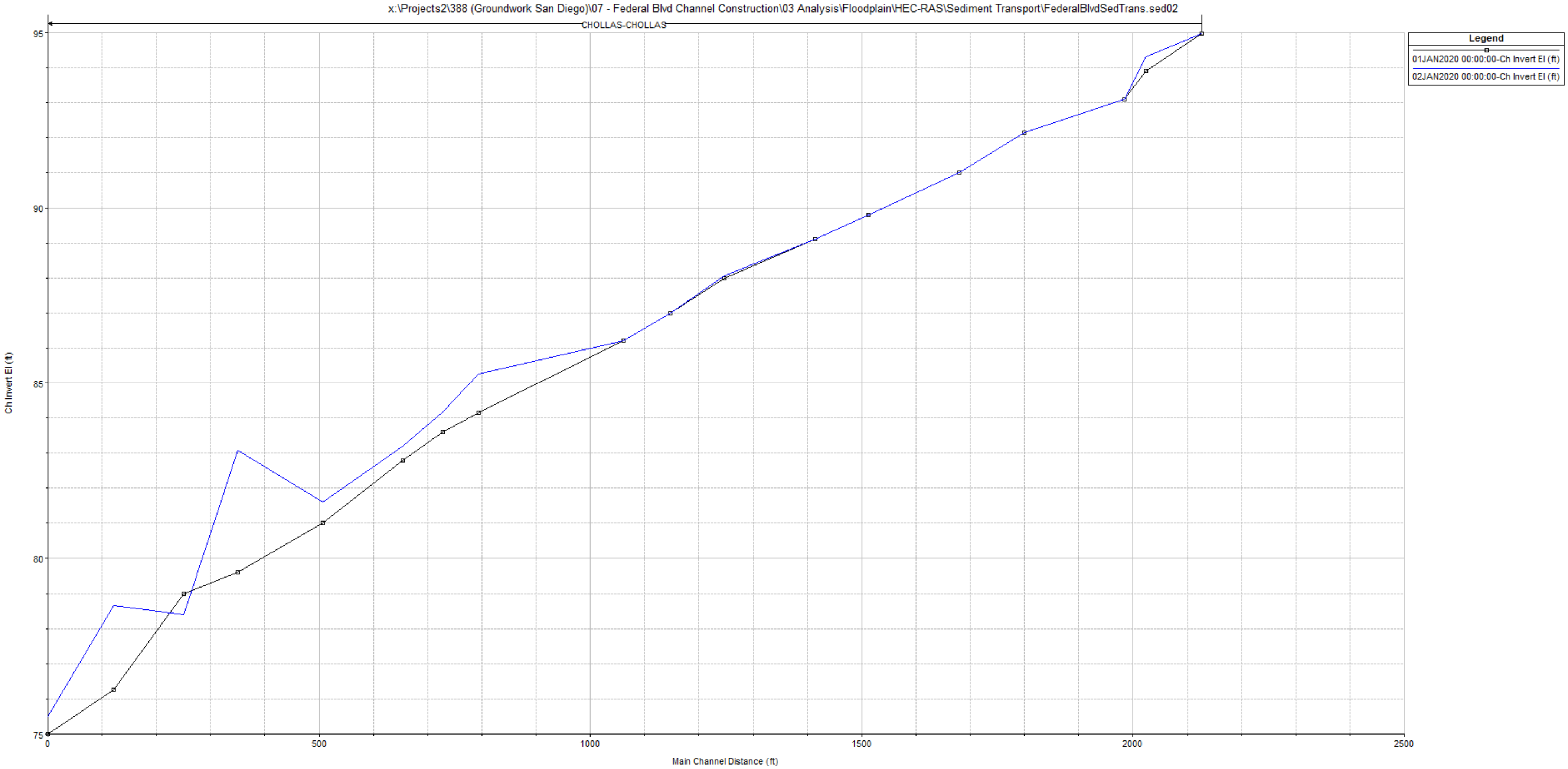
EXISTING 2 YEAR EQUILIBRIUM LOAD



EXISTING 10 YEAR EQUILIBRIUM LOAD



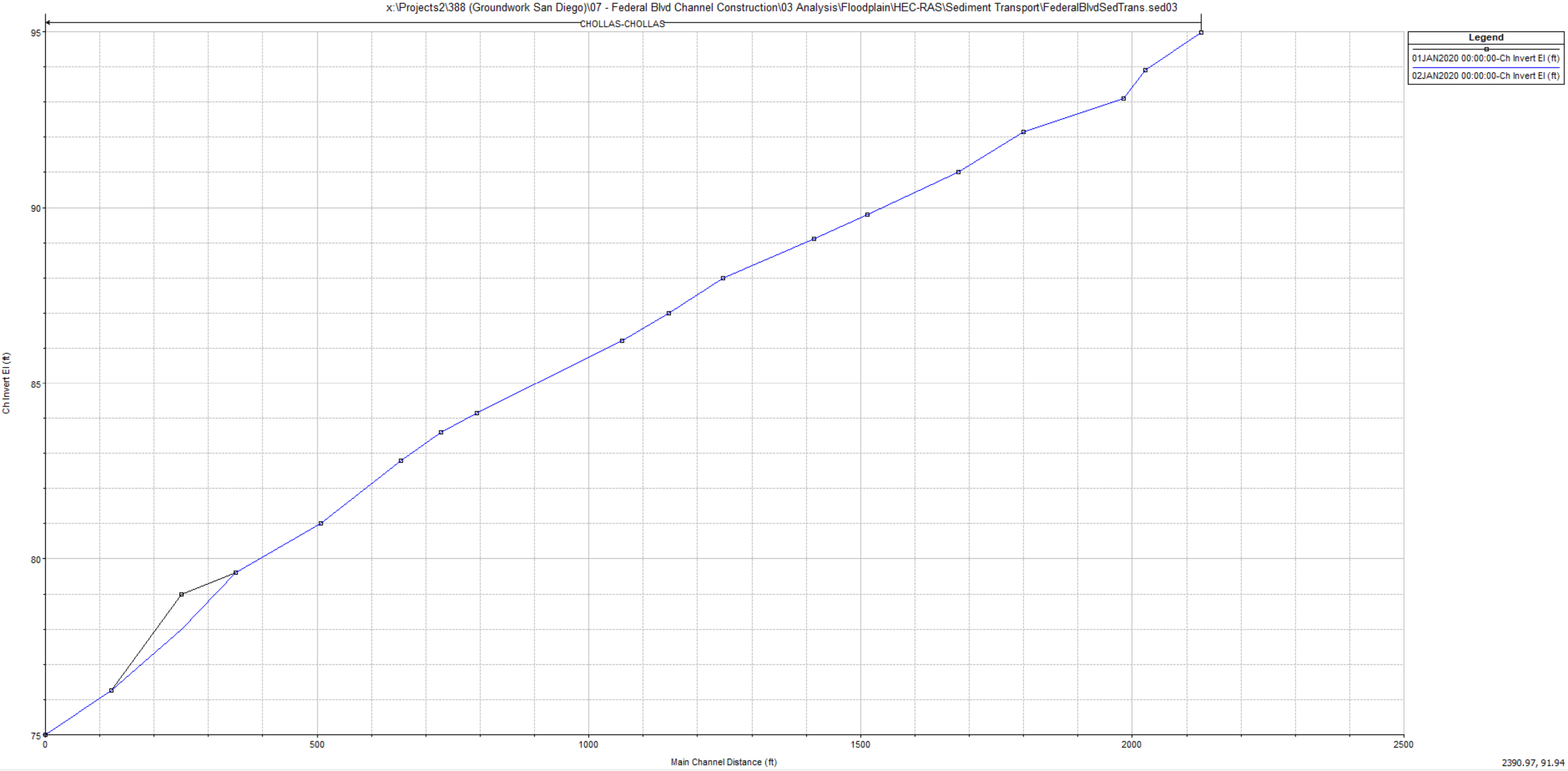
EXISTING 100 YEAR EQUILIBRIUM LOAD



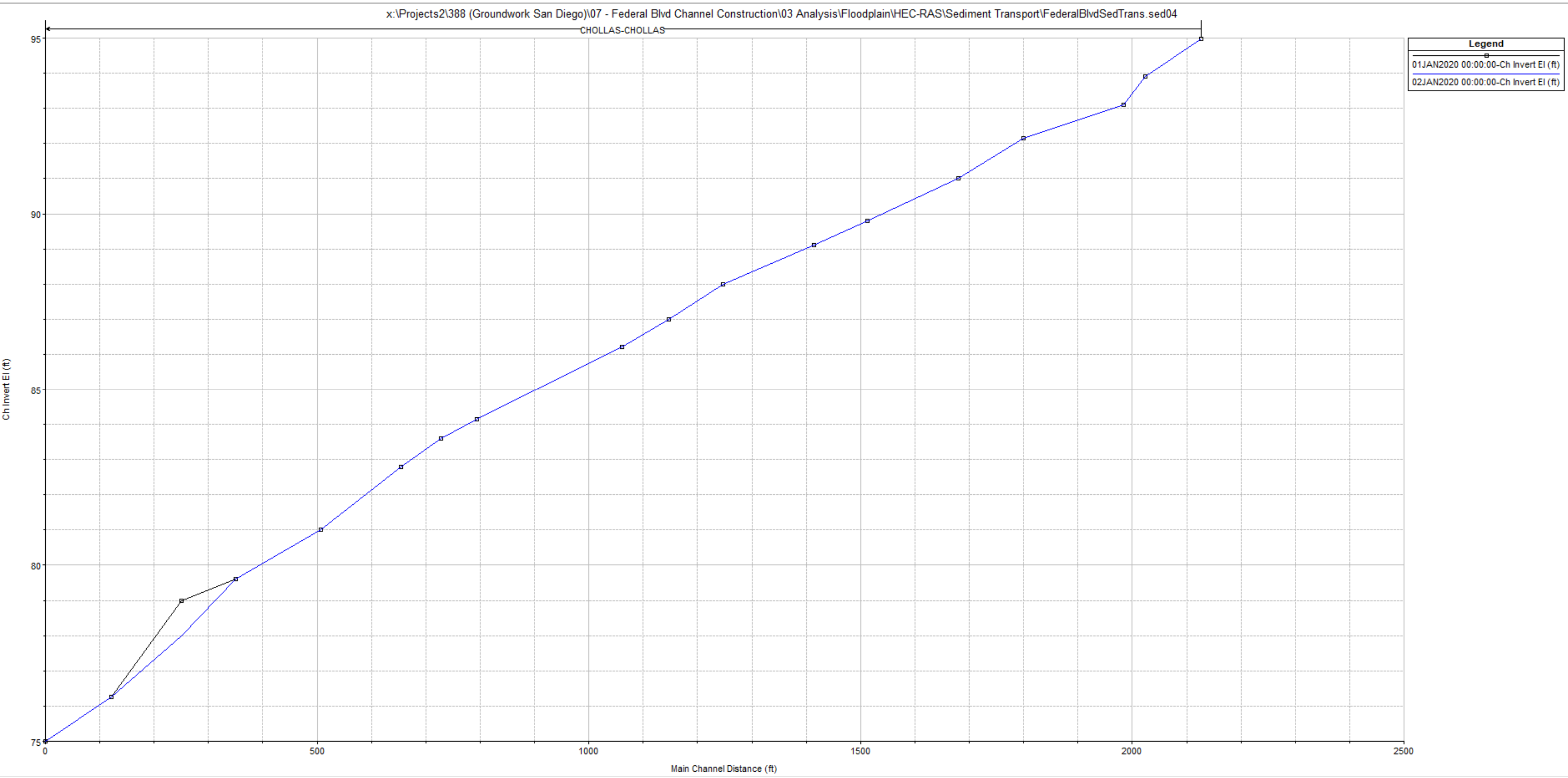
EXISTING CONDITION

NO LOAD

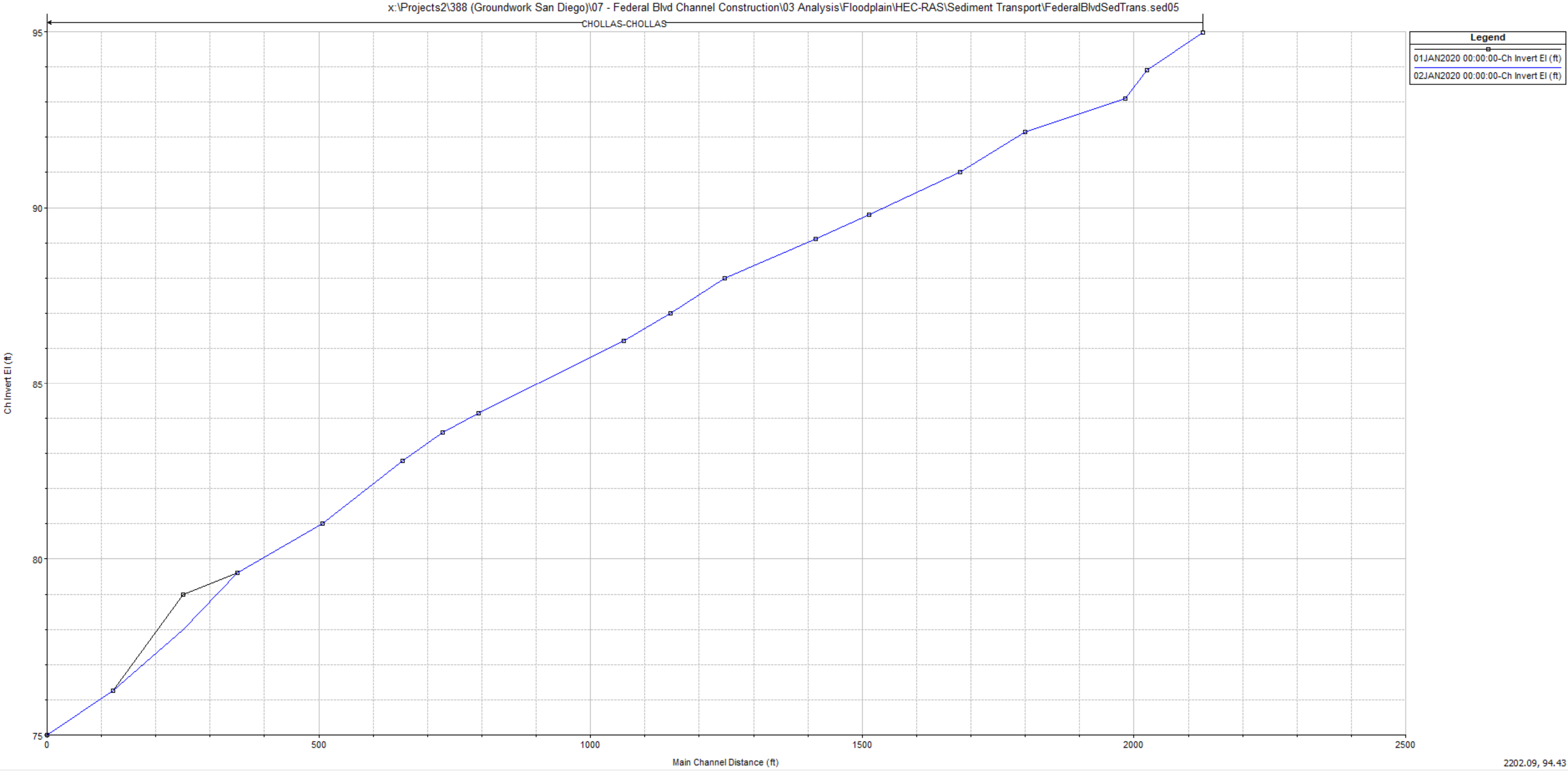
EXISTING 2 YEAR NO LOAD



EXISTING 10 YEAR NO LOAD



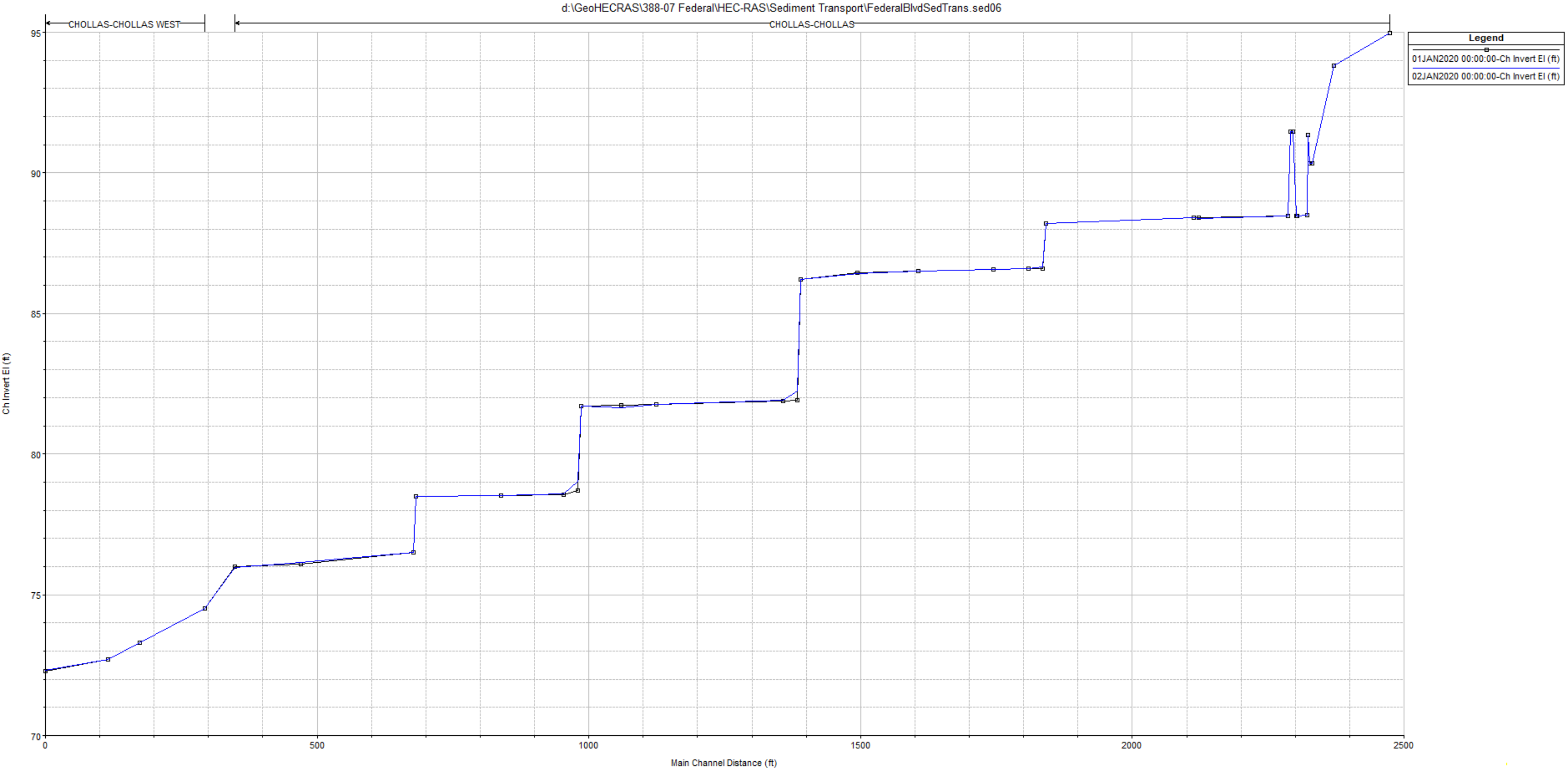
EXISTING 100 YEAR NO LOAD



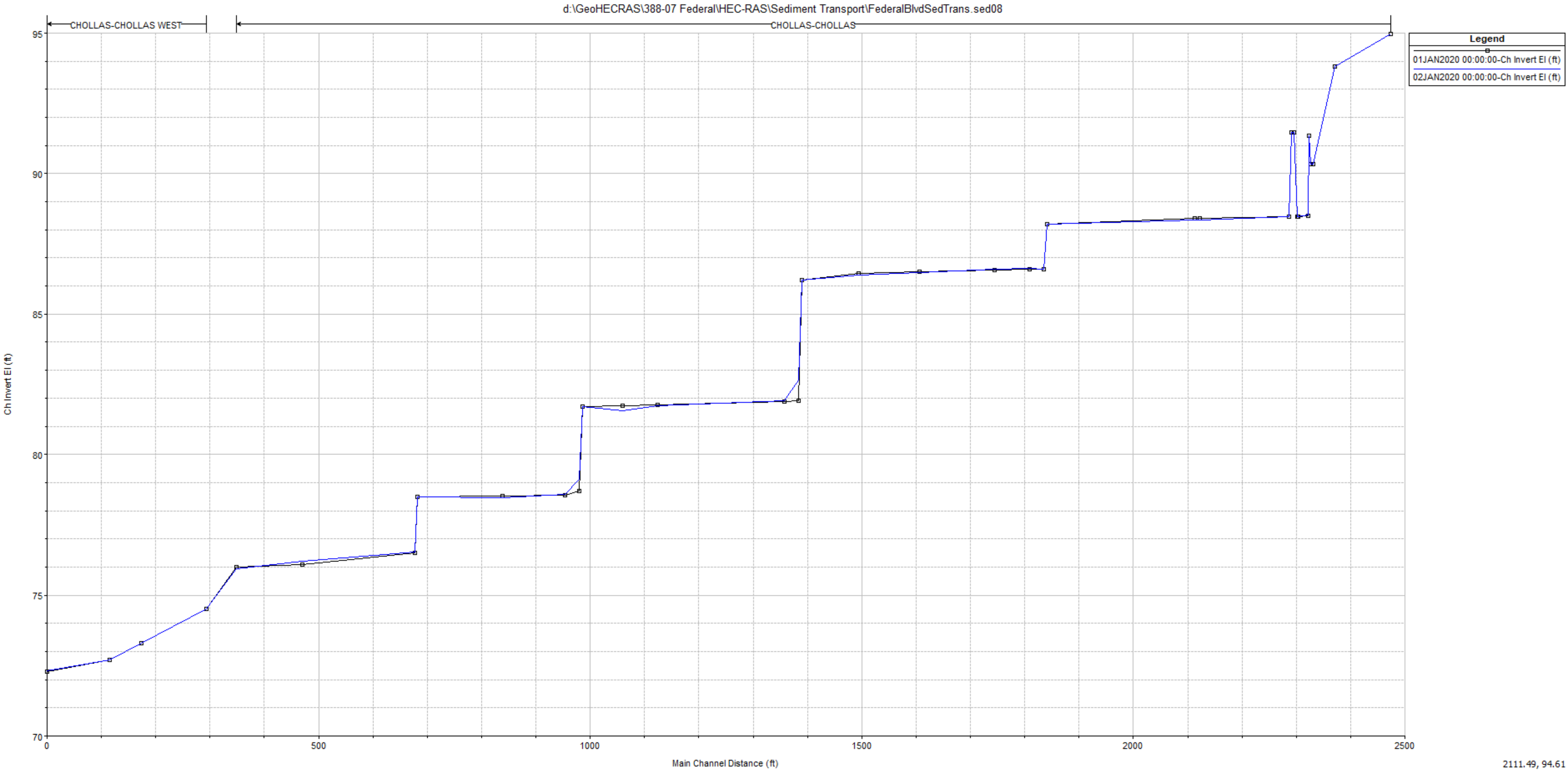
PROPOSED CONDITION

EQUILIBRIUM LOAD

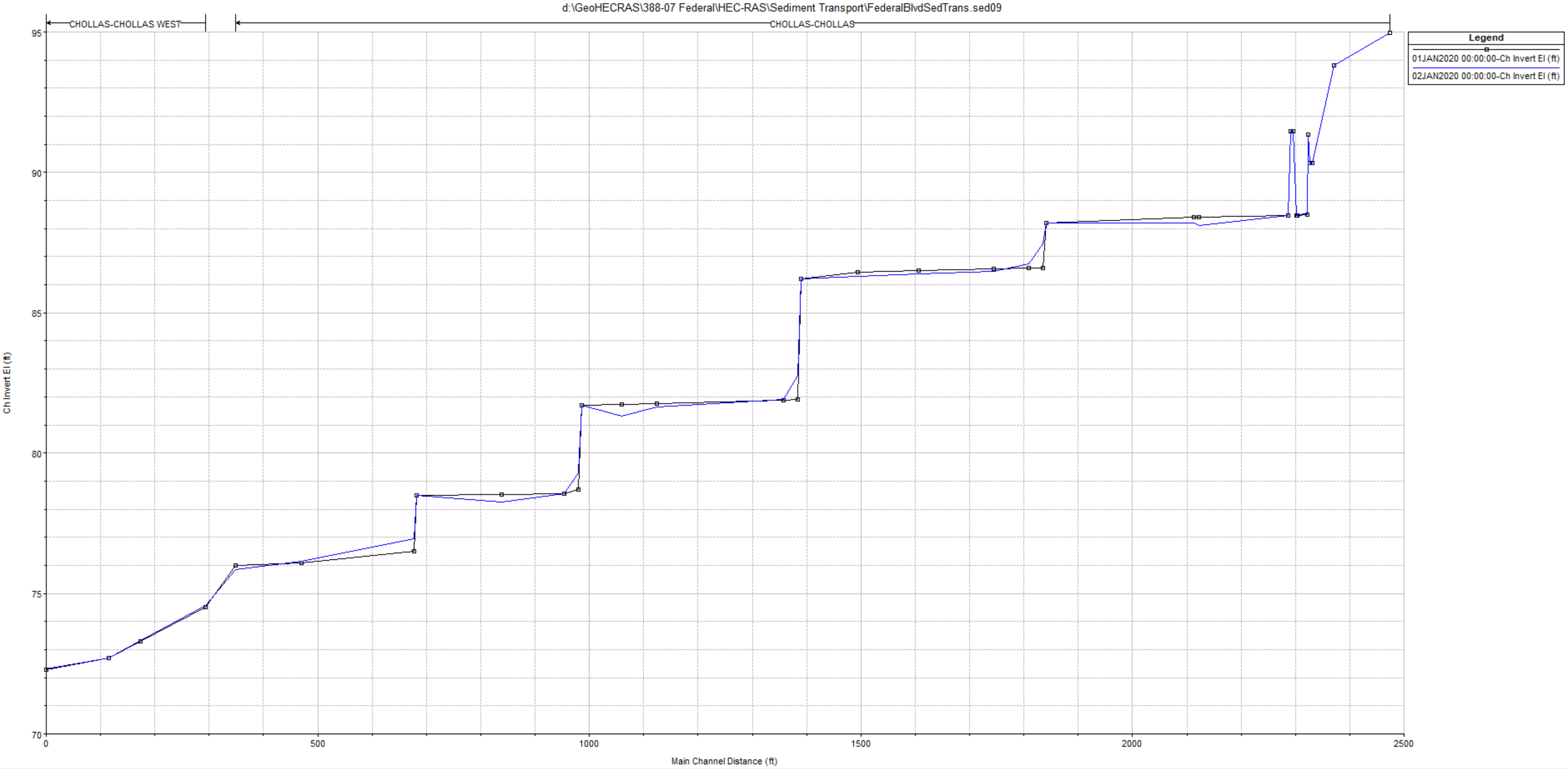
PROPOSED 2 YEAR EQUILIBRIUM LOAD



PROPOSED 10 YEAR EQUILIBRIUM LOAD



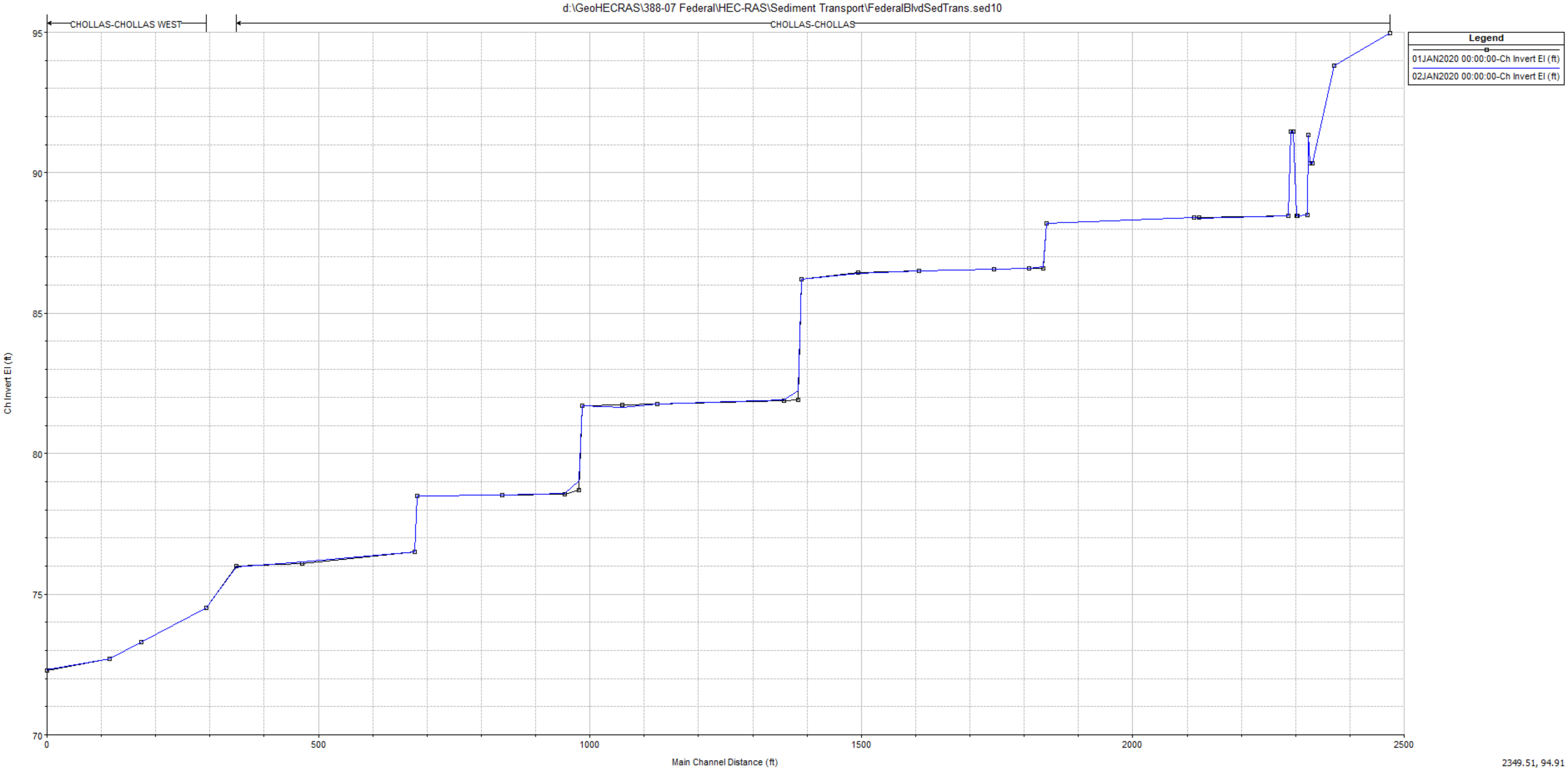
PROPOSED 100 YEAR EQUILIBRIUM LOAD



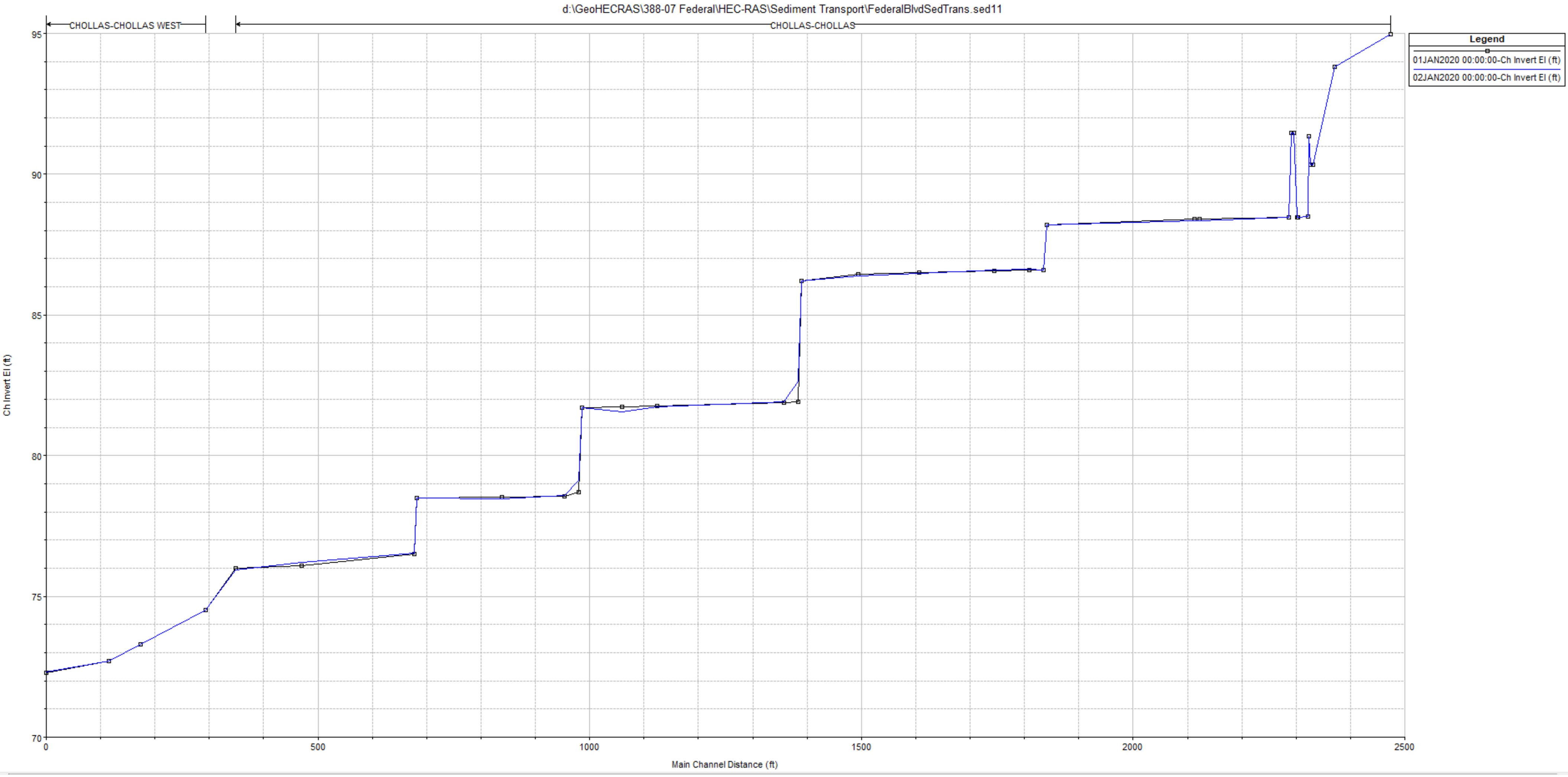
PROPOSED CONDITION

NO LOAD

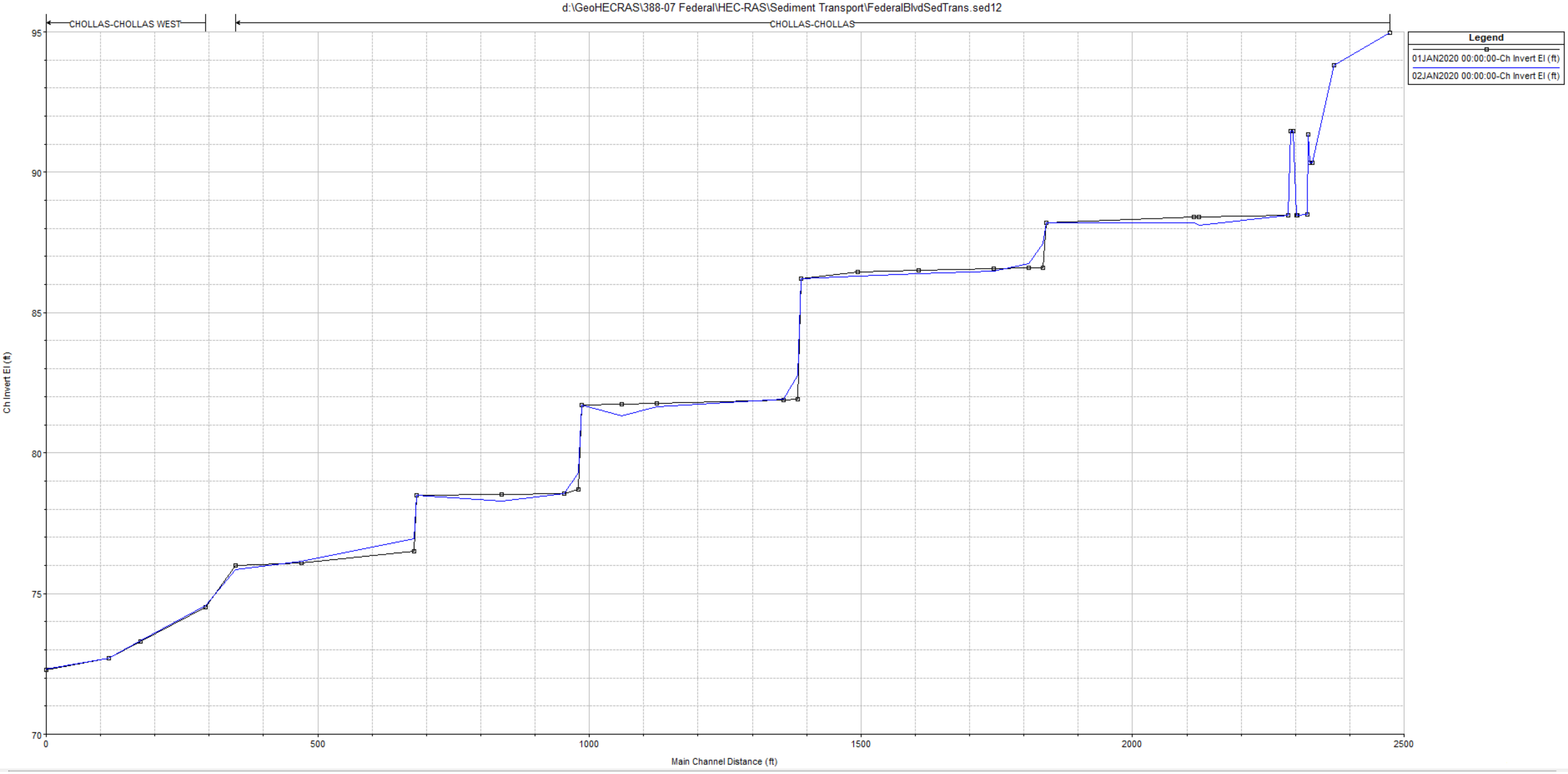
PROPOSED 2 YEAR NO LOAD



PROPOSED 10 YEAR NO LOAD



PROPOSED 100 YEAR NO LOAD



F - Stone Sizing Calculations

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: **Cross Section 4215**

Assume:
SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 1340 lbs (1 ton class) (Corps Table 3-1)

D50(min) = 2.49 ft
D30(min) = 2.08 ft
D15(min) = 1.69 ft

D100(max) = 4.26 ft
D90(min) = 3.01 ft
D85(min) = 2.94 ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	2680 - 6700	37.70 - 51.17
50	1340 - 1985	29.93 - 34.12
15	419 - 993	20.31 - 27.08

Minimum Layer Thickness, T* = 51.2 in = 4.26 feet
Use Layer Thickness, T = **51.6** in = 4.30 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = **52.5** ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = **9.74** ft
n = **0.047** **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
µ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 73.6 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 614 sq ft
D = A/TW = 8.34 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 84.16
R = A/P = 7.30 ft
V = Vavg = Q/A = 5.70 fps **Calculated** **5.85** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.58 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.002405
Average Shear Stress on Bed, t = Ww R S = 1.10 psf
Stream Power = tV = 6.41 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 0.92 ft
Froude Number = V/(gD)^(1/2) = 0.36 Subcritical Tranquil
Reynolds Number = VR/µ = 3,953,654 Turbulent

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.041
n(max) = 0.046

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25642 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.01

Use Ct = 1.00 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.51 for trapezoidal channel
4.27 for natural channel

Use Vss/Vavg = 0.82
Vss = 4.80

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 17.59 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 19.10 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 4139

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) =	1.10	ft	D100(max) =	1.89	ft
D30(min) =	0.92	ft	D90(min) =	1.32	ft
D15(min) =	0.75	ft	D85(min) =	1.30	ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	232	-	580	16.68	-	22.64
50	116	-	172	13.24	-	15.09
15	36	-	86	8.98	-	11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

	Given:			Ww =	62.4	unit weight, pcf
	Q =	3,500	cfs	µ =	1.08E-05	kinematic viscosity, ft^2/sec
	B =	52.5	ft	a =	1.15	energy coefficient
left side	ZL =	2.00	H:1V	g =	32.174	gravity, ft/sec^2
right side	ZR =	0.17	H:1V			
	Y =	7.26	ft			
	n =	0.041	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) = 68.3 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 438 sq ft
D = A/TW = 6.42 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 76.10
R = A/P = 5.76 ft
V = Vavg = Q/A = 7.98 fps **Calculated** **8.02** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.14 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.004717
Average Shear Stress on Bed, t = Ww R S = 1.70 psf
Stream Power = tV = 13.60 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.74 ft
Froude Number = V/(gD)^(1/2) = 0.56 Subcritical Tranquil
Reynolds Number = VR/µ = 4,277,462 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.24983 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.48 for trapezoidal channel
4.25 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.58

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.44 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.74 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3750

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 604 lbs (1/2 ton class) (Corps Table 3-1)

D50(min) = 1.91 ft
D30(min) = 1.59 ft
D15(min) = 1.30 ft

D100(max) = 3.27 ft
D90(min) = 2.30 ft
D85(min) = 2.26 ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	1208 - 3020	28.91 - 39.24
50	604 - 895	22.95 - 26.16
15	189 - 447	15.57 - 20.76

Minimum Layer Thickness, T* = 39.2 in = 3.27 feet
Use Layer Thickness, T = 51.6 in = 4.30 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 65.8 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 5.97 ft
n = 0.045 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
µ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 78.8 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 431 sq ft
D = A/TW = 5.48 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 85.20
R = A/P = 5.06 ft
V = Vavg = Q/A = 8.11 fps **Calculated** **8.20** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.18 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.007052
Average Shear Stress on Bed, t = Ww R S = 2.23 psf
Stream Power = tV = 18.27 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.82 ft
Froude Number = V/(gD)^(1/2) = 0.62 Subcritical Tranquil
Reynolds Number = VR/µ = 3,845,053 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.039
n(max) = 0.044

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.26226 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.32

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.53 for trapezoidal channel
4.29 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.72

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 5.37 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 5.83 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3744

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 604 lbs (1/2 ton class) (Corps Table 3-1)

D50(min) : 1.91 ft   D100(max) = 3.27 ft
D30(min) : 1.59 ft   D90(min) = 2.30 ft
D15(min) : 1.30 ft   D85(min) = 2.26 ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	1208 - 3020	28.91 - 39.24
50	604 - 895	22.95 - 26.16
15	189 - 447	15.57 - 20.76

Minimum Layer Thickness, T* = 39.2 in = 3.27 feet
Use Layer Thickness, T = 51.6 in = 4.30 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:

Q = 3,500 cfs
B = 59.8 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 7.78 ft
n = 0.045 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 76.7 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 531 sq ft
D = A/TW = 6.92 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 85.09
R = A/P = 6.24 ft
V = Vavg = Q/A = 6.59 fps **Calculated** **6.74** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.78 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.003607
Average Shear Stress on Bed, t = Ww R S = 1.40 psf
Stream Power = tV = 9.47 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.23 ft
Froude Number = V/(gD)^(1/2) = 0.45 Subcritical Tranquil
Reynolds Number = VR/μ = 3,893,978 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.039
n(max) = 0.044

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25994 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.32

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.52 for trapezoidal channel
4.28 for natural channel

Use Vss/Vavg = 0.82
Vss = 5.53

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 9.36 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 10.17 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3652

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) = 1.10 ft D100(max) = 1.89 ft
D30(min) = 0.92 ft D90(min) = 1.32 ft
D15(min) = 0.75 ft D85(min) = 1.30 ft

RIPRAP GRADATION

Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	232 - 580	16.68 - 22.64
50	116 - 172	13.24 - 15.09
15	36 - 86	8.98 - 11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 59.8 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 7.47 ft
n = 0.041 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 76.0 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 507 sq ft
D = A/TW = 6.67 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 84.08
R = A/P = 6.03 ft
V = Vavg = Q/A = 6.90 fps **Calculated** **7.06** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.85 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.003436
Average Shear Stress on Bed, t = Ww R S = 1.29 psf
Stream Power = tV = 9.13 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.35 ft
Froude Number = V/(gD)^(1/2) = 0.48 Subcritical Tranquil
Reynolds Number = VR/μ = 3,943,730 Turbulent

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25917 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.52 for trapezoidal channel
4.28 for natural channel

Use Vss/Vavg = 0.82
Vss = 5.79

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 4.76 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 5.17 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3513

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) :	1.10	ft	D100(max) =	1.89	ft
D30(min) :	0.92	ft	D90(min) =	1.32	ft
D15(min) :	0.75	ft	D85(min) =	1.30	ft

RIPRAP GRADATION

Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	232 - 580	16.68 - 22.64
50	116 - 172	13.24 - 15.09
15	36 - 86	8.98 - 11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

	Given:			Ww =	62.4	unit weight, pcf
	Q =	3,500	cfs	µ =	1.08E-05	kinematic viscosity, ft^2/sec
	B =	**59.8**	ft	a =	1.15	energy coefficient
left side	ZL =	2.00	H:1V	g =	32.174	gravity, ft/sec^2
right side	ZR =	0.17	H:1V			
	Y =	**6.97**	ft			
	n =	**0.041**	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) =	74.9	ft	
A = B*Y + ZL*Y^2 + ZR*Y^2 =	470	sq ft	
D = A/TW =	6.27	ft	
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 =	82.46		
R = A/P =	5.69	ft	
V = Vavg = Q/A = 7.45 fps **Calculated**	**7.63**	fps	**HEC-RAS max velocity**
hv = aV^2/2g =	0.99	ft	
S = [(n/1.49)(V/R^(2/3))]^2 =	0.004335		
Average Shear Stress on Bed, t = Ww R S =	1.54	psf	
Stream Power = tV =	11.75	ft lb/sec/sq ft	
Antidune Height, H(<y) = 0.027 V^2 =	1.57	ft	
Froude Number = V/(gD)^(1/2) =	0.54	Subcritical	Tranquil
Reynolds Number = VR/µ =	4,022,836	Turbulent	

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25793 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.51 for trapezoidal channel
4.27 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.26

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.86 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 4.19 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3402

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) :	1.10	ft	D100(max) =	1.89	ft
D30(min) :	0.92	ft	D90(min) =	1.32	ft
D15(min) :	0.75	ft	D85(min) =	1.30	ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	232	-	580	16.68	-	22.64
50	116	-	172	13.24	-	15.09
15	36	-	86	8.98	-	11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:

	Q =	3,500	cfs	Ww =	62.4	unit weight, pcf
	B =	59.8	ft	μ =	1.08E-05	kinematic viscosity, ft^2/sec
left side	ZL =	2.00	H:1V	a =	1.15	energy coefficient
right side	ZR =	0.17	H:1V	g =	32.174	gravity, ft/sec^2
	Y =	6.47	ft			
	n =	0.041	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) = 73.8 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 432 sq ft
D = A/TW = 5.85 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 80.83
R = A/P = 5.35 ft
V = Vavg = Q/A = 8.10 fps **Calculated** **8.09** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.17 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.005298
Average Shear Stress on Bed, t = Ww R S = 1.77 psf
Stream Power = tV = 14.30 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.77 ft
Froude Number = V/(gD)^(1/2) = 0.59 Subcritical Tranquil
Reynolds Number = VR/μ = 4,006,467 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25666 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.51 for trapezoidal channel
4.27 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.63

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.27 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.55 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3299

Assume:
SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 1340 lbs (1 ton class) (Corps Table 3-1)

D50(min) = 2.49 ft
D30(min) = 2.08 ft
D15(min) = 1.69 ft
D100(max) = 4.26 ft
D90(min) = 3.01 ft
D85(min) = 2.94 ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	2680	-	6700	37.70	-	51.17
50	1340	-	1985	29.93	-	34.12
15	419	-	993	20.31	-	27.08

Minimum Layer Thickness, T* = 51.2 in = 4.26 feet
Use Layer Thickness, T = 64.8 in = 5.40 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 61.1 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 4.53 ft
n = 0.047 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 70.9 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 299 sq ft
D = A/TW = 4.22 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 75.82
R = A/P = 3.94 ft
V = Vavg = Q/A = 11.70 fps **Calculated** **12.02** fps **HEC-RAS max velocity**
hv = aV^2/2g = 2.45 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.023070
Average Shear Stress on Bed, t = Ww R S = 5.68 psf
Stream Power = tV = 68.25 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 3.90 ft
Froude Number = V/(gD)^(1/2) = 1.03 Supercritical Unstable
Reynolds Number = VR/μ = 4,389,479 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations

0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.041

n(max) = 0.046

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock

0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends

2.25317 outside of bends, (Plate B-40)

1.25 downstream of concrete channels

1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74

T/T* = 1.27

Use Ct = 0.96 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °

Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.49 for trapezoidal channel

4.26 for natural channel

Use Vss/Vavg = 0.82

Vss = 9.86

Safety Factors

for channel invert

SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.50 > 1.1 OK

for channel side slopes

SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.71 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3293

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 1340 lbs (1 ton class) (Corps Table 3-1)

D50(min) =	2.49	ft	D100(max) =	4.26	ft
D30(min) =	2.08	ft	D90(min) =	3.01	ft
D15(min) =	1.69	ft	D85(min) =	2.94	ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	2680	-	6700	37.70	-	51.17
50	1340	-	1985	29.93	-	34.12
15	419	-	993	20.31	-	27.08

Minimum Layer Thickness, T* = 51.2 in = 4.26 feet
Use Layer Thickness, T = 64.8 in = 5.40 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

	Given:			Ww =	62.4	unit weight, pcf
	Q =	3,500	cfs	µ =	1.08E-05	kinematic viscosity, ft^2/sec
	B =	54.4	ft	a =	1.15	energy coefficient
left side	ZL =	2.00	H:1V	g =	32.174	gravity, ft/sec^2
right side	ZR =	0.17	H:1V			
	Y =	8.18	ft			
	n =	0.047	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) =	72.2	ft	
A = B*Y + ZL*Y^2 + ZR*Y^2 =	518	sq ft	
D = A/TW =	7.17	ft	
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 =	80.99		
R = A/P =	6.39	ft	
V = Vavg = Q/A = 6.76 fps **Calculated**	**7.00**	fps	**HEC-RAS max velocity**
hv = aV^2/2g =	0.82	ft	
S = [(n/1.49)(V/R^(2/3))]^2 =	0.004111		
Average Shear Stress on Bed, t = Ww R S =	1.64	psf	
Stream Power = tV =	11.48	ft lb/sec/sq ft	
Antidune Height, H(<y) = 0.027 V^2 =	1.32	ft	
Froude Number = V/(gD)^(1/2) =	0.46	Subcritical	Tranquil
Reynolds Number = VR/µ =	4,142,276	Turbulent	

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.041
n(max) = 0.046

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25465 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.27

Use Ct = 0.96 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.50 for trapezoidal channel
4.27 for natural channel

Use Vss/Vavg = 0.82
Vss = 5.74

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 11.18 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 12.14 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 3267

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) = 1.10 ft
D30(min) = 0.92 ft
D15(min) = 0.75 ft
D100(max) = 1.89 ft
D90(min) = 1.32 ft
D85(min) = 1.30 ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	232	-	580	16.68	-	22.64
50	116	-	172	13.24	-	15.09
15	36	-	86	8.98	-	11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 54.4 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 8.09 ft
n = 0.041 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 72.0 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 511 sq ft
D = A/TW = 7.10 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 80.70
R = A/P = 6.33 ft
V = Vavg = Q/A = 6.85 fps **Calculated** **7.08** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.84 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.003239
Average Shear Stress on Bed, t = Ww R S = 1.28 psf
Stream Power = tV = 9.06 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.35 ft
Froude Number = V/(gD)^(1/2) = 0.47 Subcritical Tranquil
Reynolds Number = VR/μ = 4,152,123 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25441 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.50 for trapezoidal channel
4.27 for natural channel

Use Vss/Vavg = 0.82
Vss = 5.81

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 4.83 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 5.24 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: **Cross Section 3031**

Assume:
SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) : 1.10 ft
D30(min) : 0.92 ft
D15(min) : 0.75 ft
D100(max) = 1.89 ft
D90(min) = 1.32 ft
D85(min) = 1.30 ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	232	-	580	16.68	-	22.64
50	116	-	172	13.24	-	15.09
15	36	-	86	8.98	-	11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 56.5 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 7.24 ft
n = 0.041 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 72.2 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 466 sq ft
D = A/TW = 6.45 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 80.03
R = A/P = 5.82 ft
V = Vavg = Q/A = 7.51 fps **Calculated** **7.71** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.01 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.004298
Average Shear Stress on Bed, t = Ww R S = 1.56 psf
Stream Power = tV = 12.04 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.60 ft
Froude Number = V/(gD)^(1/2) = 0.54 Subcritical Tranquil
Reynolds Number = VR/μ = 4,156,091 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25472 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.50 for trapezoidal channel
4.27 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.32

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.79 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 4.12 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 2966

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) =	1.10	ft	D100(max) =	1.89	ft
D30(min) =	0.92	ft	D90(min) =	1.32	ft
D15(min) =	0.75	ft	D85(min) =	1.30	ft

R I P R A P G R A D A T I O N		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	232 - 580	16.68 - 22.64
50	116 - 172	13.24 - 15.09
15	36 - 86	8.98 - 11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

	Given:			Ww =	62.4	unit weight, pcf
	Q =	3,500	cfs	µ =	1.08E-05	kinematic viscosity, ft^2/sec
	B =	**49.3**	ft	a =	1.15	energy coefficient
left side	ZL =	2.00	H:1V	g =	32.174	gravity, ft/sec^2
right side	ZR =	0.17	H:1V			
	Y =	**6.19**	ft			
	n =	**0.041**	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) =	62.7	ft	
A = B*Y + ZL*Y^2 + ZR*Y^2 =	347	sq ft	
D = A/TW =	5.53	ft	
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 =	69.42		
R = A/P =	4.99	ft	
V = Vavg = Q/A = 10.09 fps **Calculated**	**10.46**	fps	**HEC-RAS max velocity**
hv = aV^2/2g =	1.82	ft	
S = [(n/1.49)(V/R^(2/3))]^2 =	0.009703		
Average Shear Stress on Bed, t = Ww R S =	3.02	psf	
Stream Power = tV =	31.63	ft lb/sec/sq ft	
Antidune Height, H(<y) = 0.027 V^2 =	2.95	ft	
Froude Number = V/(gD)^(1/2) =	0.78	Subcritical	Tranquil
Reynolds Number = VR/µ =	4,837,565	Turbulent	

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.2425 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.45 for trapezoidal channel
4.23 for natural channel

Use Vss/Vavg = 0.82
Vss = 8.58

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 1.70 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 1.85 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: **Cross Section 2892**

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 1340 lbs (1 ton class) (Corps Table 3-1)

D50(min) : 2.49 ft
D30(min) : 2.08 ft
D15(min) : 1.69 ft

D100(max) = 4.26 ft
D90(min) = 3.01 ft
D85(min) = 2.94 ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	2680 - 6700	37.70 - 51.17
50	1340 - 1985	29.93 - 34.12
15	419 - 993	20.31 - 27.08

Minimum Layer Thickness, T* = 51.2 in = 4.26 feet
Use Layer Thickness, T = **64.8** in = 5.40 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = **58.0** ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = **4.67** ft
n = **0.047** **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 68.1 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 295 sq ft
D = A/TW = 4.32 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 73.18
R = A/P = 4.02 ft
V = Vavg = Q/A = 11.88 fps **Calculated** **12.21** fps **HEC-RAS max velocity**
hv = aV^2/2g = 2.52 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.023171
Average Shear Stress on Bed, t = Ww R S = 5.82 psf
Stream Power = tV = 71.05 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 4.03 ft
Froude Number = V/(gD)^(1/2) = 1.04 Supercritical Unstable
Reynolds Number = VR/μ = 4,550,106 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.041
n(max) = 0.046

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.24967 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.27

Use Ct = 0.96 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.48 for trapezoidal channel
4.25 for natural channel

Use Vss/Vavg = 0.82
Vss = 10.01

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.42 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.63 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: **Cross Section 2886**

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 1340 lbs (1 ton class) (Corps Table 3-1)

D50(min) :	2.49	ft	D100(max) =	4.26	ft
D30(min) :	2.08	ft	D90(min) =	3.01	ft
D15(min) :	1.69	ft	D85(min) =	2.94	ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	2680 - 6700	37.70 - 51.17
50	1340 - 1985	29.93 - 34.12
15	419 - 993	20.31 - 27.08

Minimum Layer Thickness, T* = 51.2 in = 4.26 feet
Use Layer Thickness, T = 64.8 in = 5.40 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

	Given:			Ww =	62.4	unit weight, pcf
	Q =	3,500	cfs	µ =	1.08E-05	kinematic viscosity, ft^2/sec
	B =	51.2	ft	a =	1.15	energy coefficient
left side	ZL =	2.00	H:1V	g =	32.174	gravity, ft/sec^2
right side	ZR =	0.17	H:1V			
	Y =	7.50	ft			
	n =	0.047	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) = 67.5 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 445 sq ft
D = A/TW = 6.60 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 75.58
R = A/P = 5.89 ft
V = Vavg = Q/A = 7.86 fps **Calculated** **8.04** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.11 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.006049
Average Shear Stress on Bed, t = Ww R S = 2.22 psf
Stream Power = tV = 17.87 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.75 ft
Froude Number = V/(gD)^(1/2) = 0.55 Subcritical Tranquil
Reynolds Number = VR/µ = 4,383,558 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.041
n(max) = 0.046

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.24883 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.27

Use Ct = 0.96 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.48 for trapezoidal channel
4.25 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.59

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 7.74 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 8.41 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 2861

Assume:
SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) = 1.10 ft
D30(min) = 0.92 ft
D15(min) = 0.75 ft
D100(max) = 1.89 ft
D90(min) = 1.32 ft
D85(min) = 1.30 ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	232	-	580	16.68	-	22.64
50	116	-	172	13.24	-	15.09
15	36	-	86	8.98	-	11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 51.8 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 7.32 ft
n = 0.041 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 67.7 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 437 sq ft
D = A/TW = 6.46 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 75.59
R = A/P = 5.79 ft
V = Vavg = Q/A = 8.00 fps **Calculated** **8.29** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.14 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.005011
Average Shear Stress on Bed, t = Ww R S = 1.81 psf
Stream Power = tV = 14.99 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.86 ft
Froude Number = V/(gD)^(1/2) = 0.57 Subcritical Tranquil
Reynolds Number = VR/μ = 4,440,596 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.2491 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.48 for trapezoidal channel
4.25 for natural channel

Use Vss/Vavg = 0.82
Vss = 6.80

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.17 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.45 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 2744

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) :	1.10	ft	D100(max) =	1.89	ft
D30(min) :	0.92	ft	D90(min) =	1.32	ft
D15(min) :	0.75	ft	D85(min) =	1.30	ft

RIPRAP GRADATION

Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	232 - 580	16.68 - 22.64
50	116 - 172	13.24 - 15.09
15	36 - 86	8.98 - 11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:

	Q =	3,500	cfs	Ww =	62.4	unit weight, pcf
	B =	52.8	ft	µ =	1.08E-05	kinematic viscosity, ft^2/sec
left side	ZL =	2.00	H:1V	a =	1.15	energy coefficient
right side	ZR =	0.17	H:1V	g =	32.174	gravity, ft/sec^2
	Y =	6.36	ft			
	n =	0.041	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) =	66.6	ft	
A = B*Y + ZL*Y^2 + ZR*Y^2 =	380	sq ft	
D = A/TW =	5.70	ft	
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 =	73.47		
R = A/P =	5.17	ft	
V = Vavg = Q/A = 9.22 fps **Calculated**	**9.52**	fps	**HEC-RAS max velocity**
hv = aV^2/2g =	1.52	ft	
S = [(n/1.49)(V/R^(2/3))]^2 =	0.007680		
Average Shear Stress on Bed, t = Ww R S =	2.48	psf	
Stream Power = tV =	23.58	ft lb/sec/sq ft	
Antidune Height, H(<y) = 0.027 V^2 =	2.45	ft	
Froude Number = V/(gD)^(1/2) =	0.70	Subcritical	Tranquil
Reynolds Number = VR/µ =	4,555,367	Turbulent	

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.2477 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.47 for trapezoidal channel
4.25 for natural channel

Use Vss/Vavg = 0.82
Vss = 7.81

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.17 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.35 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 2623

Assume:
SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 604 lbs (1/2 ton class) (Corps Table 3-1)

D50(min) = 1.91 ft D100(max) = 3.27 ft
D30(min) = 1.59 ft D90(min) = 2.30 ft
D15(min) = 1.30 ft D85(min) = 2.26 ft

RIPRAP GRADATION						
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs			Limits of Stone Diameter. in		
100	1208	-	3020	28.91	-	39.24
50	604	-	895	22.95	-	26.16
15	189	-	447	15.57	-	20.76

Minimum Layer Thickness, T* = 39.2 in = 3.27 feet
Use Layer Thickness, T = 51.6 in = 4.30 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 68.3 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 4.71 ft
n = 0.045 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 78.5 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 346 sq ft
D = A/TW = 4.40 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 83.61
R = A/P = 4.14 ft
V = Vavg = Q/A = 10.12 fps **Calculated** **10.34** fps **HEC-RAS max velocity**
hv = aV^2/2g = 1.83 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.014691
Average Shear Stress on Bed, t = Ww R S = 3.79 psf
Stream Power = tV = 39.20 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 2.89 ft
Froude Number = V/(gD)^(1/2) = 0.87 Subcritical Unstable
Reynolds Number = VR/μ = 3,959,311 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.039
n(max) = 0.044

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.262 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.32

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.53 for trapezoidal channel
4.29 for natural channel

Use Vss/Vavg = 0.82
Vss = 8.48

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.83 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 3.08 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: **Cross Section 2621**

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 604 lbs (1/2 ton class) (Corps Table 3-1)

D50(min) = 1.91 ft D100(max) = 3.27 ft
D30(min) = 1.59 ft D90(min) = 2.30 ft
D15(min) = 1.30 ft D85(min) = 2.26 ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	1208 - 3020	28.91 - 39.24
50	604 - 895	22.95 - 26.16
15	189 - 447	15.57 - 20.76

Minimum Layer Thickness, T* = 39.2 in = 3.27 feet
Use Layer Thickness, T = 51.6 in = 4.30 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 59.3 ft
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 7.70 ft
n = 0.045 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 76.0 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 521 sq ft
D = A/TW = 6.85 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 84.33
R = A/P = 6.18 ft
V = Vavg = Q/A = 6.72 fps **Calculated** **6.99** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.81 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.003932
Average Shear Stress on Bed, t = Ww R S = 1.52 psf
Stream Power = tV = 10.59 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.32 ft
Froude Number = V/(gD)^(1/2) = 0.47 Subcritical Tranquil
Reynolds Number = VR/μ = 3,998,232 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.039
n(max) = 0.044

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.25917 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.74
T/T* = 1.32

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.52 for trapezoidal channel
4.28 for natural channel

Use Vss/Vavg = 0.82
Vss = 5.73

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 8.53 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 9.26 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: Cross Section 2375

Assume:

SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) =	1.10	ft	D100(max) =	1.89	ft
D30(min) =	0.92	ft	D90(min) =	1.32	ft
D15(min) =	0.75	ft	D85(min) =	1.30	ft

R I P R A P G R A D A T I O N		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	232 - 580	16.68 - 22.64
50	116 - 172	13.24 - 15.09
15	36 - 86	8.98 - 11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:

	Q =	3,500	cfs	Ww =	62.4	unit weight, pcf
	B =	70.2	ft	µ =	1.08E-05	kinematic viscosity, ft^2/sec
				a =	1.15	energy coefficient
left side	ZL =	2.00	H:1V	g =	32.174	gravity, ft/sec^2
right side	ZR =	0.17	H:1V			
	Y =	7.21	ft			
	n =	0.041	**(SDDDM Table 7-4)**			
	r =	0.00	ft, centerline bend radius			

TW = B+Y(ZL+ZR) = 85.8 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 563 sq ft
D = A/TW = 6.55 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 93.64
R = A/P = 6.01 ft
V = Vavg = Q/A = 6.22 fps **Calculated** **6.38** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.69 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.002822
Average Shear Stress on Bed, t = Ww R S = 1.06 psf
Stream Power = tV = 6.75 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 1.10 ft
Froude Number = V/(gD)^(1/2) = 0.44 Subcritical Tranquil
Reynolds Number = VR/µ = 3,549,061 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.26974 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.56 for trapezoidal channel
4.31 for natural channel

Use Vss/Vavg = 0.82
Vss = 5.23

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 6.08 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 6.61 > 1.1 OK

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

STONE DESIGN - Army Corps of Engineers Method

Ref: U.S. Army Corps of Engineers, EM 1110-2-1601, 1 Jul 91, 30 Jun 94
Ref: City of San Diego, Drainage Design Manual, Jan 2017
SECTION: **Cross Section 2254**

Assume:
SSD Specific Weight of Stone, Ws = 165 pcf

Try W50(min) = 116 lbs (light class) (Corps Table 3-1)

D50(min) = 1.10 ft
D30(min) = 0.92 ft
D15(min) = 0.75 ft
D100(max) = 1.89 ft
D90(min) = 1.32 ft
D85(min) = 1.30 ft

RIPRAP GRADATION		
Percent Lighter By Weight (SSD)	Limits of Stone Weight, lbs	Limits of Stone Diameter. in
100	232 - 580	16.68 - 22.64
50	116 - 172	13.24 - 15.09
15	36 - 86	8.98 - 11.98

Minimum Layer Thickness, T* = 22.6 in = 1.89 feet
Use Layer Thickness, T = 30.0 in = 2.50 feet **(SDDDM Table 7-6)**

Hydraulic Parameters for Trapezoidal Cross Section

Given:
Q = 3,500 cfs
B = 70.2 ft check
left side ZL = 2.00 H:1V
right side ZR = 0.17 H:1V
Y = 7.54 ft
n = 0.041 **(SDDDM Table 7-4)**
r = 0.00 ft, centerline bend radius

Ww = 62.4 unit weight, pcf
μ = 1.08E-05 kinematic viscosity, ft^2/sec
a = 1.15 energy coefficient
g = 32.174 gravity, ft/sec^2

TW = B+Y(ZL+ZR) = 86.6 ft
A = B*Y + ZL*Y^2 + ZR*Y^2 = 591 sq ft
D = A/TW = 6.83 ft
P = B + Y(1+ZL^2)^0.5 + Y(1+ZR^2)^0.5 = 94.71
R = A/P = 6.24 ft
V = Vavg = Q/A = 5.92 fps **Calculated** **10.09** fps **HEC-RAS max velocity**
hv = aV^2/2g = 0.63 ft
S = [(n/1.49)(V/R^(2/3))]^2 = 0.006710
Average Shear Stress on Bed, t = Ww R S = 2.61 psf
Stream Power = tV = 26.36 ft lb/sec/sq ft
Antidune Height, H(<y) = 0.027 V^2 = 2.75 ft
Froude Number = V/(gD)^(1/2) = 0.68 Subcritical Tranquil
Reynolds Number = VR/μ = 5,829,909 Turbulent

Project	Federal Blvd. Dechannelization and Trail Project (388-07)	**Date**	17-Feb-21	**By**	L. Ryan
Client	Groundwork San Diego	**Checked**	3-Mar-21	**By**	J. Duewel PE
Subject	Channel stone sizing	**Approved**	5-Mar-21	**By**	T. Walker PE

Channel Roughness

K = 0.034 for velocity and stone size calculations
0.038 for capacity and freeboard calculations

n(min) = K[D90(min)]^(1/6) = 0.036
n(max) = 0.040

Stone Size Analysis

Stability Coefficient for Incipient Failure, Cs = 0.30 for angular rock
0.36 for rounded rock

Use Cs = 0.36

Vertical Velocity Distribution Coefficient, Cv = 1.00 for straight channels, inside of bends
2.27047 outside of bends, (Plate B-40)
1.25 downstream of concrete channels
1.25 end of dikes

Use Cv = 1.00

Thickness Coefficient

for D85/D15 = 1.73
T/T* = 1.33

Use Ct = 0.95 (Plate B-40)

Side Slope Correction Factor

Side Slope Angle, Ø = 26.57 °
Riprap Repose Angle, ß = 40.00 °

K1 = [1-sin^2(Ø)/sin^2(ß)]^(1/2) = 0.72 (Eq. 3-4)

Side Slope Riprap Design Velocities, Vss/Vavg 5.56 for trapezoidal channel
4.31 for natural channel

Use Vss/Vavg = 0.82
Vss = 8.27

Safety Factors

for channel invert
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*V/((g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 1.96 > 1.1 OK

for channel side slopes
SF = D30(min)/{CsCvCt*y[(Ww/(Ws-Ww))^(1/2)*Vss/((K1*g*y)^(1/2)]^2.5} (Eq. 3-3)

SF = 2.12 > 1.1 OK

G - Retaining Wall Design

Stability Calculations for The Enviro-Block™ Retaining wall System

Federal Boulevard Dechannelization and Trail Project

San Diego, California

Prepared for:

Tory R. Walker Engineering
122 Civil Center Drive, Suite 206
Vista, California 92084

Prepared By:
Inter-Block Retaining Systems Inc.
PO Box 2992
Valley Center, California 92082

April 8, 2021

REGISTERED PROFESSIONAL ENGINEER
DAVID M. SANDERFER
No. C29666
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Introduction

The Enviro-Block™ retaining wall system is a modular, concrete gravity wall design. The system incorporates interlocking blocks, each weighing about 4,000 pounds. When installed, each unit requires about 2.5' by 2.5 feet by 5' of space. The total volume of each unit is about 29 cubic feet, after considering the beveling of every edge of the block. Each block has two large 4 inch high male keys at the top, which are used to interlock the wall. The interlocked wall will still yield 1/2" per 5 feet of length, allowing a more uniform base loading and less stress on the concrete.

Enviro-Block™ Specifications

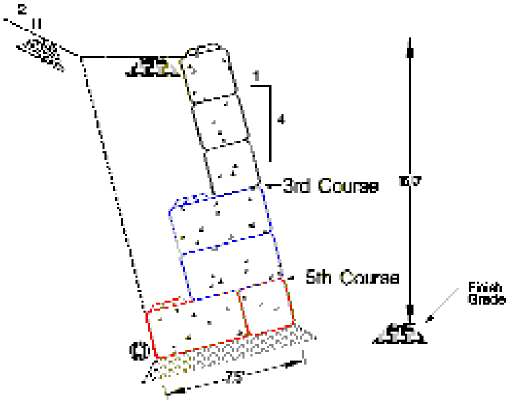
Description	US Standard	Metric SI
Height	2.46'/29.5" ±¼"	750mm ±6mm
Width	2.46'/29.5" ±¼"	750mm ±6mm
Length	4.92'/59.1" ±½"	1500mm ±12mm
Volume	28.7ft^3/1.06yds^3 ±0.03yds^3	0.81m^3 ±0.02m^3
Average Weight/Mass	3,969lbs ±104.5lbs	1801kg ± 47.5kg
Historical Compressive Strength[†]	3,214psi ± 955psi[‡]	22,166kPa ± 6,586kPa[‡]

Additional Features

- Incorporates 100% post consumer concrete (Spec concrete available on request)
- Plantable crevices
- Quickly installed
- Removable & reusable for storm damage mitigation
- Attractive colors and textures available for spec jobs

General Design Criteria

The calculations assume the earth pressure acts along a plane parallel to the face of the wall. To ensure overall wall stability, each course before a change in geometry is calculated, since all higher blocks will be more stable. For instance, with the 15.0 foot design the third course down from the top is calculated and checked for overturning stability. The geometry of the cross section changes on the next row down, since more mass is needed for the increase in wall height. Then the fifth row is checked for overturning and finally the bottom row is calculated to check for bearing, overturning and sliding stability.



To ensure long term stability, a drain is encased in crushed rock and placed behind the wall to lessen saturated conditions. Also the base is generally laid with crushed rock to increase friction, distribute the load and stabilize the grade.

[†] Schmidt Hammer test results available upon request

[‡] Compressive strength standard deviation of one sigma assumes a normal distribution and would apply to 66% of all blocks. Actual sample strength was 4,900psi ±3,400psi.

Equations Used for Enviro-Block™ Stability Calculations

Coulomb's Active Earth Pressure Coefficient

$$K_a = \frac{\sin^2(\beta - \phi)}{\sin^2 \beta \sin(\beta - \delta)\left(1 + \sqrt{\frac{\sin(\phi + \delta)\sin(\phi - \alpha)}{\sin(\beta + \delta)\sin(\beta - \alpha)}}\right)^2}$$

where

β = counter-clockwise rotation of the wall from the horizontal
δ = angle of wall friction
α = angle of the slope behind the wall
ϕ = internal angle of friction of the backfill

Coulomb's Active Earth Force

$$F_a = K_a \gamma_{soil} \frac{[H \cos(\theta)]^2}{2}$$

where

H = height of the wall face, unbattered
θ = rotation of wall from the vertical, where 0° is vertical and 90° is horizontal
γ_{soil} = density of the soil in the backfill

Coulomb's Active Earth Pressure with a Surcharge on the Backfill

$$F_a = K_a \gamma_{eq} \frac{[H \cos(\theta)]^2}{2} + F_a^{'}$$

where

$$\gamma_{eq} = \gamma_{soil} + \left[\frac{\sin(\beta)}{\sin(\beta+\alpha)}\right]\left(\frac{2q}{H}\right)\cos(\alpha)$$ [1]

q = uniform surcharge on the backfill

and

$$F_a^{'} = \frac{q}{180°}\left([H \cos(\theta)](\theta_2 - \theta_1)\right)$$

where

$$\theta_1 = \tan^{-1}\left(\frac{b^{'}}{H \cos(\theta)}\right)$$

and

$$\theta_2 = \tan^{-1}\left(\frac{a^{'} + b^{'}}{H \cos(\theta)}\right)$$

where

$a^{'}$ = width of the surcharge
$b^{'}$ = distance from the back of the wall to the beginning of the surcharge

Active Earth Force per Unit Length of Wall

$$F_{wall} = F_a \sin(\delta)$$

---

[1] Braja Das, Principles of Engineering (Third Edition), 291

Reaction at the Base of the Wall

$$\Sigma F_{normal} = W_{wall}\cos(\theta) + F_a \sin(\delta) - N = 0$$

where

W_{wall} = weight of the wall, both concrete & earth resting on its base

therefore

$$N = W_{wall}\cos(\theta) + F_a \sin(\delta)$$

so

$$\Sigma F_{resisting} = W_{wall}\sin(\theta) + N\tan(\phi_{base})$$

where

ϕ_{base} = friction angle of the base material

$$\Sigma F_{driving} = F_a \cos(\delta)$$

$$\text{Factor of Safety}_{\text{sliding}} = \frac{\Sigma F_{resisting}}{\Sigma F_{driving}}$$

therefore

$$\frac{W_{wall}\sin(\theta) + N\tan(\phi_{base})}{F_a \cos(\delta)}$$

Moments about the Toe of the Wall

$$\Sigma M_{resisting} = X_c \bullet W_{wall} \cos(\theta) + Y_c \bullet W_{wall} \sin(\theta) + L_{base} \bullet F_a \sin(\delta)$$

where

X_c & Y_c *are the centers of mass for the cross section*

$$\Sigma M_{driving} = Y_p \left[\left(F_a - F_a^{'}\right)\cos(\delta)\right] + \left[\frac{2}{3} H \cos(\theta)\right] F_a^{'}$$

where

$$Y_p = \frac{1}{3} H \cos(\theta)$$

Factor of Safety$_{\text{overturning}}$ = $\dfrac{\Sigma M_{resisting}}{\Sigma M_{driving}}$

therefore

$$\frac{X_c \bullet W_{wall} \cos(\theta) + Y_c \bullet W_{wall} \sin(\theta) + L_{base} \bullet F_a \sin(\delta)}{Y_p \left[\left(F_a - F_a^{'}\right)\cos(\delta)\right] + \left[\frac{2}{3} H \cos(\theta)\right] F_a^{'}}$$

Location of Reaction & Toe Pressure

The net moment about the toe

$$M_{net} = \Sigma M_{resisting} - \sum M_{driving}$$

Eccentricity

$$e = \frac{L_{base}}{2} - \frac{M_{net}}{\sum V}$$

The pressure distribuiton under the slab

$$q = \frac{\Sigma V}{A} \pm \frac{M_{net} y}{I}$$

where

$\sum V = F_{normal}$ = the sum of the vertical forces per unit length of the wall

$A = L_{base} \bullet 1ft$ = the area per unit length of the base section

$I = \frac{1}{12} \bullet \frac{1ft}{L_{base}^2}$ = the moment of inertia per unit length of the base section

$y = \frac{L_{base}}{2}$ for maximum and minimum pressures

L_{base} = the length of the base

thus

$$e = \frac{L_{base}}{2} - \frac{\Sigma M_{resisting} - \sum M_{driving}}{F_{normal}}$$

Maximum & Minimum Bearing Pressures

$$q_{\max} = \left[\frac{N}{L_{base}}\right]\left[1 + \frac{6e}{L_{base}}\right]$$

$$q_{\min} = \left[\frac{N}{L_{base}}\right]\left[1 - \frac{6e}{L_{base}}\right]$$

Maximum Bearing Pressure for a Resultant outside the Middle One-third

$$q_{\max} = \left[\frac{4}{3}\right]\left[\frac{N}{L_{base} - 2e}\right] \Rightarrow$$

Factor of Safety$_{\text{bearing}}$ = $\dfrac{q_{ultimate}}{q_{\max}} = \dfrac{q_{allowable} \bullet FOS_{bearing}}{q_{\max}}$

Seismic Equations Used for Enviro-Block™ Stability Calculations

Mononobe-Okabe Seismic Active Earth Force Solution

$$F_{ae} = K_{ae}\gamma_{soil}\left(1-k_v\right)\frac{\left[H\cos(\theta)\right]^2}{2}$$

Where

Active Earth Pressure Coefficient

$$K_{ae} = \frac{\sin^2\left(\phi+\left(\pi-\beta\right)-\theta'\right)}{\cos\theta'\sin^2\left(\pi-\beta\right)\sin\left(\beta-\theta'-\delta\right)\left[1+\sqrt{\frac{\sin\left(\phi+\delta\right)\sin\left(\phi-\theta'-\alpha\right)}{\sin\left(\left(\pi-\beta\right)-\delta-\theta'\right)\sin\left(\alpha+\left(\pi-\beta\right)\right)}}\right]^2}$$

where

$$\theta' = \arctan\left[\frac{k_h}{\left(1-k_v\right)}\right]$$

and

α = angle of the slope behind the wall
β = counter-clockwise rotation of the wall from the horizontal
δ = angle of wall friction
ϕ = internal angle of friction of the backfill
γ_{soil} = density of the soil in the backfill

$$k_{hl} = \frac{\text{horizontal earthquake acceleration component}}{\text{g}}$$

$$k_v = \frac{\text{verticall earthquake acceleration component}}{\text{g}}$$

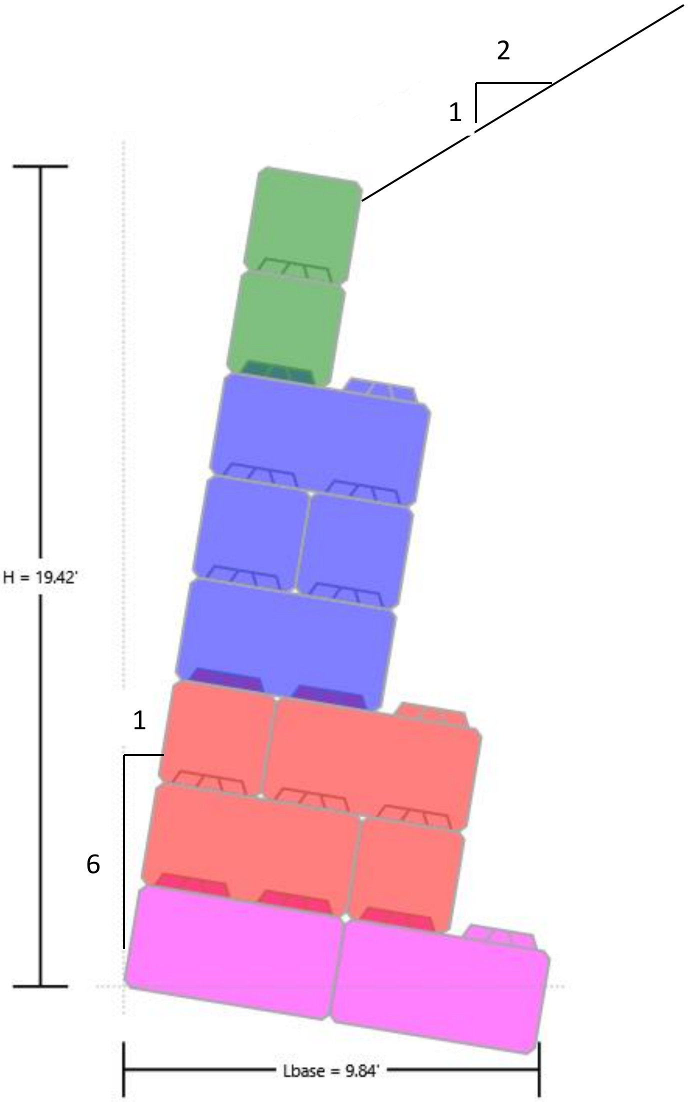
Location of Resultant Force

$Y_{pe} = 0.6H$ (typical)

$$\Delta F_{ae} = F_{ae} - F_a$$

$$\bar{z} = \frac{Y_{pe} \bullet \Delta F_{ae} + Y_p F_a}{P_{ae}}$$

Federal Blvd. Enviro-Block Section A



Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**20.00ft**
Wall Batter	6.00V:1H
Slope Batter	2.00H:1V
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft^3

Surcharge Parameters

$Surcharge_{uniform}$	0.00lb/ft^2
$Surcharge_{strip}$	0.00lb/ft^2
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft^2
$Surcharge_{vertical}$	0.00lb/ft^2

Cross Section

A

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_a	F_a	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
50.66lb/ft^2	0.42	9,857.69lb/ft	3,479.08lb/ft	29,149.98lb/ft	17,871.34lb/ft	9,223.34lb/ft	**1.94**	1.5

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
237,544.17lb	60,652.32lb	**3.92**	2.0

Bearing Summary Analysis

Eccentricity	**-1.07ft**	Middle Third	±1.67ft
Bearing q_{toe}	**1,046.48lb/ft^2**	$Bearing_{allowable}$	4,800.00lb/ft^2
Bearing q_{heel}	**4,783.52lb/ft^2**	$FOS_{bearing}$	**3.00**
Bearing q_{max}	**4,783.52lb/ft^2**	$FOS_{ultimate}$	**3.01**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	26.57º	0.464rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	

Mass Data

γ_{block}	138.00lb/ft^3
γ_{soileq}	120.00lb/ft^3
γ_{eq}	0.00lb/ft^3
W_{wall}	26,025.00lb
½ Blocks	18
½ Earth	14

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	6.42ft
$Y_{centroid}$	8.88ft
L_{base}	10.00ft
Y_p	6.58ft
	0.33H

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill material
φ_{base}	Friction angle of the base

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Project: Federal Blvd Dechannelization
Enviro-Block Retaining Wall

Designed by:	JM	Date:	04/05/2021
Reviewed by:	DMS	Date:	04/06/2021
Approved by:	DMS	Date:	04/06/2021

Stability Calculations for Enviro-Block™ Retaining Wall System

4/6/2021

Wall Parameters

H_{wall}	**20.00ft**
Wall Batter	6.00V:1H
Slope Batter	Flat
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

$Surcharge_{uniform}$	870.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

Seismic A

k_h	0.21
k_v	0.00

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_{ae}	F_{ae}	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
77.56lb/ft²	0.37	15,093.42lb/ft	5,326.93lb/ft	38,506.76lb/ft	23,485.97lb/ft	14,122.15lb/ft	**1.66**	1.125

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
315,329.50lb	118,638.22lb	**2.66**	1.500

Bearing Summary Analysis

Eccentricity	**-0.11ft**	Middle Third	±1.67ft
Bearing q_{toe}	**3,601.23lb/ft²**	$Bearing_{allowable}$	6,800.00lb/ft²
Bearing q_{heel}	**4,100.13lb/ft²**	$FOS_{bearing}$	1.50
Bearing q_{max}	**4,100.13lb/ft²**	$FOS_{ultimate}$	**2.49**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	0.00º	0.000rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	
θ'	11.86º	0.207rad

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	207.00lb/ft³
γ_{eq}	87.00lb/ft³
W_{wall}	33,637.50lb
½ Blocks	18
½ Earth	14

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	6.42ft
$Y_{centroid}$	8.88ft
L_{base}	10.00ft
Y_{pe}	11.84ft
	0.60H
$\bar{\bar{z}}$	8.40ft

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill material
φ_{base}	Friction angle of the base

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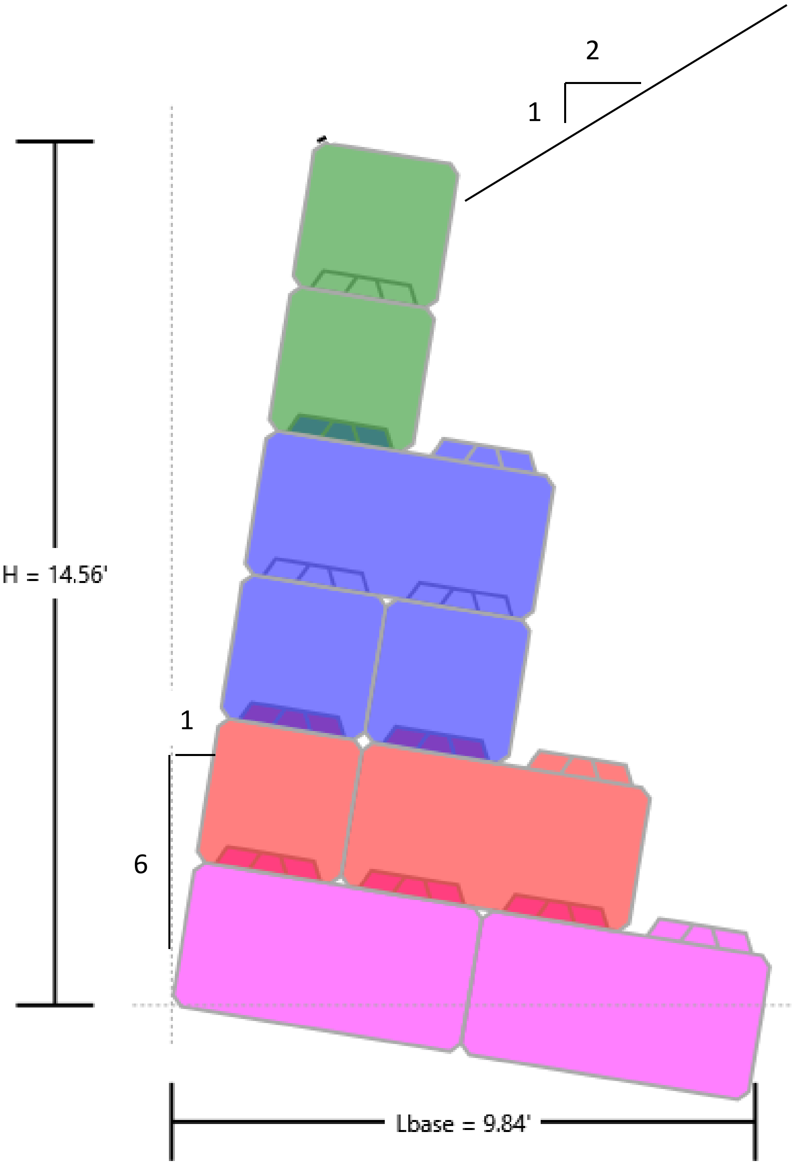
Approved by:	DMS	Date:	04/06/2021

Federal Blvd Enviro-Block Section B



Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**15.00ft**
Wall Batter	6.00V:1H
Slope Batter	2.00H:1V
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

Surcharge Parameters

$Surcharge_{uniform}$	0.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

B

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_a	F_a	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
50.66lb/ft²	0.42	5,544.95lb/ft	1,956.98lb/ft	16,493.96lb/ft	10,114.09lb/ft	5,188.13lb/ft	**1.95**	1.5

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
100,880.49lb	25,587.70lb	**3.94**	2.0

Bearing Summary Analysis

Eccentricity	**-0.81ft**	Middle Third	±1.25ft
Bearing q_{toe}	**765.55lb/ft²**	$Bearing_{allowable}$	4,000.00lb/ft²
Bearing q_{heel}	**3,632.84lb/ft²**	$FOS_{bearing}$	3.00
Bearing q_{max}	**3,632.84lb/ft²**	$FOS_{ultimate}$	**3.30**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	26.57º	0.464rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	120.00lb/ft³
γ_{eq}	0.00lb/ft³
W_{wall}	14,737.50lb
½ Blocks	11
½ Earth	7

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	4.82ft
$Y_{centroid}$	6.67ft
L_{base}	7.50ft
Y_p	4.93ft
	0.33H

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill materia
φ_{base}	Friction angle of the base

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Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**15.00ft**
Wall Batter	6.00V:1H
Slope Batter	Flat
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft^3

$\text{Surcharge}_{uniform}$	660.00lb/ft^2
Surcharge_{strip}	0.00lb/ft^2
$\text{Width}_{surcharge}$	0.00ft
$\text{Dist}_{application}$	0.00ft
$\text{Surcharge}_{horizonta}$	0.00lb/ft^2
$\text{Surcharge}_{vertical}$	0.00lb/ft^2

Cross Section

Seismic B

k_h	0.21
k_v	0.00

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_{ae}	F_{ae}	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
77.94lb/ft^2	0.37	8,531.06lb/ft	3,010.87lb/ft	21,345.47lb/ft	13,009.32lb/ft	7,982.09lb/ft	**1.63**	1.125

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
131,304.24lb	50,391.18lb	**2.61**	1.500

Bearing Summary Analysis

Eccentricity	**-0.04ft**	Middle Third	±1.25ft
Bearing q_{toe}	**2,753.52lb/ft^2**	$\text{Bearing}_{allowable}$	5,300.00lb/ft^2
Bearing q_{heel}	**2,938.60lb/ft^2**	$\text{FOS}_{bearing}$	1.50
Bearing q_{max}	**2,938.60lb/ft^2**	$\text{FOS}_{ultimate}$	**2.71**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	0.00º	0.000rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	
θ'	11.86º	0.207rad

Mass Data

γ_{block}	138.00lb/ft^3
γ_{soileq}	208.00lb/ft^3
γ_{eq}	88.00lb/ft^3
W_{wall}	18,587.50lb
½ Blocks	11
½ Earth	7

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	4.82ft
$Y_{centroid}$	6.67ft
L_{base}	7.50ft
Y_{pe}	8.88ft
	0.60H
$\bar{\bar{z}}$	6.31ft

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill materia
φ_{base}	Friction angle of the base

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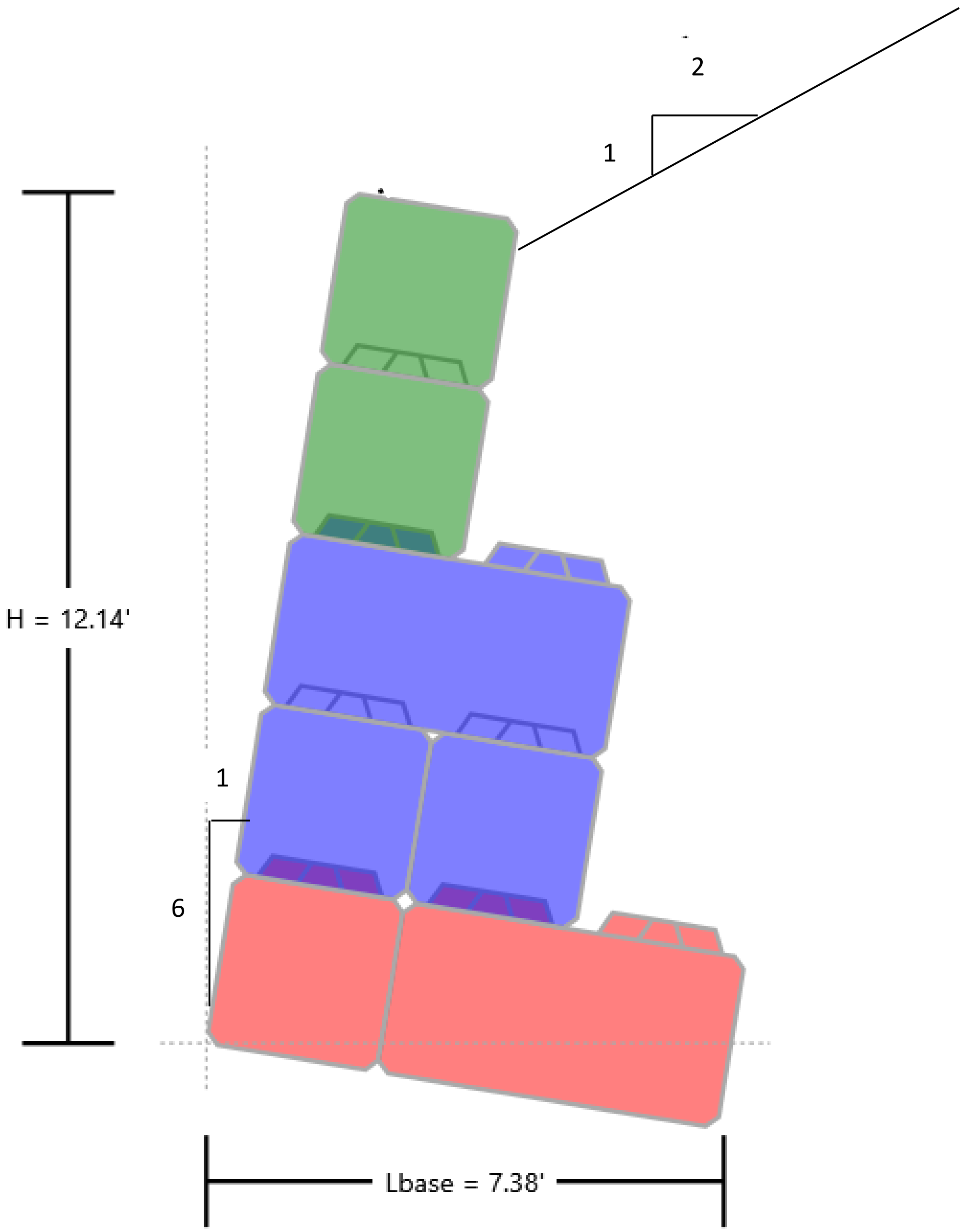
Enviro-Block Retaining Wall

Designed by:	JM	Date:	04/05/2021
Reviewed by:	DMS	Date:	04/06/2021
Approved by:	DMS	Date:	04/06/2021

Federal Blvd Enviro-Block Section C



Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**12.50ft**
Wall Batter	6.00V:1H
Slope Batter	2.00H:1V
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

Surcharge Parameters

$Surcharge_{uniform}$	0.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

C

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_a	F_a	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
50.66lb/ft²	0.42	3,850.66lb/ft	1,359.02lb/ft	13,454.67lb/ft	8,289.96lb/ft	3,602.87lb/ft	2.30	1.5

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
77,027.50lb	14,807.69lb	5.20	2.0

Bearing Summary Analysis

Eccentricity	-0.87ft	Middle Third	±1.25ft
Bearing q_{toe}	539.05lb/ft²	$Bearing_{allowable}$	4,000.00lb/ft²
Bearing q_{heel}	3,048.87lb/ft²	$FOS_{bearing}$	3.00
Bearing q_{max}	3,048.87lb/ft²	$FOS_{ultimate}$	3.94

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	26.57º	0.464rad
θ	9.46º	0.165rad
φ_{base}	0.47µ	

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	120.00lb/ft³
γ_{eq}	0.00lb/ft³
W_{wall}	12,262.50lb
½ Blocks	9
½ Earth	6

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	4.62ft
$Y_{centroid}$	5.45ft
L_{base}	7.50ft
Y_p	4.11ft
	0.33H

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill materia
φ_{base}	Friction angle of the base

REGISTERED PROFESSIONAL ENGINEER
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No. C29666
Exp. 3-31-23
CIVIL
STATE OF CALIFORNIA

Project: Federal Blvd Dechannelization
Enviro-Block Retaining Wall

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Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**12.50ft**
Wall Batter	6.00V:1H
Slope Batter	Flat
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

$Surcharge_{uniform}$	550.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

Seismic C

k_h	0.21
k_v	0.00

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_{ae}	F_{ae}	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
77.94lb/ft²	0.37	5,924.35lb/ft	2,090.88lb/ft	17,441.64lb/ft	10,691.63lb/ft	5,543.12lb/ft	**1.93**	1.125

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
100,502.66lb	29,161.56lb	**3.45**	1.500

Bearing Summary Analysis

Eccentricity	**-0.34ft**	Middle Third	±1.25ft
Bearing q_{toe}	**1,692.49lb/ft²**	$Bearing_{allowable}$	5,300.00lb/ft²
Bearing q_{heel}	**2,958.61lb/ft²**	$FOS_{bearing}$	1.50
Bearing q_{max}	**2,958.61lb/ft²**	$FOS_{ultimate}$	**2.69**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	0.00º	0.000rad
θ	9.46º	0.165rad
φ_{base}	0.47µ	
θ'	11.86º	0.207rad

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	208.00lb/ft³
γ_{eq}	88.00lb/ft³
W_{wall}	15,562.50lb
½ Blocks	9
½ Earth	6

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	4.62ft
$Y_{centroid}$	5.45ft
L_{base}	7.50ft
Y_{pe}	7.40ft
	0.60H
$\bar{\bar{z}}$	5.26ft

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill material
φ_{base}	Friction angle of the base

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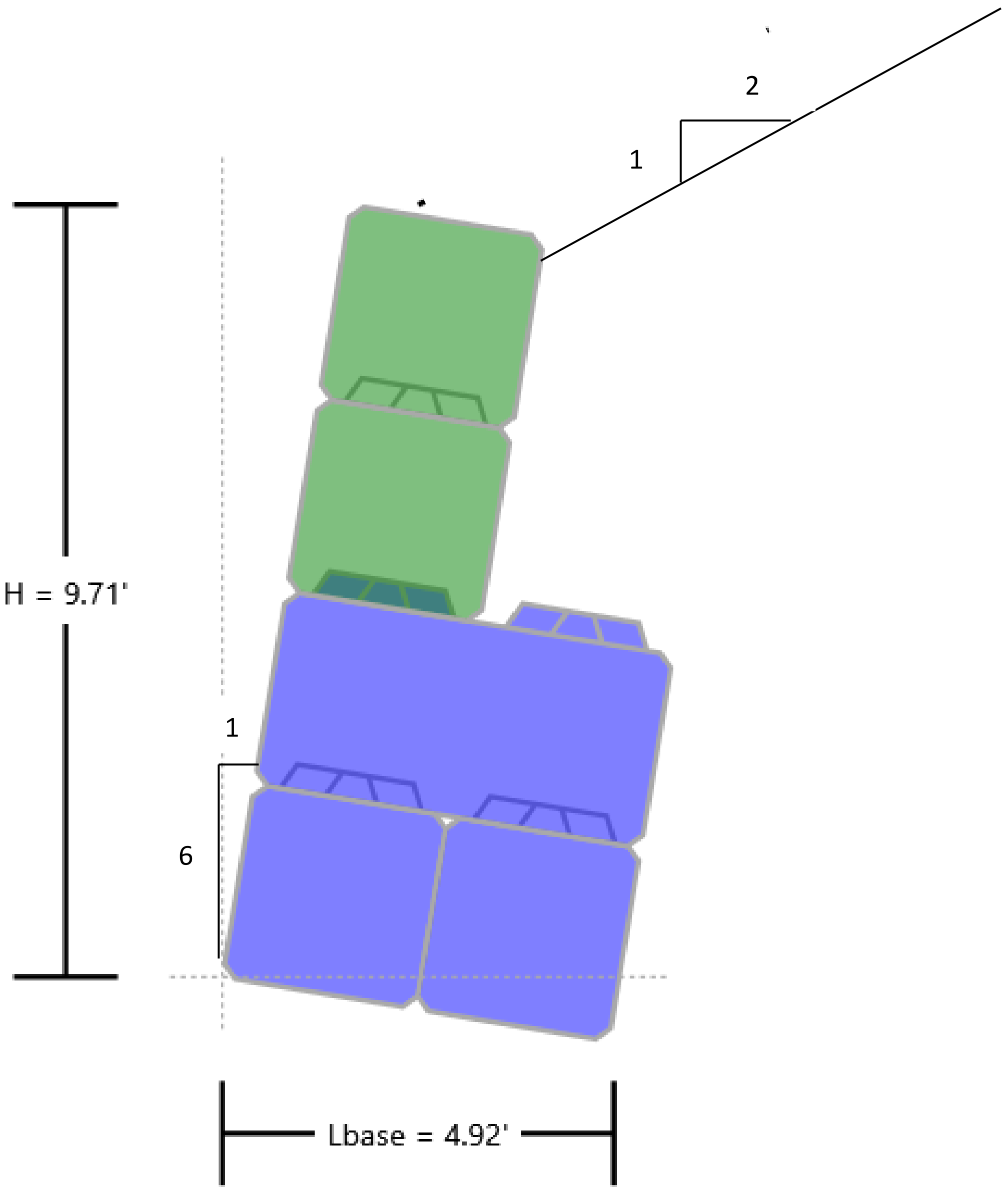
Federal Blvd Enviro-Block Section D



Stability Calculations for Enviro-Block™ Retaining Wall System

4/6/2021

Wall Parameters

H_{wall}	**10.00ft**
Wall Batter	6.00V:1H
Slope Batter	2.00H:1V
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

Surcharge Parameters

$Surcharge_{uniform}$	0.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

D

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_a	F_a	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
50.66lb/ft²	0.42	2,464.42lb/ft	869.77lb/ft	7,453.95lb/ft	4,573.20lb/ft	2,305.84lb/ft	**1.98**	1.5

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
30,510.17lb	7,581.54lb	**4.02**	2.0

Bearing Summary Analysis

Eccentricity	**-0.58ft**	Middle Third	±0.83ft
Bearing q_{toe}	**460.29lb/ft²**	$Bearing_{allowable}$	4,000.00lb/ft²
Bearing q_{heel}	**2,521.29lb/ft²**	$FOS_{bearing}$	3.00
Bearing q_{max}	**2,521.29lb/ft²**	$FOS_{ultimate}$	**4.76**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	26.57º	0.464rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	120.00lb/ft³
γ_{eq}	0.00lb/ft³
W_{wall}	6,675.00lb
½ Blocks	6
½ Earth	2

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	3.23ft
$Y_{centroid}$	4.44ft
L_{base}	5.00ft
Y_p	3.29ft
	0.33H

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill materia
φ_{base}	Friction angle of the base

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Stability Calculations for Enviro-Block™ Retaining Wall System

4/6/2021

Wall Parameters

H_{wall}	**10.00ft**
Wall Batter	6.00V:1H
Slope Batter	Flat
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

$Surcharge_{uniform}$	440.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

Seismic D

k_h	0.21
k_v	0.00

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_{ae}	F_{ae}	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
77.94lb/ft²	0.37	3,791.58lb/ft	1,338.17lb/ft	9,007.38lb/ft	5,478.41lb/ft	3,547.59lb/ft	**1.54**	1.125

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
37,163.38lb	14,930.72lb	**2.49**	1.500

Bearing Summary Analysis

Eccentricity	**0.03ft**	Middle Third	±0.83ft
Bearing q_{toe}	**1,870.07lb/ft²**	$Bearing_{allowable}$	5,300.00lb/ft²
Bearing q_{heel}	**1,732.89lb/ft²**	$FOS_{bearing}$	1.50
Bearing q_{max}	**1,870.07lb/ft²**	$FOS_{ultimate}$	**4.25**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	0.00º	0.000rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	
θ'	11.86º	0.207rad

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	208.00lb/ft³
γ_{eq}	88.00lb/ft³
W_{wall}	7,775.00lb
½ Blocks	6
½ Earth	2

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	3.23ft
$Y_{centroid}$	4.44ft
L_{base}	5.00ft
Y_{pe}	5.92ft
	0.60H
$\bar{\bar{z}}$	4.21ft

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill material
φ_{base}	Friction angle of the base

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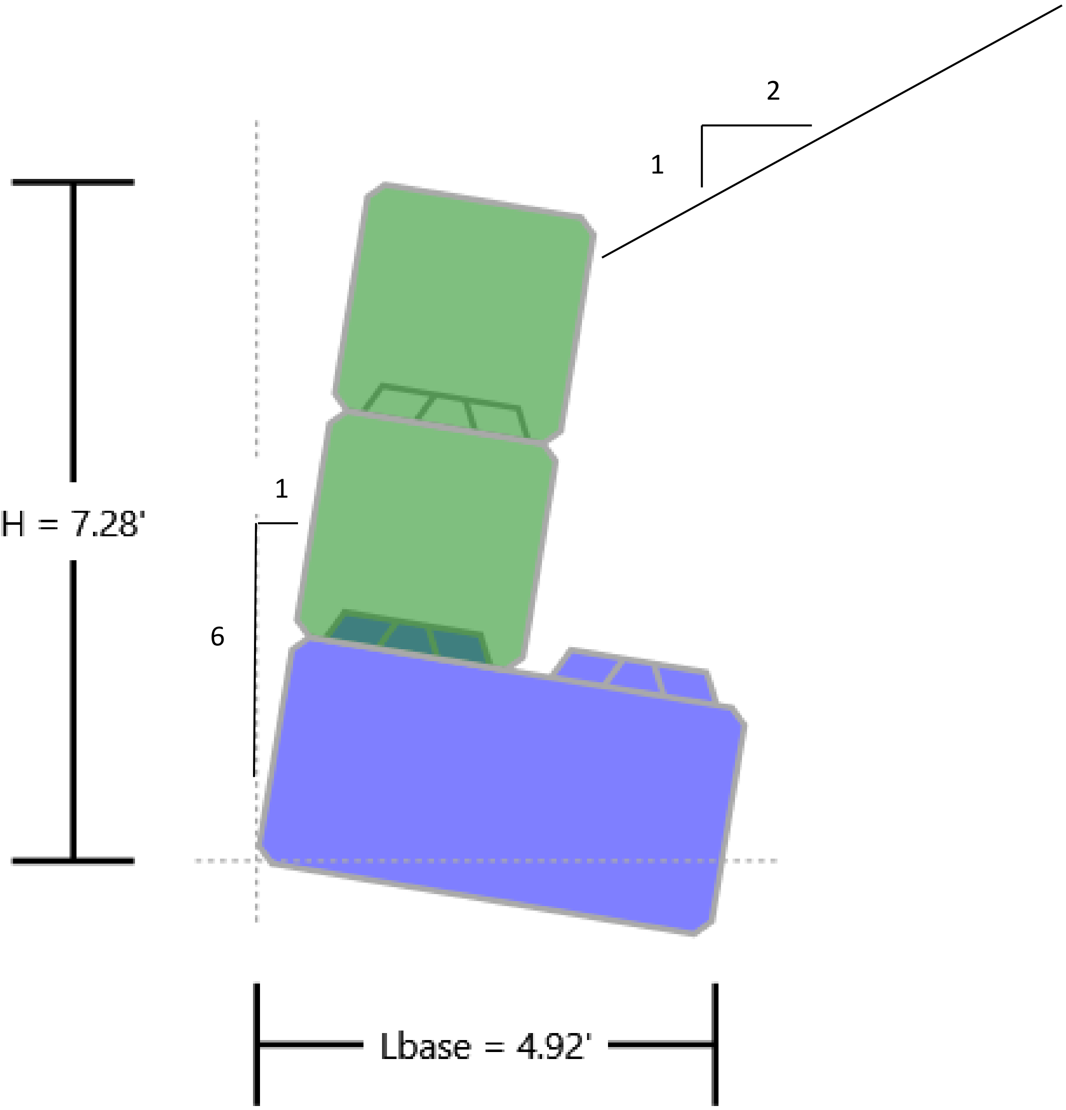
Federal Blvd Enviro-Block Section E



Stability Calculations for Enviro-Block™ Retaining Wall System

4/6/2021

Wall Parameters

H_{wall}	**7.50ft**
Wall Batter	6.00V:1H
Slope Batter	2.00H:1V
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft^3

Surcharge Parameters

$Surcharge_{uniform}$	0.00lb/ft^2
$Surcharge_{strip}$	0.00lb/ft^2
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft^2
$Surcharge_{vertical}$	0.00lb/ft^2

Cross Section

E

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_a	F_a	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
50.66lb/ft^2	0.42	1,386.24lb/ft	489.25lb/ft	5,371.90lb/ft	3,318.73lb/ft	1,297.03lb/ft	**2.56**	1.5

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
19,815.32lb	3,198.46lb	**6.20**	2.0

Bearing Summary Analysis

Eccentricity	**-0.59ft**	Middle Third	±0.83ft
Bearing q_{toe}	**309.47lb/ft^2**	$Bearing_{allowable}$	4,000.00lb/ft^2
Bearing q_{heel}	**1,839.29lb/ft^2**	$FOS_{bearing}$	3.00
Bearing q_{max}	**1,839.29lb/ft^2**	$FOS_{ultimate}$	**6.52**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	26.57º	0.464rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	

Mass Data

γ_{block}	138.00lb/ft^3
γ_{soileq}	120.00lb/ft^3
γ_{eq}	0.00lb/ft^3
W_{wall}	4,950.00lb
½ Blocks	4
½ Earth	2

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	3.02ft
$Y_{centroid}$	3.24ft
L_{base}	5.00ft
Y_p	2.47ft
	0.33H

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill material
φ_{base}	Friction angle of the base

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Approved by:	DMS	Date:	04/06/2021

Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**7.50ft**
Wall Batter	6.00V:1H
Slope Batter	Flat
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

$Surcharge_{uniform}$	330.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

Seismic E

k_h	0.21
k_v	0.00

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_{ae}	F_{ae}	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
77.94lb/ft²	0.37	2,132.77lb/ft	752.72lb/ft	6,720.40lb/ft	4,128.39lb/ft	1,995.52lb/ft	**2.07**	1.125

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
24,992.48lb	6,298.90lb	**3.97**	1.500

Bearing Summary Analysis

Eccentricity	**-0.28ft**	Middle Third	±0.83ft
Bearing q_{toe}	**889.86lb/ft²**	$Bearing_{allowable}$	5,300.00lb/ft²
Bearing q_{heel}	**1,798.30lb/ft²**	$FOS_{bearing}$	1.50
Bearing q_{max}	**1,798.30lb/ft²**	$FOS_{ultimate}$	**4.42**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	0.00º	0.000rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	
θ'	11.86º	0.207rad

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	208.00lb/ft³
γ_{eq}	88.00lb/ft³
W_{wall}	6,050.00lb
½ Blocks	4
½ Earth	2

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	3.02ft
$Y_{centroid}$	3.24ft
L_{base}	5.00ft
Y_{pe}	4.44ft
	0.60H
$\bar{\bar{z}}$	3.16ft

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill materia
φ_{base}	Friction angle of the base

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Enviro-Block Retaining Wall

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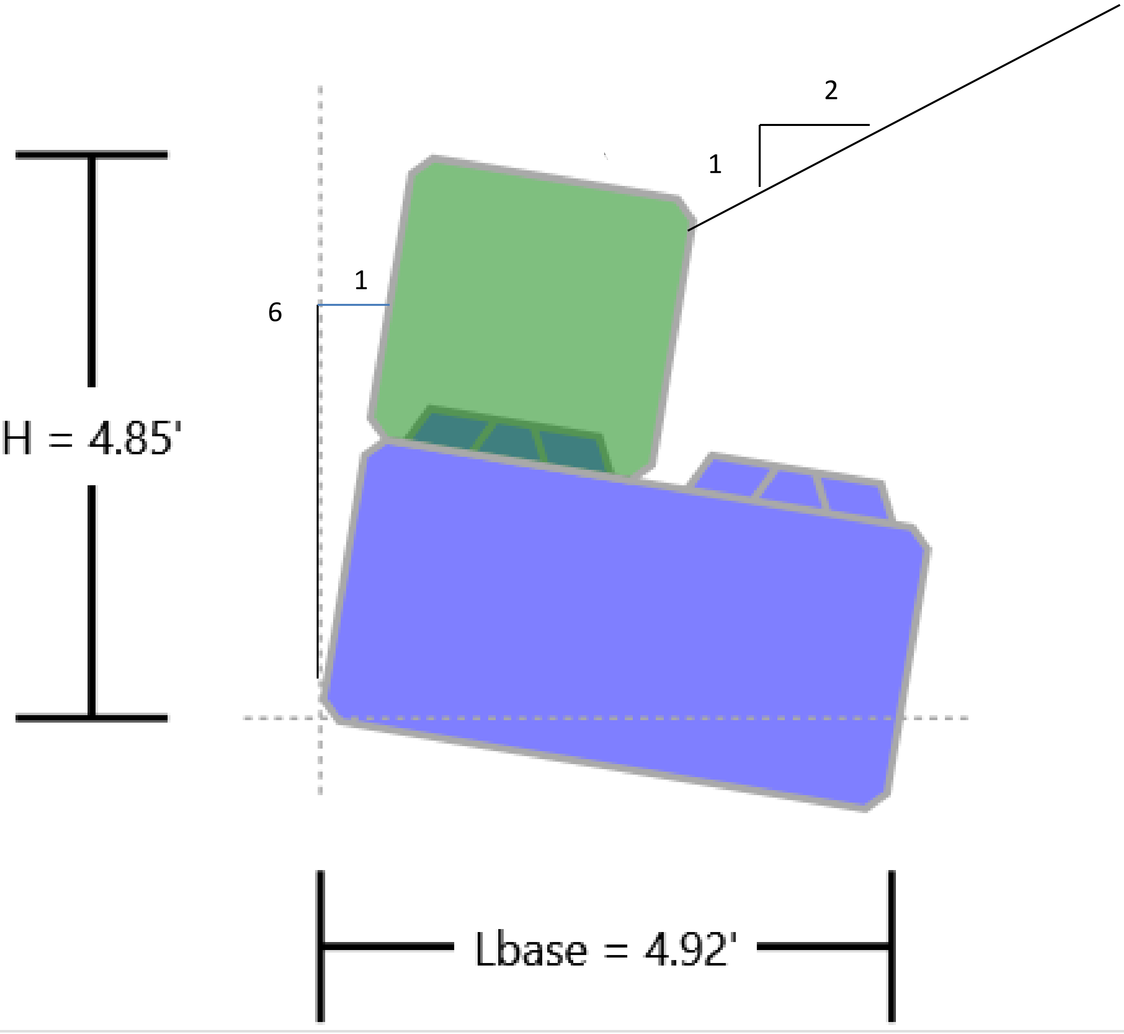
Federal Blvd Enviro-Block Section F



Stability Calculations for Enviro-Block™ Retaining Wall System 4/6/2021

Wall Parameters

H_{wall}	**5.00ft**
Wall Batter	6.00V:1H
Slope Batter	2.00H:1V
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft^3

Surcharge Parameters

$Surcharge_{uniform}$	0.00lb/ft^2
$Surcharge_{strip}$	0.00lb/ft^2
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft^2
$Surcharge_{vertical}$	0.00lb/ft^2

Cross Section

F

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_a	F_a	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
50.66lb/ft^2	0.42	616.11lb/ft	217.44lb/ft	3,509.53lb/ft	2,185.20lb/ft	576.46lb/ft	**3.79**	1.5

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
11,507.40lb	947.69lb	**12.14**	2.0

Bearing Summary Analysis

Eccentricity	**-0.51ft**	Middle Third	±0.83ft
Bearing q_{toe}	**273.30lb/ft^2**	$Bearing_{allowable}$	4,000.00lb/ft^2
Bearing q_{heel}	**1,130.52lb/ft^2**	$FOS_{bearing}$	3.00
Bearing q_{max}	**1,130.52lb/ft^2**	$FOS_{ultimate}$	**10.61**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	26.57º	0.464rad
θ	9.46º	0.165rad
φ_{base}	0.47μ	

Mass Data

γ_{block}	138.00lb/ft^3
γ_{soileq}	120.00lb/ft^3
γ_{eq}	0.00lb/ft^3
W_{wall}	3,337.50lb
½ Blocks	3
½ Earth	1

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	2.83ft
$Y_{centroid}$	2.02ft
L_{base}	5.00ft
Y_p	1.64ft
	0.33H

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill material
φ_{base}	Friction angle of the base

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Approved by: DMS Date: 04/06/2021

Stability Calculations for Enviro-Block™ Retaining Wall System 4/8/2021

Wall Parameters

H_{wall}	**5.00ft**
Wall Batter	6.00V:1H
Slope Batter	Flat
$\varphi_{backfill}$	31.00º
φ_{base}	25.00º
γ_{soil}	120.00lb/ft³

$Surcharge_{uniform}$	220.00lb/ft²
$Surcharge_{strip}$	0.00lb/ft²
$Width_{surcharge}$	0.00ft
$Dist_{application}$	0.00ft
$Surcharge_{horizonta}$	0.00lb/ft²
$Surcharge_{vertical}$	0.00lb/ft²

Cross Section

Seismic F

k_h	0.21
k_v	0.00

delta = 2/3

Sliding Analysis Summary

Equivalent Fluid Pressure	*Earth Pressure Coefficient*	*Active Earth Pressure*	*Earth Friction on Wall*	*Reaction at Base*	*Resisting Force*	*Driving Force*	*Factor of Safety*	
EFP	K_{ae}	F_{ae}	F_{fwall}	F_{nbase}	$\Sigma F_{resisting}$	$\Sigma F_{driving}$	Sliding	CalTrans Spec
77.94lb/ft²	0.37	947.90lb/ft	334.54lb/ft	4,169.15lb/ft	2,583.21lb/ft	886.90lb/ft	**2.91**	1.125

Overturning Analysis Summary

Moment Resisting	*Moment Driving*	*Factor of Safety*	
$\Sigma M_{resisting}$	$\Sigma M_{driving}$	Overturning	CalTrans Spec
13,810.08lb	1,866.34lb	**7.40**	1.500

Bearing Summary Analysis

Eccentricity	**-0.36ft**	Middle Third	±0.83ft
Bearing q_{toe}	**468.82lb/ft²**	$Bearing_{allowable}$	5,300.00lb/ft²
Bearing q_{heel}	**1,198.84lb/ft²**	$FOS_{bearing}$	1.50
Bearing q_{max}	**1,198.84lb/ft²**	$FOS_{ultimate}$	**6.63**

Angle Data

β	80.54º	1.406rad
δ	20.67º	0.361rad
α	0.00º	0.000rad
θ	9.46º	0.165rad
φ_{base}	0.47µ	
θ'	11.86º	0.207rad

Mass Data

γ_{block}	138.00lb/ft³
γ_{soileq}	208.00lb/ft³
γ_{eq}	88.00lb/ft³
W_{wall}	3,887.50lb
½ Blocks	3
½ Earth	1

Additional Equivalents

F'_a	0.00lb/ft
H'_{wall}	0.00ft
W'_{wall}	0.00lb
F_p	0.00lb/ft

Moments

$X_{centroid}$	2.83ft
$Y_{centroid}$	2.02ft
L_{base}	5.00ft
Y_{pe}	2.96ft
	0.60H
$\bar{\bar{z}}$	2.10ft

Legend

β	Rotation of wall from the horizontal
δ	Angle of earth pressure, wall friction
α	Angle of the slope behind the wall
θ	Rotation of wall from the vertical
φ	Internal friction of the backfill materia
φ_{base}	Friction angle of the base

REGISTERED PROFESSIONAL ENGINEER
DAVID M. SANDERFER
No. C29666
Exp. 3-31-23
CIVIL
STATE OF CALIFORNIA

Project: Federal Blvd Dechannelization
Enviro-Block Retaining Wall

Designed by:	JM	Date:	04/05/2021
Reviewed by:	DMS	Date:	04/06/2021
Approved by:	DMS	Date:	04/06/2021

H - VCP Encasement Calculation

Bookmark Page

Project Details

Name: 388-07 (Federal Blvd.)
Location:
Engineer:
Prepared by:
Manhole from:
To:
Project Notes:

Soil Details

Soil Type: GW-Well Graded Gravel
Soil Weight: 124 (85-150 lbs./ft^3)

Per Table 4-1 NCPI Engineering Manual

Trench Details

Pipe Size: 8 in.
Pipe Strength:
ASTM C700 (2200) lbs/LF
(minimum 3-edge bearing strength)
Trench Type:

● Constant Width and Depth
○ Variable Width/Constant Depth
○ Constant Width/Variable Depth

Trench Width: 24 (in.)
Trench Depth: 2
(To the nearest ½ foot over the top of the pipe (in ft.))

Live Load Data

Applicable at cover depths of 8 feet or less
Live Load ☑ Enable Live Load Calculations

Wheel Load: 50000 lbs.
(10,000-60,000 lbs.)

Impact Factor: Highway (1.5)

Standard	Axle Load	Wheel Load
AASHTO H-15 and HS-15	24,000 lbs.	12,000 lbs.
AASHTO H-20 and HS-20	32,000 lbs.	16,000 lbs.
AASHTO H-25 and HS-25	40,000 lbs.	20,000 lbs.

Assume medium size tracked excavator (e.g. CAT 320)

- Approximate operating weight = 50,000 lb
- 2 tracks ⇒ 25,000 lb per track
- Assume worst case 50,000 lb acts as point load or wheel load (conservative assumption)

⇒ use wheel load = 50,000 lb

Get Results

Load Factors

For each bedding class shown in ASTM C 12, a load factor is provided. This factor is the amount of structural enhancement the bedding will give as a multiplier of the specified 3-edge bearing strength of the pipe. The bearing strength is multiplied by the appropriate load factor to give the load bearing capacity of the installed pipe. (The load bearing capacity is also referred to as field supporting strength).

Example:

Class C Bedding = Load Factor of 1.5

8" Extra Strength VCP = 2200 Bearing Strength (the minimum per ASTM C700)

Load Factor x Minimum Pipe Bearing Strength = Field Supporting Strength

1.5 X 2200 = 3300 Load Bearing Capacity

Safety Factor

The safety factor is the result of dividing the load bearing capacity of the installed pipe by the calculated backfill load on the pipe. A design safety factor within the range of 1.0 to 1.5 is desirable.

Example:

3300 Load Bearing Capacity (from Load Factor example)

2540 Trench Load (a function of soil type, soil weight, trench depth, and width)

Field Supporting Strength / Backfill Load = Safety Factor

3300 / 2540 = 1.3 Safety Factor

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Trench Load Results
Constant Width/Constant Depth

www.ncpi.org/ncpi-toolbox.html
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TRENCH LOAD AND SAFETY FACTORS
Calculations Using ASTM C12 Bedding Factors

Project: 388-07 (Federal Blvd.)
Location:

Engineer:

These results are based on the Marston equations for soil loads on rigid conduits. This tool provides the user with design options that are considered sound. Design and construction standards vary throughout the country. It is recognized that there may be other equally satisfactory methods.

Prepared by:
Pipe Standard Specified: **ASTM C700 Extra Strength**
Minimum Strength (3-edge bearing): **2200 lbs/LF**
Soil Weight: **124 lbs./cu. ft.**
Soil Type: **GW-Well Graded Gravel**
Kμ' Used: **0.165**
Total Load at Specified Width: **5,562 lbs./lin. ft.**
Earth Load at Transition[2]: **312 lbs./lin. ft.**

Pipe Size: **8 in.**
Specified Trench Width: **24 in.**
Trench Depth: **2' over top of pipe**
Live Load:**50000 lbs.**
Impact Factor: **1.5**
Transmitted Live Load: **5,250 lbs./lin. ft.**
Transition Width: **19 in.**

Project Notes:

	Load Factor	Safety Factor	SF @ Transition
Class D	1.1	0.44	0.44
Class C	1.5	0.59	0.59
Class B	1.9	0.75	0.75
Crushed Stone Encasement	2.2	0.87	0.87
Concrete Cradle	3.4	1.34	1.34
CLSM[1]	2.8	1.11	1.11

Note 1: When CLSM bedding is utilized, consideration should be given to the use of the modified Marston Equation for computation of backfill load. The results above are solely based on the conventional Marston Equation which are extremely conservative when CLSM bedding is properly constructed. See chapter 4 of the NCPI Engineering Manual for more information.

Note 2: Transition Width represents the trench width where backfill loads reach a maximum and are equal to embankment load. Further widening of the trench beyond this width will not affect the backfill load.

National Clay Pipe Institute - N6369 US Hwy 12, Suite A - Elkhorn, WI 53121, USA - 262/742-2904 - www.ncpi.org

VCP sewer encased in concrete ⇒ use Concrete Cradle values

⇒ Safety Factor = 1.34
NCPI recommends safety factor of 1.0 to 1.5 ⇒ OK