



# SPRINGDALE Utah

## **Memorandum**

**To:** Planning Commission

**From:** Niall Connolly, Principal Planner

**Date:** June 14th 2024

**Re:** Erosion Hazard Permit - George A Barker River Park to 1599 Zion Park Blvd

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### **Introduction**

In 2019, the Town adopted the Virgin River Management Plan. In preparing this plan, it emerged that erosion from the river could potentially pose a risk to some of Springdale's key infrastructure just north of the George A Barker River Park. This includes buried utility lines, the sidewalk and cycle lane and - significantly, State Route 9. This risk is most acute where the river bends immediately to the north of the River Park (see aerial photo below). Without intervention, SR-9 and this other infrastructure will continue to be at risk from erosion. Given that it is the only road through town and is the principal route to Zion National Park, damage to SR-9 would have severe consequences. This risk was further substantiated by an Erosion Hazard Risk Assessment which Rosenberg completed for the Town in 2021.



**Figure 1. Aerial View showing bend in the North Fork of the Virgin River**

Arising from this, the Town applied for, and was awarded a grant from FEMA under the Building Resilient Infrastructure and Communities (BRIC) program. This grant will partially fund the design and construction of erosion protection at this location. Through a competitive Request for Proposals process, the Town selected Rosenberg Engineering to design and oversee the permitting and construction of the project.

### The Proposal

The proposal consists of rock rip-rap erosion protection with willow bundles along the west side of the river. It extends from the northern pedestrian bridge to the northern boundary of the property at 1599 Zion Park Blvd, as shown in the diagram below.

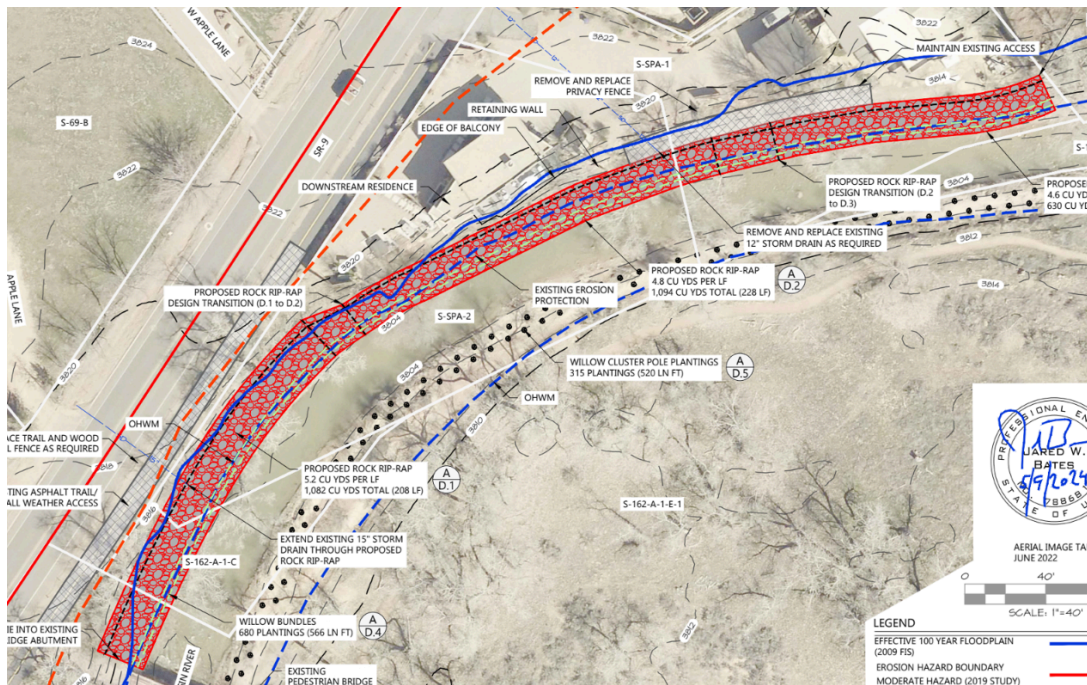
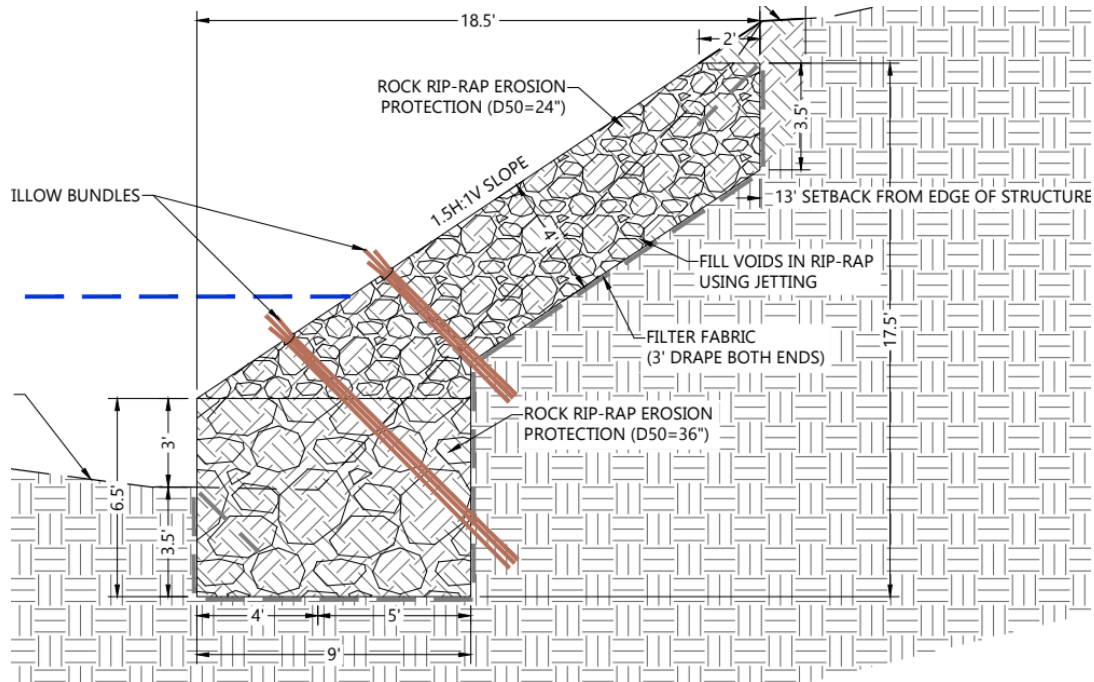


Figure 2. Diagram showing the extent of erosion protection proposed in plan



**Figure 3. Cross section of the erosion protection showing rip-rap and willow bundles**

The entire length of the proposed erosion protection is 573 ft. The design proposes three separate sections of the erosion protection, to accommodate the different site constraints along the length of the river. The southernmost section is 208 ft in length, and consists of a 24.5 ft x 19.5 ft section of rip-rap. The next section is 228 ft in length, and consists of a 18.5 ft x 17.5 ft section of rip-rap. The third length is 137 ft and consists of a 19 ft x 15ft section of rip-rap.

### **Other Regulatory Processes**

The project required a joint Stream Alteration permit from the Utah State Engineer’s Office and the US Army Corps of Engineers. This permit was approved in February 2024. This permit addresses the potential environmental, cultural and construction phase impacts on the river.

The project also requires a floodplain development permit and an excavation permit from the Town. These permits ensure that there is no increase in flood risk to property as a result of the proposed improvements, and that all grading complies with the Town’s grading ordinance. Floodplain Development Permits and Excavation Permits are generally approved by staff rather than the Planning Commission.

### **Erosion Risk at Adjoining Property - 1559 and 1599 Zion Park Blvd**

During the design process, the Town was approached by the Spainhowers, who own the neighboring properties at 1559 and 1599 Zion Park Blvd. The Spainhowers expressed concern about the risk of erosion to their properties, and wished to see if the project could be expanded to include protection to their properties also. The Town agreed to this, on condition that the Spainhower’s pay for the design and construction on their part of the project. The project has proceeded on that basis.



**Figure 4. Aerial view of the Spainhower's property**

Rosenberg carried out the design work for the Spainhower's property also. For permitting purposes, the State and USACE required the Town and the Spainhower's plans to be considered as a single project. The Town has also considered all of the improvements as one single project for this permit application.

**Engineering Review**

This erosion permit application was reviewed by the Town Engineer (Sunrise Engineering). Sunrise Engineering provided their comments to the Town by a letter dated May 21st, 2024. The review did not uncover any significant issues with the proposal, but identified some points to be addressed. Rosenberg provided a response to Sunrise, and made some associated updates to the Erosion Hazard Assessment. Sunrise then confirmed that all relevant points had been addressed, and that the proposal complies with the Town's Erosion Hazard Zone ordinance.

The appendices of this report contain the final, updated Erosion Hazard Assessment, as well as the correspondence with Sunrise Engineering and Rosenberg Associates.

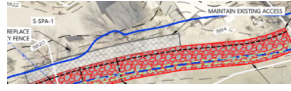
**Staff Analysis**

<i>Standard</i>	<i>Requirement</i>	<i>Proposal</i>	<i>Comments</i>
<i>Floodplain</i>	An erosion hazard	The erosion study	Complies.

	<p>permit application must include an engineering analysis. This must identify potential impacts on adjacent properties and ensure that no increases to base flood elevations of more than one foot occur within the property limits and no increases may occur on adjacent properties.</p>	<p>included a HEC-RAS hydraulic model. This determined that there would be no increase to base flood elevation on adjacent property, but there would be an increase of 0.1 ft on the property (i.e. less than 1 ft).</p>	<p>The applicant will also be required to apply for a floodplain development permit prior to construction.</p>
<p><i>Stream Stability Impacts</i></p>	<p>Engineering analyses must be submitted to document all impacts on adjacent properties due to the proposed land disturbance activities. It is the applicant's responsibility to demonstrate that any such impacts are minimal, justified, and consistent with the goals and objectives of the Virgin River Management Plan, and will not cause adverse or detrimental conditions on adjacent, upstream, or downstream properties.</p>	<p>The analysis provided demonstrates that no impacts to stream stability or sediment transport are anticipated.</p>	<p>Complies.</p>

<p><i>Erosion Protection Improvements</i></p>	<p>Bioengineering techniques combining natural vegetation and live materials to provide a stable streambank as envisioned by the Virgin River Management Plan (VRMP) are required for all erosion protection improvements, unless an engineering analysis demonstrates such techniques are not feasible. All erosion protection improvements shall be as minimally impactful to the natural function and appearance of the river system and riparian area as possible. Structural erosion protection improvements such as rock riprap, concrete or gabion structures, etc. may only be used to protect existing or planned structures and infrastructure located within the high risk erosion hazard zone, and only after the Town Engineer has validated an applicant's engineering analysis documenting bioengineering is not a feasible option.</p>	<p>The proposed erosion protection is designed to be constructed of rip rap. Rip rap is not considered bioengineering.</p> <p>The study concluded that the sole use of bioengineering techniques was insufficient due to the high velocities of the river. At this particular location, the infrastructure that needs to be protected is extremely close to the river channel. Further, the existing river banks are already oversteepened due to historic encroachment on the river at this location. This leaves only a narrow width between the river and the infrastructure in which to build the erosion protection. The infrastructure to be protected includes SR-9 and the Town's utility lines. Loss of this infrastructure would have severe consequences.</p> <p>Additionally, the establishment of vegetation above the low flow channel was determined to be a further obstacle to relying solely on bioengineering techniques.</p>	<p>Complies.</p>
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		<p>The rip rap is proposed to be supplemented with willow bundle planting (see section 3.3 of the Erosion Hazard Assessment). Willow planting is also proposed on the opposite bank, as well as additional revegetation with native plant species.</p>	
<i>Materials</i>	<p>Where possible and feasible, stone for rip rap and gabion baskets shall resemble stone naturally found in Springdale in appearance.</p>	<p>The proposed type of rock is not specified in the report. Local sandstone may not be the most appropriate material from an engineering perspective.</p>	<p>The planning commission may wish to apply a condition requiring stone resembling that naturally occurring in Springdale, if feasible from an engineering perspective.</p>
<i>Maintenance</i>	<p>The owner of property where erosion protection improvements are located shall inspect all erosion protection improvements at least annually and immediately after major flooding events to assess damage and determine if repairs are necessary. The Town of Springdale has the right to inspect all erosion protection improvements as often as the Town deems necessary. If the Town's inspection reveals necessary repairs to</p>	<p>Because the river is tight against SR-9 and the Spainhower's property, there is not space to construct a new, dedicated, all weather access for maintenance.</p> <p>However, access for maintenance is still possible. For the Town owned section and the southern portion of 1559 Zion Park Blvd, access will be available from the Town sidewalk and cycle lane.</p> <p>For the northern portion of 1559, and</p>	<p>Complies.</p> <p>A perpetual private easement should be recorded to provide unobstructed access for inspection and maintenance at 1559 and 1599 Zion Park Blvd. The planning commission may wish to apply a condition to this effect.</p>

	<p>the erosion protection improvements, the property owner shall make the required repairs as soon as feasibly possible after being noticed in writing by the Town. All proposed erosion protection measures shall require a perpetual private easement to be recorded providing unobstructed access for inspection and maintenance of the erosion protection improvements. The costs to inspect, repair and maintain these improvements shall be the sole responsibility of the applicant or property owner. Required maintenance and repairs shall be completed within a reasonable time at no cost to the Town of Springdale.</p>	<p>for 1599, an existing access area is identified as hatched gray on the plan:</p>  <p>The Erosion Hazard Assessment recommends that this area remains accessible.</p>	
<p><i>Revegetation</i></p>	<p>Any proposed disturbance to existing vegetation on the riverbank or within the floodplain must be mitigated by replacing the disturbed vegetation with native riparian plants in accordance with the approved plant list. The replacement vegetation shall be selected to best enhance the</p>	<p>The rock rip-rap erosion protection is designed to be interspersed with Willow Bundles.</p> <p>The Erosion Hazard Assessment identifies the following species for revegetation:</p> <ul style="list-style-type: none"> <li>● Gooding Willow</li> <li>● Coyote Willow</li> </ul>	<p>Complies</p>

	<p>natural function of the river system (e.g. flexible species closest to the river, large woody vegetation farther from the river on upper flood terraces). The engineering analysis shall include a section describing the required vegetation mitigation and planting requirements</p>	<ul style="list-style-type: none"> <li>● Freemont Cottonwood</li> </ul>	
<p><i>Statement of methodologies and findings</i></p>	<p>The analysis must include a summary of the methodologies used to support the impact analysis. The engineering analysis and findings shall be summarized in an engineering report including all assumptions, computations and other documentation supporting the analyses and conclusions. The report shall include the engineer's professional opinion that when the land disturbance activities and mitigation measures, if any, are implemented, the proposed land disturbance will not adversely affect reaches or properties upstream, downstream, and across the river from the proposed project. The report must also</p>	<p>The erosion hazard assessment includes appendices which support the engineer's opinion. This has been reviewed by the Town Engineer.</p>	<p>Complies.</p>

	include the engineer's opinion that the proposed land disturbance minimizes the risk of flood and erosion damage to adjacent properties and the watercourse.		
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**Planning Commission Action**

The Planning Commission should review the proposed Erosion Hazard Zone Permit to determine if it complies with the applicable standards in the Town Ordinance. Staff recommends the Commission specifically consider the following:

- Does the proposed development meet all the requirements of the erosion hazard zone ordinance (Section 10-13E of the Town Code)?

**Sample Motion Language**

The Commission may refer to the following sample language when making a motion on the application:

*The Planning Commission **approves/denies** the proposed Erosion Hazard Zone Permit for the Streambank Protection Project at the George A Barker River Park, 1559 Zion Park Blvd and 1599 Zion Park Blvd, as discussed in the Commission meeting on June 19, 2024. This motion is based on the following findings:*

[LIST FINDINGS]

If making a motion for approval the Commission may wish to consider the following conditions of approval:

1. Any vegetation in the riparian zone that is disturbed during construction must be replaced with appropriate revegetation, using plants native to Zion Canyon.
2. The owner of the property at 1559 and 1599 Zion Park Blvd must record a perpetual private easement to allow for unobstructed access for maintenance and inspection purposes.
3. The applicant must obtain a floodplain development permit and an excavation permit from the Town prior to construction.
4. Where feasible from an engineering perspective, the rip rap must be constructed of stone occurring naturally in the Springdale area.

**Appendices**

1. Erosion Hazard Assessment - including erosion protection plans and appendices
2. Review letter from Sunrise Engineering
3. Response to Sunrise review from Rosenberg Associates

**Appendix 1: Erosion Hazard Assessment - including erosion protection plans and appendices**

# EROSION HAZARD ASSESSMENT

Zion Park Boulevard Erosion Protection  
Springdale, Utah



Prepared For:

**Town of Springdale**  
118 Lion Boulevard  
Springdale, Utah 84767  
(435) 772-3434

**Rosenberg Associates**  
Project No: 11545-23-006  
May 21, 2024



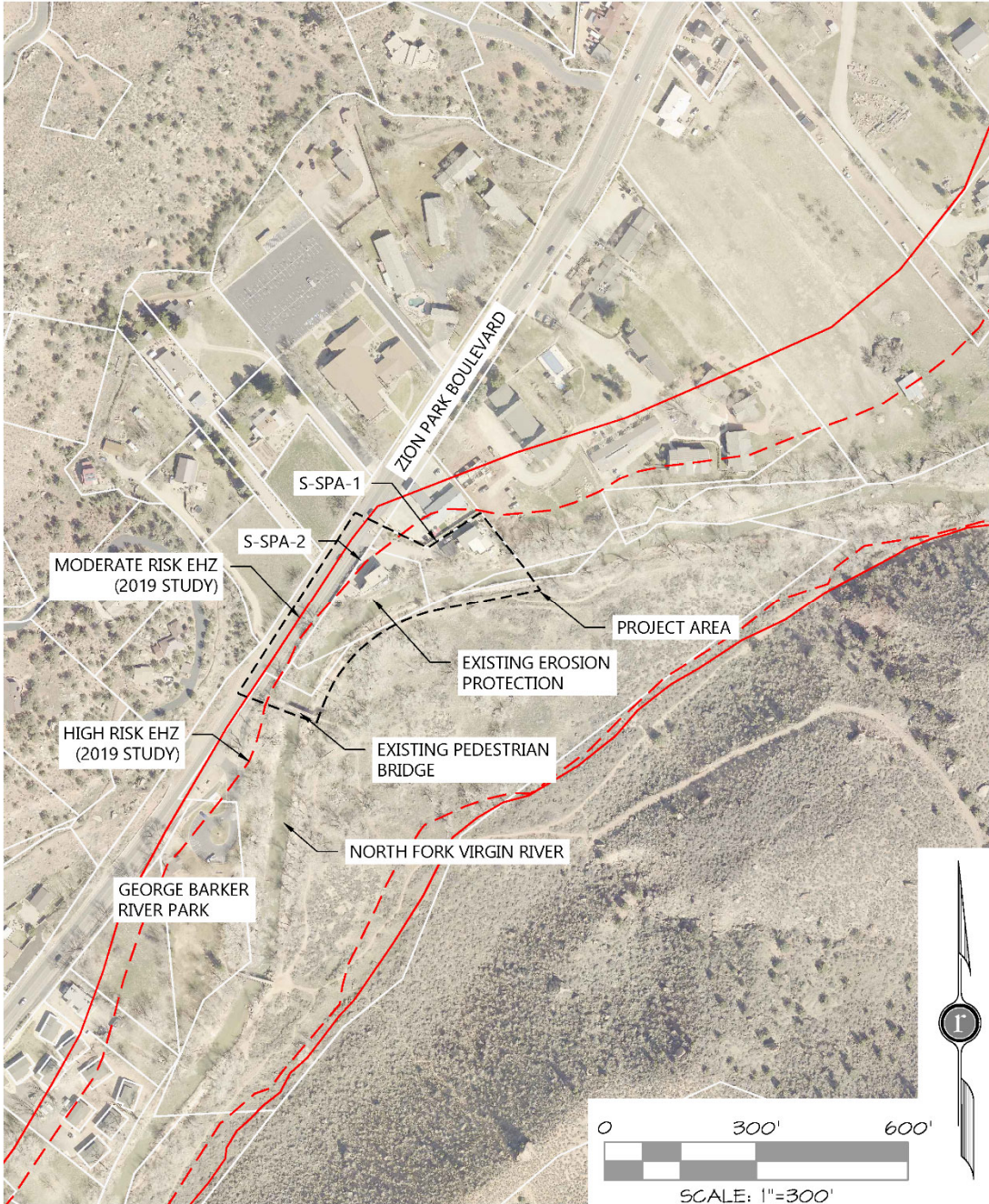
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# 1.0 INTRODUCTION

## 1.1 PROJECT OVERVIEW & LOCATION

The project area covers approximately 2.3 acres along the right (west) overbank of the North Fork of the Virgin River, just upstream of George Barker River Park in Springdale, UT, located within Section 32, Township 41 South, Range 10 West, Salt Lake Base and Meridian. The project area is bounded by Zion Park Boulevard to the west, municipally owned land to the south and east, and private land owned by others to the north. Refer to *Figure 1 – Vicinity Map*.

**Figure 1 – Vicinity Map**



The Erosion Hazard Zone (EHZ) consists of areas adjacent to the river channel likely to suffer flood related damage by a typical series of flood events over a 60 year period, plus the erosion caused by a single 100 year flood event. The EHZ also includes areas prone to natural channel movement due to geomorphic processes such as meander migration or channel avulsion. It is important to recognize an EHZ is not a “no build” zone, but it serves notice to landowners of the inherent risk that should be addressed through engineering design, insurance, appropriate land uses or avoidance. The Town of Springdale requires an Erosion Hazard Assessment be completed as part of any proposed development or building permits issued on properties impacted by the established EHZ.

An *Erosion Hazard Risk Assessment* (Reference 1) of a portion of the project area was previously completed by Rosenberg Associates, for the Town of Springdale, in order to estimate the lateral migration distances of the North Fork of the Virgin River during the 100 year, 50 year, and 10 year flood events. As the finding of the study concluded that Zion Park Boulevard and associated utilities were at risk, this analysis served as the basis for the Building Resilient Infrastructure and Communities (BRIC) grant application that was applied for and awarded to the Town. Funding secured through the BRIC grant is intended to be used to protect the right (west) overbank of the North Fork of the Virgin River adjacent to Zion Park Boulevard. As part of a larger effort by the Town to ensure erosion hazards are mitigated within this reach of the North Fork of the Virgin River, the initial study area was expanded to include the residential lots located upstream. The current project area now includes parcels S-SPA-1 and S-SPA-2 (developed residential lots), as well as the initial project area. Any work completed outside of the scope covered in the BRIC grant award is to be funded by the private property owner.

The project area is located within the HREHZ (High Risk Erosion Hazard Zone), and MREHZ (Moderate Risk Erosion Hazard Zone) as defined by the *Draft Erosion Hazard Delineation* (Reference 2). The purpose of this document is to assess the erosion hazard risks associated with the North Fork of the Virgin River within the project area, present recommendations to mitigate the risk of lateral erosion damage to existing residential infrastructure and Zion Park Boulevard, and to ensure proposed improvements associated with the project do not increase the risk of erosion to adjacent properties.

## **2.0 SITE INVESTIGATION**

### **2.1 SITE CONDITIONS**

The study reach of the North Fork of the Virgin River extends approximately 570 feet upstream of the pedestrian bridge located at the northern end of George Barker River Park. At the downstream end of the study reach, the low flow channel of the river consists of a wide, sandy bed with occasional cobbles and boulders. Along the left (east) overbank, the gently sloping active floodplain is sparsely vegetated with coyote willows, mule fat, and young cottonwoods. The low terrace is vegetated with mature cottonwoods and various bunchgrasses. Along the right (west) overbank, the active floodplain is narrow and steep (1.5:1) and is located along the outside of a major river bend. Immediately adjacent to the low flow channel, the banks are almost vertical, with cottonwoods and other vegetation being undercut in a few locations, exposing bare soil. The active floodplain is moderately vegetated with coyote willows, mule fat, mature cottonwoods, and rabbitbrush. These species provide some resistance to erosion and

are likely responsible for preventing large scale vertical cut banks from forming previously. It is assumed that during the construction of Zion Park Boulevard and the associated utility improvements, the North Fork of the Virgin River was heavily encroached upon.

Adjacent to the downstream residence, the conditions (slope, vegetative cover, sediment texture and relief) of the low flow channel, active floodplain, and low terraces are similar to the downstream conditions. The existing residential infrastructure is located approximately 15' away from the edge of the low flow channel, and heavily encroached upon the North Fork of the Virgin River during construction. Existing erosion protection is present along the right (west) overbank and extends from the flowline to the top of the bank. This erosion protection has previously been damaged by high flow events, with a few of the sandstone boulders having been washed away and undercut. The presence of the existing erosion protection and vegetation is likely responsible for preventing large scale vertical cutbanks from forming previously.

Adjacent to the upstream residence, the low flow channel becomes relatively more incised. The existing residential infrastructure is located approximately 28' away from the edge of the low flow channel. The active floodplain along the left (east) overbank narrows and steepens to a 2:1 slope, and is moderately vegetated with coyote willows, Russian Olive, tamarisk, rabbitbrush and mule fat. The low terrace is vegetated with mature cottonwoods and various bunchgrasses. Along the right (west) overbank, the slope of the active floodplain lessens to a 2:1 slope, and the height of the bank decreases. The floodplain is sparsely vegetated with coyote willows, and cottonwoods. In areas where vegetation is sparse or primarily composed of bunchgrasses, small vertical cutbanks (0.5 – 2') have formed. The upstream residence also heavily encroached upon the North Fork of the Virgin River during construction.

The right (west) overbank adjacent to Zion Park Boulevard, and both the upstream and downstream residences are located entirely within the HREHZ and are located along the outside of a major river bend.



**Figure 2** – March 3, 2023. Image of the downstream section of the project area, looking upstream from the pedestrian bridge. This image shows the proximity of the North Fork of the Virgin River to Zion Park Boulevard and the asphalt trail, which are visible on the left side of the picture. The right (west) overbank at this location is steep (1.5:1) and is moderately vegetated with coyote willows, mule fat, mature cottonwoods, and rabbitbrush. This bank is located entirely within the HREHZ.



**Figure 4** – July 27, 2023. Looking downstream along the right (west) overbank of the North Fork of the Virgin River at the downstream section of the project area. This image shows the slope of the overbank (1.5:1), and the rapid transition from riparian vegetation to upland vegetation, which occurs within 5' from the edge of the channel.



**Figure 4** – September 26, 2023. Looking across the North Fork of the Virgin River from the left (east) overbank at one of the undercut mature cottonwoods adjacent to the downstream residence.



**Figure 5** – September 26, 2023. Looking across the North Fork of the Virgin River from the left (east) overbank at the existing erosion protection, located adjacent to the downstream residence. This erosion protection has previously been damaged by high flow events.



**Figure 6** – September 26, 2023. Closeup image of the damaged existing erosion protection adjacent to the downstream residence.



**Figure 7** – July 27, 2023. Looking upstream along the right (west) overbank at the downstream residence. This image depicts the proximity of the residential infrastructure to the top of the bank.



**Figure 8** – July 27, 2023. Looking upstream along the right (west) overbank adjacent to the downstream residence. A narrow band of riparian vegetation is present at the base of the damaged existing erosion protection.



**Figure 9** – July 27, 2023. Looking downstream along the right (west) overbank adjacent to the retaining wall. This image depicts the proximity of the residential infrastructure to the top of the bank. A narrow band of riparian vegetation is present at the base of the bank.



**Figure 10** – July 27, 2023. Looking downstream along the right (west) overbank in between the residences. The streambank at this location is sparsely vegetated with riparian vegetation and is primarily composed of bunchgrasses and other upland herbaceous vegetation.



**Figure 11** – July 27, 2023. Looking downstream along the right (west) overbank just upstream of the privacy fence. The transition in slope from 1.5:1 to 2:1 and decrease in bank height is visible at this location. The streambank is sparsely vegetated with riparian vegetation at the toe of the slope.



**Figure 12** – July 27, 2023. Looking upstream along the right (west) overbank adjacent to the upstream residence. A small, almost vertical bank that is devoid of vegetation is visible in the front of this image. The transition from riparian to upland vegetation occurs within 5' of the edge of the low flow channel.



**Figure 13** – July 27, 2023. Looking downstream along the right (west) overbank adjacent to the upstream residence. A small almost vertical bank that is devoid of vegetation is visible in this image, as is the proximity of the upstream residence to the low flow channel.



**Figure 13** – July 27, 2023. Looking downstream along the right (west) overbank adjacent to the upstream residence. This image shows the rapid transition from riparian vegetation to upland vegetation.

## 2.2 GEOLOGY AND SOILS INFORMATION

The NRCS has classified soils within most of the project area as *FA - Fluvaquents and Torrifluvents, sandy* and *NaC – Naplene silt loam*, 2 to 6 percent slopes (Reference 3). The FA soil unit is relatively loose, fine-grained soil associated with river channel and floodplain environments. The NaC soil unit is a relatively loose, silty loam associated with alluvial fans and valleys. These soils generally have a minimum distance to lithic bedrock of 80". These soil units within the project area have a high potential for erosion and scour damage due to their composition and location.

An investigation of the regional and local geology of the study reach was performed using geologic mapping data obtained from the Utah Geologic Survey (UGS) database. The geology of the stream bed and banks can greatly influence the erosivity of the floodplain, in turn affecting the lateral erosion distances expected during a flood. The spatial extent of the geologic units within the river systems can provide information of where the river has been in the past. The proposed project area is located within the Qath and Qafc geologic units, which are described as follows in the 2002 Interim Geologic Map of the Springdale East Quadrangle, Washington County, Utah (Reference 4).

**Qath: Level 3 ("historic") alluvial terrace deposits (Historical):** Deposits forming terraces 8 to 15 feet (2.4-4.6 m) above active channel; commonly mantled by fine-grained overbank silt, sand, and clay deposits; vegetated by cottonwood trees and mature shrubs; Hereford and others (1995) called these deposits the "historic" level; historic photographs show that the sediments of this level were deposited mostly

between A.D. 1883 and 1926 (1926 to 1940 was a period of arroyo cutting) (Hereford and others, 1995).

**Qafc: Young alluvial-fan and colluvial deposits (Holocene to upper Pleistocene):**

Reddish-brown, poorly stratified, poorly sorted, coarse- to fine-grained sand and pebble to cobble gravel with silt and scattered boulders; clasts are angular to subangular and locally derived; deposited by debris flows and sheet wash at decrease in slopes and at mouths of small ephemeral channels that flow into Virgin River valley and major tributaries; mostly graded to and partially mantle Qath and Qats alluvial deposits, and commonly includes small secondary fan (not mapped separately) inset into main deposit that is graded to the active or modern channel; commonly interfingers with and covers alluvial stream deposits; forms most surfaces cultivated and built on by communities of Rockville and Springdale; in many areas debris flows have been deposited on these surfaces in historical times, sometimes causing considerable damage to buildings and roads; 0 to 30 feet (0-9 m) thick.

The fine-grained alluvial material of units Qath and Qafc is associated with modern, active channel processes and is highly erosive. The USGS map material description is consistent with the finding in the NRCS soil survey and the site investigation.

### **2.3 EFFECTIVE FLOODPLAIN INFORMATION**

A portion of the project area, including the right (west) overbank and the existing residential infrastructure is located within Zone AE. Zone AE is defined as areas inside the 1.0% annual chance floodplain according to FEMA Flood Insurance Rate Map (FIRM), panel 49053C 0895G, dated April 2, 2009 (Reference 5).

### **2.4 FLOODPLAIN ANALYSIS**

To determine the impacts of placing fill within the project area as part of protecting the existing stream bank, and residential infrastructure, a HEC-RAS hydraulic model was prepared based on existing and proposed conditions and compared with the regulatory model of the North Fork of the Virgin River along the study reach. The existing conditions hydraulic model was prepared with geometric data derived from 2017 Washinton County LiDAR topography, 2023 field survey data, and 2009 Washington County FIS (Reference 5) regulatory flow information. The proposed conditions hydraulic model was developed by adjusting the elevations along the right (west) overbank based on proposed site improvements. Effective water surface elevations at cross sections not included in the 2009 Washington County FIS were determined using linear interpolation between regulatory 100-year water surface elevations at established FEMA cross sections. Table 1 below provides a comparison between effective, existing, and proposed water surface elevations.

<b>Table 1</b>				
<b>100 Year Water Surface Elevations</b>				
<b>Station</b>	<b>Effective 100 Year Water Surface Elevation</b>	<b>Existing 100 Year Water Surface Elevation</b>	<b>Proposed 100 Year Water Surface Elevation</b>	<b>Difference (Proposed - Existing)</b>
8+445.468 (FEMA R)	3821.13'	3819.9'	3819.89'	-0.01'
8+096.55	3817.8'	3818.19'	3818.17'	-0.02'
7+744.93	3816.21'	3816.42'	3816.41'	-0.01'
7+600.735 (FEMA Q)	3816.06'	3816.08'	3816.01'	-0.07'
7+402.373 (FEMA P)	3815.18'	3815.4'	3815.34'	-0.06'
7+296.517	3812.34'	3814.05'	3814.15'	0.10'
7+276.270 (FEMA O)	3811.7'	3811.2'	3811.2'	0.00'
7+146.536 (FEMA N)	3811.46'	3810.86'	3810.86'	0.00'
6+886.104 (FEMA M)	3809.39'	3808.99'	3808.99'	0.00'

As shown in Table 1 above, the proposed improvements raise the 100-year water surface elevations less than 1' within the property limits, meeting the requirements of Ordinance 2020-04. The proposed improvements do not increase water surface elevations at properties adjacent to the project area. See the Floodplain Exhibit, the Proposed Erosion Protection Exhibit, and the hydraulic calculations included in the Appendix for additional information.

### **3.0 RIVER MEANDER & SCOUR ANALYSIS**

#### **3.1 HISTORICAL AERIAL PHOTO ANALYSIS**

Historic aerial photos from 1973 to 2022 of the study reach were reviewed to establish the location of the North Fork of the Virgin River active channel and determine meander patterns and trends over the extended recent time period, including the impacts of the significant flood events in 2005 and 2010. The results of the analysis illustrate encroachment of the North Fork of the Virgin River towards Zion Park Boulevard within the project area. The active channel has laterally migrated to the west since 1973, with a shift of approximately 5 feet during the last 30 years. The lateral movement of the North Fork of the Virgin River is likely due to a lack of significant riparian vegetation along the right (west) overbank, and the geology and soils of the adjacent active floodplain.

#### **3.2 SCOUR ANALYSIS**

This study utilized the previously calculated scour depths from the *Erosion Hazard Risk Assessment* (Reference 1). Scour depths were calculated based on the North Fork of the

Virgin River 100-year flood event.

Total estimated scour depth along the study reach was based on the Clark County Regional Flood Control District Hydrologic Criteria and Drainage Design Manual, which uses a sum of long term degradation, bend scour, and (1/2) anti-dune scour (Reference 6). Table 3 lists the individual components and total scour value calculated along the channel. Refer to the Appendix for the scour calculations.

<b>Table 3 - Total Scour Depths</b>	
<i>1/2 Anti-Dune Scour</i>	0.38 ft
<i>Bend Scour</i>	6.20 ft
<i>Long Term Degradation</i>	2.00 ft
<b>Total Scour</b>	<b>8.58 ft</b>

### **3.3 ANALYSIS OF EROSION HAZARD RISK**

The Erosion Hazard Risk Assessment completed in 2021 found that this reach of the North Fork of the Virgin River within the project area is at risk from lateral migration of the channel bank towards Zion Park Boulevard due to a single event of varying magnitudes (10 year, 50 year and 100 year recurrence intervals). In addition to the previously completed study, other factors were analyzed to determine the erosion hazard risk to Zion Park Boulevard and the existing residential infrastructure. The project area is located along the outside of a major river bend, and partially within the HREHZ. Along the right (west) overbank, the existing infrastructure encroached heavily upon the North Fork of the Virgin River during construction, which contributes to the hazard. The bank is also steep and almost vertical in a few locations, which also contributes to the hazard. The right (west) overbank is vegetated with a narrow strip of riparian species to varying degrees, and in locations where there is a lack of well-established vegetation, small vertical cutbanks have formed. At the downstream section of the project area, a few of the mature cottonwoods have been undercut, and their roots exposed. If the trend continues, it can be assumed that these cottonwoods will continue to be undercut and likely will collapse into the river, removing bank protection and potentially increasing the risk of lateral migration. The presence of old, damaged rock rip-rap erosion protection serves as evidence that erosion has recently occurred adjacent to the downstream residence. Erosion protection is recommended to protect the existing improvements from the high velocity flows expected during a 100 year flood event.

The sole use of bioengineering techniques was considered for the proposed erosion protection improvements but was deemed to be insufficient due to the high velocities and erosive forces present in the North Fork of the Virgin River during high flow events, and the steep slope of the right (west) overbank. The highest velocities present within the study reach based on the proposed conditions HEC-RAS model is 13.52 ft/sec (Cross Section 7+296.517), which is higher than the permissible velocities (3.0 – 10.0 ft/sec) for feasible bioengineering methods (Reference 7).

Additionally, as riparian species need access to water year-round, plants used for bioengineering would be unable to establish at an elevation higher than 5 feet above the low flow channel. Sole use of soil bioengineering methods would therefore leave the upper portion of the bank unprotected.

As the sole use of bioengineering techniques is not feasible due to site constraints, erosion protection in the form of rock rip-rap supplemented by willow bundles is recommended to protect the existing improvements from the high velocity flows expected during a 100 year flood event. Supplementing the rock rip-rap erosion protection with native willow bundles will increase the structure's strength, durability and reliability. The roots of the willows will increase tensile strength, binding the rock rip-rap together, as well as the soil. The stems, branches, and leaves will increase the surface roughness of the structure and help shield the rock and soil from erosive forces.

Calculations of required rock rip-rap size for the study reach based on tractive stress were used along with the scour depths listed above to determine the quantity of rock necessary to protect the site. A rock rip-rap section consisting of 18" D50 (median particle size) rock, 3 feet thick, extending from a height 1 foot above the base flood elevation to a depth 8.6 feet below the flowline elevation on a 1.5:1 slope would require 4.8 cubic yards per linear foot. This theoretical section is likely not feasible as placement of the rock to scour depths below the river flowline would be extremely difficult but is used to determine the volume of rock required to adequately protect the site from scour. The volume of rock required below the flowline based on the theoretical section is 1.5 cubic yards per linear foot. This volume of rock can instead be added above the flowline as a launch pad to avoid the complications associated with placement of rock below flowline of the river. Similar designs have been used successfully along the Virgin River and are based on concepts used by the NRCS (Reference 8). Due to varying site constraints, including differences in proximity of the existing improvements to the edge of the central channel, and changes in bank height and slope, three different sections of rock rip-rap supplemented with native willow bundles are proposed.

Adjacent to Zion Park Boulevard, the height of the right (west) overbank is great enough that it is feasible to extend the section to 1 foot above the base flood elevation while tying into existing ground. The erosion protection should therefore be placed from 1 foot above the base flood elevation to 3.5' below the river flowline, incorporating a launch pad consisting of at least 1.5 cubic yards per linear foot based on the theoretical section described above.

Adjacent to the downstream residence, it is not feasible to construct the section to an elevation 1 foot above the base flood elevation, as this would include placement of fill in the floodway, creation of a dike that could cause flows to become trapped within the property, and it would encroach upon the existing residential infrastructure. The erosion protection should therefore be placed from the existing ground elevation to 3.5' below the flowline elevation, incorporating a launch pad consisting of at least 1.5 cubic yards per linear foot based on the theoretical section described above.

Adjacent to the upstream residence, it is not feasible to construct the section to an elevation 1 foot above the base flood elevation, as there is a decrease in bank height, this would include placement of fill in the floodway, creation of a dike that could cause flows to become trapped within the property, and it would encroach upon the existing residential infrastructure. As a result, the erosion protection should be placed from the existing ground elevation to 5' below the flowline elevation, incorporating a launch pad

consisting of at least 1.5 cubic yards per linear foot based on the theoretical section described above, while disturbing the streambank as little as possible.

Two rows of native willow bundles are to be installed along the toe of the proposed rock, within or immediately outside of the ordinary high water mark. See the Proposed Erosion Protection Plans in the Appendix for a typical section detail and additional information.

Based on the Engineer's experience working in this reach of the North Fork of the Virgin River, it is assumed that the project is susceptible to potential damage caused by major flooding and scour. It is the opinion of the Engineer that placement of erosion protection is required to adequately protect the property.

## **4.0 RECOMMENDATIONS**

### **4.1 PROPOSED IMPROVEMENTS**

Rock rip-rap erosion protection supplemented with willow bundles is recommended to protect Zion Park Boulevard, the right (west) overbank of the North Fork of the Virgin River, and the existing residential infrastructure. The location of the proposed erosion protection follows the major bend of the river before curving into the bank to tie into the right (west) overbank just upstream of the existing residential infrastructure, which will prevent the river from flanking the rock rip-rap. The proposed rock rip-rap erosion protection consists of three different design sections to accommodate varying site constraints. The design section adjacent to Zion Park Boulevard should tie into the existing pedestrian bridge abutment and extend 208' upstream before transitioning to the design section located adjacent to the downstream residence as shown on the Proposed Erosion Protection Plan. This proposed rock rip-rap section consists of a 24.5' wide by 19.5' deep section of 24" D50 (median size) rock and 36" (median size) rock, extending from 3.5' below the river flowline to 1 foot above the 100 year water surface elevation. The 36" D50 (median size) rock is to be placed at the base of the proposed section due to the vertical component of the toe and to further reinforce the toe of the slope. The total volume of rock required is 1,180 cubic yards (5.2 cubic yards over 208 lineal feet).

The design section adjacent to the downstream residence will tie into the erosion protection adjacent to Zion Park Boulevard and continue upstream for 228'. This proposed rock rip-rap section consists of an 18.5' wide by 17.5' deep section of 24" D50 (median size) rock and 36" (median size) rock, extending from 3.5' below the river flowline up to the existing ground elevation. The 36" D50 (median size) rock is to be placed at the base of the proposed section due to the location of the vertical component of the toe and to further reinforce the toe of the slope. The total volume of rock required is 1,094 cubic yards (4.8 cubic yards over 208 lineal feet). At the upstream end, this erosion protection section will transition to the third design, located adjacent to the upstream residence as shown on the Proposed Erosion Protection Plan.

The design section adjacent to the upstream residence will tie into the section downstream and continue upstream for 137 linear feet before curving into the bank as shown on the Proposed Erosion Protection Plan. This proposed rock rip-rap section consists of a 19' wide by 15' deep section of 24" D50 (median size) rock and 36" (median size) rock, extending from 3.5' below the river flowline up to the existing ground

elevation. The 36" D50 (median size) rock is to be placed at the base of the proposed section due to the vertical component of the toe and to further reinforce the toe of the slope. The total volume of rock required is 630 cubic yards (4.6 cubic yards over 137 lineal feet).

As part of the erosion protection improvements, portions of the existing bank that are close to vertical will be regraded to a 1.5:1 slope.

The proposed erosion protection improvements were designed to be as minimally impactful to the natural function of the river system and riparian area as possible, and to adhere to the recommendations and requirements listed within the *Virgin River Management Plan* (Reference 9) and the Town's code. The proposed erosion protection is designed to disturb the existing bank as little as possible, while protecting the existing residential infrastructure, Zion Park Boulevard, and essential utilities. The slope of the exposed face of the rock rip-rap mimics the natural slope of the bank upstream and downstream of the proposed improvements and the use of water jetting during the installation of the proposed erosion protection will provide suitable habitat for riparian vegetation. The utilization of rock rip-rap was used as a last resort and will be supplemented with native willow bundles within or immediately adjacent to the ordinary high water mark. Over time, the installation of native willows will enable the proposed erosion protection to blend as much as possible with the natural character of the river corridor in the nearby area.

#### **4.2 DO NOT DISTURB THE STREAM BANKS & RIPARIAN ZONE**

No disturbance should be allowed within the regulatory floodplain, North Fork of the Virgin River wet stream, or the riparian zone without the necessary regulatory permits. Significant biological conditions are anticipated to be part of the regulatory permits issued by the Corps of Engineers or the State Engineers Office as part of any proposed disturbance within the jurisdictional areas. The existing North Fork Virgin River riparian zones should remain undisturbed during the construction process except for the permitted activities. In addition, any disturbed areas within the riparian corridor should be re-vegetated with native Coyote Willow, Gooding Willow or Fremont Cottonwood plantings as appropriate. All proposed grading should adhere to the recommendations of the *Virgin River Management Plan* (Reference 9) as it relates to grading, surface drainage and surface roughness. A Grading Permit and a Floodplain Development Permit is required by the Town of Springdale prior to construction of erosion protection improvements.

#### **4.3 IMPACTS TO STREAM STABILITY AND ADJACENT PROPERTIES**

As shown in Table 1, Table 2, and the Floodplain Exhibits included in the Appendix, 100 year water surface elevations within the project area and adjacent properties will not increase above the effective water surface elevations as a result of the proposed improvements. A stream alteration permit will be required from the Utah Division of Water Resources as part of the proposed improvements are located within the ordinary high water mark of the river. No impacts to stream stability or sediment transport patterns are anticipated as the bank will be restored to a more natural, stable condition. Based on the proposed erosion protection design, no impacts to adjacent property owners are anticipated for this project.

#### **4.4 PROVIDE FOR PERPETUAL ACCESS & MAINTENANCE**

Perpetual maintenance of the proposed erosion protection improvements and legal access to the area between the existing structures and the proposed erosion protection is required. Due to site constraints, the installation of new all-weather access is not feasible. As a result, it is required that the existing access point be maintained. Routine inspection of the improvements and access should be completed at least annually and immediately following any major flood event in the river. Maintenance of the proposed erosion protection and access will be the responsibility of the property owner. Any required repair of the improvements or access shall be completed in a timely manner as per the direction of a professional engineer or his assignee.

#### **4.5 PROPERTY OWNERS SHALL ACKNOWLEDGE RISKS**

It should be acknowledged by any current or future property owners that flood events larger than the 100 year flood can and do occur. Areas adjacent to the North Fork of the Virgin River are susceptible to flooding and erosion damage beyond the design events analyzed in this report. Development plans should consider the risk of erosion, sedimentation, and flood damage from large flood events during the design of structural foundation systems, utilities, pavements, and site drainage. Approval of future building permit approvals for the property should be conditioned upon acknowledgement by property owners of the potential risks of flood and erosion damage at this location.

### **5.0 ENGINEER'S OPINION OF RISK**

The findings and recommendations presented in this document are based on a review of existing technical studies concerning the flooding and erosion hazard risks at this location on the North Fork of the Virgin River; a site investigation to determine existing conditions; evaluation of other erosion protection counter measures already in place; engineering analysis and past professional experience working in the area. It is the professional engineering opinion of Rosenberg Associates that if the recommendations presented in this document are implemented and maintained properly, then the risk of lateral bank erosion to Zion Park Boulevard, essential utilities and existing residential infrastructure will be mitigated as required by the Town of Springdale code. No adverse effects to properties upstream, downstream, or across the river are anticipated with the proposed project.

## REFERENCES

1. Erosion Hazard Risk Assessment, Rosenberg Associates, August, 2021.
2. Draft Erosion Hazard Delineation, Rosenberg Associates, January, 2020.
3. Custom Soil Resource Report for Washington County Area, Utah, Natural Resources Conservation Service, January 18, 2024.
4. Interim Geologic Map of the Springdale East Quadrangle, Washington County, Utah, Utah Geologic Survey, 2002.
5. Washington County Flood Insurance Study, Federal Emergency Management Agency, April 2, 2009.
6. Hydrologic Criteria and Drainage Design Manual, Clark County Regional Flood Control District, 1999.
7. Bank Stabilization Design Guidelines, U.S. Department of the Interior, 2015.
8. NCHRP Report 568 – Riprap Design Criteria, Recommended Specifications, and Quality Control, The National Cooperative Highway Research Program, 2006.
9. Virgin River Management Plan, Town of Springdale, 2019.

## **APPENDIX**

*Custom Soil Resource Report for Washington County Area, Utah – NRCS  
FIRMette Washington County FIS, Panel 49053C 0915G  
Floodplain Exhibit – North Fork Virgin River, Rosenberg Associates, 2024  
Proposed Erosion Protection Plans, Rosenberg Associates, 2024*

Hydraulic Model Data  
Scour Calcs

# Custom Soil Resource Report for Washington County Area, Utah



# Preface

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

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

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist ([http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2\\_053951](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

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

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

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

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# How Soil Surveys Are Made

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Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

## Custom Soil Resource Report

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

## Custom Soil Resource Report

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

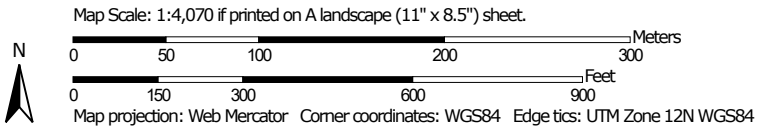
---

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

# Custom Soil Resource Report Soil Map




Soil Map may not be valid at this scale.




### MAP LEGEND

**Area of Interest (AOI)**

 Area of Interest (AOI)




















**Soils**







 Soil Map Unit Polygons

 Soil Map Unit Lines


 Soil Map Unit Points

**Special Point Features**






-  Blowout
-  Borrow Pit
-  Clay Spot
-  Closed Depression
-  Gravel Pit
-  Gravelly Spot
-  Landfill
-  Lava Flow
-  Marsh or swamp
-  Mine or Quarry
-  Miscellaneous Water
-  Perennial Water
-  Rock Outcrop
-  Saline Spot
-  Sandy Spot
-  Severely Eroded Spot
-  Sinkhole
-  Slide or Slip
-  Sodic Spot

-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features

**Water Features**

 Streams and Canals

**Transportation**

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

**Background**

 Aerial Photography

### MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Washington County Area, Utah  
 Survey Area Data: Version 17, Sep 9, 2023

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

Date(s) aerial images were photographed: Sep 8, 2022—Sep 29, 2022

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

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
FA	Fluvaquents and torrifluvents, sandy	10.1	15.6%
MBG	Mathis-Rock outcrop complex, 20 to 50 percent slopes	22.8	35.1%
NaC	Naplene silt loam, 2 to 6 percent slopes	27.8	42.9%
W	Water	4.1	6.3%
<b>Totals for Area of Interest</b>		<b>64.8</b>	<b>100.0%</b>

## Map Unit Descriptions

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

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

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

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate

## Custom Soil Resource Report

pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

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

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

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

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

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

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

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

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

## Washington County Area, Utah

### FA—Fluvaquents and torrifluents, sandy

#### Map Unit Setting

*National map unit symbol:* j8dt  
*Elevation:* 2,500 to 3,000 feet  
*Mean annual precipitation:* 8 to 11 inches  
*Mean annual air temperature:* 57 to 67 degrees F  
*Frost-free period:* 190 to 205 days  
*Farmland classification:* Not prime farmland

#### Map Unit Composition

*Fluvaquents and similar soils:* 55 percent  
*Torrifluents and similar soils:* 35 percent  
*Minor components:* 10 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Fluvaquents

##### Setting

*Landform:* Swales  
*Landform position (three-dimensional):* Talf  
*Down-slope shape:* Concave  
*Across-slope shape:* Concave  
*Parent material:* Sandy alluvium derived from limestone, sandstone, and shale

##### Typical profile

*H1 - 0 to 5 inches:* fine sand  
*H2 - 5 to 60 inches:* stratified fine sand to silt loam

##### Properties and qualities

*Slope:* 0 to 2 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Poorly drained  
*Runoff class:* Negligible  
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)  
*Depth to water table:* About 6 to 24 inches  
*Frequency of flooding:* Frequent  
*Frequency of ponding:* Rare  
*Calcium carbonate, maximum content:* 20 percent  
*Maximum salinity:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)  
*Sodium adsorption ratio, maximum:* 10.0  
*Available water supply, 0 to 60 inches:* Low (about 4.2 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 7w  
*Hydrologic Soil Group:* A/D  
*Ecological site:* R035XY011UT - Loamy Bottom (Basin Big Sagebrush)  
*Hydric soil rating:* Yes

## Description of Torrfluvents

### Setting

*Landform:* Flood plains  
*Landform position (three-dimensional):* Talf  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Alluvium derived from limestone, sandstone, and shale

### Typical profile

*H1 - 0 to 5 inches:* loamy fine sand  
*H2 - 5 to 60 inches:* stratified loamy fine sand to silt loam

### Properties and qualities

*Slope:* 0 to 3 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Well drained  
*Runoff class:* Very low  
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)  
*Depth to water table:* About 42 to 72 inches  
*Frequency of flooding:* Frequent  
*Frequency of ponding:* None  
*Calcium carbonate, maximum content:* 20 percent  
*Maximum salinity:* Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)  
*Sodium adsorption ratio, maximum:* 5.0  
*Available water supply, 0 to 60 inches:* Low (about 4.8 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 7w  
*Hydrologic Soil Group:* A  
*Ecological site:* R035XY011UT - Loamy Bottom (Basin Big Sagebrush)  
*Other vegetative classification:* Loamy Bottom (Basin Big Sagebrush)  
(035XY011UT)  
*Hydric soil rating:* No

## Minor Components

### Riverwash

*Percent of map unit:* 4 percent  
*Landform:* Flood plains  
*Landform position (three-dimensional):* Dip  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Hydric soil rating:* Yes

### Tobler, silty clay loam

*Percent of map unit:* 3 percent

### Tobler, fine sandy loam

*Percent of map unit:* 3 percent

## **MBG—Mathis-Rock outcrop complex, 20 to 50 percent slopes**

### **Map Unit Setting**

*National map unit symbol:* j8fn  
*Elevation:* 4,000 to 5,500 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 52 to 59 degrees F  
*Frost-free period:* 165 to 170 days  
*Farmland classification:* Not prime farmland

### **Map Unit Composition**

*Mathis and similar soils:* 50 percent  
*Rock outcrop:* 20 percent  
*Minor components:* 30 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### **Description of Mathis**

#### **Setting**

*Landform:* Mountain slopes, mesas  
*Landform position (three-dimensional):* Mountainflank  
*Down-slope shape:* Convex, linear  
*Across-slope shape:* Convex  
*Parent material:* Material derived mainly from sandstone

#### **Typical profile**

*H1 - 0 to 4 inches:* very stony loamy fine sand  
*H2 - 4 to 10 inches:* gravelly loamy fine sand  
*H3 - 10 to 26 inches:* very gravelly loamy sand  
*H4 - 26 to 33 inches:* extremely gravelly fine sand  
*H5 - 33 to 37 inches:* unweathered bedrock

#### **Properties and qualities**

*Slope:* 20 to 50 percent  
*Depth to restrictive feature:* 20 to 40 inches to lithic bedrock  
*Drainage class:* Somewhat excessively drained  
*Runoff class:* Very high  
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately high (0.00 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum content:* 20 percent  
*Maximum salinity:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)  
*Available water supply, 0 to 60 inches:* Very low (about 1.5 inches)

#### **Interpretive groups**

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 7s

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*Hydrologic Soil Group: A*

*Ecological site: R035XY323UT - Upland Stony Sand (Utah Juniper-Pinyon)*

*Other vegetative classification: Upland Stony Loam (Pinyon-Utah Juniper)  
(035XY321UT)*

*Hydric soil rating: No*

### Minor Components

#### Tacan

*Percent of map unit: 6 percent*

#### Bond

*Percent of map unit: 6 percent*

#### Eroded land

*Percent of map unit: 6 percent*

#### Redbank

*Percent of map unit: 6 percent*

#### Rock land, stony

*Percent of map unit: 6 percent*

## NaC—Naplene silt loam, 2 to 6 percent slopes

### Map Unit Setting

*National map unit symbol: j8fz*

*Elevation: 3,600 to 5,300 feet*

*Mean annual precipitation: 14 to 15 inches*

*Mean annual air temperature: 44 to 52 degrees F*

*Frost-free period: 140 to 160 days*

*Farmland classification: Prime farmland if irrigated*

### Map Unit Composition

*Naplene and similar soils: 75 percent*

*Minor components: 25 percent*

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

### Description of Naplene

#### Setting

*Landform: Alluvial fans, valleys*

*Landform position (three-dimensional): Talf*

*Down-slope shape: Linear*

*Across-slope shape: Concave*

*Parent material: Alluvium derived from igneous and sedimentary rock*

#### Typical profile

*H1 - 0 to 2 inches: silt loam*

*H2 - 2 to 7 inches: silt loam*

*H3 - 7 to 15 inches: silt loam*

*H4 - 15 to 22 inches: silty clay loam*

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*H5 - 22 to 39 inches: silt loam*

*H6 - 39 to 60 inches: silt loam*

### **Properties and qualities**

*Slope: 2 to 6 percent*

*Depth to restrictive feature: More than 80 inches*

*Drainage class: Well drained*

*Runoff class: Low*

*Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)*

*Depth to water table: More than 80 inches*

*Frequency of flooding: None*

*Frequency of ponding: None*

*Calcium carbonate, maximum content: 20 percent*

*Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)*

*Available water supply, 0 to 60 inches: High (about 10.8 inches)*

### **Interpretive groups**

*Land capability classification (irrigated): 3e*

*Land capability classification (nonirrigated): 6e*

*Hydrologic Soil Group: C*

*Ecological site: R035XY306UT - Upland Loam (Basin Big Sagebrush)*

*Hydric soil rating: No*

### **Minor Components**

#### **Schmutz**

*Percent of map unit: 5 percent*

#### **Chilton**

*Percent of map unit: 5 percent*

#### **Mespun**

*Percent of map unit: 5 percent*

#### **Redbank**

*Percent of map unit: 5 percent*

#### **Clovis**

*Percent of map unit: 5 percent*

## **W—Water**

### **Map Unit Composition**

*Water: 100 percent*

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

# Soil Information for All Uses

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## Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

## Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

## Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

*Hydrologic soil group* is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007 (<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission

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rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

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

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

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

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

*Depth* to the upper and lower boundaries of each layer is indicated.

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

*Classification* of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group

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index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

*Percentage of rock fragments* larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

*Percentage (of soil particles) passing designated sieves* is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

*Liquid limit and plasticity index (Atterberg limits)* indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

### References:

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

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

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Absence of an entry indicates that the data were not estimated. The asterisk '\*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties—Washington County Area, Utah														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>
FA—Fluvaquents and torrifluents, sandy														
Fluvaquents	55	A/D	0-5	Fine sand	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	65-73-80	20-28-35	0-7 -14	NP
			5-60	Stratified fine sand to silt loam	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	65-73-80	20-28-35	15-20-25	NP-3 -5
Torrifluents	35	A	0-5	Loamy fine sand	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	75-83-90	35-43-50	0-7 -14	NP
			5-60	Stratified loamy fine sand to silt loam	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	50-63-75	10-20-30	15-20-25	NP-3 -5
MBG—Mathis-Rock outcrop complex, 20 to 50 percent slopes														
Mathis	50	A	0-4	Very stony loamy fine sand	GM, GW-GM, SP-SM	A-1-a	5-10- 15	15-20-25	45-55-65	35-48-60	20-30-40	5-10- 15	0-0 -0	NP
			4-10	Gravelly loamy fine sand	SM	A-1-b	0- 0- 0	5-10- 15	75-80-85	65-70-75	35-43-50	15-20-25	0-0 -0	NP
			10-26	Very gravelly loamy sand	SM, GP-GM	A-1-a	0- 0- 0	20-25-30	45-50-55	40-45-50	20-25-30	5-10- 15	0-0 -0	NP
			26-33	Extremely gravelly fine sand	GW-GM	A-1-a	0- 0- 0	20-25-30	35-40-45	25-30-35	20-25-30	5- 8- 10	0-0 -0	NP
			33-37	Unweathered bedrock	—	—	—	—	—	—	—	—	—	—

Custom Soil Resource Report

Engineering Properties—Washington County Area, Utah														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>
NaC—Naplene silt loam, 2 to 6 percent slopes														
Naplene	75	C	0-2	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100 -100	95-98-1 00	85-93-1 00	65-78- 90	25-30 -35	5-10-15
			2-7	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100 -100	95-98-1 00	85-93-1 00	65-78- 90	25-30 -35	5-10-15
			7-15	Silt loam	CL, CL-ML	A-6, A-4	0- 0- 0	0- 0- 0	100-100 -100	95-98-1 00	85-93-1 00	65-78- 90	25-30 -35	5-10-15
			15-22	Silty clay loam	CL	A-6	0- 0- 0	0- 0- 0	100-100 -100	95-98-1 00	85-93-1 00	80-88- 95	30-35 -40	10-13-1 5
			22-39	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100 -100	95-98-1 00	85-93-1 00	65-78- 90	25-30 -35	5-10-15
			39-60	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100 -100	95-98-1 00	85-93-1 00	65-78- 90	25-30 -35	5-10-15

# References

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- American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.
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- Federal Register. July 13, 1994. Changes in hydric soils of the United States.
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- United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084>

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United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2\\_054242](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242)

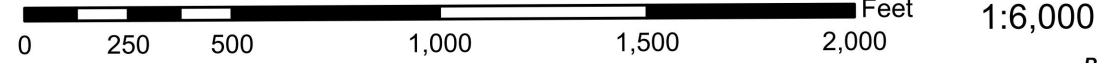
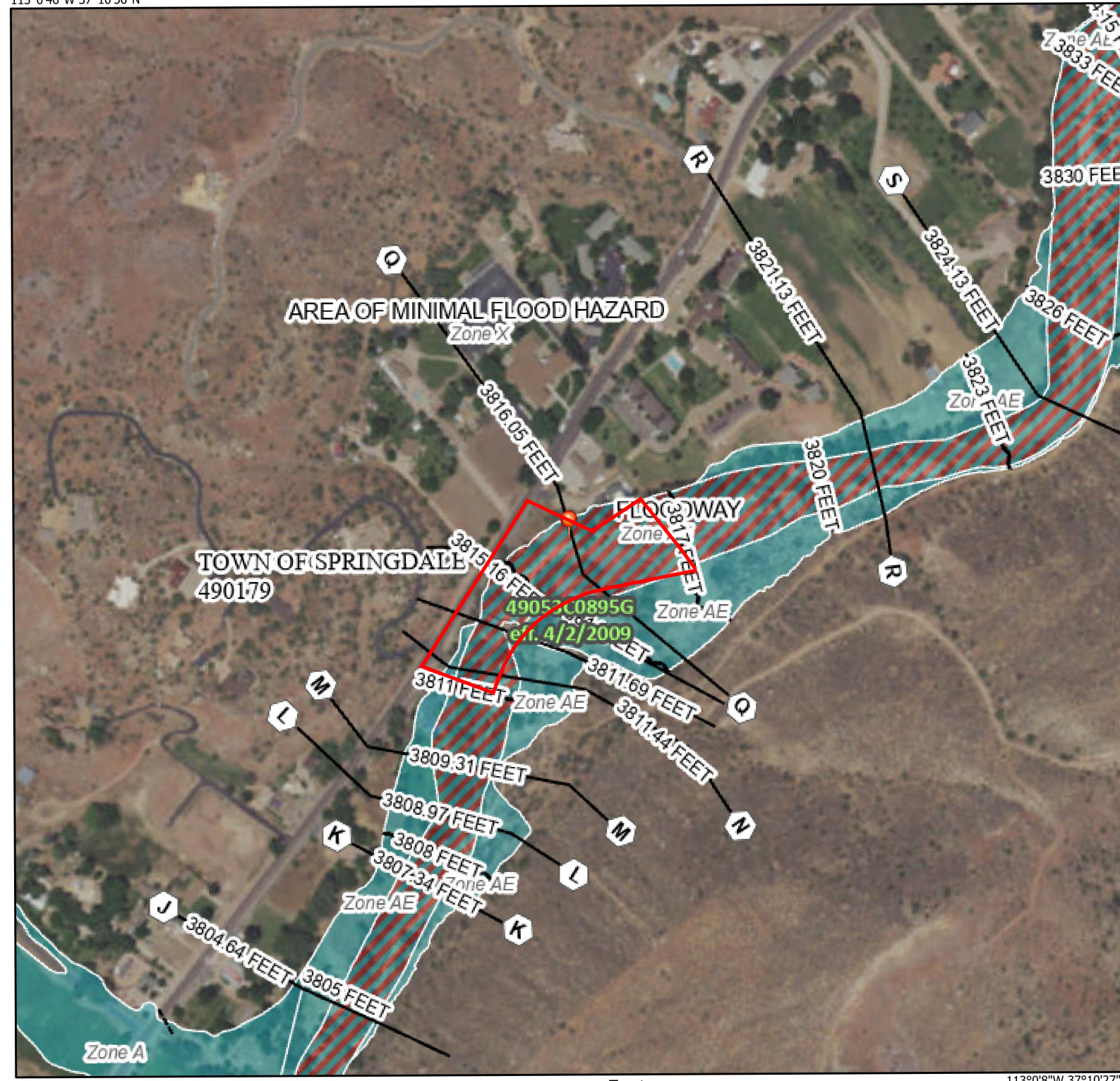
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# National Flood Hazard Layer FIRMette



113°0'46"W 37°10'56"N



Basemap Imagery Source: USGS National Map 2023

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

- SPECIAL FLOOD HAZARD AREAS**
  - Without Base Flood Elevation (BFE) Zone A, V, A99
  - With BFE or Depth Zone AE, AO, AH, VE, AR
  - Regulatory Floodway
  
- OTHER AREAS OF FLOOD HAZARD**
  - 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
  - Future Conditions 1% Annual Chance Flood Hazard Zone X
  - Area with Reduced Flood Risk due to Levee. See Notes. Zone X
  - Area with Flood Risk due to Levee Zone D
  
- OTHER AREAS**
  - NO SCREEN Area of Minimal Flood Hazard Zone X
  - Effective LOMRs
  - Area of Undetermined Flood Hazard Zone D
  
- GENERAL STRUCTURES**
  - Channel, Culvert, or Storm Sewer
  - Levee, Dike, or Floodwall
  
- OTHER FEATURES**
  - 20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
  - 17.5 Coastal Transect
  - Base Flood Elevation Line (BFE)
  - Limit of Study
  - Jurisdiction Boundary
  - Coastal Transect Baseline
  - Profile Baseline
  - Hydrographic Feature
  
- MAP PANELS**
  - Digital Data Available
  - No Digital Data Available
  - Unmapped

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

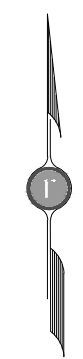
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 4/29/2024 at 6:22 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

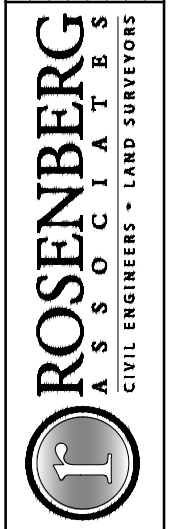
This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

## LEGEND

PROJECT AREA

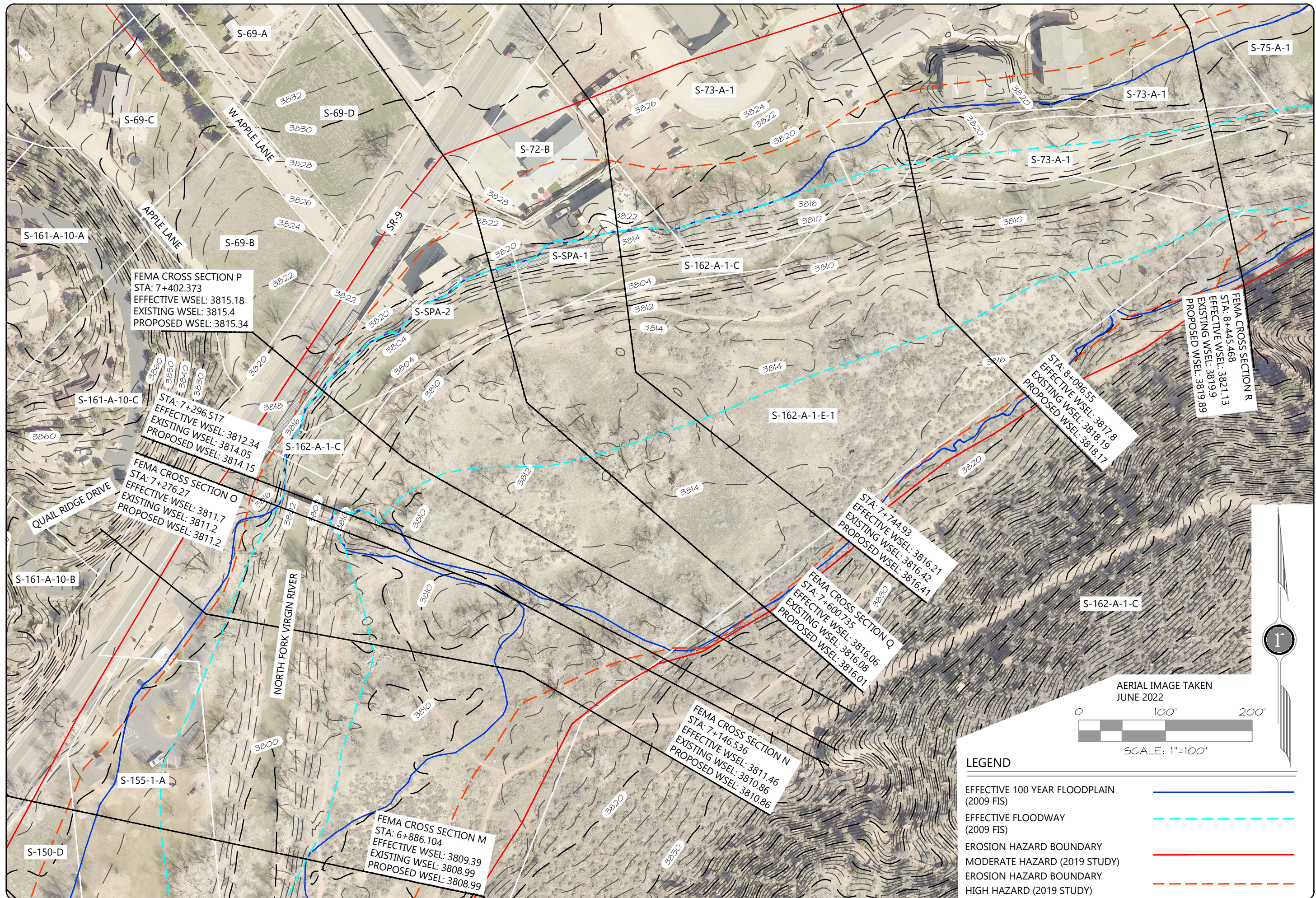


DATE:	4/24/2024
JOB NO.:	1545-23-006
DESIGNED BY:	WJP
CHECKED BY:	JNB
DWG.:	EHZ
DATE:	
REVISIONS:	



352 East Riverside Drive, Suite A-2  
St. George, Utah 84790  
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FEMA FIRMETTE - 0895G  
FOR  
ZION PARK BOULEVARD EROSION PROTECTION  
SPRINGDALE  
UTAH



FEMA CROSS SECTION P  
 STA: 7+402.373  
 EFFECTIVE WSEL: 3815.18  
 EXISTING WSEL: 3815.4  
 PROPOSED WSEL: 3815.34

STA: 7+296.517  
 EFFECTIVE WSEL: 3812.34  
 EXISTING WSEL: 3814.05  
 PROPOSED WSEL: 3814.15

FEMA CROSS SECTION O  
 STA: 7+276.27  
 EFFECTIVE WSEL: 3811.7  
 EXISTING WSEL: 3811.2  
 PROPOSED WSEL: 3811.2

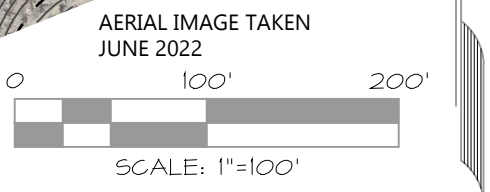
FEMA CROSS SECTION Q  
 STA: 7+600.735  
 EFFECTIVE WSEL: 3816.06  
 EXISTING WSEL: 3816.08  
 PROPOSED WSEL: 3816.01

FEMA CROSS SECTION N  
 STA: 7+146.536  
 EFFECTIVE WSEL: 3811.46  
 EXISTING WSEL: 3810.86  
 PROPOSED WSEL: 3810.86

FEMA CROSS SECTION M  
 STA: 6+886.104  
 EFFECTIVE WSEL: 3809.39  
 EXISTING WSEL: 3808.99  
 PROPOSED WSEL: 3808.99

FEMA CROSS SECTION R  
 STA: 8+445.468  
 EFFECTIVE WSEL: 3821.13  
 EXISTING WSEL: 3819.9  
 PROPOSED WSEL: 3819.89

STA: 8+096.55  
 EFFECTIVE WSEL: 3817.8  
 EXISTING WSEL: 3818.19  
 PROPOSED WSEL: 3818.17



**LEGEND**

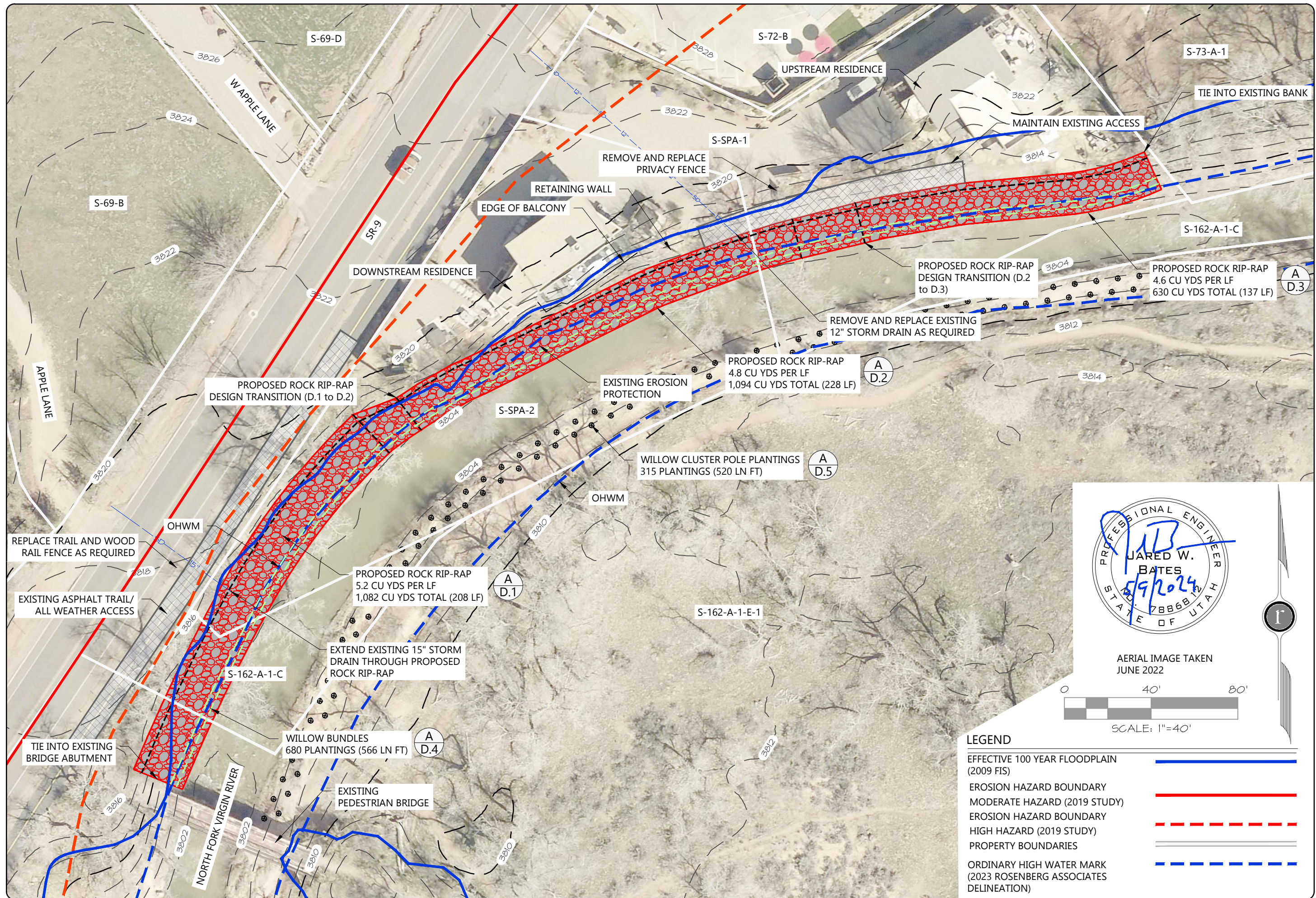
EFFECTIVE 100 YEAR FLOODPLAIN (2009 FIS)	
EFFECTIVE FLOODWAY (2009 FIS)	
EROSION HAZARD BOUNDARY MODERATE HAZARD (2019 STUDY)	
EROSION HAZARD BOUNDARY HIGH HAZARD (2019 STUDY)	

DATE	4/24/2024
JOB NO.	1545-23-006
DESIGNED BY	JLP
CHECKED BY	JMB
DWG.	EHZ
DATE	
DATE	
DATE	
DATE	
DATE	

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FLOODPLAIN EXHIBIT - NORTH FORK VIRGIN RIVER  
 FOR  
 ZION PARK BOULEVARD EROSION PROTECTION  
 SPRINGDALE  
 UTAH

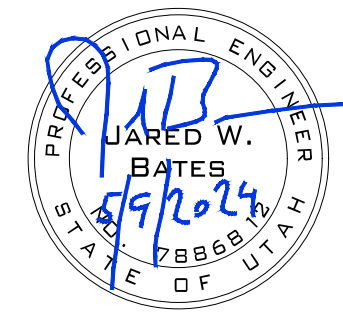


DATE	4/24/2024
JOB NO.	1545-23-006
DESIGNED BY	JWP
CHECKED BY	JWB
DWG.	EHZ
DATE	
REVISIONS	

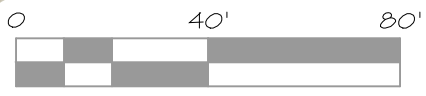
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**EROSION PROTECTION PLAN - NORTH FORK VIRGIN RIVER**  
 FOR  
**ZION PARK BOULEVARD EROSION PROTECTION**  
 SPRINGDALE  
 UTAH



AERIAL IMAGE TAKEN  
 JUNE 2022



**LEGEND**

EFFECTIVE 100 YEAR FLOODPLAIN (2009 FIS)	
EROSION HAZARD BOUNDARY MODERATE HAZARD (2019 STUDY)	
EROSION HAZARD BOUNDARY HIGH HAZARD (2019 STUDY)	
PROPERTY BOUNDARIES	
ORDINARY HIGH WATER MARK (2023 ROSENBERG ASSOCIATES DELINEATION)	

**RIP-RAP CONSTRUCTION NOTES**

1. AVERAGE ROCK SIZE, D50=24" AND D50=36". USE ANGULAR-SHAPED ROCK FREE FROM CRACKS, OVERBURDEN, SHALE; WITH A MINIMUM DENSITY OF 156 LB. PER CUBIC FT. (SPECIFIC GRAVITY = 2.50), WITH THE BREADTH OR THICKNESS OF A SINGLE STONE NOT LESS THAN ONE THIRD ITS LENGTH. FURNISH ROCK GRADED AS INDICATED IN THE TABLE. ALL ROCK RIP-RAP SHALL BE INSPECTED BY THE ENGINEER PRIOR TO INSTALLATION AND BACKFILL.
2. FILTER FABRIC SHALL BE MIRIFI 180 N 8 OZ. NON WOVEN GEO-TEXTILE OR APPROVED EQUAL. FABRIC SHALL BE PLACED AS SHOWN HEREON AND INSTALLED ACCORDING TO MANUFACTURE'S INSTRUCTIONS. CARE SHALL BE TAKEN TO PREVENT FABRIC FROM TEARING DURING ROCK PLACEMENT.
3. CONTRACTOR SHALL FILL VOIDS IN RIP-RAP EROSION PROTECTION WITH SEDIMENT USING WATER JETTING OR OTHER APPROVED METHODS. ALL ROCK RIP-RAP SHALL BE INSPECTED BY THE ENGINEER PRIOR TO SEDIMENT PLACEMENT.
4. ALL UNSUITABLE VEGETATION AND WOODY DEBRIS MATERIAL SHALL BE REMOVED FROM THE WORK AREA AND DISPOSED OF PROPERLY OFFSITE.
5. ALL WORK SHALL COMPLY WITH THE ARMY CORPS OF ENGINEERS AND STATE OF UTAH PERMIT REQUIREMENT & CONDITIONS.
6. RIP-RAP EROSION PROTECTION REPAIR TERMINATION LOCATIONS TO BE VERIFIED BY ENGINEER BASED ON FIELD CONDITIONS.

**QUANTITIES**

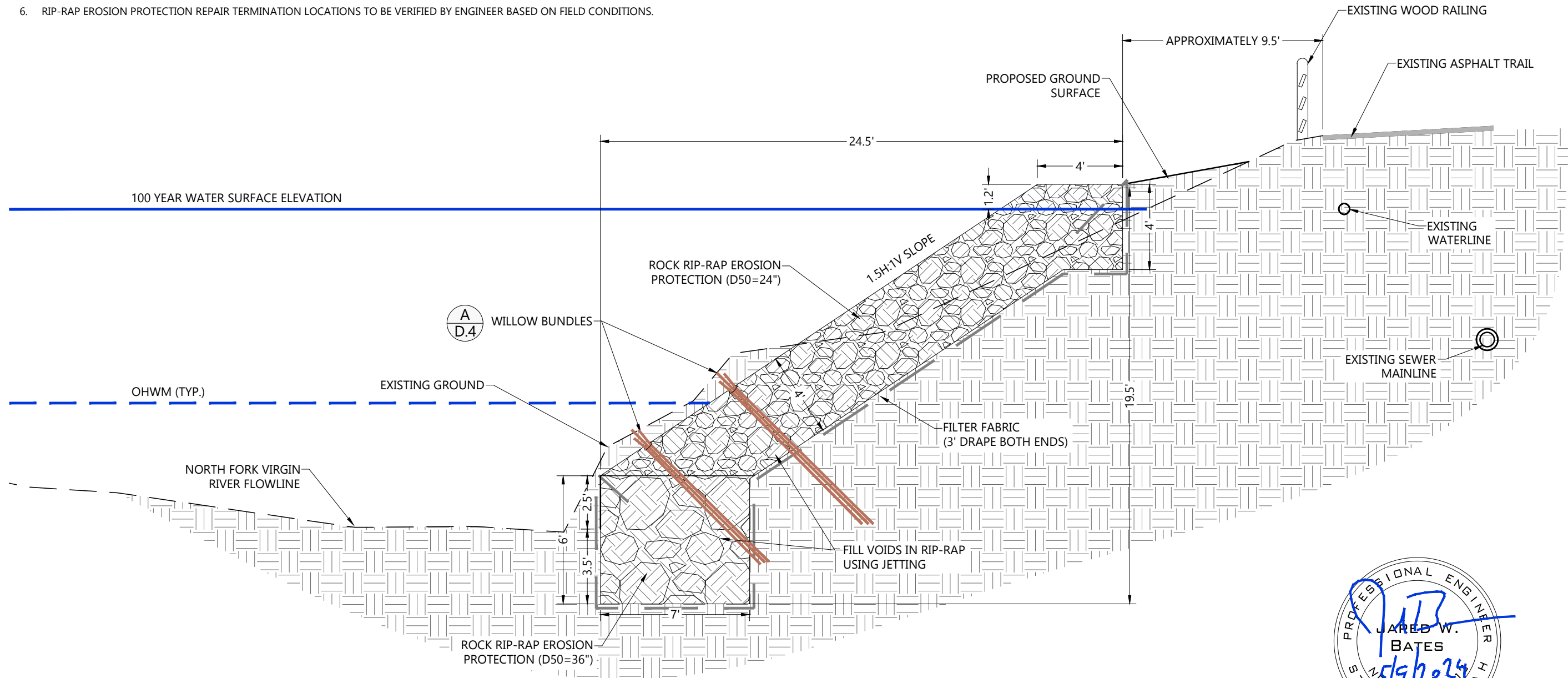
ROCK RIP-RAP D50=24":	3.6 CU YDS PER LF
ROCK RIP-RAP D50=36":	1.6 CU YDS PER LF
FILTER FABRIC:	5.5 SQ YDS PER LF

**ROCK GRADATION (24" D50)**

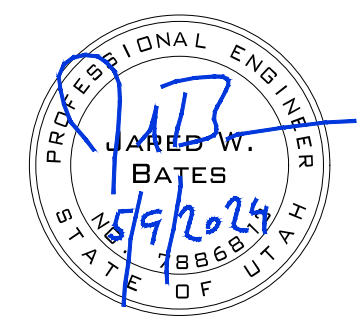
D100	36"
D75	30"
D50	24"
D25	18"
MIN SIZE	9"

**ROCK GRADATION (36" D50)**

D100	54"
D75	45"
D50	36"
D25	24"
MIN SIZE	12"



**A RIP-RAP EROSION PROTECTION - TYPICAL SECTION**  
SCALE: 1"=5'



DATE:	5/9/24
JOB NO.:	1545-23-006
DESIGNED BY:	JWP
CHECKED BY:	JWB
DWG.:	PERMIT
DATE:	
DATE:	
DATE:	
DATE:	
DATE:	
DATE:	

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RIP-RAP EROSION PROTECTION TYPICAL DETAIL  
FOR  
ZION PARK BOULEVARD EROSION PROTECTION  
SPRINGDALE  
UTAH

**RIP-RAP CONSTRUCTION NOTES**

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5. ALL WORK SHALL COMPLY WITH THE ARMY CORPS OF ENGINEERS AND STATE OF UTAH PERMIT REQUIREMENT & CONDITIONS.
6. RIP-RAP EROSION PROTECTION REPAIR TERMINATION LOCATIONS TO BE VERIFIED BY ENGINEER BASED ON FIELD CONDITIONS.

**QUANTITIES**

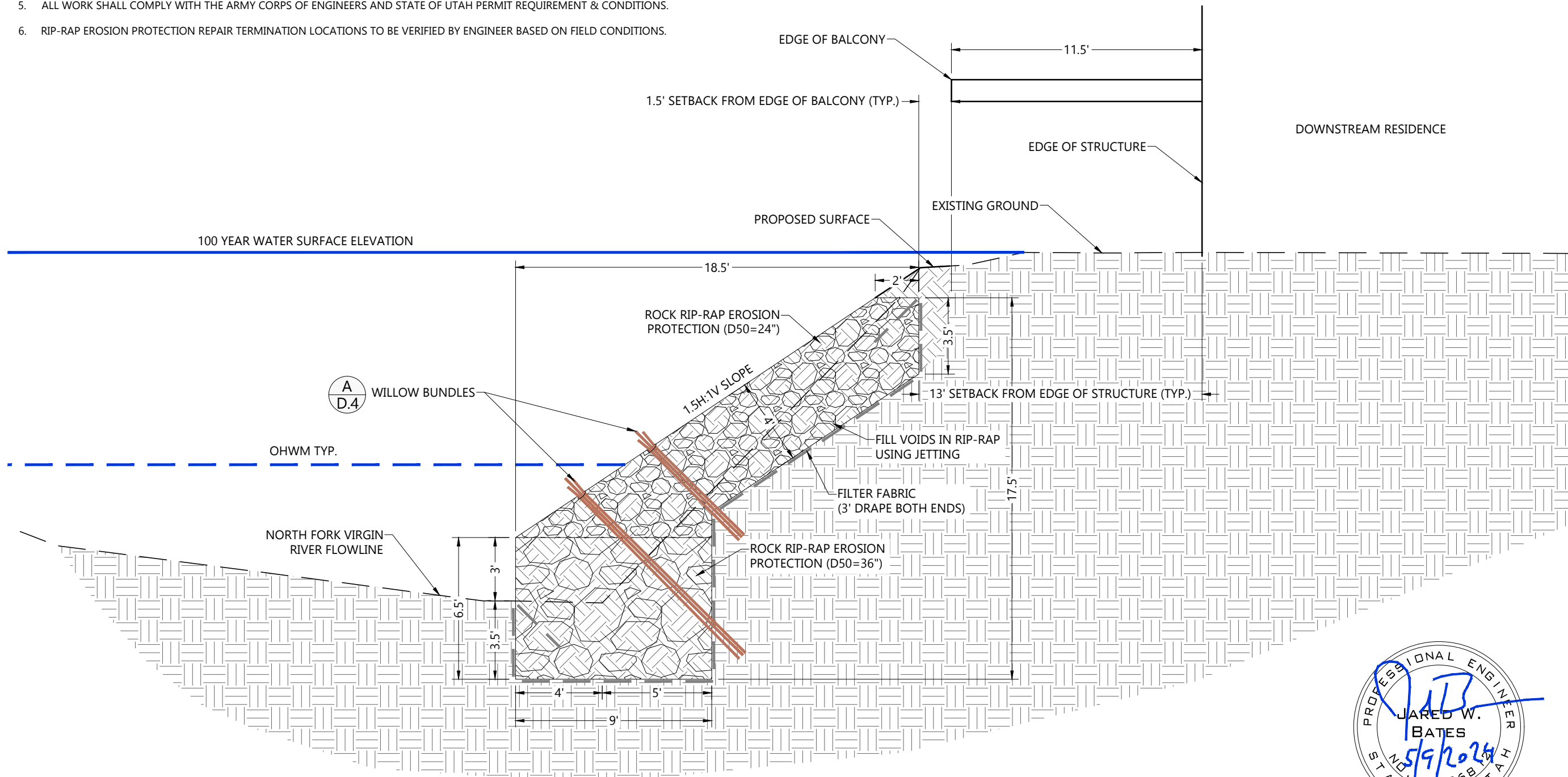
ROCK RIP-RAP D50=24":	2.6 CU YDS PER LF
ROCK RIP-RAP D50=36":	2.2 CU YDS PER LF
FILTER FABRIC:	4.6 SQ YDS PER LF

**ROCK GRADATION (24" D50)**

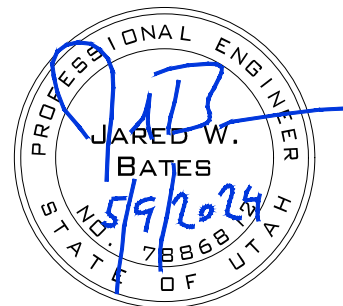
D100	36"
D75	30"
D50	24"
D25	18"
MIN SIZE	9"

**ROCK GRADATION (36" D50)**

D100	54"
D75	45"
D50	36"
D25	24"
MIN SIZE	12"



**A RIP-RAP EROSION PROTECTION - TYPICAL SECTION**  
SCALE: 1"=5'



DATE:	5/9/24
JOB NO.:	1545-23-006
DESIGNED BY:	JWP
CHECKED BY:	JWB
DWG.:	PERMIT
DATE:	
REVISIONS:	

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RIP-RAP EROSION PROTECTION TYPICAL DETAIL  
FOR  
ZION PARK BOULEVARD EROSION PROTECTION  
SPRINGDALE  
UTAH

**RIP-RAP CONSTRUCTION NOTES**

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6. RIP-RAP EROSION PROTECTION REPAIR TERMINATION LOCATIONS TO BE VERIFIED BY ENGINEER BASED ON FIELD CONDITIONS.

**QUANTITIES**

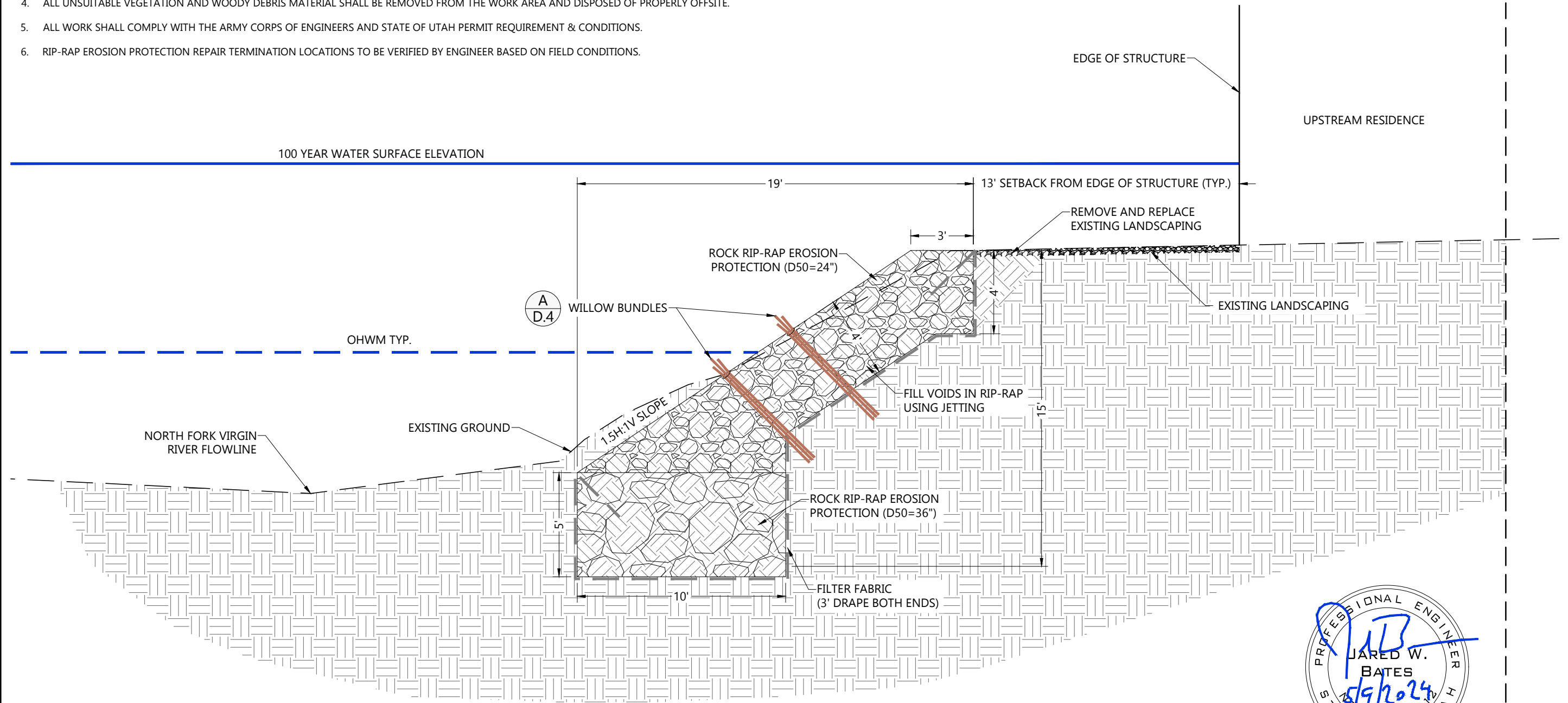
ROCK RIP-RAP D50=24":	2.8 CU YDS PER LF
ROCK RIP-RAP D50=36":	1.8 CU YDS PER LF
FILTER FABRIC:	4.6 SQ YDS PER LF

**ROCK GRADATION (24" D50)**

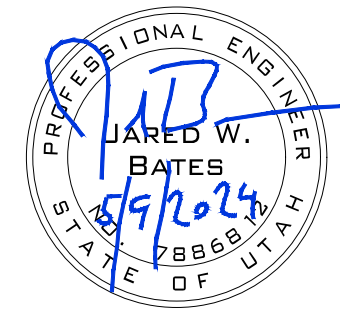
D100	36"
D75	30"
D50	24"
D25	18"
MIN SIZE	9"

**ROCK GRADATION (36" D50)**

D100	54"
D75	45"
D50	36"
D25	24"
MIN SIZE	12"



**A RIP-RAP EROSION PROTECTION - TYPICAL SECTION**  
SCALE: 1"=5'

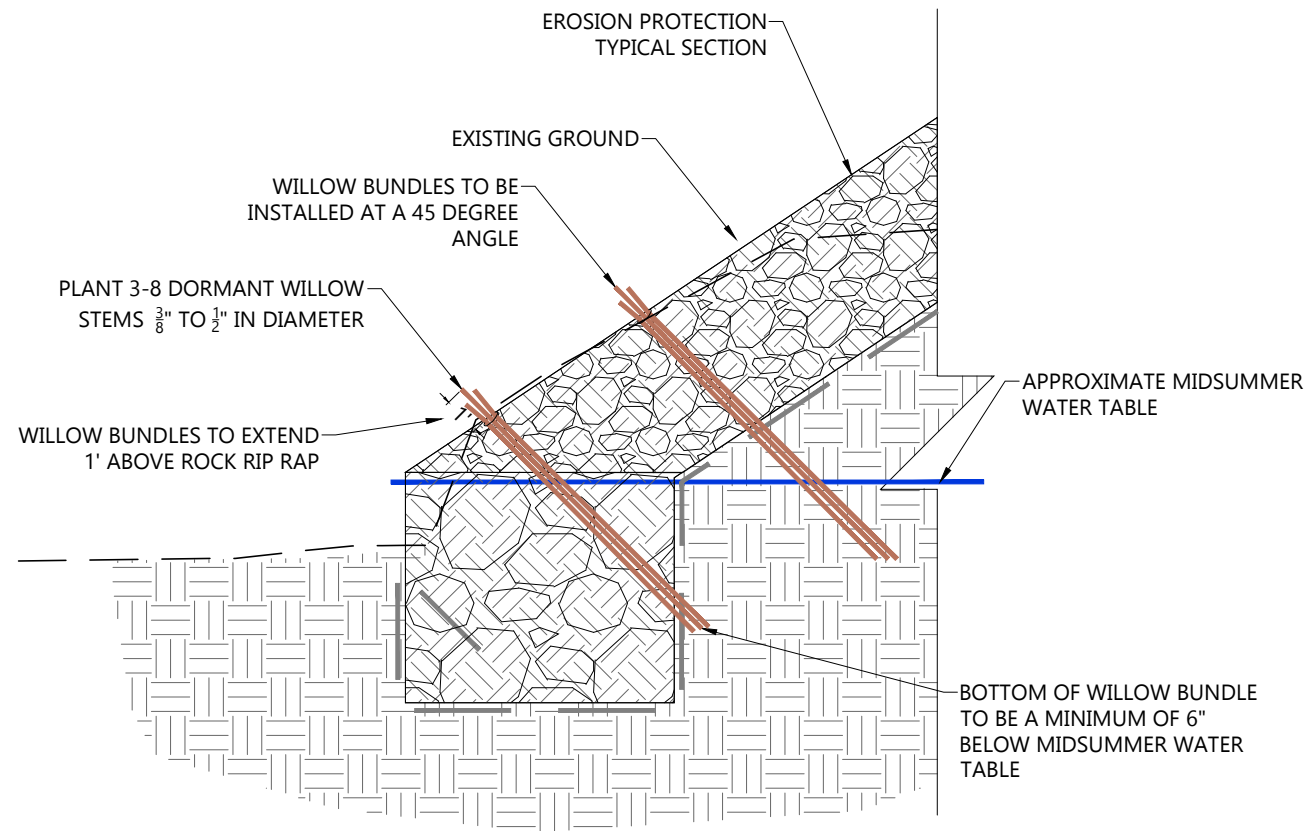


DATE:	5/9/24
JOB NO.:	1545-23-006
DESIGNED BY:	JWB
CHECKED BY:	JWB
DWG.:	PERMIT
DATE:	
REVISIONS:	

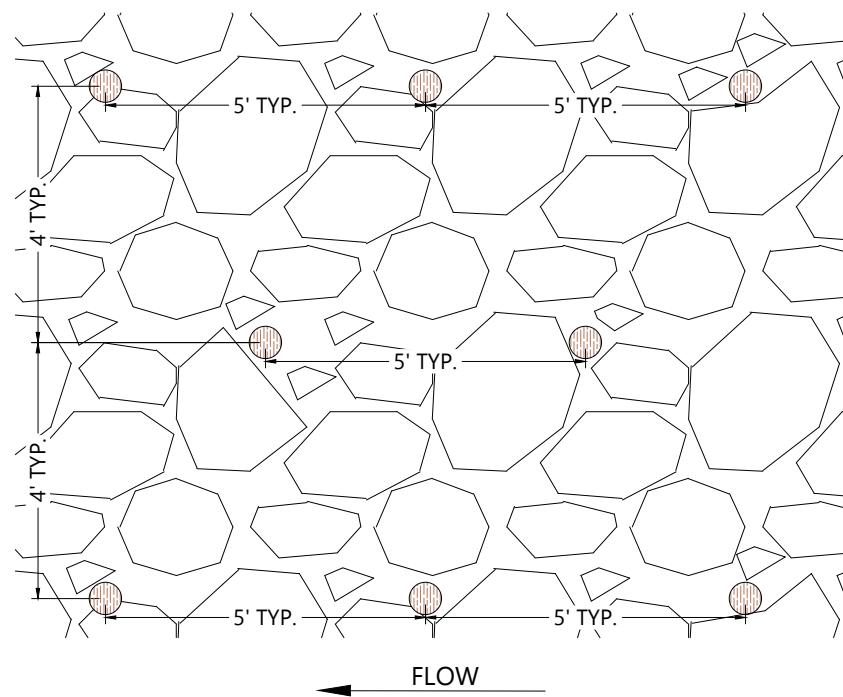
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RIP-RAP EROSION PROTECTION TYPICAL DETAIL  
FOR  
ZION PARK BOULEVARD EROSION PROTECTION  
SPRINGDALE  
UTAH



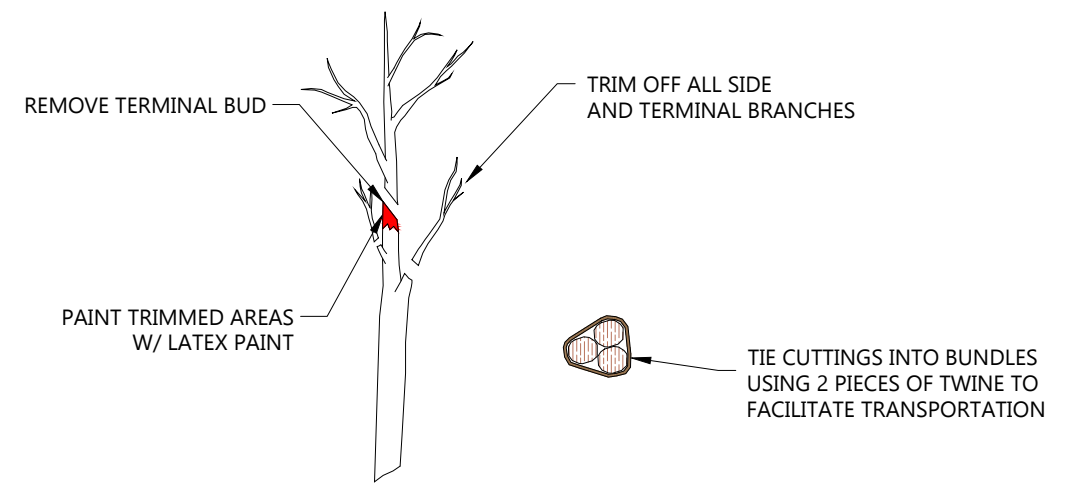
**A WILLOW BUNDLES**  
SCALE: 1"=5'



**B WILLOW BUNDLES PLAN VIEW**  
SCALE: 1"=2'

**VEGETATED RIP-RAP CONSTRUCTION NOTES**

1. WILLOW BUNDLES TO BE COMPOSED OF NATIVE COYOTE WILLOWS (*SALIX EXIGUA*) THAT ARE HARVESTED WHILE DORMANT.
2. THERE SHALL BE 3-8 WILLOWS PER BUNDLE, TIED WITH BIODEGRADABLE TWINE EVERY 2-4 FEET.
3. WILLOW BUNDLES TO BE INSTALLED WITH A STINGER BAR ATTACHMENT AFTER BANK GRADING AND ROCK RIP-RAP PLACEMENT IS COMPLETED.
4. WILLOWS TO BE INSTALLED AT A 45 DEGREE ANGLE AND EXTEND A MINIMUM OF 6" BELOW THE MIDSUMMER WATER TABLE TO 1' ABOVE THE TOP OF THE ROCK RIP-RAP.
5. CONTRACTOR TO BACKFILL AROUND WILLOW BUNDLES WITH NATIVE SOIL TO INCREASE SOIL CONTACT. ENTIRETY OF BUNDLE TO HAVE SOIL CONTACT EXCEPT FOR PORTION EXTRUDING FROM ROCK RIP-RAP.
6. ALL UNSUITABLE VEGETATION AND WOODY DEBRIS MATERIAL SHALL BE REMOVED FROM THE WORK AREA AND DISPOSED OF PROPERLY OFFSITE.
7. ALL WORK SHALL COMPLY WITH THE ARMY CORPS OF ENGINEERS AND STATE OF UTAH PERMIT REQUIREMENT & CONDITIONS.
8. WILLOW BUNDLE LOCATIONS TO BE VERIFIED BY ENGINEER BASED ON FIELD CONDITIONS.



**C HARVESTED WILLOW**  
SCALE: 1"=2'

DATE:	5/1/24
JOB NO.:	1545-23-006
DESIGNED BY:	JLF
CHECKED BY:	JNB
DWG.:	PERMIT
DATE:	
REVISIONS:	

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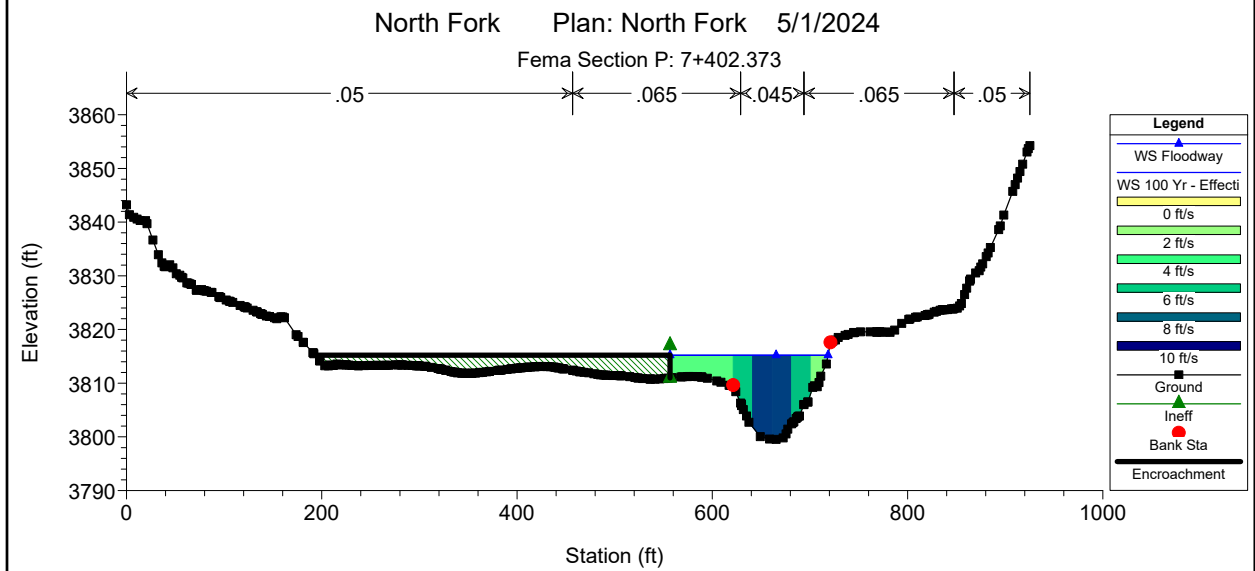
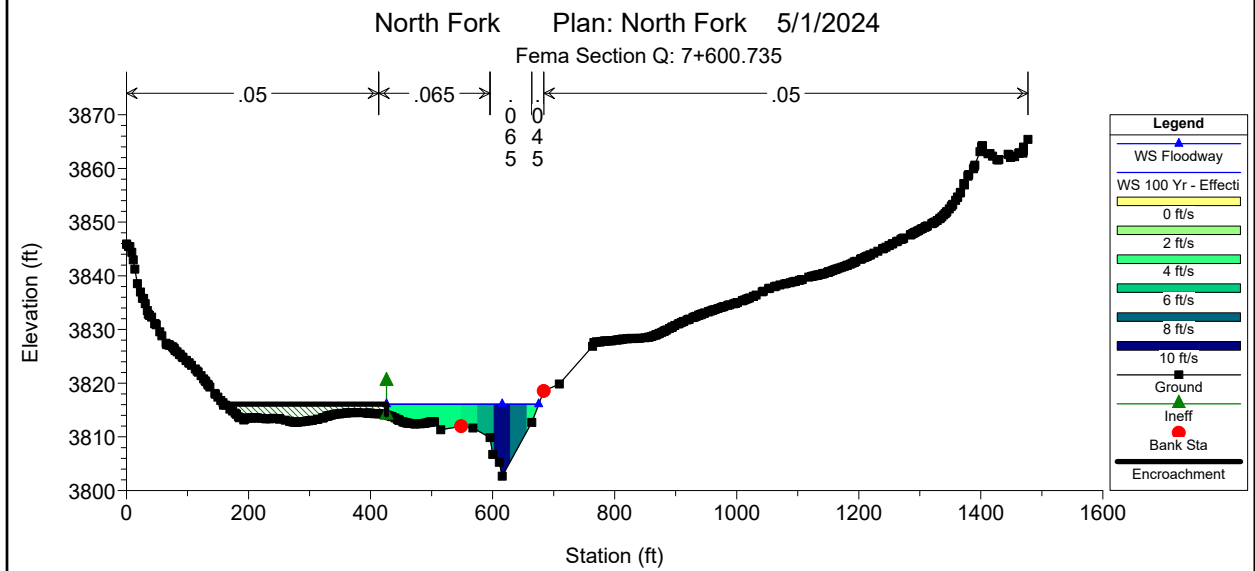
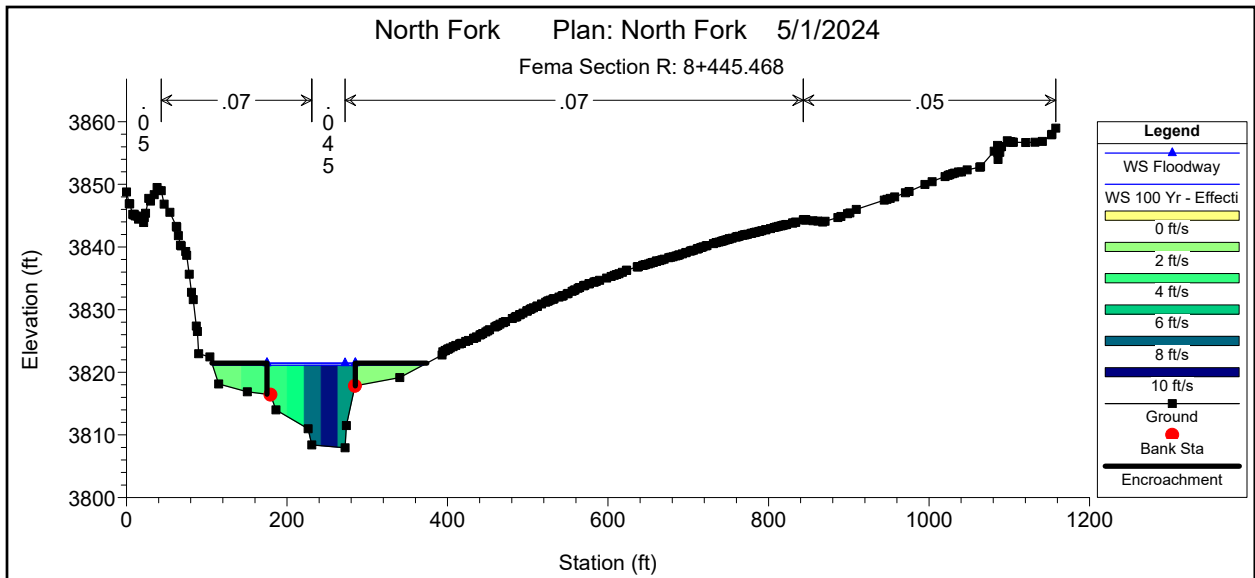
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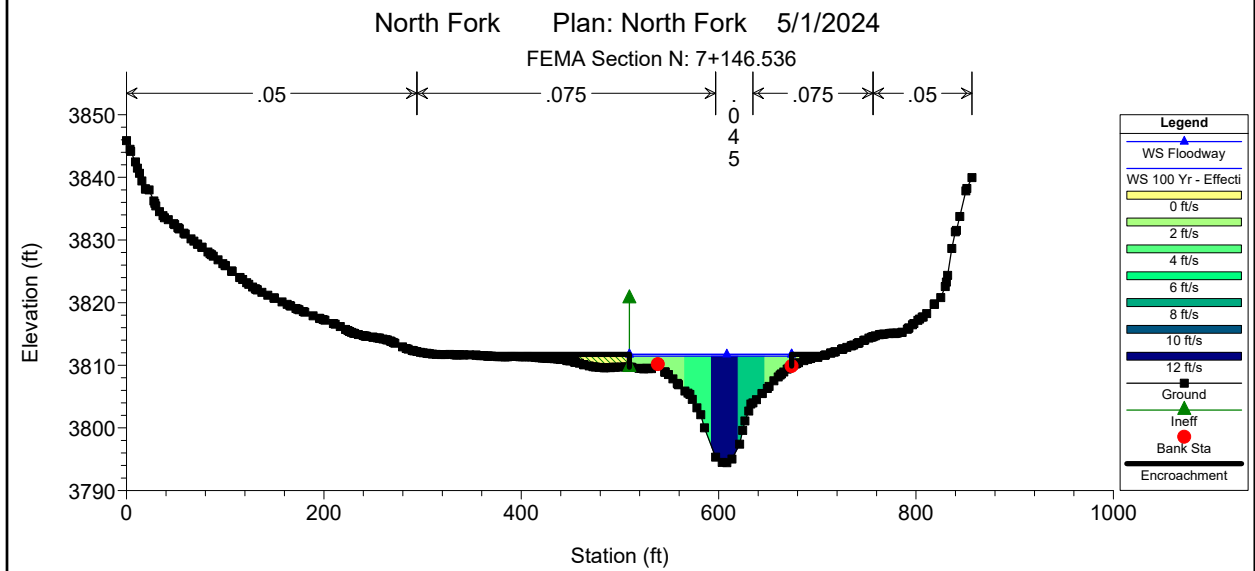
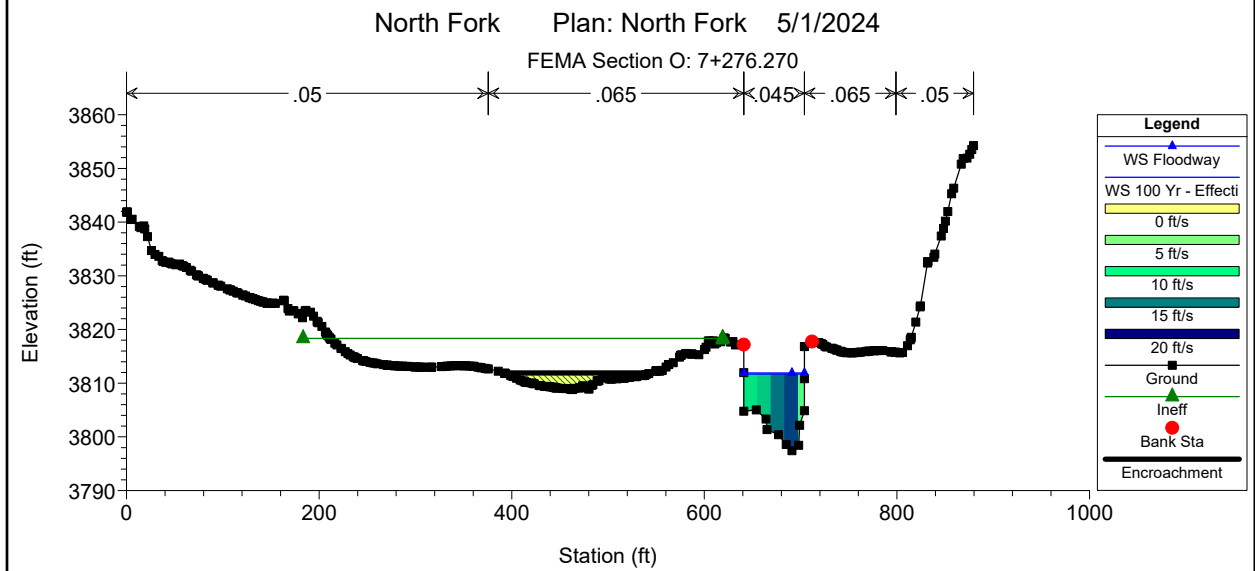
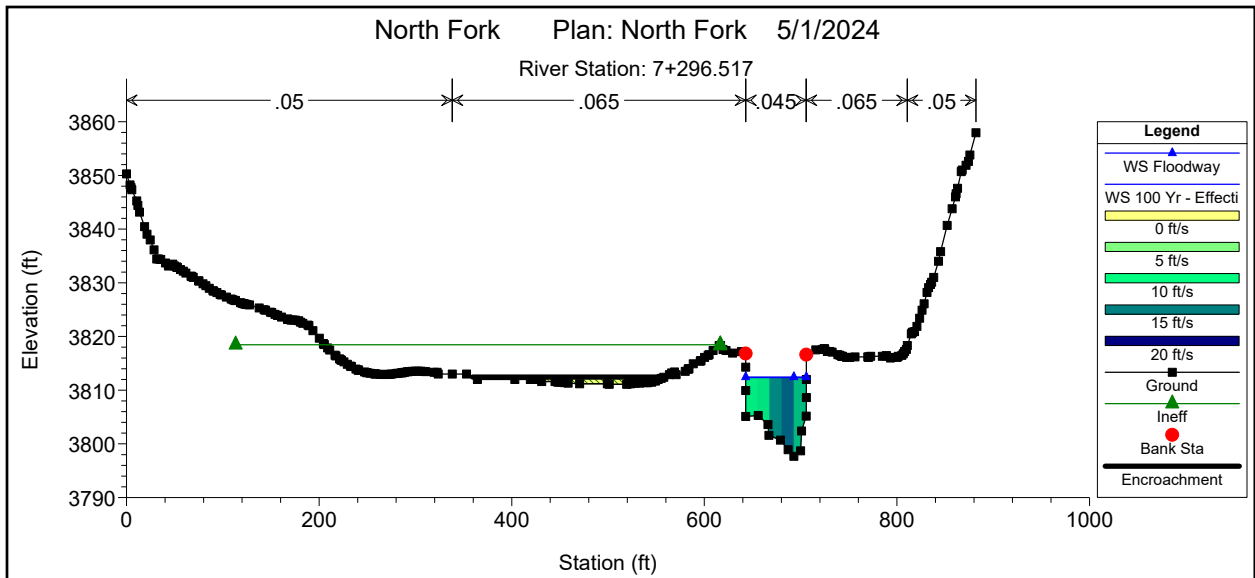
WILLOW BUNDLES TYPICAL DETAIL  
FOR  
ZION PARK BOULEVARD EROSION PROTECTION  
SPRINGDALE  
UTAH



**HEC-RAS Model Results - Effective Conditions - North Fork Virgin River**

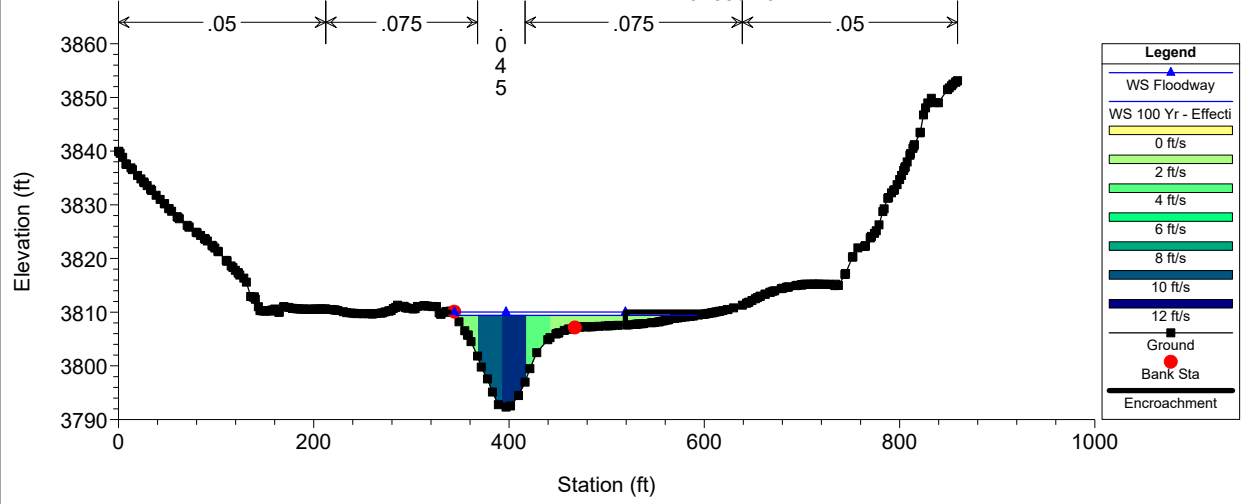
FEMA Sta	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Max Chl Dpth (ft)	Hydr Dpth (ft)	Vel Right (ft/s)
R	8+445.468	100 Yr	8830	3807.94	3821.13	3821.82	0.004186	7.1	1508.8	262.08	0.39	13.18	5.76	2.24
	8+445.468	Floodway	8830	3807.94	3821.46	3822.44	0.005069	7.98	1121.6	110	0.44	13.52	10.2	0.68
Q	7+600.735	100 Yr	8830	3802.67	3816.06	3816.86	0.00888	7.75	1293.15	516.74	0.53	13.38	5.18	
	7+600.735	Floodway	8830	3802.67	3816.1	3816.89	0.008735	7.71	1302.4	249.54	0.52	13.42	5.22	
P	7+402.373	100 Yr	8830	3799.55	3815.18	3815.95	0.002964	7.38	1353.2	525.26	0.39	15.63	8.36	
	7+402.373	Floodway	8830	3799.55	3815.21	3815.99	0.002955	7.38	1359.13	161.9	0.39	15.66	8.39	
	7+296.517	100 Yr	8830	3797.7	3812.34	3815.18	0.012495	13.52	652.97	259.62	0.74	14.64	10.36	
	7+296.517	Floodway	8830	3797.7	3812.45	3815.23	0.012132	13.38	659.85	63.03	0.73	14.75	10.47	
		Bridge												
O	7+276.270	100 Yr	8830	3797.41	3811.7	3814.74	0.012796	13.98	631.41	209.09	0.78	14.29	10.02	
	7+276.270	Floodway	8830	3797.41	3811.91	3814.82	0.012048	13.7	644.61	63.03	0.76	14.5	10.23	
N	7+146.536	100 Yr	8830	3794.44	3811.46	3812.39	0.008	7.83	1179.18	335.78	0.48	17.02	6.06	1.33
	7+146.536	Floodway	8830	3794.44	3811.73	3812.61	0.007334	7.58	1204.11	164.49	0.46	17.29	7.32	
M	6+886.104	100 Yr	8830	3792.32	3809.39	3810.38	0.007454	8.15	1213.3	246.09	0.49	17.07	4.93	2.15
	6+886.104	Floodway	8830	3792.32	3810.02	3810.88	0.005991	7.58	1250.55	174.9	0.44	17.7	7.15	2.83





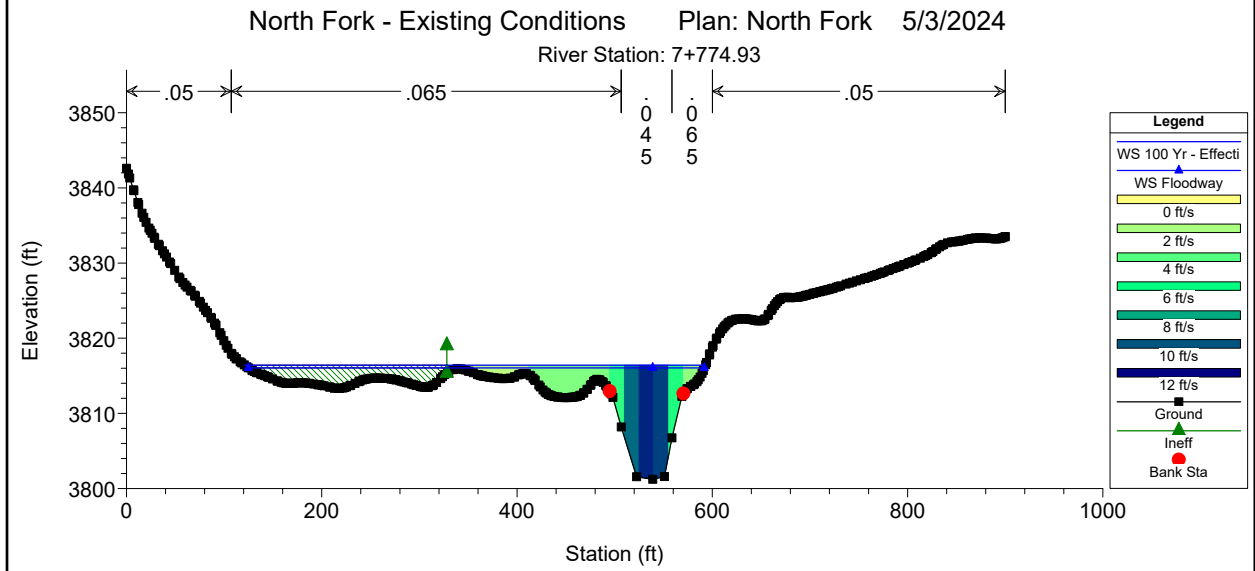
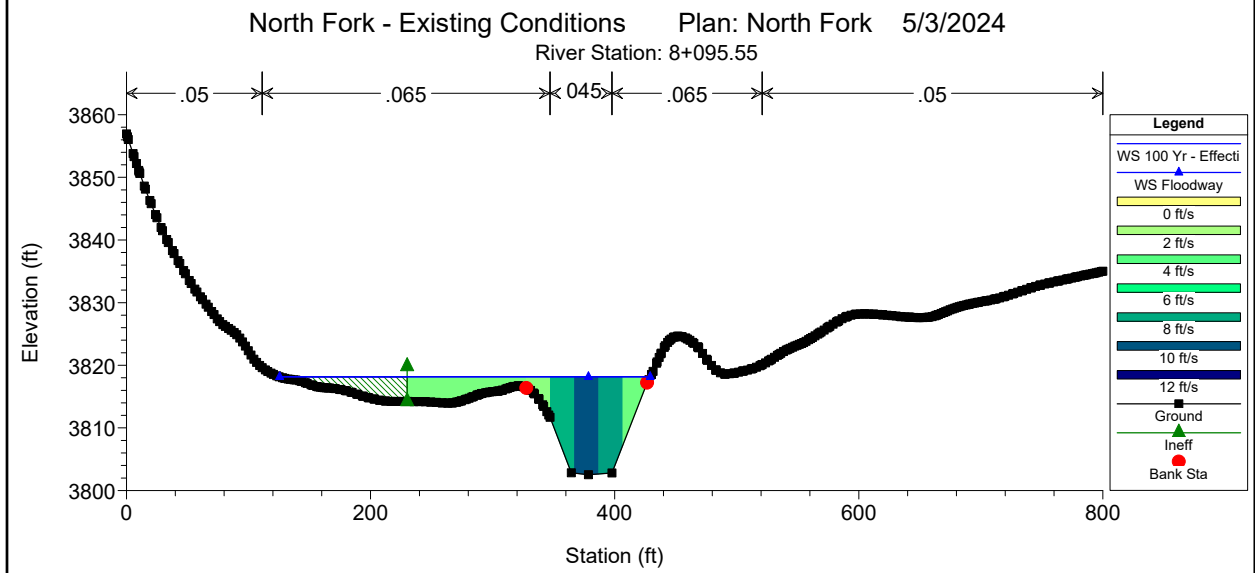
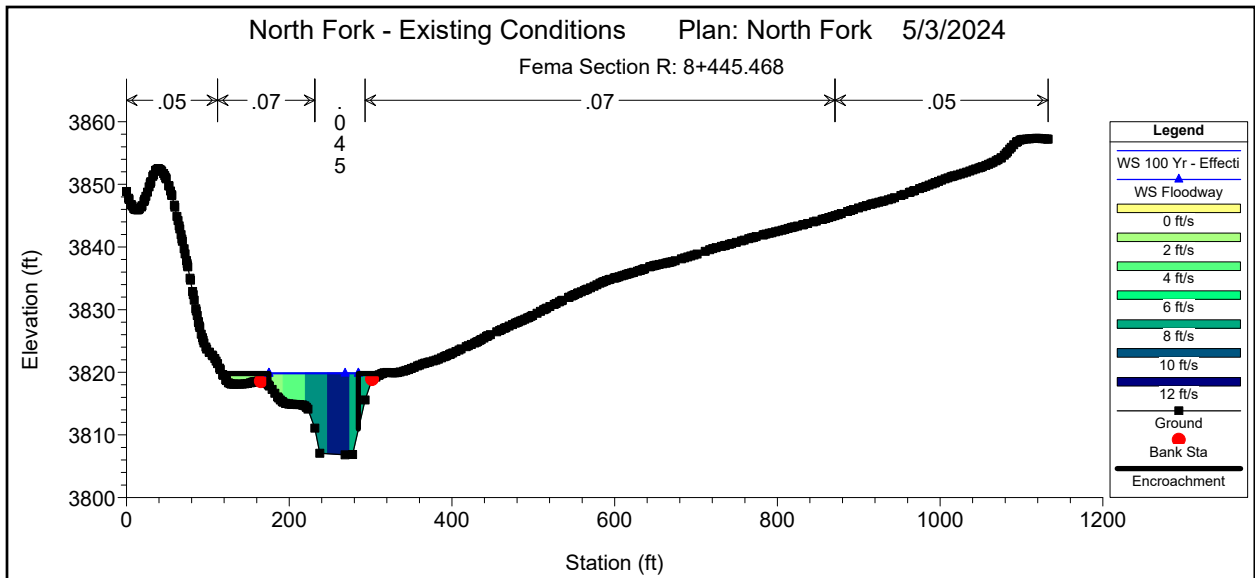
North Fork Plan: North Fork 5/1/2024

FEMA Section M: 6+886.104

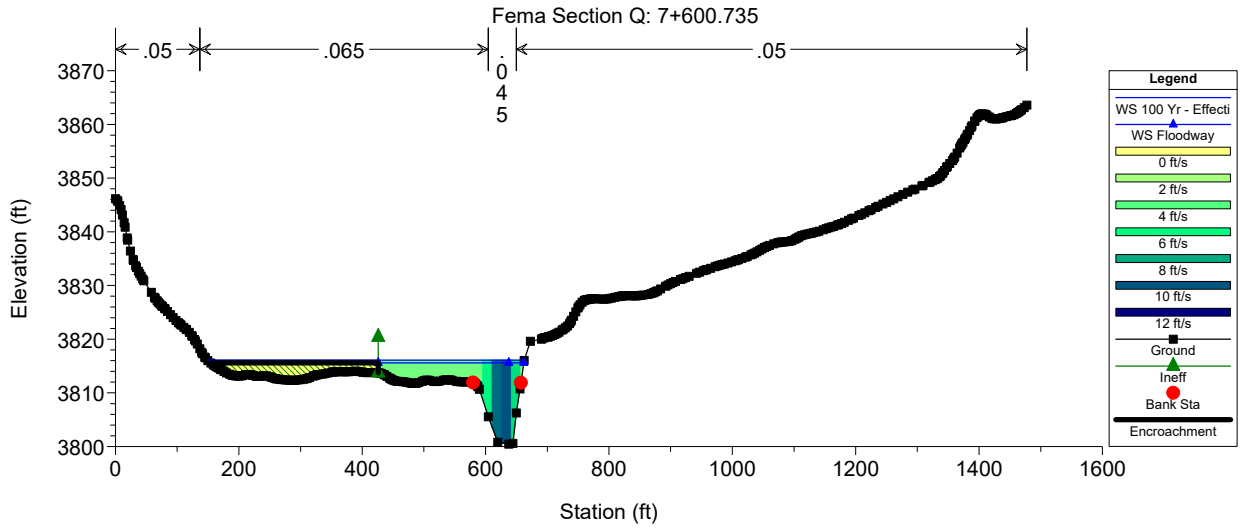


**HEC-RAS Model Results - Existing Conditions - North Fork Virgin River**

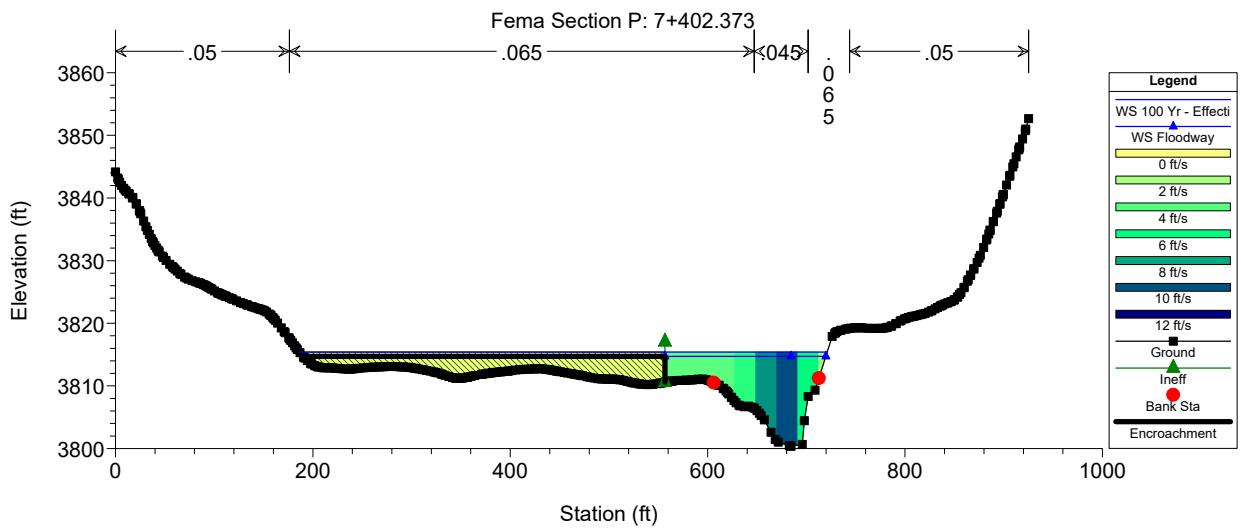
FEMA Sta	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Max Chl Dpth (ft)	Hydr Dpth (ft)	Vel Right (ft/s)
R	8+445.468	100 Yr	8830	3806.83	3819.9	3820.96	0.007757	8.34	1115.83	198.84	0.53	13.08	5.61	1.12
	8+445.468	Floodway	8830	3806.83	3819.79	3821.19	0.009171	9.48	931.64	110	0.57	12.97	8.47	
	8+096.55	100 Yr	8830	3802.52	3818.19	3819.03	0.004051	7.74	1326.66	304.51	0.43	15.66	6.65	0.88
	8+096.55	Floodway	8830	3802.52	3818.14	3819	0.004132	7.79	1316.93	303.65	0.43	15.61	6.61	0.86
	7+744.93	100 Yr	8830	3801.24	3816.42	3817.56	0.004418	9.12	1273.31	472.07	0.48	15.18	4.81	2.58
	7+744.93	Floodway	8830	3801.24	3816.04	3817.37	0.005235	9.7	1173.3	466.96	0.52	14.8	4.45	2.59
Q	7+600.735	100 Yr	8830	3800.44	3816.08	3816.89	0.003492	7.99	1455.83	513.59	0.42	15.64	6.15	2.42
	7+600.735	Floodway	8830	3800.44	3815.59	3816.56	0.00433	8.64	1341.62	235.96	0.47	15.16	5.69	2.5
P	7+402.373	100 Yr	8830	3800.37	3815.4	3816.2	0.003723	7.43	1309.28	534.8	0.41	15.04	7.96	2.12
	7+402.373	Floodway	8830	3800.37	3814.72	3815.68	0.004905	8.14	1197.02	163.12	0.47	14.35	7.34	2.16
	7+296.517	100 Yr	8830	3800.05	3814.05	3815.61	0.006683	10.03	884.8	454.8	0.56	14	9.23	1.57
	7+296.517	Floodway	8830	3800.05	3812.78	3814.84	0.010551	11.51	767.39	89.98	0.69	12.74	8.53	0.75
		Bridge												
O	7+276.270	100 Yr	8830	3799.61	3811.2	3813.8	0.011627	12.92	683.44	221.56	0.8	11.6	8.06	
	7+276.270	Floodway	8830	3799.61	3811.41	3813.88	0.010877	12.59	701.25	85.48	0.78	11.81	8.2	
N	7+146.536	100 Yr	8830	3798.79	3810.86	3812.19	0.005235	9.27	960.99	234.65	0.65	12.07	5.41	1.11
	7+146.536	Floodway	8830	3798.79	3811.15	3812.37	0.004697	8.86	1003.03	164.49	0.61	12.36	6.1	2.04
M	6+886.104	100 Yr	8830	3796.9	3808.99	3810.55	0.007504	10.3	1033.57	264.33	0.59	12.09	3.91	2.17
	6+886.104	Floodway	8830	3796.9	3809.69	3811	0.00576	9.47	1083.16	175.06	0.53	12.8	6.19	2.73



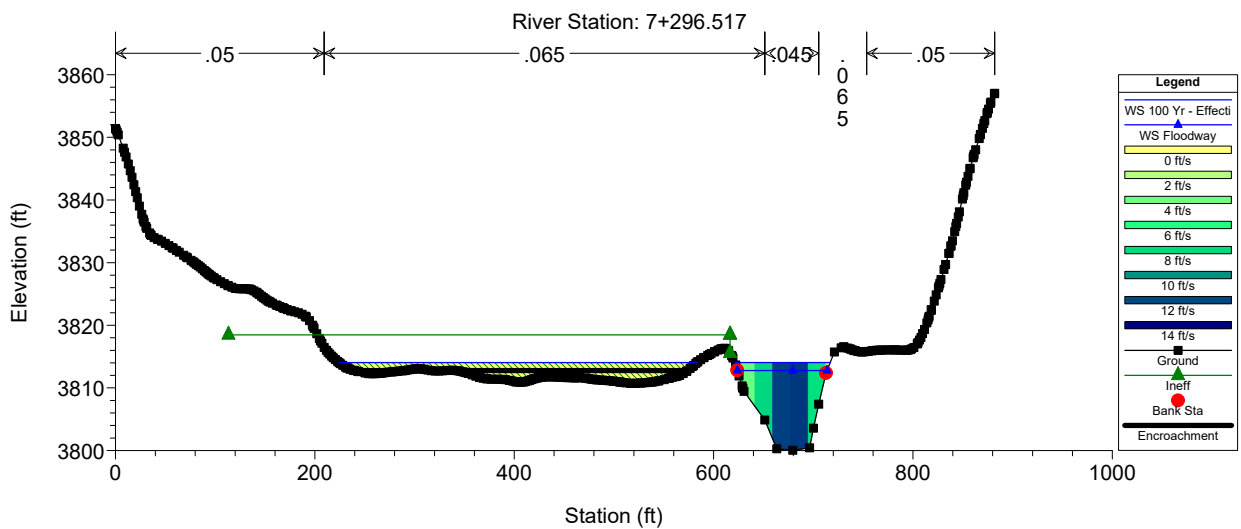
North Fork - Existing Conditions Plan: North Fork 5/3/2024



North Fork - Existing Conditions Plan: North Fork 5/3/2024

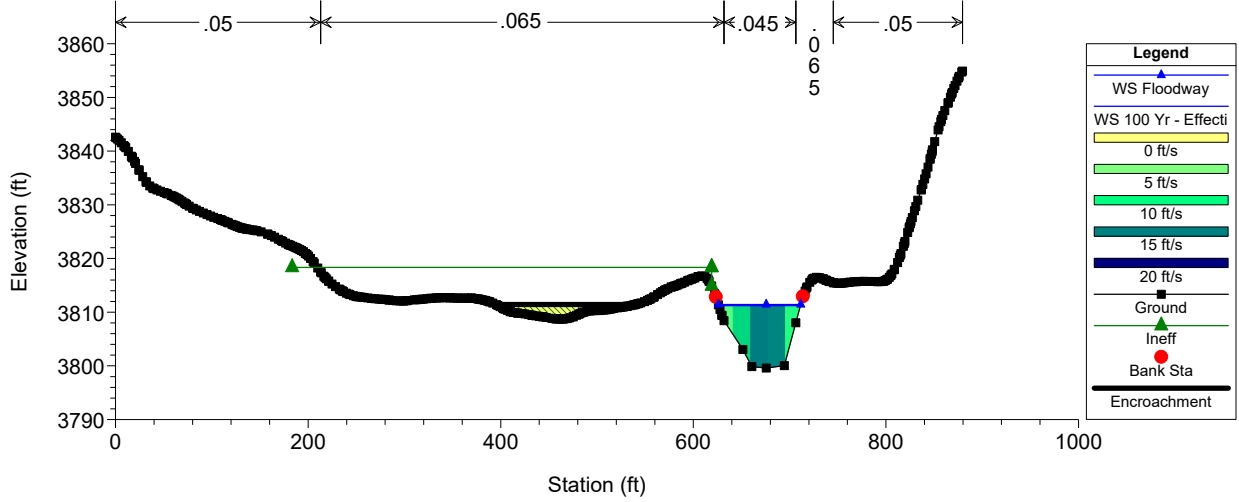


North Fork - Existing Conditions Plan: North Fork 5/3/2024



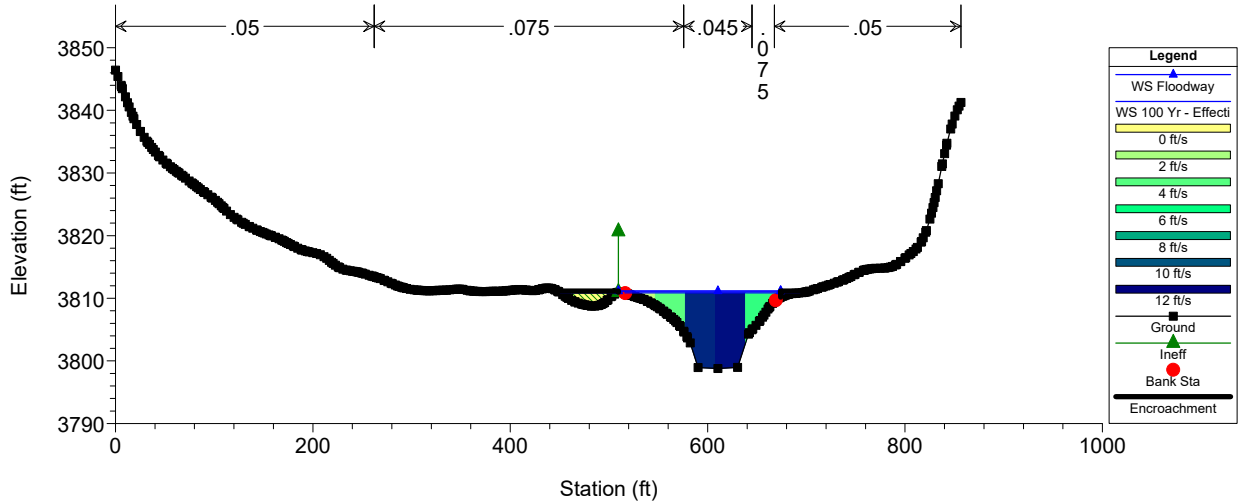
North Fork - Existing Conditions Plan: North Fork 5/3/2024

FEMA Section O: 7+276.270



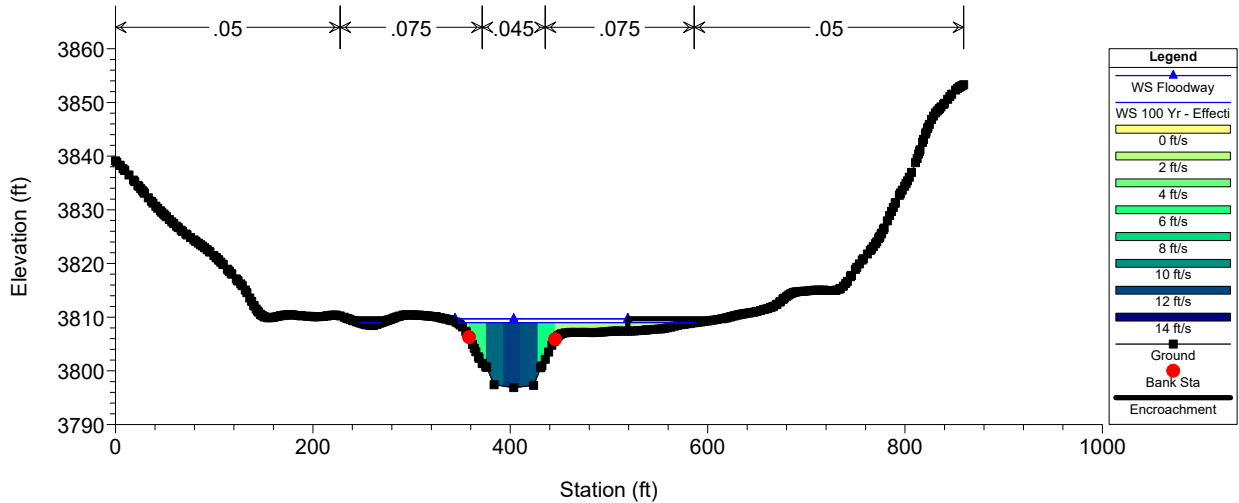
North Fork - Existing Conditions Plan: North Fork 5/3/2024

FEMA Section N: 7+146.536



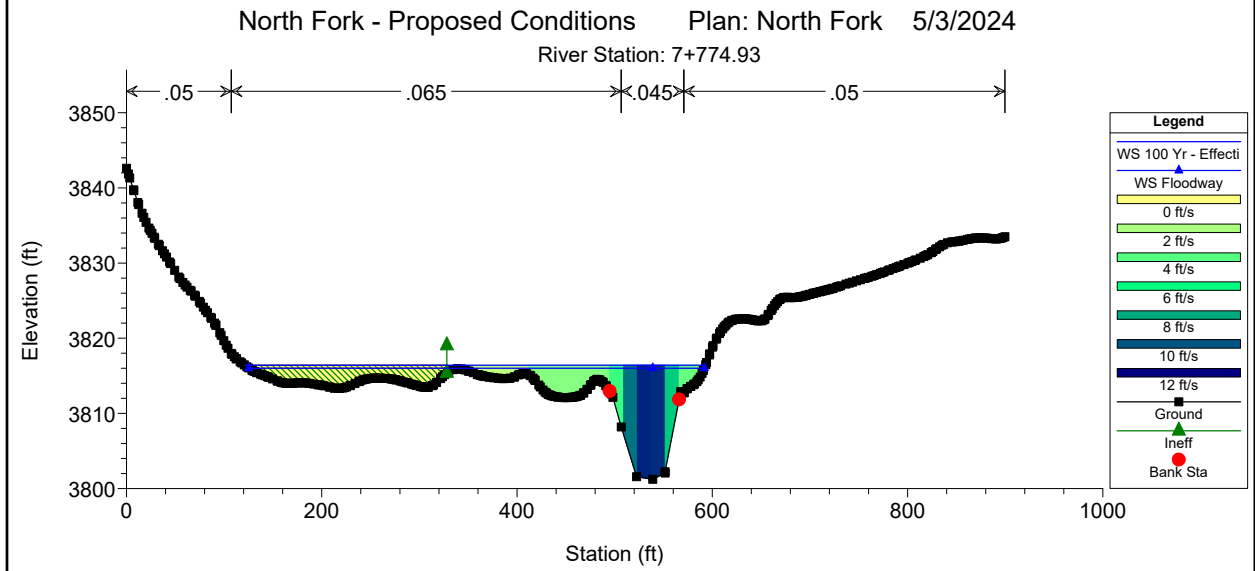
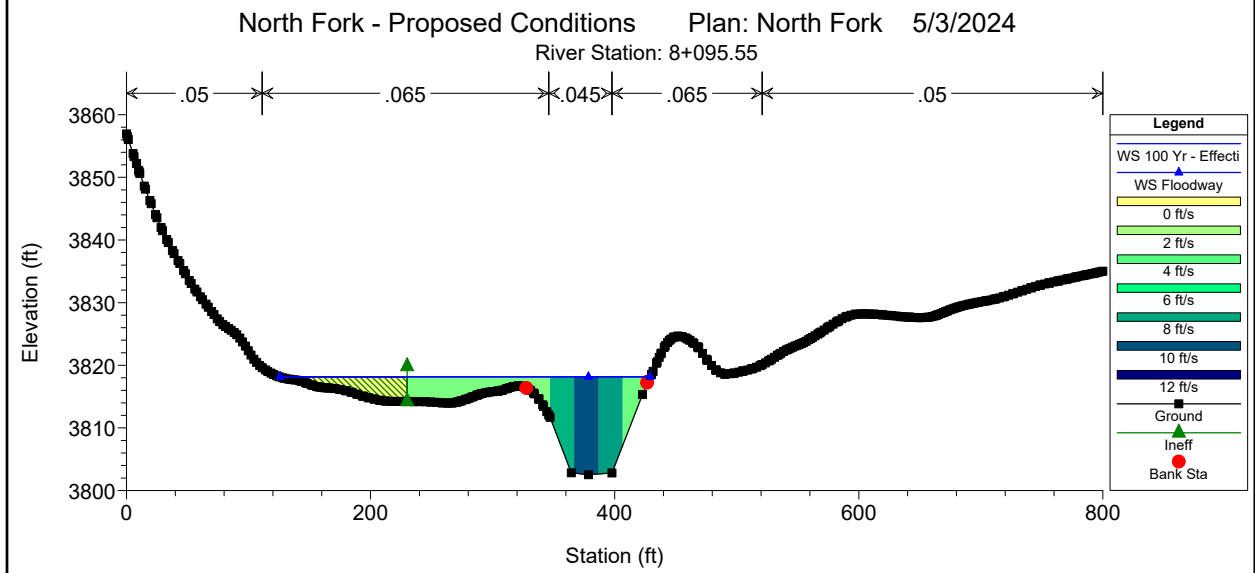
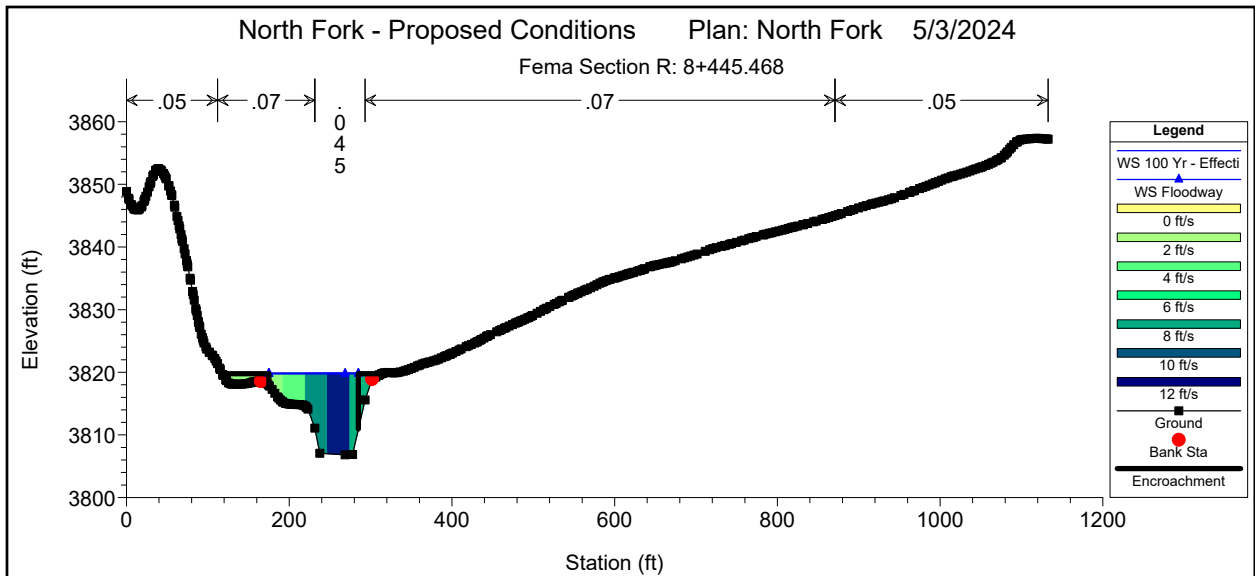
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FEMA Section M: 6+886.104

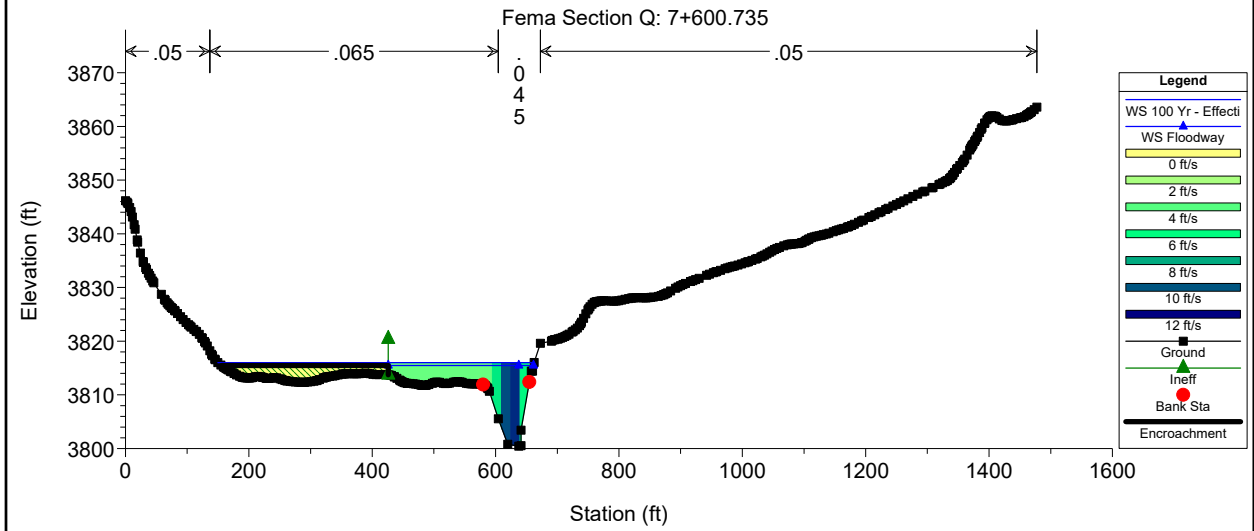


**HEC-RAS Model Results - Proposed Conditions - North Fork Virgin River**

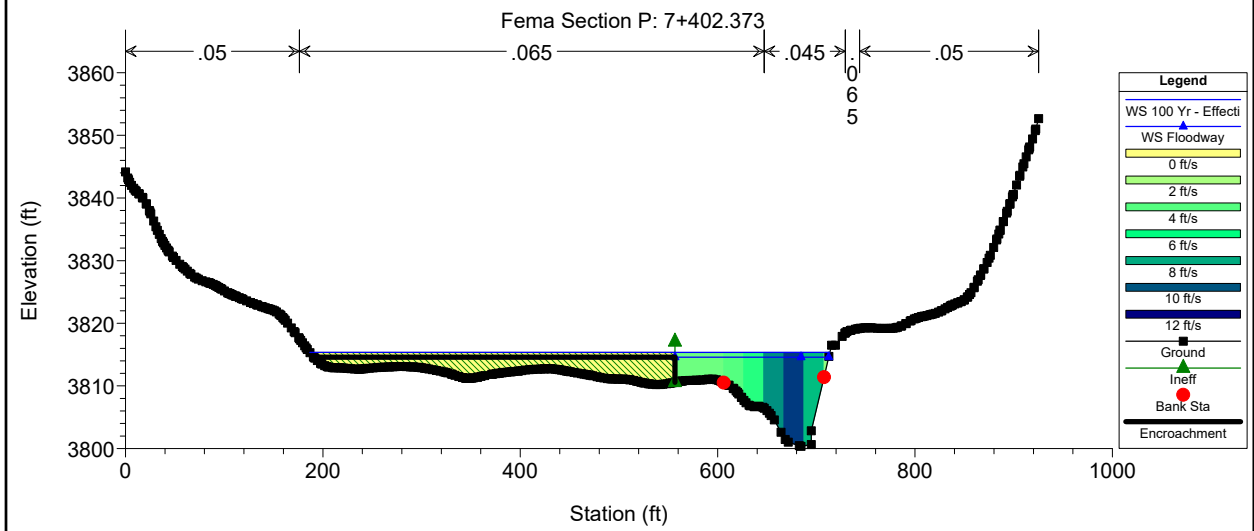
FEMA Sta	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Max Chl Dpth (ft)	Hydr Dpth (ft)	Vel Right (ft/s)
R	8+445.468	100 Yr	8830	3806.83	3819.89	3820.96	0.007798	8.35	1113.64	198.61	0.54	13.07	5.61	1.12
	8+445.468	Floodway	8830	3806.83	3819.78	3821.18	0.009209	9.49	930.44	110	0.58	12.96	8.46	
	8+096.55	100 Yr	8830	3802.52	3818.17	3819.02	0.004051	7.76	1323.25	304.24	0.43	15.65	6.64	0.87
	8+096.55	Floodway	8830	3802.52	3818.13	3818.99	0.004126	7.81	1314.25	303.4	0.43	15.6	6.6	0.85
	7+744.93	100 Yr	8830	3801.24	3816.41	3817.61	0.004003	9.37	1258.97	471.97	0.49	15.18	4.75	3.58
	7+744.93	Floodway	8830	3801.24	3816.02	3817.42	0.004776	10	1153.88	466.58	0.53	14.78	4.38	3.62
Q	7+600.735	100 Yr	8830	3800.44	3816.01	3816.91	0.004187	8.46	1384.17	512.9	0.46	15.58	5.85	2.8
	7+600.735	Floodway	8830	3800.44	3815.46	3816.57	0.005439	9.31	1253.25	235.55	0.52	15.02	5.32	2.73
P	7+402.373	100 Yr	8830	3800.37	3815.34	3816.23	0.003084	7.83	1258.7	527	0.43	14.98	8.02	2.55
	7+402.373	Floodway	8830	3800.37	3814.57	3815.67	0.004105	8.65	1138.47	155.86	0.5	14.21	7.3	2.55
	7+296.517	100 Yr	8830	3800.05	3814.15	3815.69	0.00708	9.98	888.18	454.82	0.56	14.1	9.4	1.5
	7+296.517	Floodway	8830	3800.05	3812.85	3814.9	0.011301	11.48	768.95	89.67	0.69	12.8	8.58	0.68
		Bridge												
O	7+276.270	100 Yr	8830	3799.61	3811.2	3813.8	0.011627	12.92	683.44	221.56	0.8	11.6	8.06	
	7+276.270	Floodway	8830	3799.61	3811.41	3813.88	0.010877	12.59	701.25	85.48	0.78	11.81	8.2	
N	7+146.536	100 Yr	8830	3798.79	3810.86	3812.19	0.005235	9.27	960.99	234.65	0.65	12.07	5.41	1.11
	7+146.536	Floodway	8830	3798.79	3811.15	3812.37	0.004697	8.86	1003.03	164.49	0.61	12.36	6.1	2.04
M	6+886.104	100 Yr	8830	3796.9	3808.99	3810.55	0.007504	10.3	1033.57	264.33	0.59	12.09	3.91	2.17
	6+886.104	Floodway	8830	3796.9	3809.69	3811	0.00576	9.47	1083.16	175.06	0.53	12.8	6.19	2.73



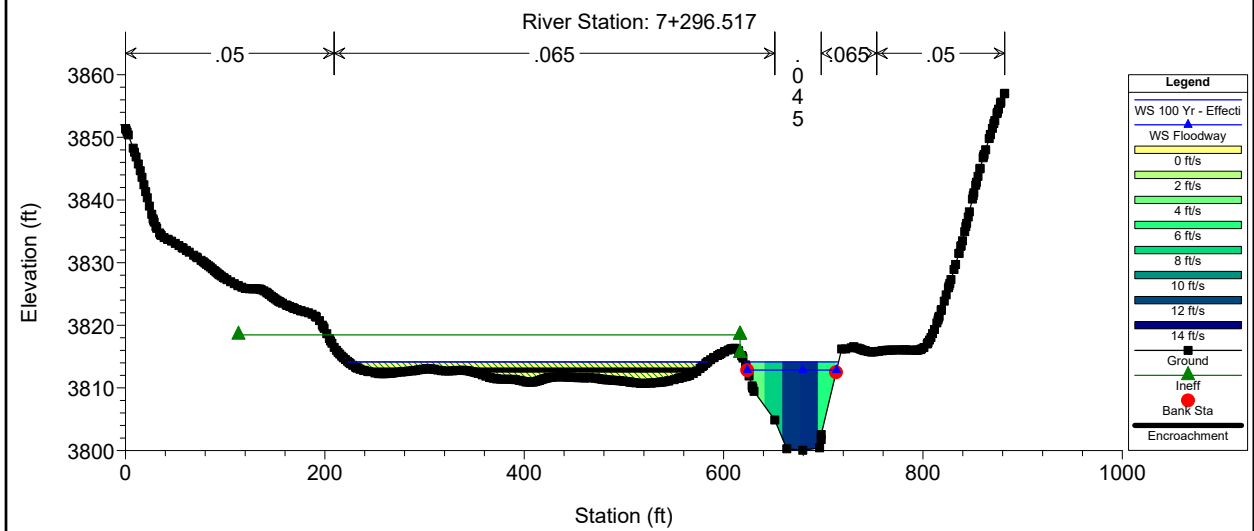
North Fork - Proposed Conditions Plan: North Fork 5/3/2024



North Fork - Proposed Conditions Plan: North Fork 5/3/2024

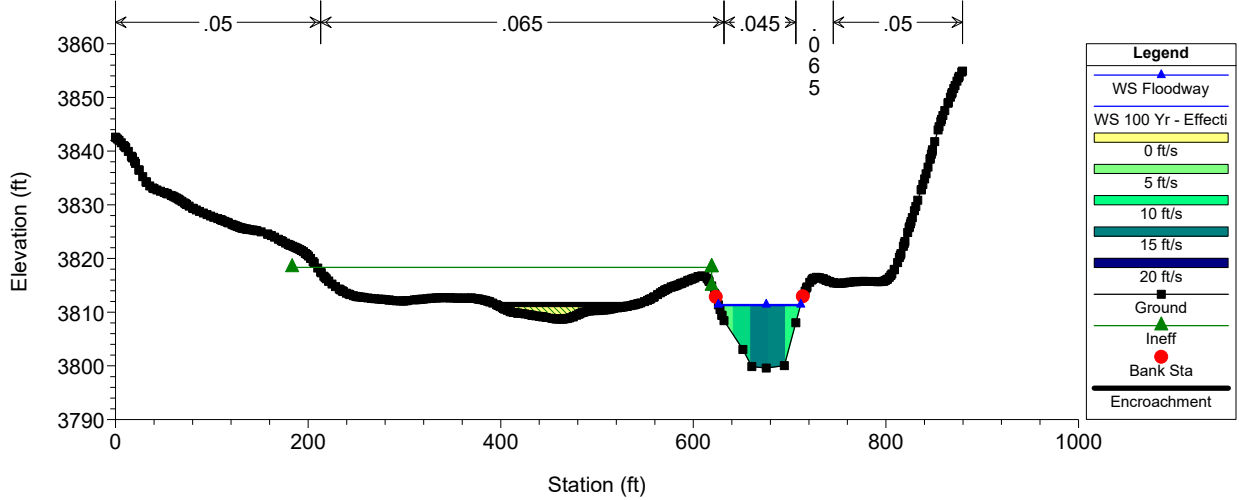


North Fork - Proposed Conditions Plan: North Fork 5/3/2024



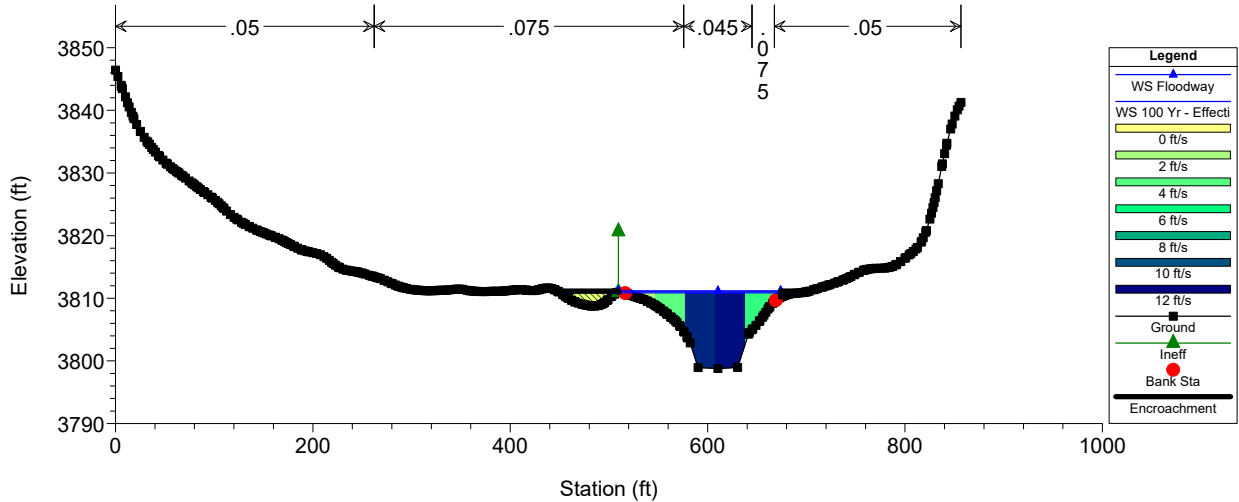
North Fork - Proposed Conditions Plan: North Fork 5/3/2024

FEMA Section O: 7+276.270



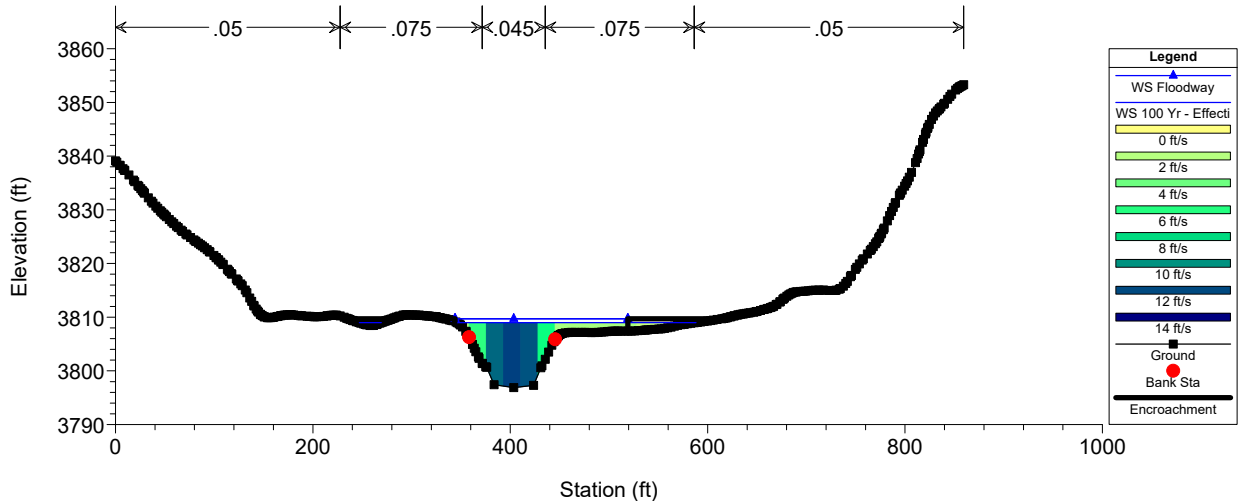
North Fork - Proposed Conditions Plan: North Fork 5/3/2024

FEMA Section N: 7+146.536



North Fork - Proposed Conditions Plan: North Fork 5/3/2024

FEMA Section M: 6+886.104





Project: SR-9 Erosion Protection BY: GRF DATE: 7/12/2021

Subject: Long Term Degradation CHKD. BY: JWB DATE: \_\_\_\_\_

Assumptions:

Long Term Degradation for this site was determined by estimating the elevation difference in the Virgin River flowline between 2009 and 2017 at three locations within the study reach (Table 3). This method was chosen as accurate river topography was available and significant storm events have occurred during this time period. The table above compares the elevation of the Virgin River flowline in 2009 (cross section data from 2009 Washington County Flood Insurance Study1) and 2017 (2017 Washington County LiDAR Topography) The 2009 elevation data is based on ground survey points while the 2017 LiDAR topography gives the elevation of the water surface. To account for the discrepancy, The 2017 LiDAR elevations were reduced by 2 feet to determine the river flowline elevation. This value represents the typical difference between the 2017 LiDAR elevation and the flowline elevation measured by 2019 ground surveys in adjacent, similar reaches of the North Fork of the Virgin River. Based on these elevations, the Virgin River experienced an elevation increase of 1.5' to 2' over 8 years within the reach. Due to the net aggradation within the channel over an 8 year period in which significant storm events have occurred, it can be assumed that long term degradation is unlikely to contribute significantly to channel scour. Therefore, a maximum scour depth of 2' due to long term degradation was assumed over a 100 year period. Proportional values were used for the 50 year and 10 year calculations.



Project: SR-9 Erosion Protection BY: GRF DATE: 7/12/2021

Subject: 100 YR Anti Dune Trough Scour CHKD. BY: JWB DATE: \_\_\_\_\_

Anti Dune Trough: (Section 704.2.1.3 - Anti Dune Trough Depth  
 Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 74+02

Given:

100 YR Average channel velocity,  $V =$  7.39 ft/s  
 Hydraulic depth,  $Y =$  8.35 ft

Anti Dune Depth based on Velocity:

Equation:

$$Z_a = 0.0137 * V^2$$

**Anti Dune Trough Depth,  $Z_a =$  0.75 ft** ←

*Anti Dune Trough Depth (max),  $Z_a =$  4.175*

Project: SR-9 Erosion Protection BY: GRF DATE: 7/12/2021

Subject: 50 YR Anti Dune Trough Scour CHKD. BY: JWB DATE: \_\_\_\_\_

Anti Dune Trough: (Section 704.2.1.3 - Anti Dune Trough Depth  
Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 74+02

Given:

100 YR Average channel velocity,  $V = 7.31$  ft/s  
Hydraulic depth,  $Y = 7.21$  ft

Anti Dune Depth based on Velocity:

Equation:

$$Z_a = 0.0137 * V^2$$

**Anti Dune Trough Depth,  $Z_a = 0.73$  ft** ←

*Anti Dune Trough Depth (max),  $Z_a = 3.605$*



Project: SR-9 Erosion Protection BY: GRF DATE: 7/12/2021

Subject: 10 YR Anti Dune Trough Scour CHKD. BY: JWB DATE: \_\_\_\_\_

Anti Dune Trough: (Section 704.2.1.3 - Anti Dune Trough Depth  
 Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 74+02

Given:

100 YR Average channel velocity,  $V = 7.01$  ft/s  
 Hydraulic depth,  $Y = 5.97$  ft

Anti Dune Depth based on Velocity:

Equation:

$$Z_a = 0.0137 * V^2$$

**Anti Dune Trough Depth,  $Z_a = 0.67$  ft** ←

*Anti Dune Trough Depth (max),  $Z_a = 2.985$*

Project: SR-9 Erosion Protection

BY: GRF DATE: 7/12/2021

Subject: 100 Year Bend Scour

CHKD. BY: JWB DATE: \_\_\_\_\_

Bend Scour: (Section 704.2.1.4 - Bend Scour

Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 76+01

Given:

Average velocity upstream from bend,  $V = 7.76$  ft/s

Maximum depth upstream of bend,  $Y_{max} = 13.38$  ft

Hydraulic depth in channel upstream of bend,  $Y_h = 5.18$  ft

Energy slope upstream of bend,  $S_e = 0.008924$  ft/ft

Angle of bend,  $\alpha = 29$  deg

\*Determined by acute angle formed by intersection between projection of flowline and line tangent to outer bank of bend

Equation:

$$Z_{bs} = \left( \frac{0.0685 * Y_{max} * V^{0.8}}{Y_h^{0.4} * S_e^{0.5}} \right) \left( 2.1 \left( \frac{\sin^2 \left( \frac{\alpha}{2} \right)^{0.2}}{\cos \alpha} \right) - 1 \right)$$

**Bend Scour,  $Z_{bs} = 6.20$  ft**



Project: SR-9 Erosion Protection

BY: GRF DATE: 7/12/2021

Subject: 50 Year Bend Scour

CHKD. BY: JWB DATE: \_\_\_\_\_

Bend Scour: (Section 704.2.1.4 - Bend Scour

Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 76+01

Given:

Average velocity upstream from bend,  $V =$  8.51 ft/s

Maximum depth upstream of bend,  $Y_{\max} =$  12.27 ft

Hydraulic depth in channel upstream of bend,  $Y_h =$  4.14 ft

Energy slope upstream of bend,  $S_e =$  0.0133 ft/ft

Angle of bend,  $\alpha =$  29 deg

\*Determined by acute angle formed by intersection between projection of flowline and line tangent to outer bank of bend

Equation:

$$Z_{bs} = \left( \frac{0.0685 * Y_{\max} * V^{0.8}}{Y_h^{0.4} * S_e^{0.5}} \right) \left( 2.1 \left( \frac{\sin^2 \left( \frac{\alpha}{2} \right)^{0.2}}{\cos \alpha} \right) - 1 \right)$$

**Bend Scour,  $Z_{bs} =$  5.49 ft**



Project: SR-9 Erosion Protection

BY: GRF DATE: 7/12/2021

Subject: 10 Year Bend Scour

CHKD. BY: JWB DATE: \_\_\_\_\_

Bend Scour: (Section 704.2.1.4 - Bend Scour

Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 76+01

Given:

Average velocity upstream from bend,  $V = 9.81$  ft/s

Maximum depth upstream of bend,  $Y_{\max} = 10.04$  ft

Hydraulic depth in channel upstream of bend,  $Y_h = 2.51$  ft

Energy slope upstream of bend,  $S_e = 0.0311$  ft/ft

Angle of bend,  $\alpha = 29$  deg

\*Determined by acute angle formed by intersection between projection of flowline and line tangent to outer bank of bend

Equation:

$$Z_{bs} = \left( \frac{0.0685 * Y_{\max} * V^{0.8}}{Y_h^{0.4} * S_e^{0.5}} \right) \left( 2.1 \left( \frac{\sin^2 \left( \frac{\alpha}{2} \right)^{0.2}}{\cos \alpha} \right) - 1 \right)$$

**Bend Scour,  $Z_{bs} = 4.02$  ft**





Project: SR-9 Erosion Protection BY: GRF DATE: 7/12/2021

Subject: Rip-Rap Size CHKD. BY: JWB DATE: \_\_\_\_\_

**Riprap Design for Channel Lining Based on Channel Velocity**

Rip-Rap: (Section 704.2.1.3 - Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:

Virgin River - North Fork Station 74+02

Given:

Mean Channel Velocity,  $V = 7.39$  fps  
 Longitudinal Channel Slope,  $S = 0.014$  ft/ft  
 Specific Gravity of Riprap Lining,  $S_s = 2.50$  minimum  $S_s = 2.50$

Smith and Murray Model Equation:

Equation:

$$V = 3(d_{50})^{0.5}(S_s-1)/S^{0.17}$$

Average Rock Size  $d_{50} = 0.63$  ft *Equation 734*  
 8 in

**Riprap Design for Channel Lining Based on Tractive Stress\***

Maximum Channel Depth,  $Y_{max} = 15.61$  ft  
 Average Energy Slope,  $S_e = 0.002976$  ft/ft  
 Channel Stability Factor,  $F_s = 1.3$  1.0 - 1.2 Straight or mildly curving reach  
 1.2 - 1.4 Moderate bend curvature with minor impact from floating debris  
 1.4 - 1.6 Sharp bend with significant impact from floating debris and wave  
 1.6 - 2.0 Rapidly varying flow with significant uncertainty in design  
 Channel Side Slopes = 1.50 H : 1V 2H : 1V max  
 Trial Average Rock Size,  $d_{50} = 18.00$  in insert a first trial, then adjust

Tractive Stress Equation  $d_{50} = 14.2F_s Y_{max}(S_e/K_1)$  *Equation 736*

**Solving**

Slope Angle with Horizontal,  $a = 0.5880$  rad  
 Angle of Repose,  $h = 0.7313$  rad  
 Bank Angle Modification Factor,  $K_1 = 0.55687 = (1-(\sin^2 a/\sin^2 h))^{0.5}$   
*Lane Equation*

Average Rock Size,  $d_{50} = 1.54$  ft  
18 in ←

The hydrodynamic force of water flowing in a channel is known as the tractive force. Flow-induced tractive force should not exceed the permissible or critical shearstress of the riprap. Theabove equation is a relationship to estimate  $d_{50}$  assuming a specific gravity of 2.50

**Appendix 2: Review Letter from Sunrise Engineering (the Town's Engineer)**



11 North 300 West, Washington, Utah 84780  
Tel: 435.652.8450 | Fax: 435.652.8416

May 21, 2024

Town of Springdale  
Mr. Niall Connolly, Principal Planner  
PO Box 187  
Springdale, UT 84767

RE: Erosion Hazard Assessment for Zion Boulevard

Dear Mr. Connolly,

Please find attached the Erosion Hazard Assessment that we have reviewed. Our engineer, Li Qi has reviewed the assessment and has provided the attached comments.

As always, we appreciate our business with the Town of Springdale. If you have any questions, please feel free to give us a call, 435-652-8450.

Sincerely,

A handwritten signature in blue ink that reads "Dustyn Shaffer". The signature is fluid and cursive, written in a professional style.

Dustyn Shaffer, P.E.  
Principal Engineer

Enclosure

**REVIEW COMMENTS ON EROSION HAZARD ASSESSMENT**  
**ZION BOULEVARD EROSION PROTECTION**  
**SPRINGDALE, UTAH**

Sunrise Engineering, LLC (SE) performed a review of the Rosenberg Associates report entitled Erosion Hazard Assessment, Zion Park Boulevard Erosion Protection, Springdale, Utah, dated May 9, 2024 (Assessment). We assumed that all the data provided by Rosenberg Associates in the Assessment is accurate.

Review Comments

**1.0 INTRODUCTION**

1.1 Project Overview & Location

- The abbreviation EHZ is defined twice.

**2.0 SITE INVESTIGATION**

2.1 Site Conditions

- Sufficient site information including site photos is provided.
- The abbreviation HREHZ is defined twice.

2.3 Geology and Soils Information

- This section should be 2.2.
- Geology and soil data are provided.
- Soil gradation(s) should be included in the Appendix if used in the scour calculations (Section 3.2).

2.4 Effective Floodplain Information

- This section should be 2.3.
- The FIRMette shows that the majority of the proposed improvement is located within Zone AE, as well as the regulatory floodway.

2.5 Floodplain Analysis

- This section should be 2.4.
- The HEC-RAS models cover the project area, and the approach appears to be correct.
- Since the majority of the proposed improvement encroaches into the regulatory floodway, “Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations” (FEMA).
- HEC-RAS model output tables show that the proposed development does not increase the floodway elevations (comparing with the effective and modified effective/existing conditions) at Crosse-sections R and Q. Consequently, the FEMA requirement of “no increases in upstream flood elevations” is met.

### **3.0 RIVER MEANDER & SCOUR ANALYSIS**

#### **3.1 Historical Aerial Photo Analysis**

The analysis is reasonable and sufficient.

#### **3.2 Scour Analysis**

- It is recommended to include the scour analysis calculations for this reach of the North Fork of the Virgin River (Reference 1) in the Appendix of this Assessment.

#### **3.3 Analysis of Erosion Hazard Risk**

- The description and analysis appear to be reasonable.
- It is recommended to include the riprap calculation sheet(s) for this reach of the North Fork of the Virgin River (Reference 1) in the Appendix of this Assessment.
- According to the Assessment, a full design (to protect the property from the erosion damage caused by a 100-year design storm) is extremely hard and not feasible. Consequently, the riprap protection is under-designed relative to a 100-year design storm event for the areas adjacent to downstream and upstream residences. In two areas the riprap protections are below the base flood elevations.
- The bank protection is designed based on the Engineer's experience working in this reach of the North Fork of the Virgin River, and similar designs have been used successfully along the Virgin River and are based on concepts used by the NRCS. Therefore, it is believed that the erosion protection design shall provide sufficient protection for the proposed improvement.

### **4.0 RECOMMENDATIONS**

#### **4.1 Proposed Improvements**

- Three different sections of the riprap erosion protection design are recommended by the Assessment and shown on the Proposed Erosion Protection Plan.
- In summary, the erosion protection design in combination with the measures recommended in the following sections shall provide adequate protection for the project.

#### **4.2 to 4.5**

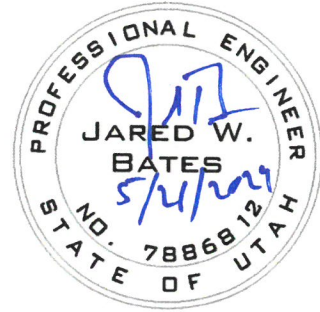
- No comments.

### **5.0 ENGINEER'S OPINION OF RISK**

- No comments.

**Appendix 3: Response to Sunrise review, from Rosenberg Associates**

**REVIEW COMMENTS ON EROSION HAZARD ASSESSMENT  
ZION BOULEVARD EROSION PROTECTION  
SPRINGDALE, UTAH**



Below in red are the responses to the comments provided by the Town Engineer.

Review Comments

**1.0 Introduction**

1.1 Project Overview & Location

- The abbreviation EHZ is defined twice.

○ Corrected

**2.0 Site Investigation**

2.1 Site Conditions

- Sufficient site information including site photos is provided.
- The abbreviation EHZ is defined twice.

○ Corrected

2.3 Geology and Soils Information

- This section should be 2.2.

○ Corrected

- Geology and soil data are provided.
- Soil gradation(s) should be included in the Appendix if used in the scour calculations (Section 3.2).

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○ Corrected

- The FIRMette shows that the majority of the proposed improvement is located within Zone AE, as well as the regulatory floodway.

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○ Corrected

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- Since the majority of the proposed improvement encroaches into the regulatory floodway, “Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations” (FEMA).

- HEC-RAS model output tables show that the proposed development does not increase the floodway elevations (comparing with the effective and modified effective/existing conditions) at Crosse-sections R and Q. Consequently, the FEMA requirement of “no increases in upstream flood elevations” is met.

### **3.0 River Meander & Scour Analysis**

#### 3.1 Historical Aerial Photo Analysis

- The analysis is reasonable and sufficient.

#### 3.2 Scour Analysis

- It is recommended to include the scour analysis calculations for this reach of the North Fork of the Virgin River (Reference 1) in the Appendix of this Assessment.
  - The scour calculations from the previous study have been included in the Appendix of the updated report.

#### 3.3 Analysis of Erosion Hazard Risk

- The description and analysis appear to be reasonable.
- It is recommended to include the riprap calculation sheet(s) for this reach of the North Fork of the Virgin River (Reference 1) in the Appendix of this Assessment.
- According to the Assessment, a full design (to protect the property from the erosion damage caused by a 100-year design storm) is extremely hard and not feasible. Consequently, the riprap protection is under-designed relative to a 100- year design storm event for the areas adjacent to downstream and upstream residences. In two areas the riprap protections are below the base flood elevations.
- The bank protection is designed based on the Engineer’s experience working in this reach of the North Fork of the Virgin River, and similar designs have been used successfully along the Virgin River and are based on concepts used by the NRCS. Therefore, it is believed that the erosion protection design shall provide sufficient protection for the proposed improvement.

### **4.0 Recommendations**

#### 4.1 Proposed Improvements

- Three different sections of the riprap erosion protection design are recommended by the Assessment and shown on the Proposed Erosion Protection Plan.
- In summary, the erosion protection design in combination with the measures recommended in the following sections shall provide adequate protection for the project.

#### 4.2 to 4.5

- No comments.

## **5.0 Engineer's Opinion of Risk**

- No comments.