Beaver Valley Headwaters Preserve: SRWC Final Report

A Compendium of Natural Resource Information Collected to Inform Management Decisions Related to Riparian Habitat, Stream Channel Restoration and Enhancement & Forest Health Resiliency

Prepared by Scott River Watershed Council
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Scott River Watershed Council

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Executive Summary

This document consists of seven different assessments completed by the Scott River Watershed Council (SRWC) on the Beaver Valley Headwaters Preserve (BVHP). These assessments were developed to inform decisions related to restoration opportunities on the property and were done in part, as deliverables for contract # CSK.F6.01 with California Trout.

Initially, the SRWC was contracted for a riparian habitat assessment during the summer of 2022. Subsequently, this work highlighted the need to investigate, document, and evaluate actively eroding gullies, which were discharging sediment directly into the East Fork of the Scott River. Considering this, Cal Trout broadened SRWC's scope of work to encompass a comprehensive assessment of roads and gullies. This expanded scope of work commenced in the winter of 2022/2023.

On Noyes Valley Creek, a tributary of the East Fork Scott River, it was determined that the conventional riparian assessment was not going to provide the information necessary to assess restoration actions. In response, SRWC installed a network of shallow (approximately 7 to 12 foot) groundwater wells in the fall of 2022 along three miles of Noyes Valley Creek. The goal was to help develop a better understanding of the groundwater/surface water relationship and how this most likely, along with long term intensive cattle grazing, was impacting the predominantly willow riparian species. Additional wells were installed in the winter of 2024 to help evaluate locations in the East Fork and Big Mill Creek for similar goals.

In the spring of 2023, the project team identified the need to obtain discharge (streamflow) for both restoration design elements and possible water dedication activities. SRWC set up and maintained two stations along the East Fork and one on Big Mill and Noyes Valley Creeks. To complement the streamflow data, SRWC also deployed temperature loggers, aiming to document the temperature regime through the project reach and the influences from the smaller tributaries such as Mule, Big Mill and Noyes Valley Creeks.

During that same year, SRWC and its partner, the Quartz Valley Indian Reservation, performed a series of direct observations to help document the presence of both coho salmon and steelhead and the types of habitats utilized throughout the reach. This field work is specifically focused on summer conditions, aquatic habitat and fishery resources. The findings of that effort can be found at the Scott River Fisheries Monitoring Report.

Another important metric to consider when evaluating overall health of a system are results from coho salmon spawning ground surveys. For the 2023/2024 season, SRWC collaborated with the Siskiyou Resource Conservation District and the Quartz Valley Indian Reservation to conduct comprehensive spawning ground surveys: Scott River Coho Salmon Spawning Ground Surveys 2023-2024.

Finally, in light of a notable upland mortality event occurring within the BVHP, SRWC obtained additional funding from the North Coast Resource Partnership (NCRP), facilitating collaboration with BB&W Associates, a forestry consulting firm. The primary focus of this effort identified areas requiring immediate attention for forest health improvement that will provide ecological uplift and increase fire resilience. Identification of wood essential for future instream restoration initiatives on BVHP and possible other Scott Valley restoration projects were a top priority for this effort.

Overall, the project aimed to assess and prioritize opportunities to improve water quality in this important tributary to the Scott River to provide habitat for listed coho salmon. Specifically, the project was to examine factors contributing to high sediment and temperature loads and the respective impacts to salmonid species within the lower East Fork Scott River East and its tributary, Big Mill Creek, through a detailed existing conditions assessment.

The assessments presented in this document consist of standalone, yet interconnected, chapters. Given the interrelated nature of each component, we have compiled them to ensure easy access to all the information gathered by the Watershed Council. A single introduction is offered for this compendium, followed by structured chapters delineating the purpose, methods, results, and recommendations for each specific topic. The seven assessments/chapters have been organized as such:

1. Riparian Habitat Assessment
2. Roads and Gullies
3. Stream Discharge and Wetted Perimeter Analysis
4. Water Temperature
5. Groundwater/Water Surface Elevation
6. Restoration Designs on Noyes Valley Creek
7. Forest Management Opportunities

A summary and key points from each chapter is provided below.

Riparian Habitat Assessment

This analysis was based on three different methodologies. We conducted field work in 2022 and completed 27 transects during which we collected data on riparian health, composition, extent, and health in each of three reaches in the East Fork Scott River. In addition, we analyzed aerial images to assess the change in streambank location and erosion over time, and finally we used remote sensing data (LiDAR and orthophotos) to document the relative elevation of the stream channel and adjacent floodplain and terrace surfaces. Several key findings from this analysis are that riparian habitat along the Middle Reach has little to no canopy and therefore, the aquatic habitat is likely affected by solar loading. In addition, the flow is shallow or non-existent in some portions of this reach and aquatic habitat improvements as well as exclusionary fencing and riparian planting could improve conditions for aquatic and riparian dependent species.

Roads and Gullies

The roads and gullies assessment were based on two separate protocols, one for roads and one for gullies. Both protocols focused on recording erosion severity and the discharge location of the resulting sediments. A significant majority of the extreme erosion points on roads are associated with gullies that discharge into the East Fork Scott River or a tributary. This assessment found that gullies likely have a far greater direct sediment impact to the stream than the property's roads due to the magnitude of sediment that gullies can deliver directly into the East Fork Scott River and its tributaries. The assessment identifies several high priority gully complexes and road erosion points for remediation and suggests that low-tech, process-based approaches may be appropriate for lower severity sites and near-term treatment, while awaiting more permanent engineered solution, at higher severity sites.

Stream Discharge

Four continuous stream discharge (streamflow) stations were established in the East Fork Scott River and tributaries to document the discharge during the water year (WY) 2023. Two stations were established on the East Fork Scott River. The upstream station was established at RKM 6.7, downstream of the China Cove Diversion (Scott River Decree Diversion 66 (Schedule E)) and the second station was established at RKM 4.1 upstream of the Parker Pasture Diversion (Scott River Decree Diversion 81 (Schedule B7)) (Scott River Decree 1980).

As anticipated, each station exhibited significant variability in discharge throughout the hydrograph. This range in flow regimes occurred during transitions into base flow in late spring or early summer, as well as during transitions out of base flow in late fall and winter. To illustrate the range of flow regime fluctuation, the East Fork Scott River downstream of China Cove (RKM 6.7) station documented a range of discharge from 163.3 to 2.4 cubic feet per second (cfs) between April 13 and September 13, 2023. The tributaries did not experience such a significant variation however as expected, baseflow conditions also experienced decreased streamflow during the months of August, September and October.

Water Temperature

The Scott River was listed for sediment and temperature impairments in accordance with Section 303(d) of the Clean Water Act in 1992 and 1998 and continues to be identified as impaired in subsequent listing cycles. During the summer and fall of 2023, SRWC established sixteen (16) water temperature stations within the East Fork of the Scott River and three (3) tributaries, Mule, Big Mill and Noyes Valley Creeks. The primary objective of this monitoring was to empirically document the temperature regime throughout the project reach to help inform future restoration activities.

The analysis of maximum water temperatures (MWAT) along the East Fork Scott River delineates a discernible trend characterized by both warming and cooling phenomena. From the upstream China Cove POD at RKM 7.5 to the upstream Mule Creek at RKM 5.95, there's a steady increase in temperature consistently noted. This trend is interrupted by a cooling effect attributed to the infusion of cold water from Mule Creek (RKM 5.9). Downstream of this cooling area, there is a subsequent warming trend from RKM 5.9 to RKM 4.7 (upstream Big Mill Creek). However, a notable cooling phenomenon emerges between the upstream and downstream Big Mill Creek stations (RKM 4.7 to RKM 4.6), marked by a significant decrease of 1.3°C. This cooling pattern persists with further temperature reduction at the input of Noyes Valley Creek (RKM 4.4).

Following a cooling trend at RKM 4.4, there is a subsequent warming phase from this station to RKM 3.8 (East Fork upstream Highway 3 Bridge). Beyond RKM 3.8, water temperatures stabilize, maintaining consistency from RKM 3.8 to downstream RKM 2.5 stations. Overall, the analysis reveals a complex interplay of factors influencing water temperature along the East Fork Scott

River, including geographic features, inflows from tributaries, increased solar exposure and potential anthropogenic influences such as irrigation practices.

Groundwater/Water Surface Elevation

In the case of Noyes Valley Creek, a tributary of the East Fork Scott River, it was concluded that the conventional riparian assessment would not yield the requisite information for assessing restoration measures. Consequently, SRWC opted to install a network of shallow groundwater wells along the approximately 4 miles of Noyes Valley Creek which lie on BVHP ownership. The objective was to get a better understanding of the connection between groundwater and surface water, especially considering the effects of cattle grazing and its potential impact on the predominantly willow riparian species. During the initial assessment of riparian health, a notable observation was the substantial presence of dead and deteriorating vegetation, likely attributed to insufficient water availability. Furthermore, this information will serve as pre-implementation data on the impacts to future restoration efforts that will target enhancement of groundwater recharge and storage.

Additional wells were installed during the winter of 2024 to assess additional locations in the East Fork and Big Mill Creek. SRWC intends to maintain the entire groundwater/surface water network of wells on BVHP going forward.

Restoration Designs on Noyes Valley Creek

SRWC, in collaboration with Cascade Stream Solutions, has developed a restoration strategy centered around the implementation of process-based techniques, notably the utilization of beaver dam analogs (BDAs). In the past, Noyes Valley Creek was inhabited by beaver, and due to reasons unknown, their presence, other than in the very lowest reach, have not been seen in many years. Given its low gradient and dense willow riparian zone, this area holds promising potential for beaver reestablishment, aligning with the unified objective of the project team and landowner. Utilizing BDAs, as seen in other areas where SRWC has employed this restoration method within the watershed, is anticipated to yield a beneficial effect on groundwater recharge, potentially enhancing summer baseflow conditions and reoccupation of beaver.

Forest Management Opportunities

Like numerous regions throughout the Western United States, the BVHP have faced significant devastation due to drought, resulting in elevated mortality rates within the Douglas fir (*Pseudotsuga menziesii*) and Ponderosa pine (*Pinus ponderosa*) species. Coupled with a century of fire suppression, this has led to a phenomenon of heightened fuel accumulation in certain areas, escalating the risk of stand-replacing wildfires. Several factors are converging to diminish forest stands in the BVHP area, including rising temperatures, prolonged drought, insect infestations, encroachment of conifers into less suitable habitats and an overall high density of conifer trees. Climate emerges as the primary catalyst for this mortality, with these additional factors exacerbating its impact.

Immediate implementation of proposed drought mortality treatments is crucial to mitigate hazardous fuel accumulation and to capitalize on the economic feasibility of tree removal.

Subsequent monitoring following treatment should be prioritized to curb the proliferation of invasive species and ensure the effectiveness of erosion control measures. While the forest stands at higher elevations within BVHP are experiencing lower mortality rates compared to lower elevations, many of these stands remain overstocked and would benefit from thinning. A future comprehensive forest management plan should encompass mechanical and non-mechanical thinning, as well as prescribed fire, and should address the entire BVHP holdings. This plan would guide future operations aimed at fostering a more diverse and fire-resilient landscape.

Introduction

Photo 1. Beaver Valley Headwater Preserve located on the East Fork of the Scott River.

The Scott River in Siskiyou County is approximately 60 miles long. The watershed drains about 800 square miles and ranges in elevation from 1,600 to 8,500 feet. The Scott River is one of four major tributaries of the Klamath River, entering the Klamath at river mile (RM) 143 at an elevation of 1,580 feet.

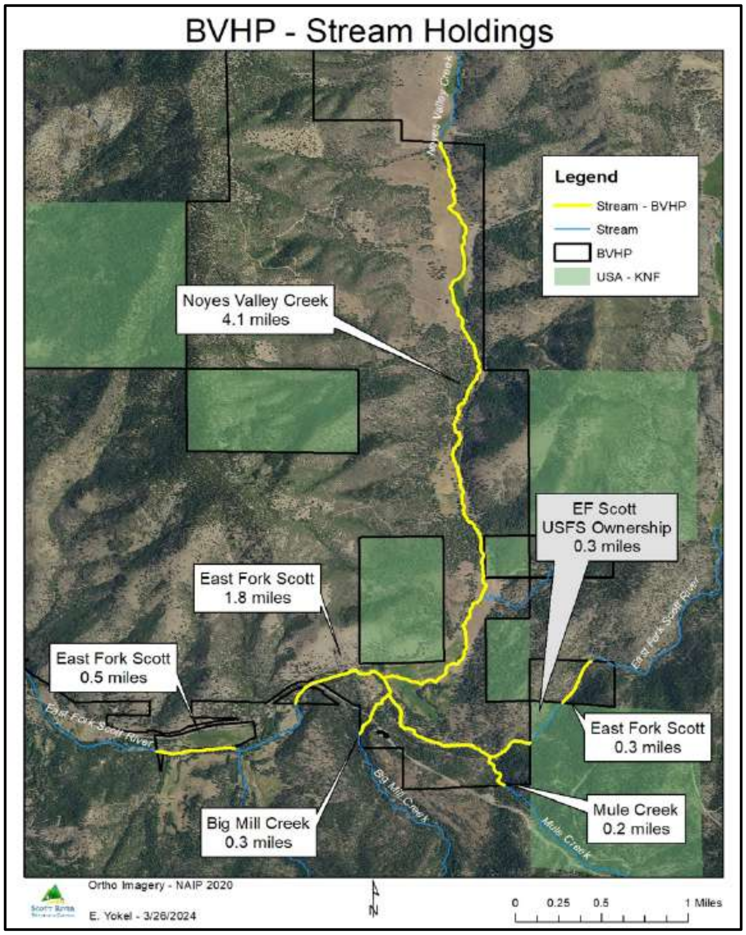
The Scott River watershed, located in northern California, is indeed heavily influenced by snowmelt. Snowmelt-driven systems like this one rely on the gradual release of water stored in snowpacks during the winter months. As temperatures rise in the spring and summer, the snow begins to melt, feeding the river and streams within the watershed. This seasonal melting pattern plays a crucial role in the hydrology and ecology of the area. However, changes in snowpack dynamics due to climate change can significantly impact these systems, affecting water availability, timing of flows, and overall ecosystem health. Managing water resources in snowmelt-driven watersheds, like the Scott River, requires careful planning and adaptation strategies to mitigate potential risks and ensure sustainable use for the future.

Before the arrival of non-indigenous settlers, the Scott Valley was inhabited by Native Americans known as the *Iruaitsu*, a band of the Shasta Indian Nation Tribe, for millennia (Kroeber, 1976). In the 1830s, Hudson Bay fur trappers discovered the area, marking the onset of significant human impact on the watershed. This impact was primarily seen in the near eradication of beavers (*Castor canadensis*). Historical records indicate that in one month alone, approximately 1800 beavers were trapped out of the watershed, which was described as a vast expanse filled with beaver dams and lodges (Wells, 1881). The abundant presence of beavers led to the Scott Valley being initially named "Beaver Valley" (Guddle and Bright, 2004). Stephen H. Meek (1805 -1889), a prominent trapper and eventual resident of Etna, California, remarked that it was "*the richest place for beaver I ever saw*" (Wells, 1881). The significant reduction in beaver populations marked the beginning of the decline of the river ecosystem.

The 1850 discovery of gold at Scott Bar attracted a wave of prospectors to the region who mined the Scott River for placer deposits within a 4.7-mile reach downstream of Callahan between approximately RKM 83.8 and RKM 91.9 (Averill, 1946). This dredging activity reached depths of 50 to 60 feet below the river channel, resulting in substantial disturbances to the channel processes and the surface and subsurface hydrology of the Scott River. These disruptions from the dredging persist to this day.

To address legacy impacts to the Scott River, implementing targeted conservation and restoration efforts, a holistic approach to watershed management, and sustainable land management practices are critical. To that end, The Wildlands Conservancy (TWC) acquired the 6,095± acre

Hayden Ranch and associated water rights, located adjacent to the East Fork Scott River in Siskiyou County (Map 1) in 2021 with funds provided by the California Wildlife Conservation Board (WCB). Through the appropriation of public funding, TWC committed to permanently protect the land for the purpose of enhancing stream flow in East Fork Scott River, Noyes Valley Creek and Big Mill Creek; preserving, restoring and managing wildlife habitat, providing compatible public access; and maintaining working landscapes and a sustainable ranching tradition. The property is now referred to as the Beaver Valley Headwaters Preserve (BVHP) (Photo 1).



Map 1: BVHP property boundaries and the extent of the East Fork Scott River and its tributaries contained within the ownership. Green shaded areas are under the ownership of USFS.

The BVHP is an approximately 6,094-acre property and encompasses 7.2 miles of stream channel in the East Fork Scott River watershed - 2.6 miles of the East Fork Scott River, 0.3 miles of Big Mill Creek, 0.2 miles of Mule Creek and 4.1 miles of Noyes Valley Creek (Map 1). There are three separate non-contiguous parcels within The Wildlands Conservancy ownership, each of which contain portions of the East Fork Scott River and its tributaries. Salmonids, including the State and Federally protected coho salmon have been documented throughout the BVHP holdings. However, coho salmon have not been documented in Mule Creek or Noyes Valley Creek.

The East Fork Scott River headwaters are in the Scott Mountains and the watershed covers a total of 113.5 square miles. Elevations in this drainage range from 2,720 feet at Callahan to 8,540 feet at China Mountain. The steep, rugged mountains of the East Fork Scott River sub-basin are composed of both sedimentary and metamorphic bedrock types, as well as large areas of mafic bedrock and a little granitic bedrock.

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Chapter 1. Riparian Habitat Assessment

1.1 Introduction

Riparian areas are transitional areas between terrestrial and aquatic ecosystems. They are distinguished by gradients in biophysical conditions, ecological processes, and biota. (National Research Council, 2002). Ecologically intact riparian areas naturally retain and recycle nutrients, modify local microclimates, and sustain broadly based food webs that help support a diverse assemblage of fish and wildlife (National Research Council, 2002). Unfortunately, riparian woodlands have largely been lost through stream channelization, development, logging, grazing and water diversion throughout the west. Only 5% to 10% of California's original (pre-European contact) riparian habitat exists today and much of the remaining habitat is in a degraded condition (Griggs, 2009). Riparian restoration is a critical task for many of California's imperiled watersheds, including the Scott River watershed.

Riparian conditions within the project reach of the East Fork Scott River watershed are generally not contiguous and often limited to single rows of trees, with many being mature to decadent. Grazing activities seem to have hindered the natural regeneration of riparian vegetation in certain areas, significantly impeding the growth of younger trees and the establishment of diverse age groups. In certain locations, channel incision has occurred, leading to a reduction in the creek bed levels. This situation may have deprived the roots of existing riparian trees of water during periods of low flow. However, the presence of key elements within the riparian zone, such as sufficient seed stocks, indicates the potential for enhancements in numerous areas.

It should be noted that unlike other areas of the Scott River, Himalayan blackberry (*Rubus armeniacus*) is not a significant source of degradation. Himalayan blackberry rapidly displaces native plant species and produces thickets so dense that the lack of light severely limits understory plant growth. Native vegetation growing beneath Himalayan blackberry becomes highly suppressed from shading and crowding. Whatever effort necessary to continue this favorable status should be maintained in all future land management and restoration activities.

1.2 Purpose

- Develop a comprehensive understanding of the vegetation within the riparian zone located along the streams on the BVHP property.
- Provide recommendations for future land management and restoration actions.

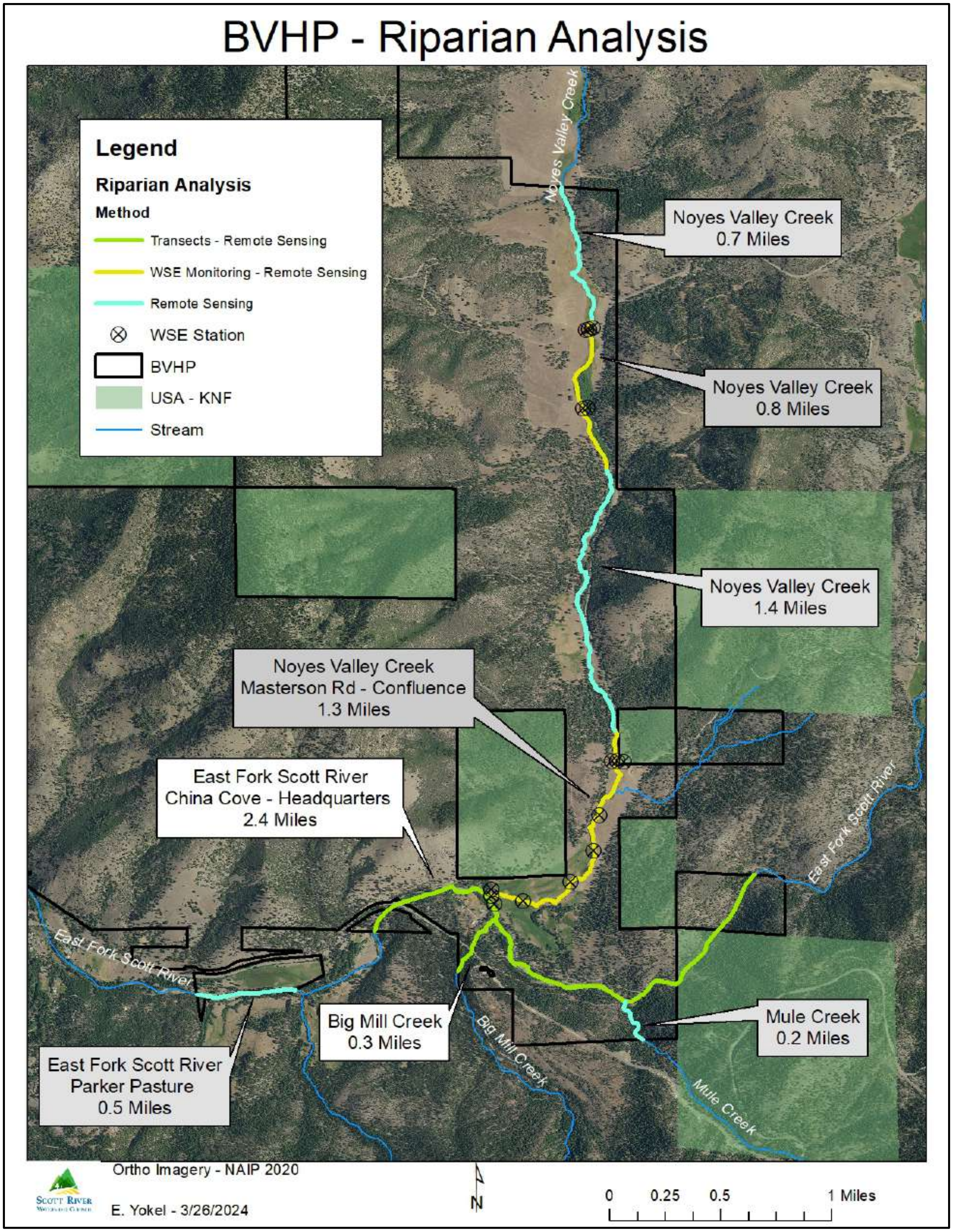
1.3 Methods

Conducting a riparian assessment involves gathering detailed information about the riparian zone, including its vegetation, structure, and overall health. This methodology provides a systematic approach to riparian assessment, allowing for a comprehensive understanding of the ecological conditions and potential stressors in the riparian zone.

Using various methodologies, a riparian vegetation inventory and analysis was conducted by SRWC over the entirety of the riparian habitat that occurs on the BVHP holdings and included portions of the East Fork Scott River, Big Mill Creek and Mule Creek and Noyes Valley Creek (Map 1.1). The three methodologies that were utilized to perform the riparian analysis included field surveyed transects, an analysis of historic orthoimagery and an analysis of LiDAR data.

Specifically, there are three main tasks that were considered for this assessment:

1. Riparian Vegetation Structure, Composition, Age Class, Frequency and Vitality: A combination of remote sensing and field assessments.
2. Stream Channel and Floodplain Condition and Evolution: Analysis of historic and current remote sensing data (LiDAR and orthophotos), historic ortho images were georeferenced and compared to current conditions and LiDAR was analyzed to document geomorphic changes.
3. Stream Channel Elevation: An analysis of existing historic remote sensing data (LiDAR and orthophotos) and current remote sensing data acquired using Unmanned Aircraft Systems (UAS) (LiDAR and photogrammetry) was evaluated to document the relative elevation of the stream channel and adjacent floodplain and terrace surfaces.

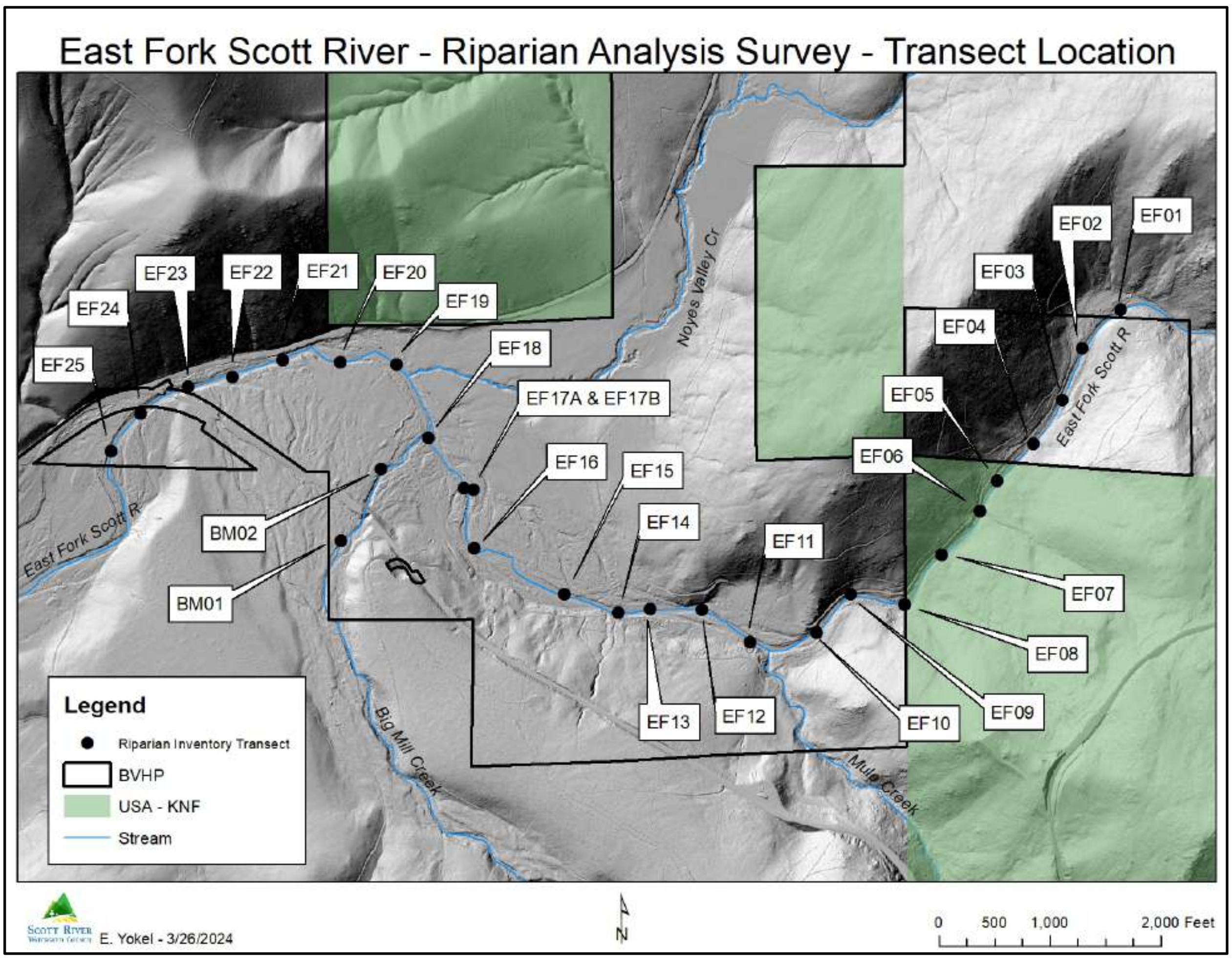


Map 1.1: Riparian analysis reaches.

SRWC implemented transect surveys in the East Fork Scott River from China Cove (RKM 7.4) to below Highway 3 (RKM 3.5) and on Big Mill Creek (RKM 0.4 to confluence) (Map 1.2). No transect surveys were performed in the Parker Pasture portion (RKM 2.65 to RKM 1.8) of the East Fork Scott River or on Noyes Valley Creek. In all reaches, SRWC conducted a remote sensing analysis using the available LiDAR products to document riparian canopy heights and densities and relative elevation of the stream and adjacent floodplain surfaces. Water surface elevation (WSE) stations were established in Noyes Valley Creek to document the relative elevation of surface water and shallow groundwater (Chapter 5).

1.3.1 Riparian Vegetation Analysis

In the summer of 2022, SRWC surveyed twenty-five (25) transects on 2.4 miles of the East Fork Scott River and two transects on 0.3 miles of Big Mill Creek (Map 1.2). At each transect, field crews collected data on riparian health, diversity, age class and species composition. The condition of the stream at the banks of the transect was assessed and sites of active erosion were documented. Assessing the condition of the stream banks was a critical element for understanding the health of the stream system.



Map 1.2: Riparian analysis survey transect location along the East Fork of the Scott River and Big Mill Creek.

On August 24, 2022, field crews collected data on transects 2 through 9. On September 1, 2022, data was collected on transects 10 through 20 and on September 13, 2022, data was collected on transects 21 through 25. Several different methods were employed to collect data during the fieldwork portion of the assessment. In general, riparian condition was characterized for the area directly adjacent to the wetted channel and the condition of the streambanks was evaluated and documented. Specifically, sites with streambank erosion and the potential for further incision were identified. Stream width and percent canopy cover were documented based on the CDFW Level IV Habitat Typing Protocol from the Salmonid Restoration Manual (2004) (Appendix 1).

Vegetation type and streambank type were also assessed. Dominant vegetation type was classified as either shrub, grass or tree. Dominant tree type was categorized into coniferous or deciduous. In addition, data was collected on dominant and subdominant species, density, root condition, diversity, health, age, and height. Root condition was classified as either adventitious or exposed based on methods described in Winward (2000). Lastly, discrete erosional features were mapped and parallel flow versus impinging flows were documented based on guidance provided in the Stream Visual Assessment Protocol (USDA NRCS, 1998). Data was entered into a standardized data sheet while in the field (Appendix 2) and was ultimately transcribed into an Excel database.

Field crews started collecting field data at the upstream end of the BVHP property on the East Fork Scott River (China Cove) and worked their way downstream. The crew established transects at sites that were representative of nearby conditions. The procedures were repeated at approximately every 500 ft unless the channel characteristics or riparian assemblage changed significantly.

In addition to the field work conducted to collect data on riparian habitat, a LiDAR analysis provided an estimate of canopy height (Appendix 3). The canopy height raster and LiDAR derived stream cross sections were calculated for an area 300 ft from the stream. Cross sections illustrating the ground elevation from the 2010 and 2018 bare earth DEMs and the canopy elevation from the 2010 highest hits DSM were calculated for the locations of the field survey riparian analysis transects in the East Fork Scott River and Big Mill Creek and for representative locations in Mule Creek and the East Fork Scott River where field surveys were not performed. Canopy height was classified into five classes representing different vegetative types: 0 - 3 ft - bare earth, grasses and small shrubs, 3 - 15 ft. large shrubs to emergent riparian vegetation (e.g. willows), 15 - 55 ft. small and medium trees, 55 - 100 ft. and 100 - 157 ft. for large trees that are presumed to be conifers.

1.3.2 Changes to Stream Channel and Floodplain Condition over Time

Comparing historic aerial photography of stream reaches on BVHP over time allows an opportunity to visually assess the changes that can be identified. Six aerial ortho images were utilized to document the stream and riparian condition over time: 1944, 1955, 1965, 2010, 2020 and 2023. Digital scans of the 1944, 1955 and 1965 images were georeferenced in GIS. The 2010 and 2020 images were collected by the USDA National Agriculture Imagery Program (NAIP) and the 2023 image was acquired by Cascade Stream Solutions.

Seven separate comparisons were created (Appendix 3). The following years were compared in this analysis:

1. 2010 vs 2023
2. 2010 to 2020
3. 1965 to 2010
4. 1955 to 1965
5. 1955 to 2020
6. 1944 to 1955
7. 1944 to 2020

Each of these comparisons are focused on the area near and surrounding the headquarters of the property.

Historic georeferenced ortho imagery from 1994 to 2020 (1994, 2002, 2005, 2012, 2014, 2016 and 2020) was utilized to digitize the alignment of the East Fork Scott River in GIS to document the geomorphic change of the channel alignment.

1.3.3 Stream Channel and Floodplain Morphology and Relative Elevation

An inundation model was created using the River Bathymetry Toolkit in ArcGIS to detrend the 2010 bare earth LiDAR Digital Elevation Model (DEM). Inundation levels at 0.5-meter increments were generated from the detrended DEM to illustrate the relative elevation of the stream and adjacent terraces (Appendix 4).

The 2010 and 2018 LiDAR bare earth DEMs data was utilized to generate comparative cross sections for the locations of the field survey riparian transects and representative areas of the tributaries in which the field surveys were not performed (Appendix 5). Also, a specific geomorphic change assessment analysis for RKM 4.2 - 4.8 (area of cut bank to upstream of Big Mill Creek) and RKM 4.8 - 5.3 (area of significant channel change upstream of Big Mill) was completed using the 2010, 2018 and 2023 LiDAR bare earth DEMs and is also included in Appendix 5.

1.4 Results

1.4.1 Vegetation Structure, Composition, Age Class, Frequency and Vitality

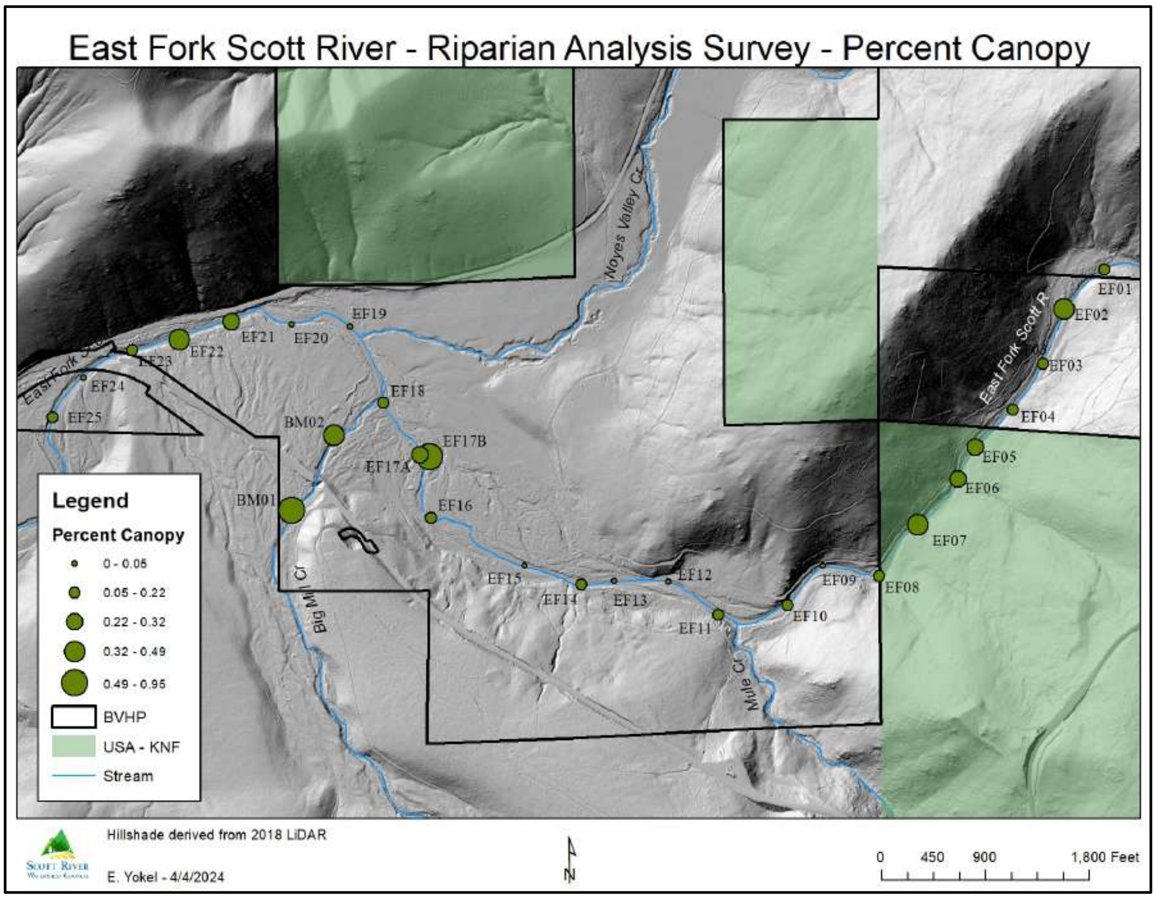
Using the riparian habitat field data and photos collected during the transect surveys, SRWC was able to document several significant findings that are described below. Data from reaches with similar findings are summarized and evaluated.

For the purposes of summarizing the transect data we divided the East Fork Scott River into three reaches with similar characteristics. The Upstream Reach goes from China Cove to Mule Creek, the Middle Reach goes from Mule Creek to Big Mill Creek and the Lower Reach goes from Big Mill Creek to HWY 3 (Table 1.1). Two transects were completed on Big Mill Creek which are included in the Lower Reach. Transect data was not collected in the Parker Pasture which runs from Taylor Creek to the downstream BVHP property boundary.

Table 1.1: Percent gradient and sinuosity of East Fork Scott River reaches.

Reach	RKM From	RKM To	Percent Gradient	Sinuosity
Upstream China Cove to Mule Creek	7.7	5.95	1.8%	1.16
Mule Creek to Big Mill Creek	5.95	4.6	1.2%	1.21
Big Mill Creek to Downstream Highway 3	4.6	3.5	0.9%	1.27
Taylor Creek to Downstream Property Boundary	2.65	1.8	1.0%	1.02

A general overview of canopy coverage at each of the transect sites as estimated using a densiometer (Map 1.3). This overview illustrates that the vegetation in the upper reach is providing a greater degree of creek coverage than vegetation growing in the middle and lower reaches. This is likely due to the change in topography and land management practices.



Map 1.3: Existing riparian canopy estimated with the use of a densiometer.

Upstream Reach of the East Fork Scott River (transects EF-01 to EF-10)

The field crew started collecting data for the transect surveys on the East Fork Scott River at the most upstream reach on the property (Map 1.3). This reach of the East Fork is defined by steep sided slopes and is a naturally confined reach of the river. There is no floodplain in this reach, and it has the highest stream gradient (1.8%) of the reaches evaluated, and it has low to moderate sinuosity. Soils in this area are the Kang-Beaughton families association (9 - 90% slopes) and Goldridge, gravelly-Clallam, deep Prather family’s association (30 - 90% slopes) (Appendix 6).

The data from transects in the Upper Reach illustrate that the biodiversity of native riparian plant species in this area is higher than elsewhere on the property and the stream width is narrow, most likely due to the topography (Table 1.2). Dominant and understory riparian plant species observed in this reach includes willow, dogbane, sedges, azalea, rose, mountain mahogany, cedar and various herbaceous species (Photo 1.1). Some of these species are observed nowhere else on the property.

Table 1.2: Riparian vegetation summary for upstream reach.

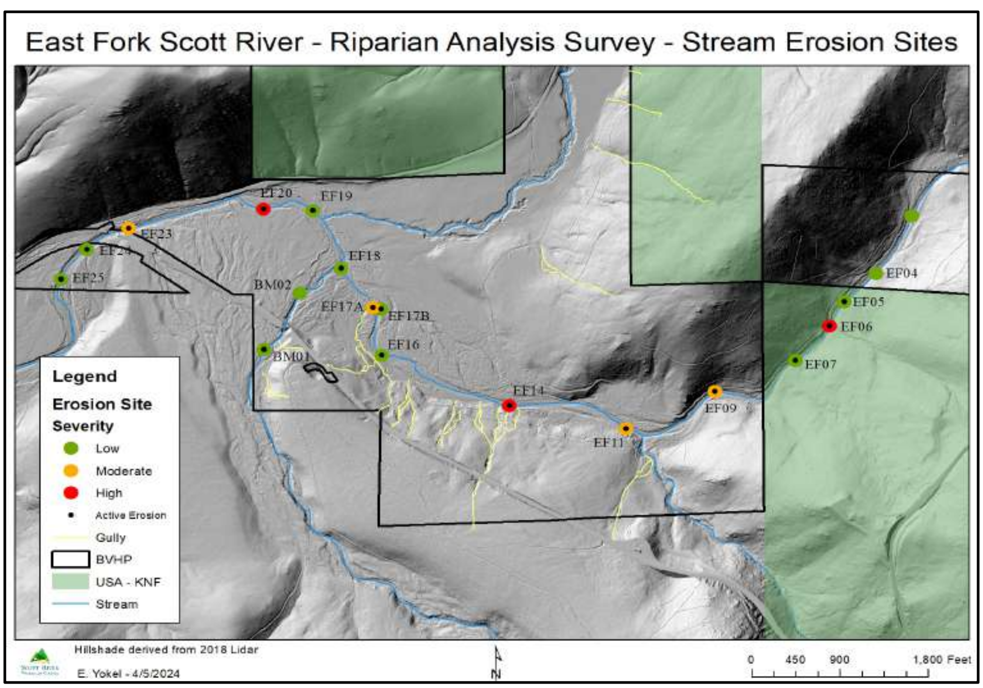
Riparian Vegetation Summary - Upstream Reach (10 transects)							
Classification		**Diversity**		**Species**			
Deciduous	58%	Mixed	74%	Willow	16%	Other (Azalea)	5%
Conifer	10%	Mono	26%	Alder	32%	Blackberry	0%
Mixed	8%			Grass/sedge	29%		
None	24%			Cedar/Conifer	18%		
Health and Vitality		**Age Classification**		**Riparian Lateral Extent**			
Healthy	47%	Immature	47%	Narrow belt		58%	
Fair/poor	47%	Mature	53%	Wide belt		24%	
Dead	6%			Single row		18%	

Photo 1.1: Transect EF-04 looking upstream at a healthy and diverse riparian understory along the banks of the East Fork. August 24, 2022.

The first site where active erosion was documented in this reach is at transect EF-05, however, at this site the erosion was considered insignificant. But at the next transect (EF-06) severe and active erosion was documented (Photo 1.2). As illustrated in Figure 7, this is the site of a drainage entering the East Fork on river left that is causing instability of the streambank. In addition, due to the deposition of bedload into the East Fork from the unnamed gully, streamflow is impinged, creating a gravel bar and a large shallow pool which is likely subject to warming in the summer sun. While active erosion was documented at transect EF-07, this erosion was also considered insignificant.

Photo 1.2: Severely eroded gully located on river left at transect EF-06. August 24, 2022.

Erosion was also documented at transect EF-09 and it was considered moderate (Map 1.2). However, if left unchecked this erosion does have the potential to undercut the road at this location. The stream width at EF-10 widens significantly, likely due to changes in the topography, which provides a break to define the middle reach. The stream width at EF-09 is 19 feet and the width at EF-11 is 22 feet (Photo 1.3).



Map 1.2: Stream erosion sites and their severity along the East Fork.

Photo 1.3: Photo taken at EF-11 looking upstream illustrates how the East Fork channel widens significantly as the topography changes. In addition, the riparian species diversity is more limited. September 1, 2022.

Middle Reach of the East Fork Scott River (transects EF-11 to EF-17)

Data on riparian habitat in the Middle Reach is summarized in Table 1.3. There were quite a few data points where no vegetation was documented. Soils in this area are Holland-Aiken families association, 2 to 15 percent slopes.

There is significant and severe erosion at transect EF-14 (Photo 1.4). Two types of erosion were observed here, a gully entering the East Fork Scott River and a large cut bank. The cut bank is approximately 12 feet high (Figure 1.4) and 165 feet long. There is a wide bar in the river due to depositional materials opposite the site of the erosion. Based on the topography the gully likely sends flashy flows into the East Fork and therefore, has created a cut bank. The erosion at EF-14 is addressed more completely elsewhere (Roads and Gullies in Chapter 2). At site EF-15, the field crews noted that the flows on September 1, 2022, were insufficient to keep the river connected and the flow goes underground. Cattle were observed in the creek at this location. As mentioned above and illustrated in Table 1.3, vegetation in the area is considered sparse.

Table 1.3: Riparian Vegetation Summary for Middle Reach.

Riparian Vegetation Summary - Middle Reach (7 transects)							
Classification		**Diversity**		**Species**			
Deciduous	41%	Mixed	59%	Blackberry	0%	Alder	28%
Mixed	6%	Mono	25%	Grass/sedge	12%	Willow	44%
Conifer	0%	None	16%	Cedar/Conifer	0%		
None	53%			None	16%		
Health and Vitality		**Age Classification**		**Riparian Lateral Extent**			
Healthy	47%	Immature	53%	Narrow belt		47%	
Fair/poor	38%	Mature	28%	Wide belt		37%	
Dead	3%	None	19%	Single row		3%	
None	12%			None		13%	

Photo 1.4: Severe erosion site located at transect EF-14. September 1, 2022.

Lower Reach of the East Fork Scott River (transects EF-18 to EF-25 and 2 transects on Big Mill Creek)

The Lower Reach is characterized by little to no canopy cover and limited plant species diversity (Table 1.4). This area has a lower gradient (0.9%) with areas of floodplain connectivity and a slightly higher sinuosity (Table 1.4). In this reach blackberry has become established at a few of the sites. Transect EF-20 is the site of significant active erosion (Photo 1.5). Active erosion was also documented at transects EF-23, EF-24 and EF-25. Soils along the East Fork in this reach are xerofluvents and are nearly level. These soils are relative recent and typical of water-deposited sediments on flood plains.

Table 1.4: Riparian vegetation summary for Middle Reach.

Riparian Vegetation Summary - Lower Reach (8 transects)							
Classification		**Diversity**		**Species**			
Deciduous	22%	Mixed	72%	Blackberry	6%	Alder	19%
Mixed	10%	Mono	22%	Grass	9%	Willow	38%
Conifer	6%	None	6%	Cedar/Conifer	12%		
None	62%			None	16%		
Health and Vitality		**Age Classification**		**Riparian Lateral Extent**			
Healthy	53%	Immature	44%	Narrow belt		47%	
Fair/poor	41%	Mature	50%	Wide belt		34%	
Dead	0%	None	6%	Single row		13%	
None	6%			None		6%	

Photo 1.5: Significant active erosion occurring at Transect EF-20. September 1, 2022.

Big Mill Creek was the site of two transects. This tributary is the only location where chokecherry and ninebark were documented (Table 1.5). There was active erosion documented at the upstream transect but it was considered insignificant.

Table 1.5: Riparian vegetation summary - Big Mill Creek.

Riparian Vegetation Summary - Big Mill Creek (2 transects)							
Classification		**Diversity**		**Species**			
Deciduous	25%	Mixed	63%	Chokecherry	12%	Alder	25%
Mixed	12%	Mono	37%	Ninebark	12%	Willow	25%
None	63%			Pine	13%	None	13%
Health and Vitality		**Age Classification**		**Riparian Lateral Extent**			
Healthy	75%	Immature	63%	Narrow belt		12%	
Fair/poor	25%	Mature	37%	Wide belt		50%	
Dead	0%			Single row		38%	

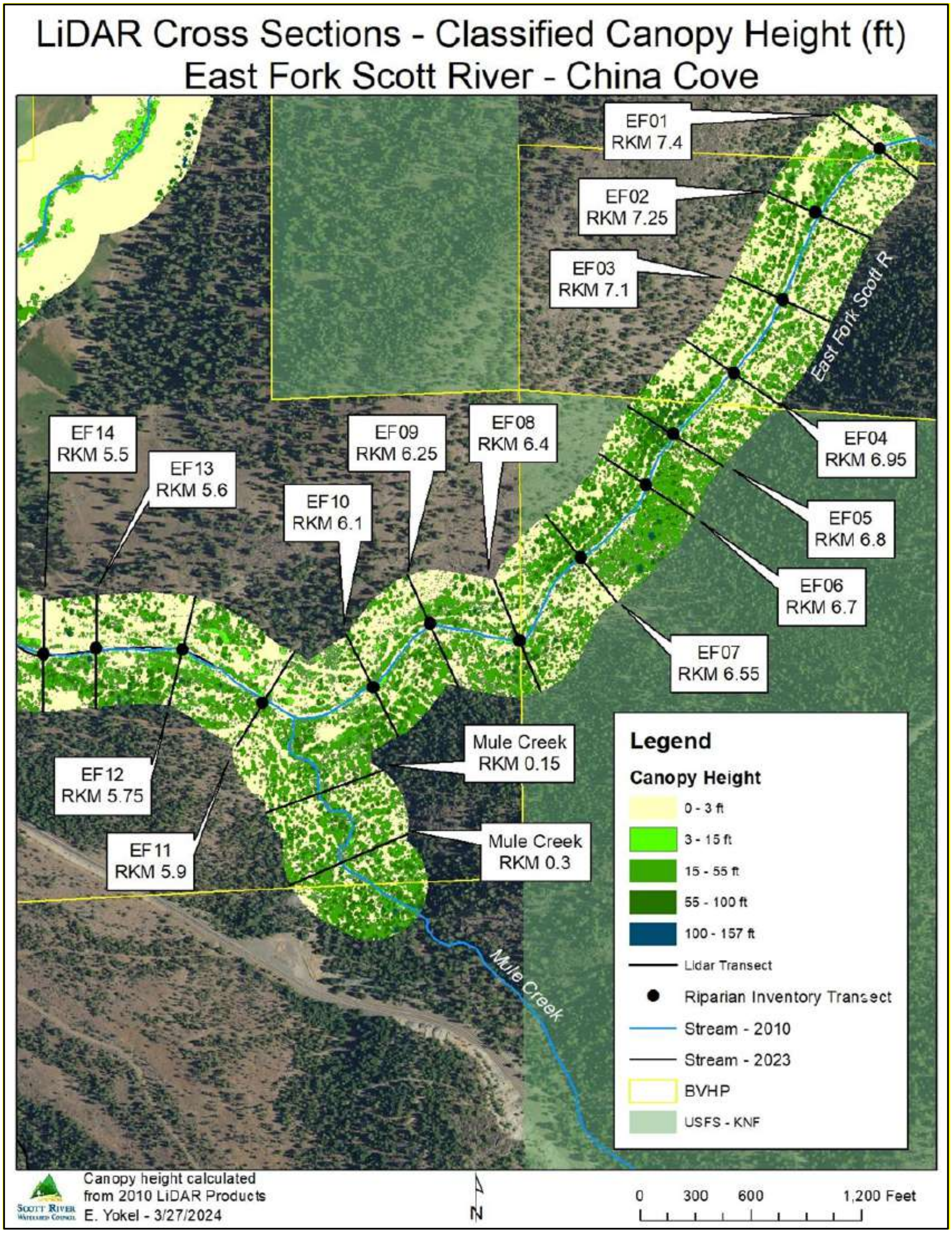
Riparian vegetation data from all of the transects shows 46% of the transects had no riparian trees (Table 1.6). However, there was a diverse array of riparian plant species on 73% of the sites. The most common species observed was willow (34%) and fortunately, only 2% of the sites had Himalayan blackberry. While 54% of the sites were identified as having healthy vegetation, 43% of the sites had vegetation that was considered in fair to poor health. Over 50% of the sites had vegetation that was immature, likely due to the flashy flows on the East Fork Scott River. A full series of photo points were established at each transect and could be used over time to document change (Appendix 7).

Table 1.6: Riparian vegetation summary - all transects combined.

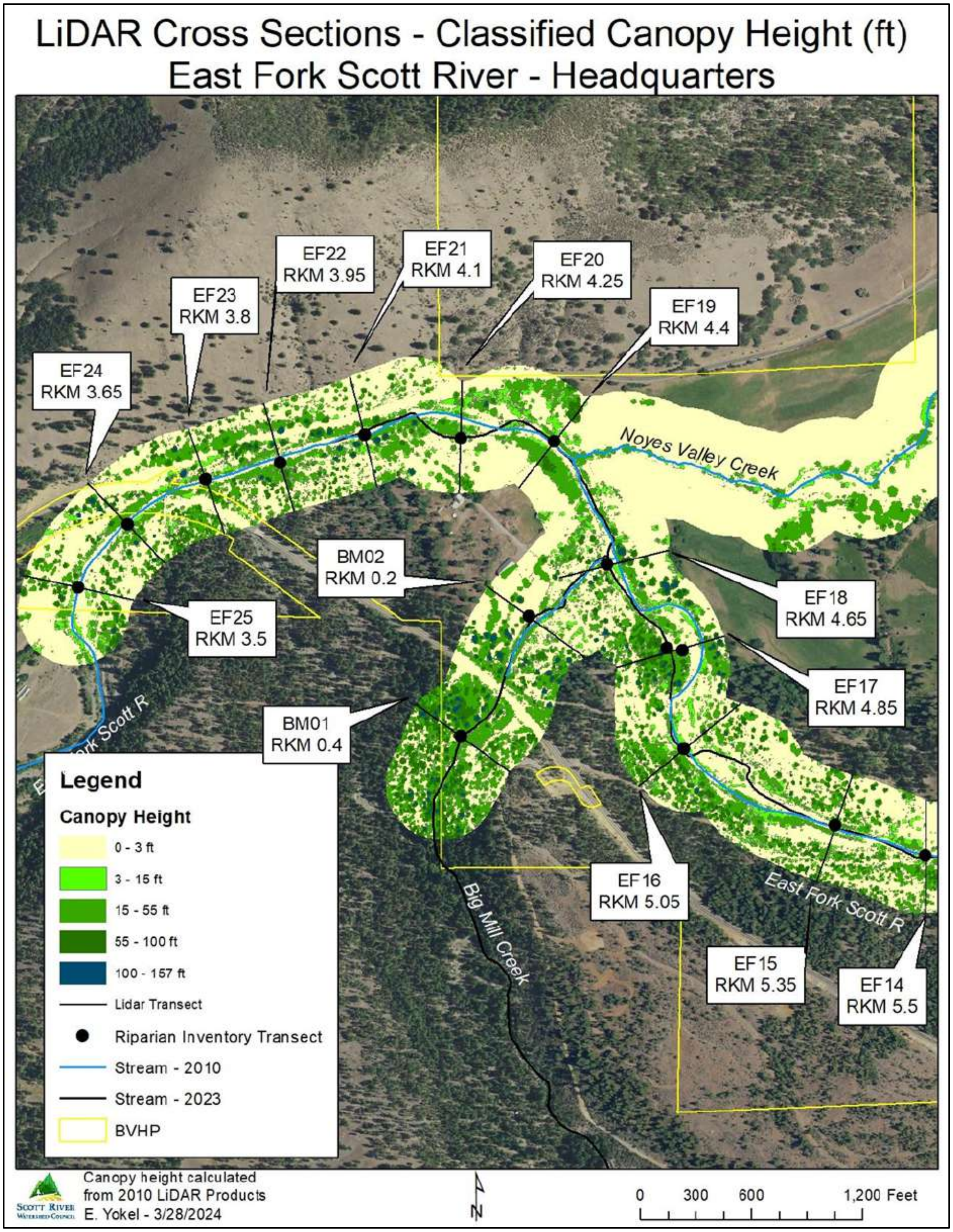
Riparian Vegetation Summary - All Transects Combined							
Classification		**Diversity**		**Species**			
Deciduous	40%	Mixed	73%	Grass/sedge	18%	Alder	26%
Mixed	8%	Mono	27%	Cedar/conifers	11%	Willow	34%
Conifer	5%			Other	5%	Mixed	4%
None	46%			Blackberry	2%		
Health and Vitality		**Age Classification**		**Riparian Lateral Extent**			
Healthy	54%	Immature	54%	Narrow belt		51%	
Fair/poor	43%	Mature	46%	Wide belt		35%	
Dead	3%			Single row		14%	

1.4.2 LiDAR Canopy Analysis

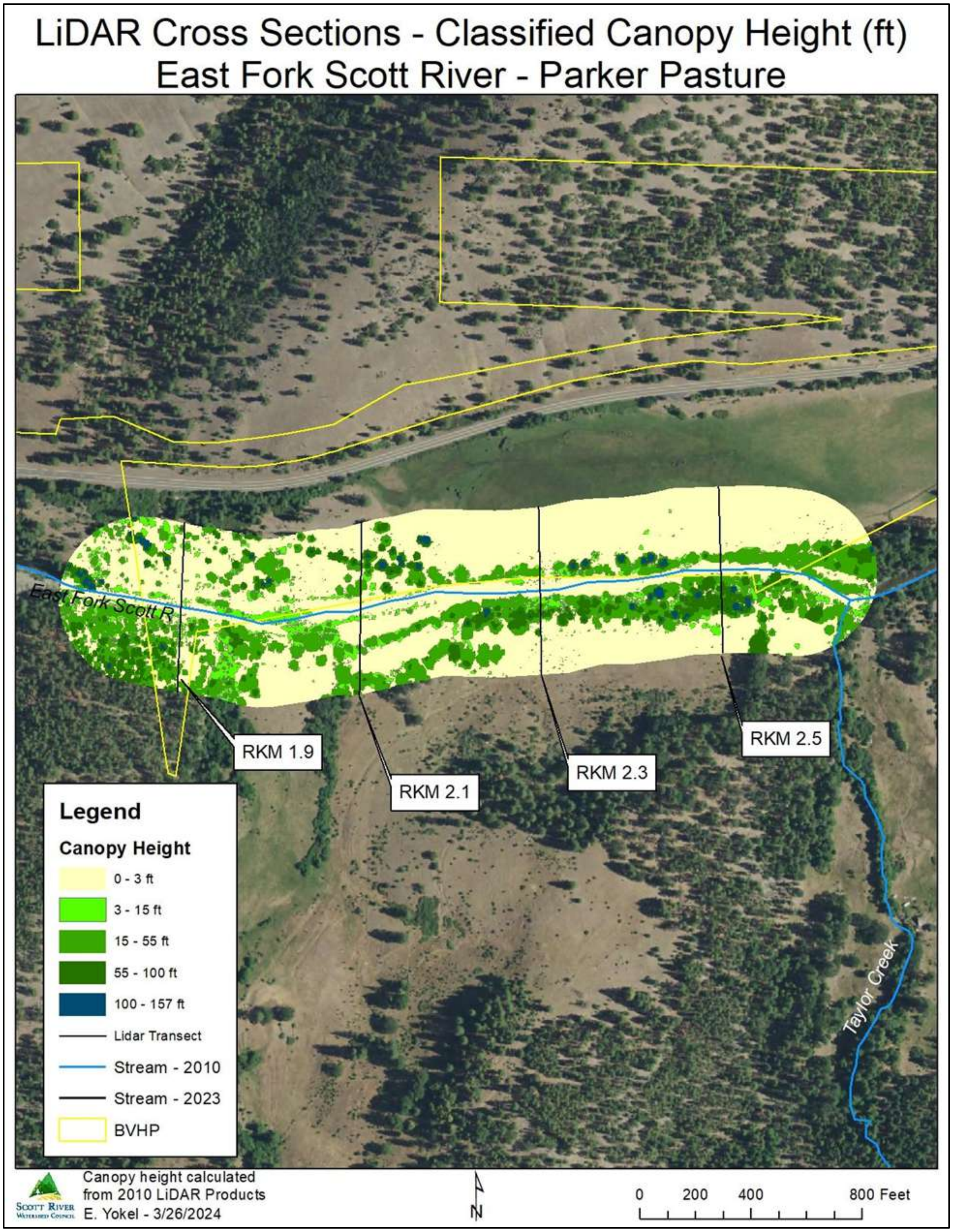
Large variations of canopy height and vegetation density were observed throughout the East Fork holdings with high densities of mature conifers documented in the upper canyon reach and the reach upstream of the Highway 3 Bridge (Maps 1.3 and 1.4) and limited vegetation densities observed in the areas of Parker pasture (Map 1.5).



Map 1.3: Classified canopy height (ft) and cross section locations - China Cove, East Fork Scott River.



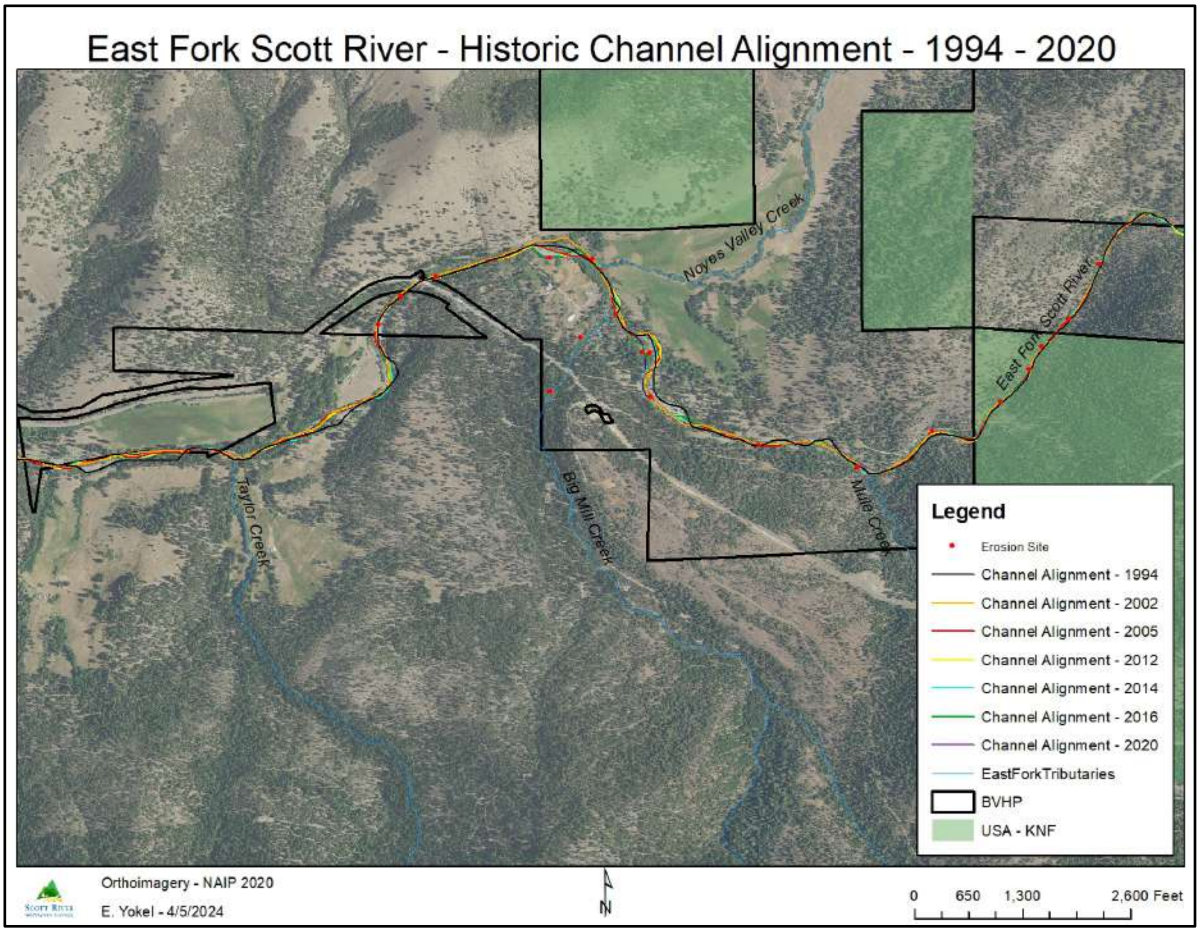
Map 1.4: Classified canopy height (ft) and cross section locations - Headquarters, East Fork Scott River.



Map 1.5: Classified canopy height (ft) and cross section locations - Parker pasture.

1.4.3 Stream Channel and Floodplain Condition and Evolution

An overview of the historic channel alignment of the East Fork Scott River from 1994 to 2020 is provided in Map 1.6. Our analysis illustrates that there are several areas in the East Fork Scott River that have exhibited significant geomorphic change in the last thirty years. Using the analysis of historic aerial photos and LiDAR, two areas between the confluence of Mule Creek and the Stagecoach Bridge stand out. The two locations of significant channel alteration are the cutbank upstream of the Stagecoach Bridge (RKM 4.1 to RKM 4.4) and the reach upstream of Big Mill Creek (RKM 4.7 to RKM 5.0) (Figures 1.1 and 1.2). Some of this change has occurred relatively recently (last 15 years) as shown through the LiDAR analysis. Analysis of the change in elevations between the LiDAR DEMs from 2010 and 2023 illustrates the magnitude of geomorphic change in the two areas (Map 1.7). Analysis of the change in stream alignment and between the 2010 and 2023 ortho images additionally illustrates the geomorphic changes (Figure 1.3).



Map 1.6: Historic channel alignment of the East Fork Scott River from 1994 to 2020.

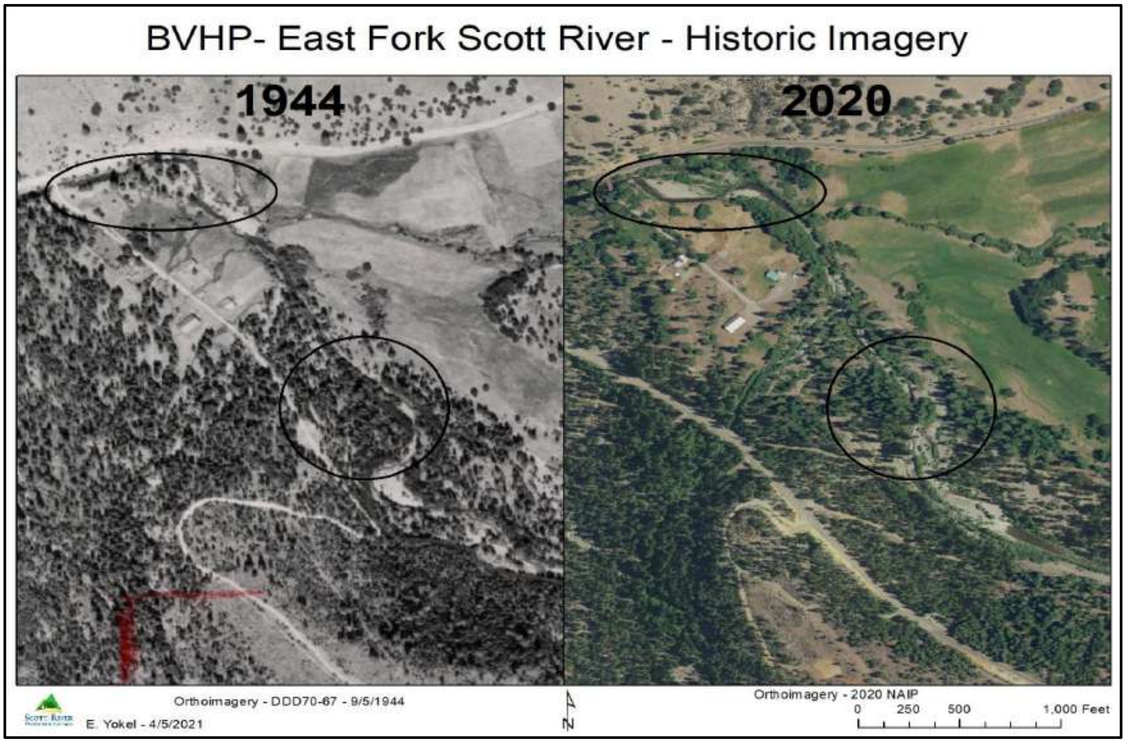


Figure 1.1: 1944 and 2020 orthoimagery illustrating two areas with significant geomorphic change.

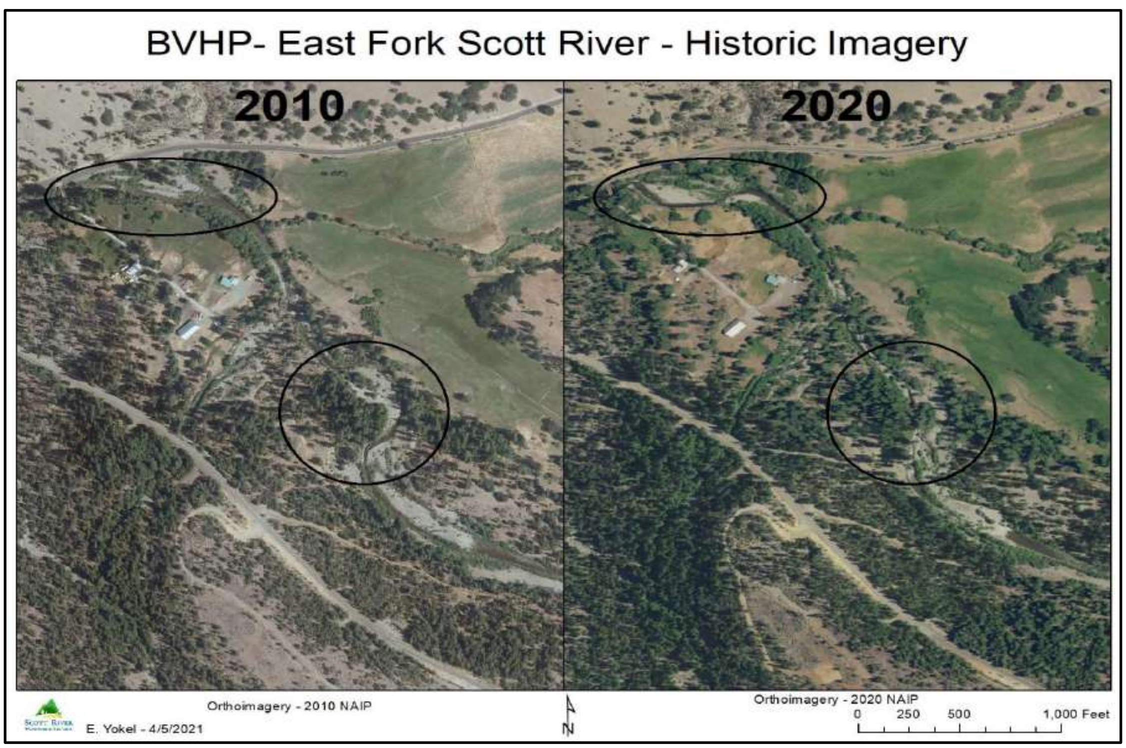
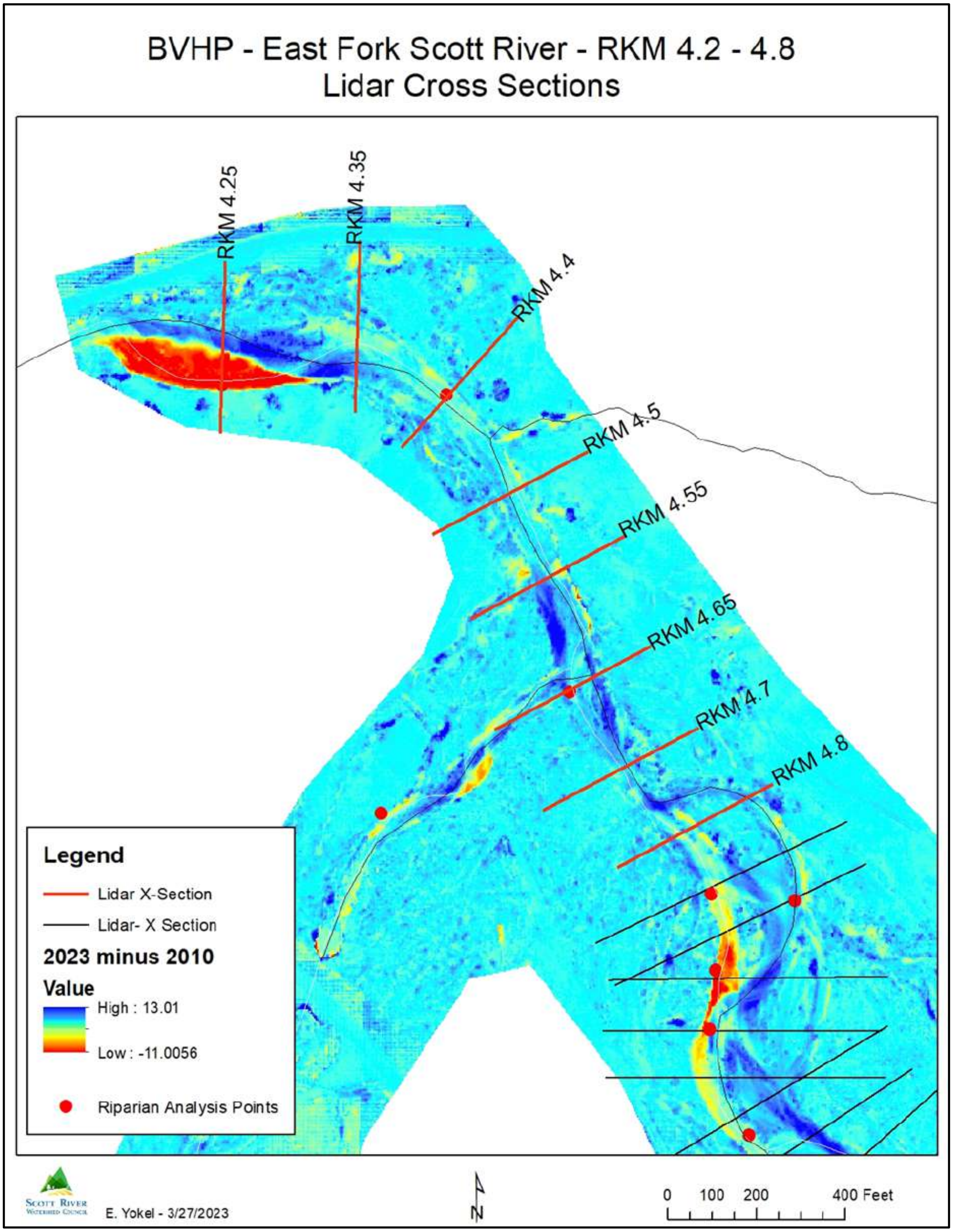


Figure 1.2: 2010 and 2020 orthoimagery illustrating two areas with significant geomorphic change.



Map 1.7: Change in elevation from 2010 to 2023.

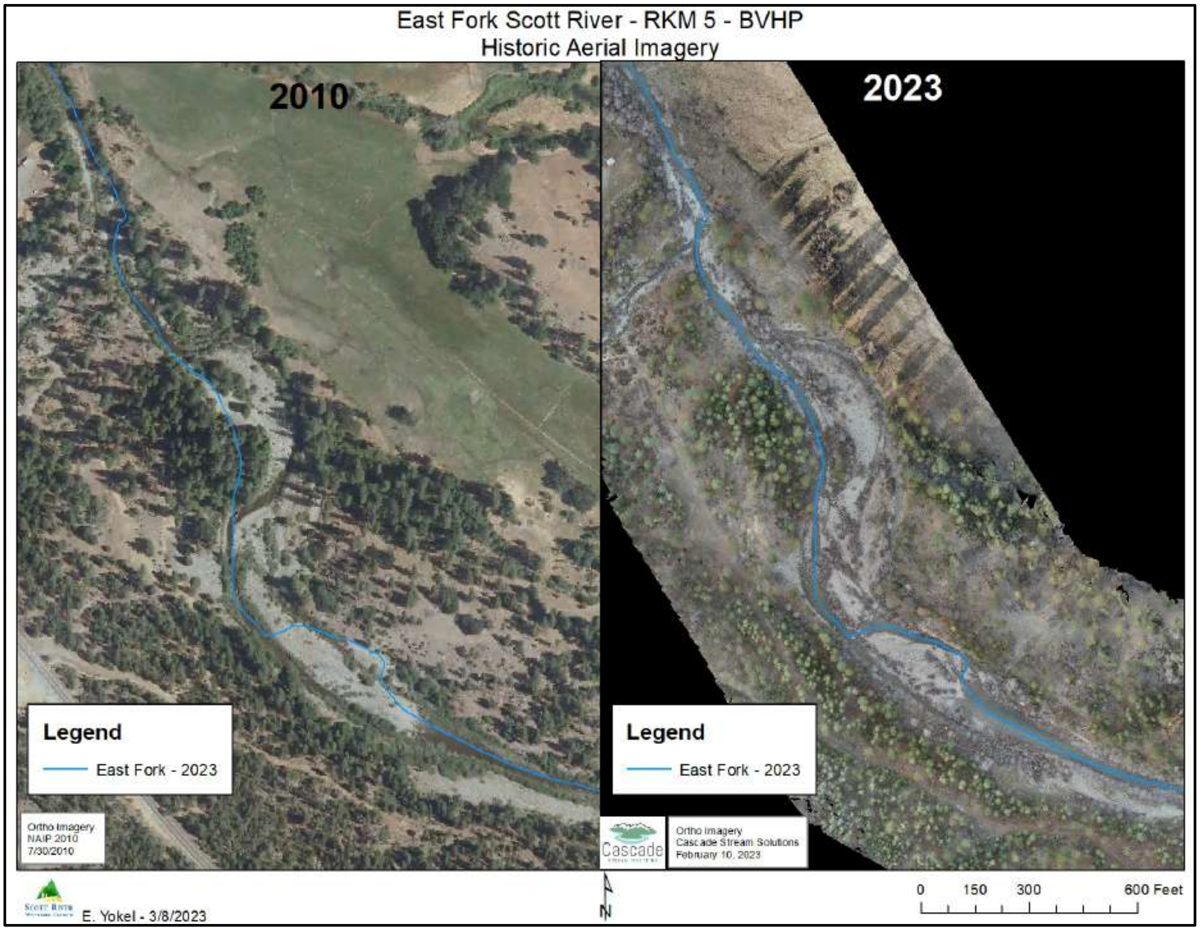
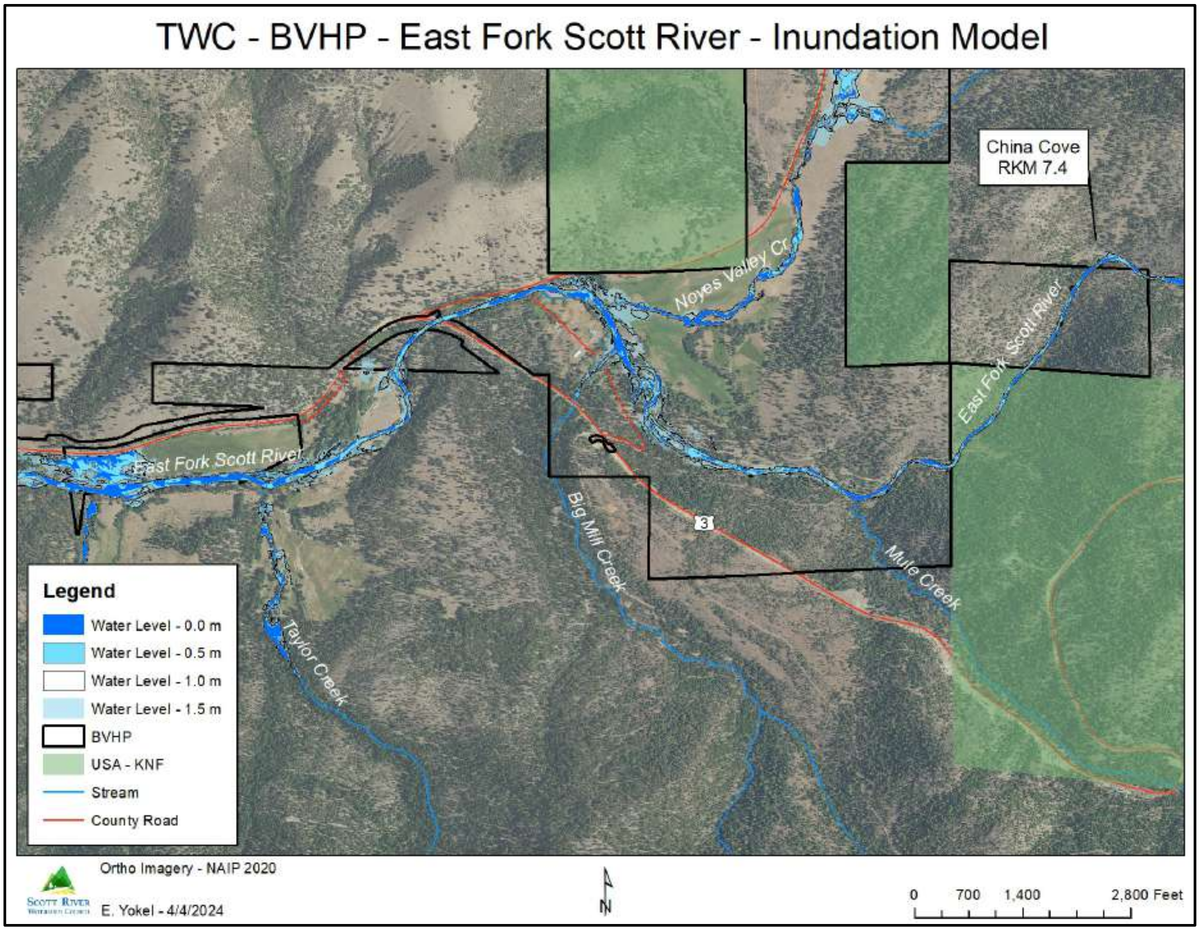


Figure 1.3: 2010 and 2023 orthoimages of reach upstream of Big Mill Creek with 2023 stream alignment.

1.4.4 Stream Channel and Floodplain Morphology and Relative Elevation

An inundation model was created using the River Bathymetry Toolkit in ArcGIS to detrend the 2010 bare earth DEM. Inundation levels at 0.5-meter increments were generated from the detrended DEM to illustrate the relative elevation of the stream and adjacent terraces (Map 1.8). The inundation model illustrates the lack of floodplain and low elevation terrace habitats in the canyon reach upstream of Mule Creek and the relatively low elevation floodplains and terraces in the reach from Mule Creek to downstream of Noyes Valley Creek. Analysis of representative LiDAR derived cross sections from the canyon reach upstream Mule Creek and from the reach with floodplain and relatively low elevation terraces illustrates the morphology of the different reaches (Figures 1.4 and 1.5). The analysis of geomorphic change of cross sections from the 2010 and 2018 LiDAR products illustrates limited areas of significant channel migration in the project reaches with the largest channel alteration occurring upstream of Big Mill Creek and downstream of Noyes Valley Creek.



Map 1.8: Inundation model of the East Fork Scott River and tributaries

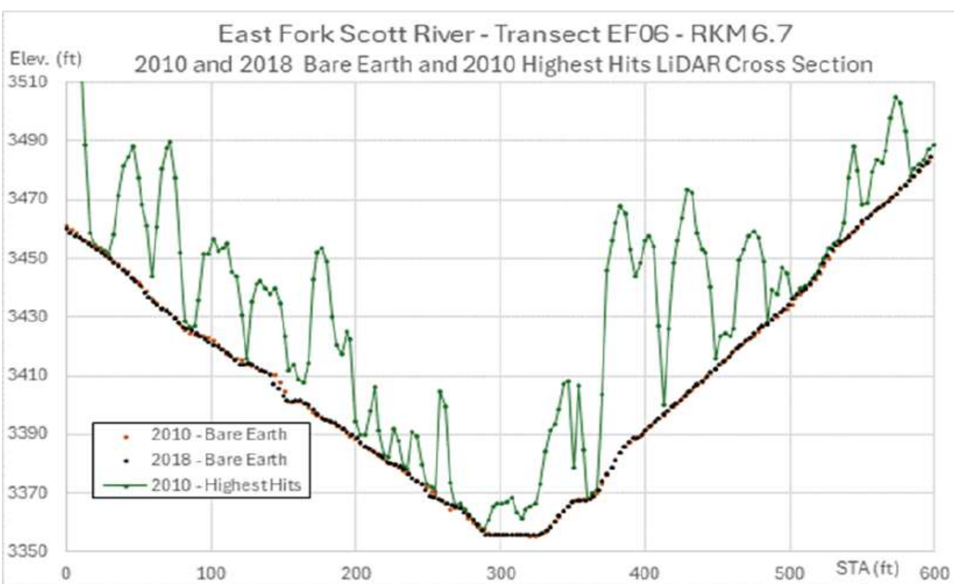


Figure 1.4: Representative cross section of East Fork Scott in canyon reach upstream of Mule Creek.

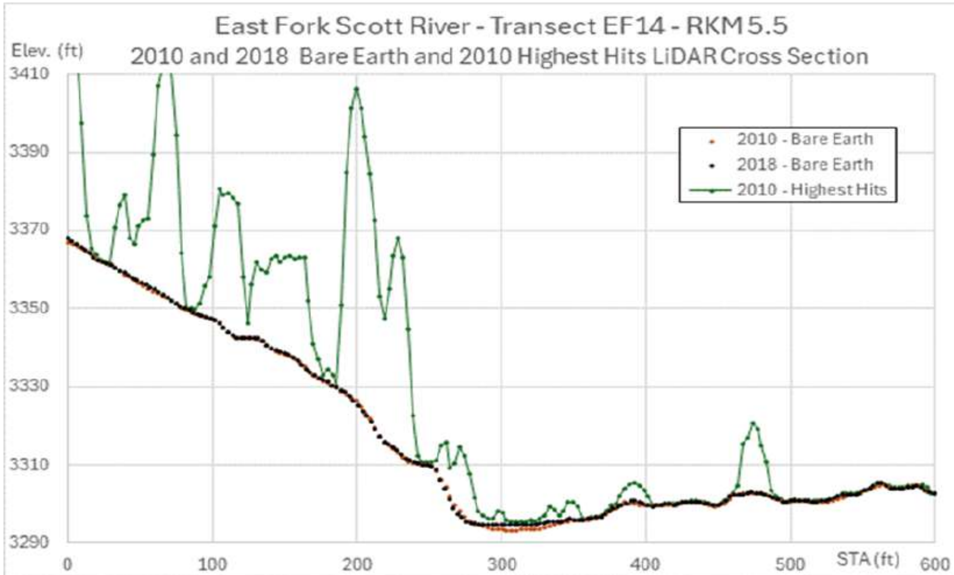


Figure 1.5: Representative cross section of East Fork Scott with floodplain on river right.

1.5 Conclusion

Based on the above-described analyses, below we provide a bulleted list of potential future actions that would aim to preserve or enhance the existing riparian vegetation and aquatic habitat on the BVHP property:

1. Large woody debris - In order to improve habitat conditions for streamside riparian habitat and rearing coho salmon, measures should be taken to create deep refugia pools in the East Fork Scott River. Installing large woody debris in key locations could provide a simple cost-effective way to achieve this goal.

2. Exclusionary fencing - Livestock exclusion fencing involves constructing a permanent fence outside of the riparian corridor along streams in livestock pastures that prevents animals from accessing the stream channel and the riparian habitat adjacent to the stream. Cattle exclusion fencing is one of the most practical approaches for initiating rapid riparian recovery or improving highly sensitive or degraded areas.

3. Develop alternative water sources to keep cattle out of the creek or employ the use of narrow cattle watering lanes, in combination with exclusion fencing, to minimize cattle loafing at, or in, the active flow channel or creek bed.

4. Actively manage invasive Himalayan blackberry to limit its spread on the BVHP property. Since Himalayan blackberry was only documented at a few of the transect sites in 2022, controlling the species now will be a wise use of time.

5. Revegetation in key areas will provide much needed canopy cover during the hot summer months and ultimately, riparian tree planting will contribute to the implementation of large woody debris in the creek channel over time.

1.6 Bibliography

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1.7 Appendices

Appendix 1.1 Methods from CDFW
Appendix 1.2 Data Sheet
Appendix 1.3 Aerial Photos Compared
Appendix 1.4 Remote Sensing Riparian Analysis
Appendix 1.5 Stream Channel and Floodplain Morphology and Relative Elevation
Appendix 1.6 Soil Type Map
Appendix 1.7 Riparian Photo Points (2022)

Chapter 2. Roads and Gullies Assessment

2.1 Introduction

Road surveys were performed on TWC's BVHP to document areas of active road related erosion with an emphasis on erosional features that deliver sediment to the East Fork Scott River and tributaries.

2.2 Purpose

- Identify and prioritize remediation of sources of sediments delivered to East Fork Scott River and its tributaries Mule Creek, Big Mill Creek and Noyes Valley Creek.
- Survey of roads and gullies on Beaver Valley Headwaters Preserve to help inform future land management and restoration actions.

2.3 Methods

2.3.1 Road Survey

SRWC developed a road survey protocol that was largely based on the US Forest Service's *The Geomorphic Road Analysis and Inventory Package (GRAIP), Volume 1*, (Black et al., 2012), the USFS's Methods for Inventory and Environmental Risk Assessment of Road Drainage Crossings (Flanagan et al., 1998) and the Handbook for Forest, Ranch & Rural Roads (Weaver et al., 2015) simplified for the scale of this project.

A hillshade model derived from the 2018 FEMA LiDAR was used to identify and digitize the roads in the project area. Field crews walked each accessible road and recorded data at points where there was indication of erosion associated with the road (in the roadbed, cut slope, fill or associated ditch or culvert). Locations and photographs were recorded with Avenza map software on GPS capable iPads.

Data collected at each road point included information about the road surface, road prism shape, water flow paths and discharge, condition and vegetation of cut- and fill-side of road (Figure 2.1), erosion of road or fill, and drain point attributes, including gullies (Figure 2.2). Drain points are "where the flow and sediment are diverted from the road prism". (Hopkins et al., 2019)

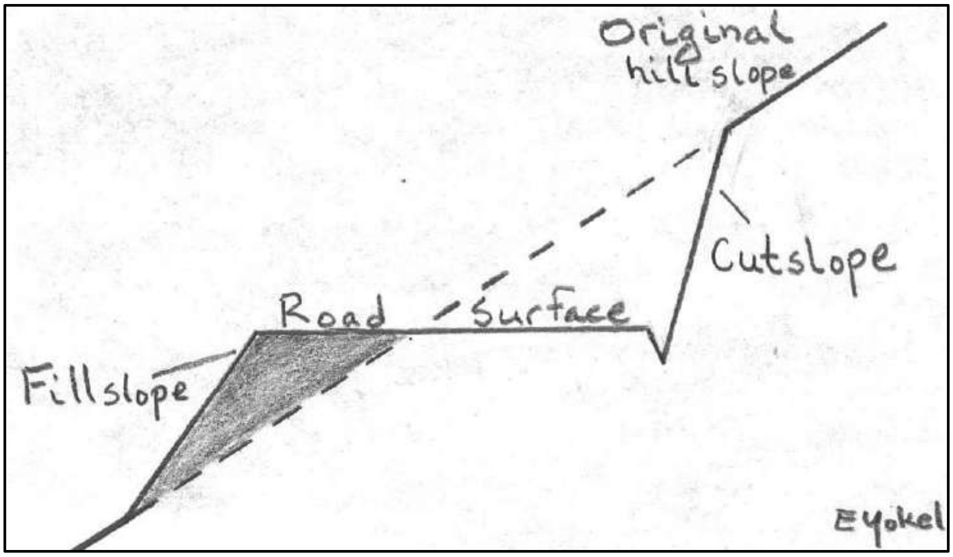


Figure 2.1: Typical diagram of a road cross section.

Location:	**Lat:**	**Observers:**		
Transect ID:	**Long:**	**Date:**		
Surface Type	**Surface Condition**	**Road Shape**		
☐ crushed rock	☐ Good	draw road prism cross sec	☐ inslope	
☐ native	☐ Rilled		☐ outslope	
☐ paved	☐ Rutted		**Flow Path Location**	**Discharge to**
	☐ Washboard		☐ Ditch	☐ Forest floor
Surface Cover (Vegetation)			☐ Concentrated (Road)	☐ gully
☐ None/fallow	**Slope Shape**		☐ Diffuse (Road)	☐ ditch
☐ grass	☐ Concave		☐ Diffuse (Road)	☐ landslide
☐ shrubs	☐ Convex			☐ wetland
☐ Other:	☐ Planar			☐ stream
CUT SIDE			**Road/Fill Erosion**	
Road Edge Condition	**Dominant Vegetation**	**Height to natural slope (ft)**	☐ no	
☐ No problem	☐ None/fallow		☐ yes	
☐ Rilling	☐ Grass		☐ mild	
☐ Raveling	☐ Reeds/Sedges	**Notes:**	☐ moderate	(gully?)
☐ Slumping	☐ Shrubs		☐ extreme (do gully survey)	
☐ Seep Spring	☐ Saplings			
☐ Bedrock	☐ Trees (conifer/ broad-leaf)		**Drain Point Attributes (if extreme erosion)**	
			☐ Broad Based Dip/Rolling Dip	
			☐ Diffuse Drainage	
FILL SIDE			☐ Ditch Relief Culvert	
Road Edge Condition	**Dominant Vegetation**		☐ Lead off Ditch/ WaterBar	
☐ No problem	☐ None/fallow		☐ Non engineered draining	
☐ Rilling	☐ Grass		☐ Stream Crossing	
☐ Raveling	☐ Reeds/Sedges		☐ Gully	
☐ Slumping	☐ Shrubs		☐ Landslide	
☐ Seep Spring	☐ Saplings			
☐ Bedrock	☐ Trees: (conifer/ broad-leaf)		**Associated Gully:**	

Figure 2.2: Road survey datasheet.

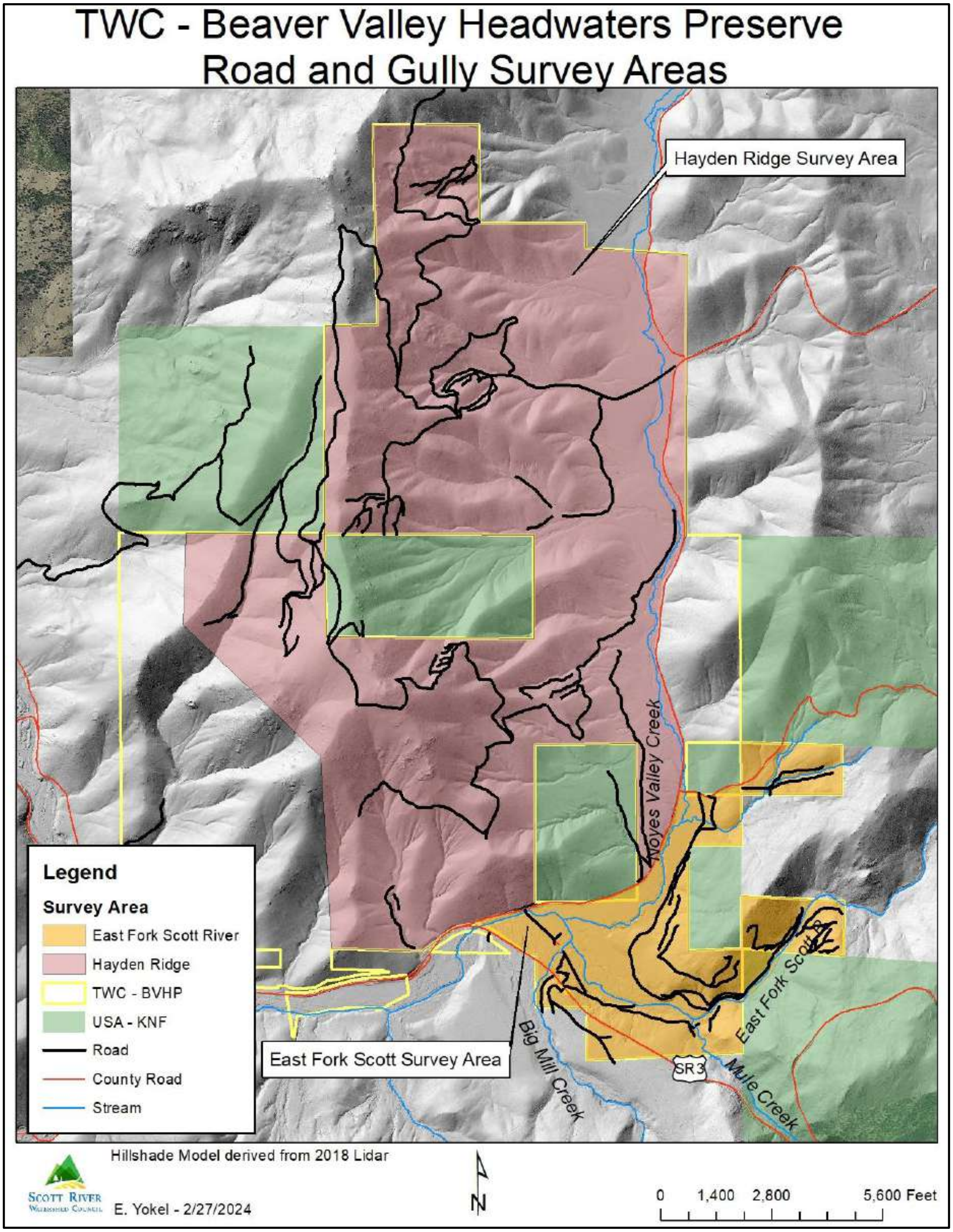
Road erosion was evaluated qualitatively and relatively based on erosion to roadbed and/or fill. Photos 2.1, 2.2 and 2.3 illustrate mild, moderate and extreme erosion points.

Photo 2.1: Example of mild erosion point. HRR20, April 18, 2023.

Photo 2.2: Example of moderate erosion point. EFR11.2, April 13, 2023.

Photo 2.3: Example of extreme erosion point, EFR13.1; April 13, 2023.

Road surveys were performed in two areas on the TWC - BVHP property: East Fork Scott River and Hayden Ridge (Map 2.1).



Map 2.1: Road and Gully Survey areas.

2.3.2 Road Analysis

Road points were separated into erosion points and other points (such as those noting road terminus or access issues). Erosion points were grouped by erosion severity and whether or not they discharge to a gully or stream. Road erosion points that discharge into a gully were addressed in the gully analysis. Road erosion points that discharged into a stream and were not associated with gullies were identified and prioritized.

2.3.3 Gully Survey

Initial work on the riparian vegetation surveys performed in 2022 had identified several gullies as a sediment source to the East Fork Scott River and the road surveys confirmed that often gullies were associated with the flow concentration and erosion features caused by roads and/or culverts. Therefore, SRWC developed a gully survey protocol to identify and prioritize gullies for remediation.

As the primary objective of this study is to identify locations to remediate sediment discharge into the East Fork Scott River and tributaries, the team developed a protocol that focused on capturing of the scale of erosion (cross-sectional area, length of gully, severity of erosion at road points) and whether there is a pathway that delivers sediment to the stream.

Gullies were initially identified and digitized from a hillshade model derived from the 2018 FEMA Lidar; additional gullies were identified through the road survey work. For each gully that had been identified, data was collected at the start and end of the gully as well as at features along the gully that captured both typical conditions as well as more severe examples of erosion. Information was collected using tablets with Avenza (for GPS tracks of gullies) and Survey 123 (for features along the length of the gully) and included location, source and/or discharge of flow, size data (length, width, depth and slope of gully and gully bank slopes), presence of headcuts, photos and notes (Figure 2.3).

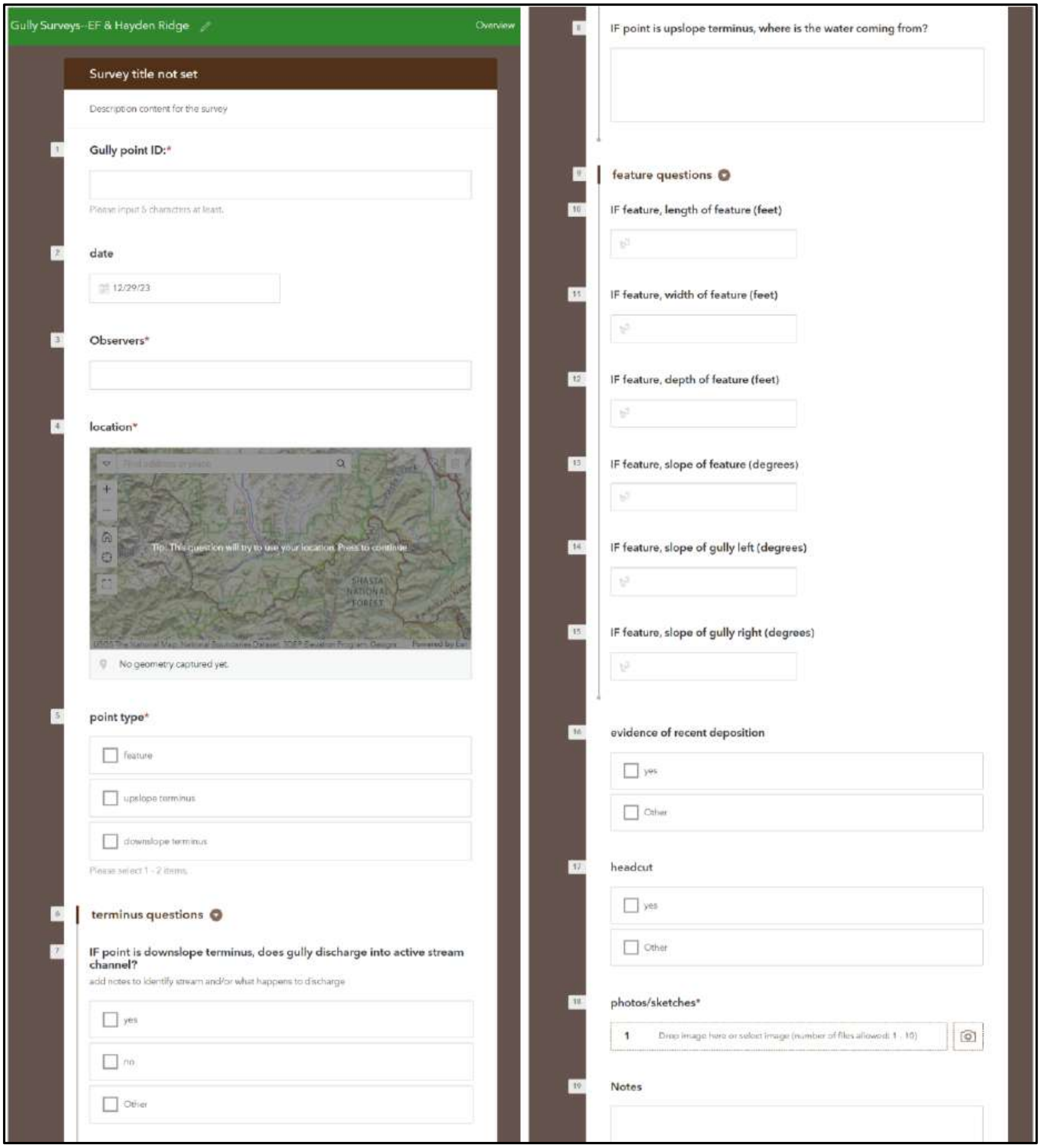


Figure 2.3: Gully survey form (Survey 123).

2.3.4 Gully Analysis

Due to bifurcations and confluences, many gullies occurred in connected complexes of individual segments. Gullies with multiple segments that had a common origin or terminus location were grouped into gully complexes. Gully segments names indicate their relationship to each other.

The segments' lengths and cross sections at individual features served to approximate the volume of sediment produced. The area of the gullies' cross-section was approximated by calculating the area of a triangle using the depth and width at each feature. Initial geospatial analysis consisted of mapping each gully feature and symbolizing it based on cross sectional area.

Gully segments were scored based on whether they were connected to a stream, their length, the largest cross-sectional area on the segment, and the erosion severity of each associated erosion road point (Table 2.1). Because the greatest concern was sediment delivery to the East Fork Scott River and its tributaries, the score for stream input is weighted over the other variables. Gully segments receiving a higher score indicate a greater potential for sediment delivery to waters of the state and a higher priority for assessment for remediation.

Table 2.1: Gully Segment Scoring.

Category	Value	Score	Value	Score	Value	Score	Value	Score
Stream Input	No	0	Only at very high flow	2	Yes	5		
Segment Length	< 750 ft	1	≥750 ft	2				
Area of Largest Cross-Section	< 5 ft^2	0	≥ 5 ft^2 & < 25 ft^2	1	≥ 25 ft^2	2		
Road Point Erosion (each point)	None	0	Mild	1	Moderate	2	Extreme	3

Next, the scoring system was adapted to address gully complexes, including the same essential categories (Table 2.2).

Table 2.2: Gully Complex Scoring.

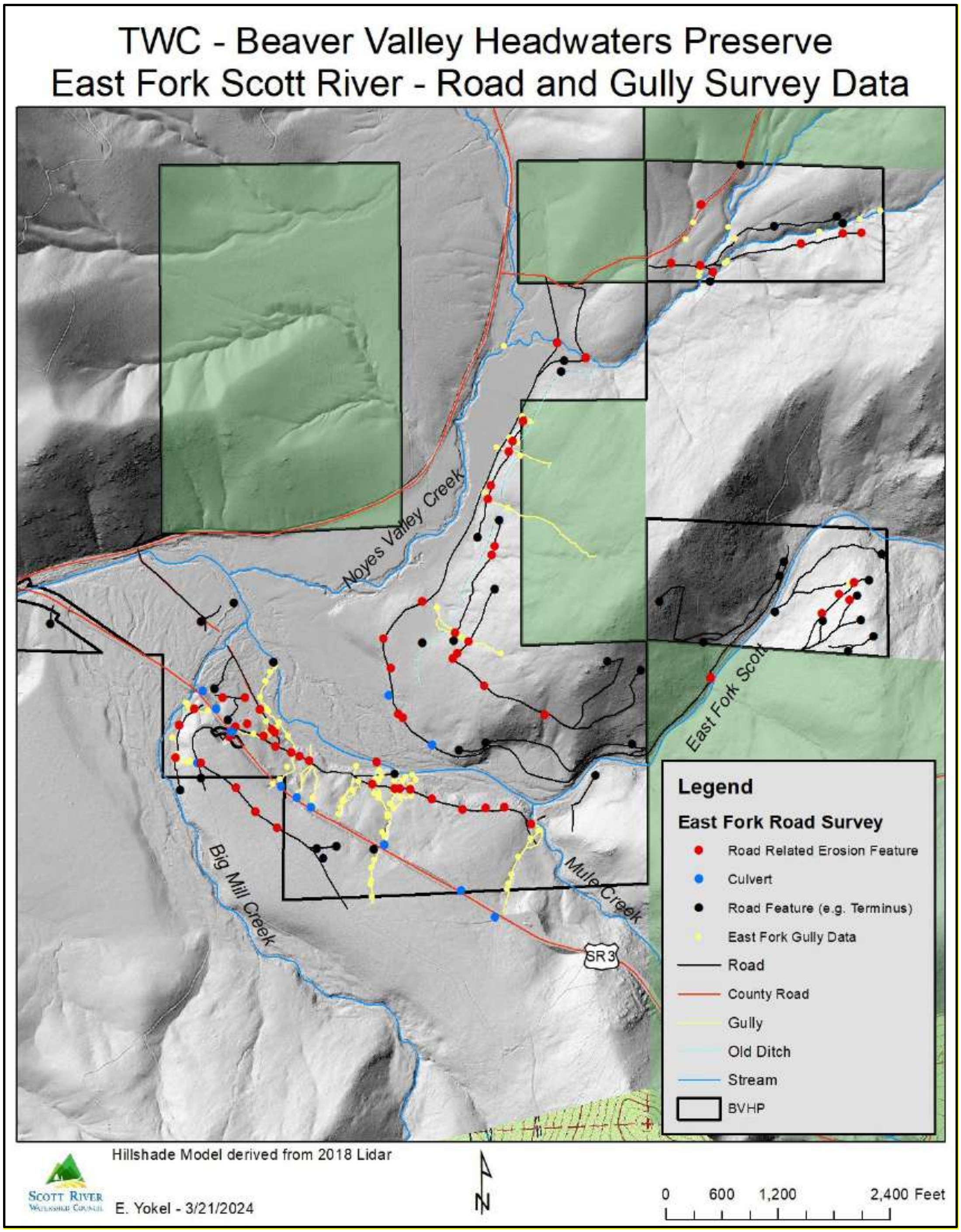
Category	Value	Score	Value	Score	Value	Score
Stream Input	No	0	Yes	5		
Segment Length	< 1000 ft	1	≥1000 ft	2		
Area of Largest Cross-Section	< 5 ft^2	0	≥ 5 ft^2 & < 25 ft^2	1	≥ 25 ft^2	2
Road Point Erosion	One point per associated erosional road point.					

2.4 Results

SRWC performed road and gully surveys on both sections of the BVHP: The East Fork Scott River area and the Hayden Ridge area. Due to logging activity in the Hayden Ridge area, some areas were not accessible.

2.4.1 East Fork Scott River Survey Area

SRWC surveyed approximately 9.6 miles of roads in the East Fork Scott River area, identifying and collecting data at 57 road erosion points. Thirty-one gully segments, making up 4.5 miles of gullies, were surveyed in the East Fork Scott River area. Twenty-two of the fifty-seven identified road erosion points were associated with gullies (Map 2.2).



Map 2.2: Road and Gully Survey results on the East Fork Scott River area.

Roads

Of the 57 road erosion points identified in the East Fork Scott area, four of them were not on BVHP property but on sections of road connecting two areas of BVHP.

Extreme road or fill erosion were identified at 19 points. Of those, 12 were associated with gullies (Table 2.3) and will be incorporated into the gully analysis. Five of the remaining seven points did not discharge sediment to a stream or gully connected to a stream. Two of them are points where a road crosses an unnamed tributary that enters Noyes Valley Creek at RKM 1.6 (Photo 2.4 & 2.5).

Of the 23 road points with moderate road or fill erosion, three were associated with gullies. One discharges into Big Mill Creek and two impact the above-mentioned unnamed tributary Noyes Valley Creek. The remaining 18 points do not deliver sediment to a stream or gully (Map 2.3).

There are 12 points with mild erosion, one of which is associated with a gully. One discharges into the East Fork Scott River on the section of the road that leads to the China Cove irrigation diversion but is on United States Forest Service land. Two impact Noyes Valley Creek.

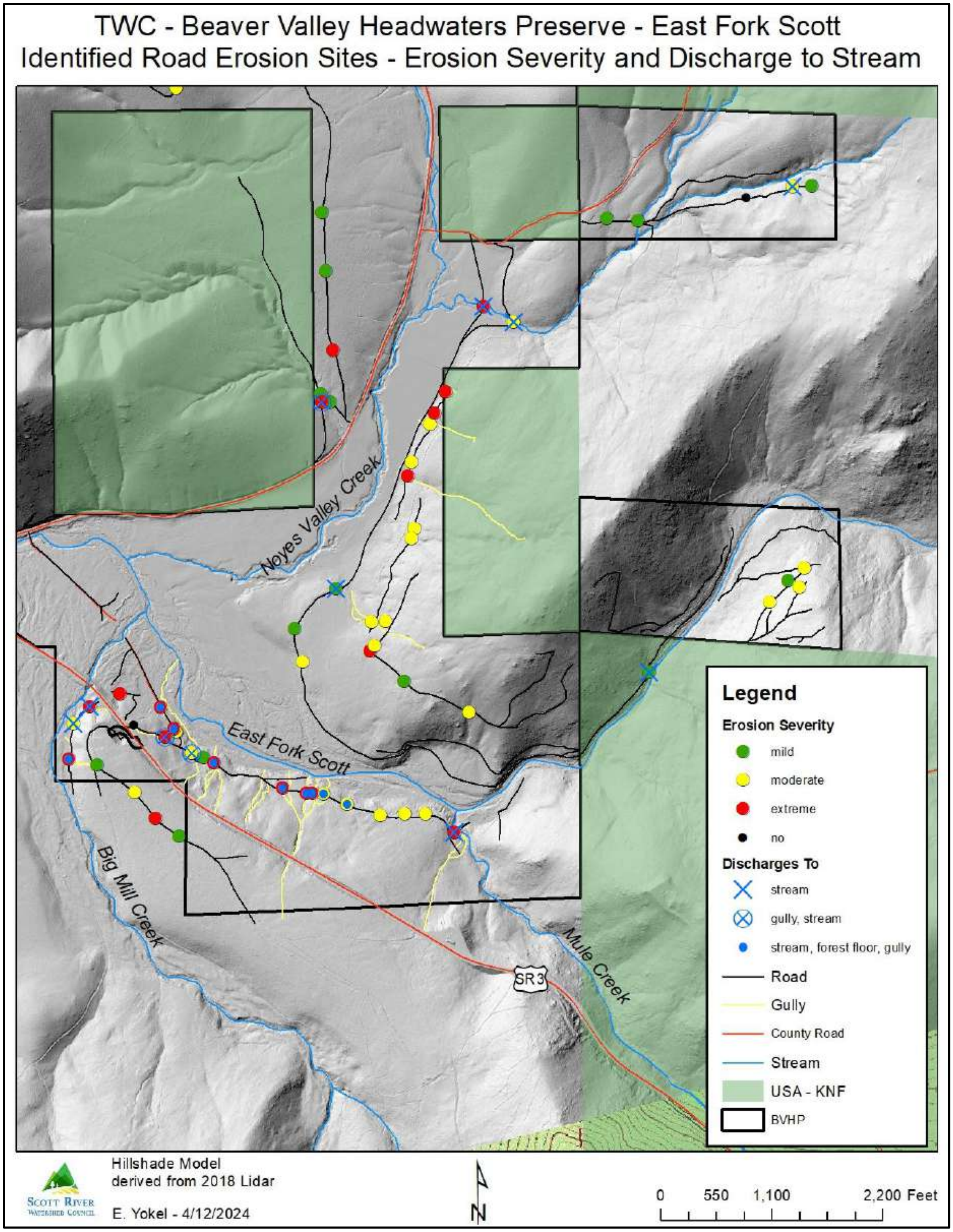
The highest priority non-gully points to treat are the road crossings with extreme erosion on the unnamed tributary to Noyes Valley Creek. Downstream of the second crossing there is significant stream incision, which likely increases sediment delivery in addition to the sediment due to the two stream crossings. An additional high priority location is the point that discharges into Big Mill Creek at RKM 0.4. While the road crossings over the unnamed tributary have greater erosion severity, they are 750 to 4800 feet upstream of the confluence of Noyes Valley Creek and the confluence is upstream of a depositional reach. The point next to Big Mill Creek has lower severity erosion but is less than 50 ft from the creek.

Table 2.3: Road Erosion Points and Gully Associations.

Erosion Severity	All Points	Associated with Gully	Discharges to Stream; Not Associated with Gully	Not Associated with Stream or Gully
None	3	1	0	2
Mild	12	1	3	8
Moderate	23	3	2	18
Extreme	19	12	2	5
Any	57	17	7	33

Photo 2.4: Road crossing unnamed tributary to Noyes Valley Creek. EFR30. May 5, 2023.

Photo 2.5: Road crossing unnamed tributary to Noyes Valley Creek. EFR49. August 5, 2023.



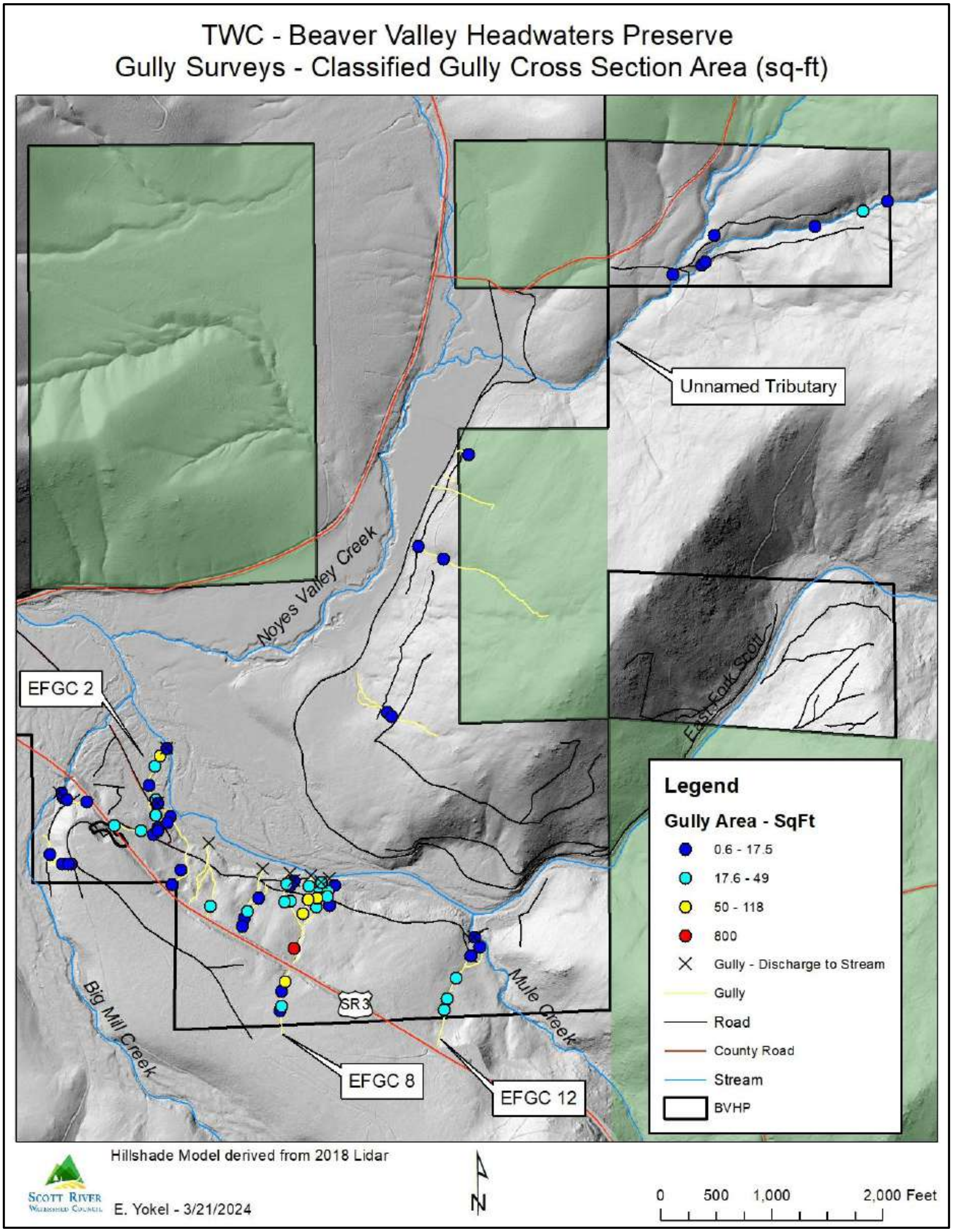
Map 2.3: East Fork Scott Survey Area - Road Survey Points - Classified by Erosion Severity.

Gullies

In the East Fork Scott River area, East Fork gullies (EFG) discharged water and sediment directly into the East Fork Scott River at 11 locations (Map 2.4). Gullies discharge into Mule Creek and Big Mill Creek, tributaries of the East Fork Scott River.

Initial mapping of the cross-section area of gully features, as shown in (Map 2.4) of the gully features made clear that some of the highest severity gully segments are part of the Gully 2 and Gully 8 Complexes. Scoring of individual segments (Table 2.3) and whole gully complexes (Table 2.4) concurred. Both scoring methods highlight East Fork Gully Complexes (EFGC) 2, 8, 12, and 5. A discussion of each of these high priority gully complexes follows, including representative photos. A more complete photographic representation of each gully can be found in Appendix A.

Maps 2.5 and 2.6 illustrate the relationship between gullies and many of the erosion points identified in the road survey. Treating the high priority gullies will reduce further damage to many of the high severity erosion points on the private roads.



Map 2.4: Classified Gully Cross Section Area (square – ft) - East Fork Scott River.

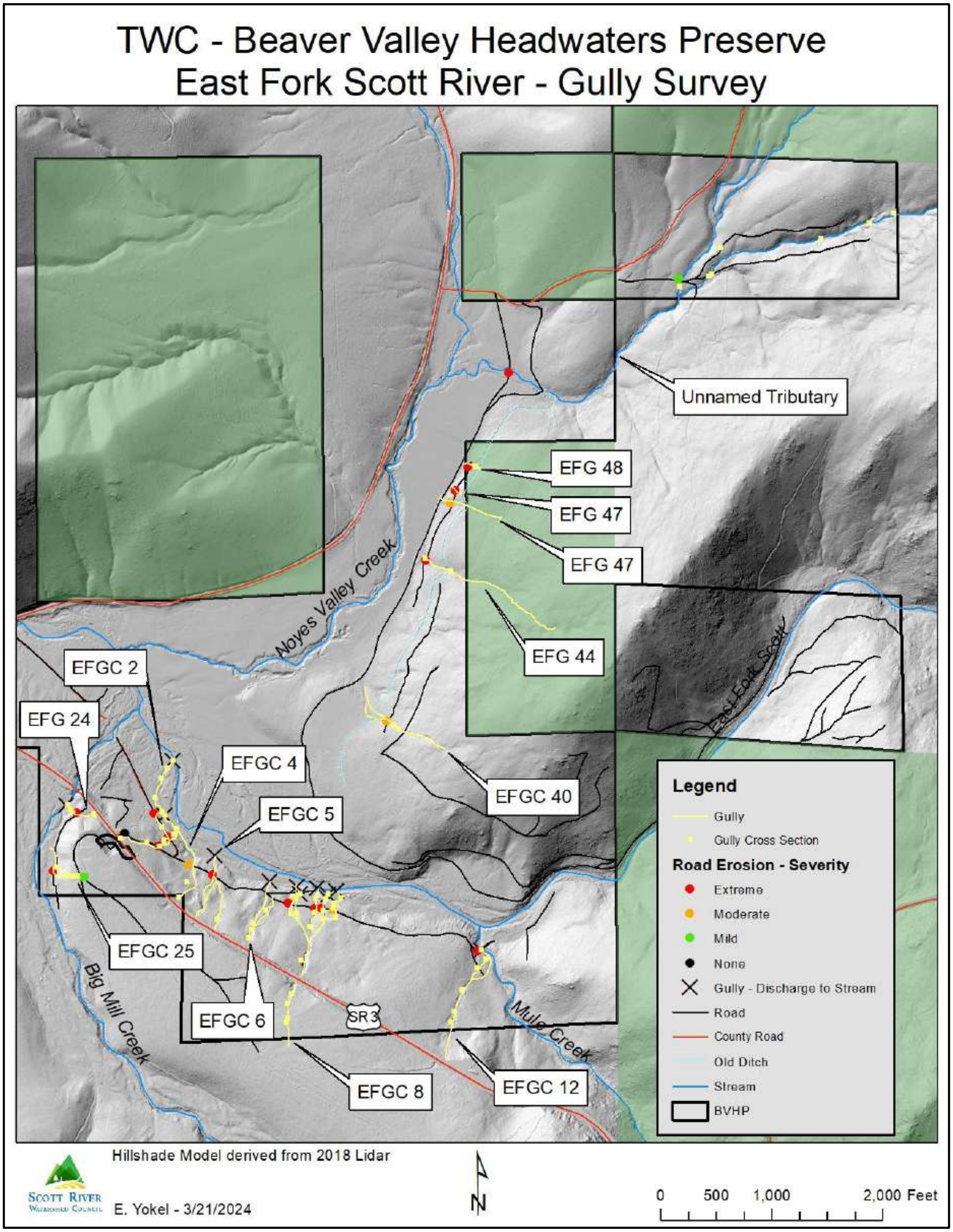
Table 2.4: Gully segment scores.

Gully ID	Stream Input	Stream Input Score	Length (ft)	Length Score	Max Cross-Section Area (ft^2)	Cross Section Score	Road Point Erosion Severity	Road Point Score	Total Score	Rank
EFG2	East Fork Scott River	5	1397	2	89	2	extreme (3)	9	18	1
EFG12	Mule Creek	5	1106	2	32	2	extreme	3	12	2
EFG8.1	East Fork Scott River	5	553	1	38	2	extreme	3	11	3
EFG8.2	East Fork Scott River	5	425	1	118	2	extreme	3	11	
EFG8.3	East Fork Scott River	5	418	1	70	2	extreme	3	11	
EFG5.1	East Fork Scott via 5.0	5	531	1	22	1	extreme	3	10	4
EFG8.4	East Fork Scott River	5	376	1	34	2	moderate	2	10	
EFG24	East Fork Scott River	5	312	1	10	1	extreme	3	10	
EFG5.0	East Fork Scott River	5	621	1		0	extreme	3	9	5
EFG5.1.1	Connected to 5.1	5	215	1		0	extreme	3	9	
EFG6	East Fork Scott River	5	578	1	40	2		0	8	6
EFG8.0	East Fork Scott River	5	590	1	74.4	2		0	8	
EFG8.01	East Fork Scott River	5	424	1	803.1	2		0	8	
EFG8.1.1	EFG8.1	5	270	1	22.6	2		0	8	
EFG4	East Fork Scott River via EFG2.1 at high flows	2	750	2	5.9	1	moderate	2	7	7
EFG12.1	Mule Creek via 12	5	319	1		0		0	6	8
EFG2.1	to EFG2 at high flows	2	444	1	5.1	1	moderate	2	6	
EFG25	None	0	521	1	16.7	2	extreme, mild	3	6	
EFG40	None	0	994	2	5.3	1	moderate	2	5	9
EFG44	None	0	1472	2	3	0	extreme	3	5	
EFG48	None	0	157	1	6.4	1	extreme	3	5	
EFG47	None	0	120	1	ND	0	extreme	3	4	10
EFG6.1	None	0	368	1	40.7	2		0	3	11
EFG46	None	0	641	1	ND	0	moderate	2	3	
EFG40.1	None	0	285	2					2	12
EFG25.1	None	0	234	1	ND	0		0	1	13

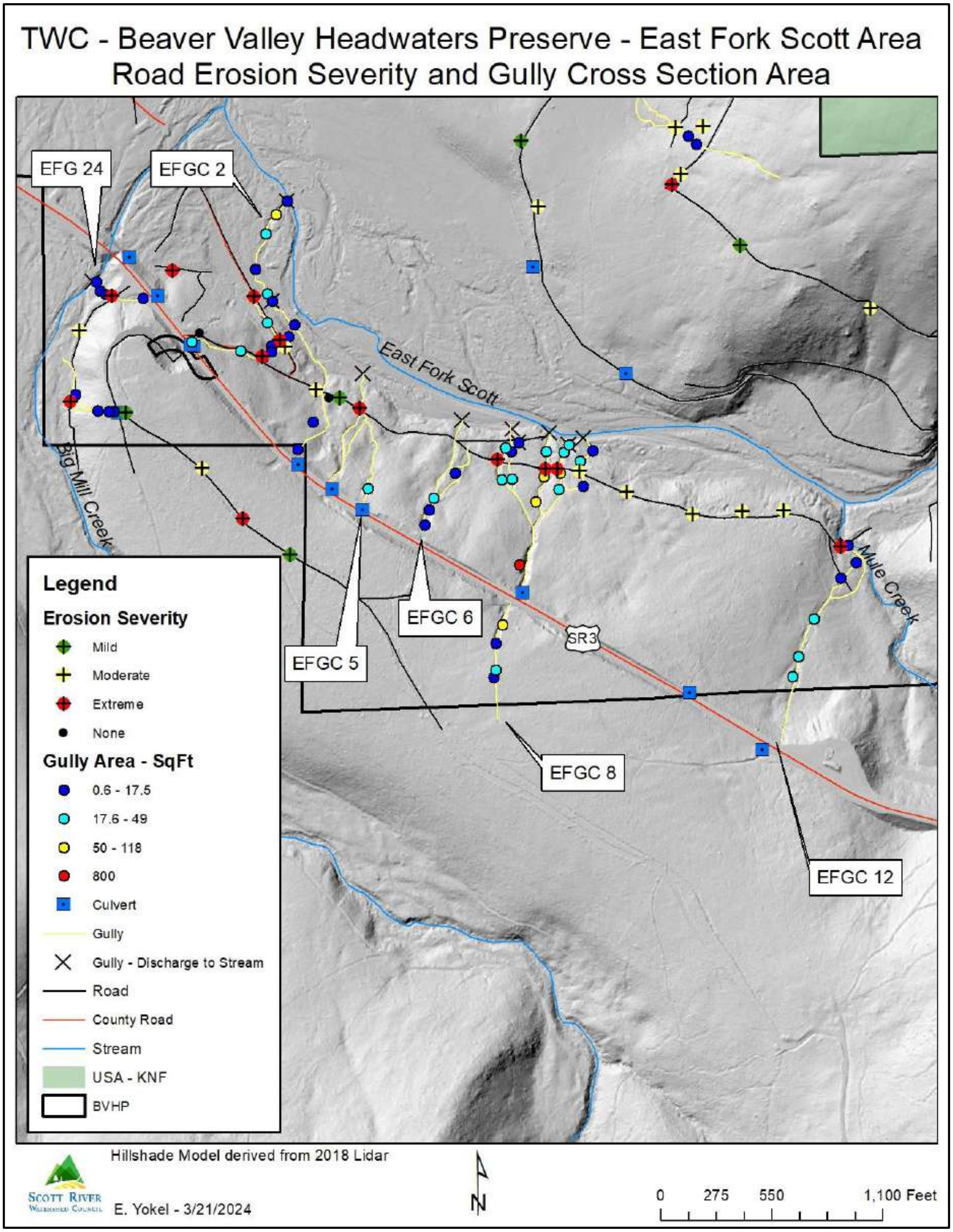
Table 2.5: Gully complex scores.

Table 5: Gully Complex Scores

Gully_ID	Stream Input	Stream Input Score	Combined Length (ft)	Length Score	Max Cross-Section Area (ft^2)	Cross Section Score	Road Point Erosion Severity	Road Point Score	Total Score	Rank
EFGC 2	East Fork Scott River	5	1842	2	88.8	2	4	4	13	1
EFGC 8	East Fork Scott River	5	3057	2	803.1	2	4	4	13	
EFGC 12	East Fork Scott River	5	1425	2	31.9	2	1	1	10	2
EFGC 5	East Fork Scott River	5	1368	2	22.2	1	1	1	9	3
EFGC 6	East Fork Scott River	5	946	1	40.7	2	0	0	8	4
EFG 24	East Fork Scott River	5	312	1	10.45	1	1	1	8	
EFG 4	connects to EFG2.1 at high flows	2	750	1	5.9	1	1	1	5	5
EFGC 25	Big Mill Creek	0	755	1	16.7	1	2	2	4	6
EFGC 40	No	0	1278	2	5.3	1	1	1	4	
EFG 44	No	0	1472	2	3	0	1	1	3	7
EFG 48	No	0	157	1	6.4	1	1	1	3	
EFG 46	No	0	641	1	ND	0	1	1	2	8



Map 2.5: Identified gullies – East Fork Scott River Section.



Map 2.6: Highway 3 to East Fork Scott River – Road erosion severity and gully cross section area.

Gully Complex 2

Gully Complex 2 begins at a culvert under Highway 3. It flows downstream as an inboard ditch on an old county road. The ditch is eroding and has no engineered outlet (Photo 2.6). This gully has four associated road erosion features. At two of the road points, the water flows down the road, causing extreme erosion (Photo 2.7). It terminates at the East Fork Scott River, discharging sediment into the river (Photo 2.8).

Table 2.6: Gully Complex 2

Length	1840 ft
Maximum cross-sectional area	89 ft^2
Number of associated road points	4
Erosion severity at road points	Extreme (3) Moderate (1)
Severity ranking	1

Photo 2.6: Outlet of Highway 3 culvert and ditch, looking upslope. EFG2a. January 19, 2024.

Photo 2.7: Water during runoff event crossing road. EFR2. January 13, 2023.

Photo 2.8: Greatest cross-section of EFGC 2 is 89 ft^2. EFG2i; January 19, 2024.

Gully Complex 8

Gully Complex 8 (Table 2.6) begins above Highway 3, collects the discharge from the inboard ditch on Highway 3, passes under Highway 3 through a culvert, and then almost immediately reaches its maximum cross section area of 63 feet wide and 26 feet deep (Photo 2.9 and Photo 2.10). Below that it bifurcates four times, into five gully segments that cross the road at four road points (three with extreme erosion, one with moderate erosion (Photo 2.11), before discharging into the East Fork Scott River (Photo 2.12).

Table 2.6: Gully Complex 8

Length	3060 ft
Maximum cross-sectional area	800 ft^2
Number of associated road points	4
Erosion severity at road points	Extreme (3), moderate (1)
Severity ranking	1

Photos 2.9 and 2.10: Maximum cross-section of Gully Complex 8 is 800ft^2. EFG8f and EFG8g; May 29, 2023.

Photo 2.11: Discharge of Gully 8.3 into the East Fork Scott. EFG9e; April 5, 2024.

Photo 2.12: Gully 8.4 discharges into the East Fork Scott River. EFG10e; April 5, 2024.

Gully Complex 12

Gully Complex 12 (Table 2.7) begins where a culvert under Highway 3 and an outboard ditch discharge water into the same area. It bifurcates once and the two segments discharge at roughly the same place into Mule Creek, which converges with the East Fork Scott River, approximately 160 feet downstream. Gully Complex 12 only crosses a road once, at the confluence of the two segments, but erosion at that point was rated extreme (Photos 2.13 and 2.14).

Table 2.7: Gully Complex 12

Length	1430 ft
Maximum cross-sectional area	30 ft^2
Number of associated road points	1
Erosion severity at road points	Extreme
Severity ranking	2

Photos 2.13 and 2.14: Greatest cross-section of Gully Complex 12 is 32 ft^2; looking up and down the gully at that point. EFG12b; May 23, 2023.

Gully Complex 5

Gully Complex 5 (Table 2.8) originates at two points: a culvert and an outboard ditch, both associated with Highway 3 (Photo 2.15). It consists of three segments that converge as they cross the private road (Photo 2.16), at a point with extreme erosion, and then discharges into the East Fork of the Scott River.

Table 2.8: Gully Complex 5

Length	1370 ft
Maximum cross-sectional area	20 ft^2
Number of associated road points	1
Erosion severity at road points	extreme
Severity ranking	3

Photo 2.15: Below Highway 3 outboard ditch. EFG6.5.2c; June 2, 2023.

Photo 2.16: Gully Complex 5 crossing the road. EFR6; May 23, 2023.

Gully 24

Gully 24 (Table 2.9) begins where the inboard ditch on Highway 3 flows past the mouth of a culvert instead of being directed into the culvert (Photo 2.17). Gully 24 continues on the inboard side of the highway, crosses the private road dirt road (extreme erosion) (Photo 2.18) and cuts down the bank to discharge in Big Mill Creek (Photos 2.19 and 2.20). Big Mill Creek joins the East Fork Scott River about 90 feet downstream.

Table 2.9: Gully Complex 24

Length	310 ft
Maximum cross-sectional area	10 ft^2
Number of associated road points	1
Erosion severity at road points	extreme
Severity ranking	4

Photo 2.17: Beginning of EFG 24. Inboard ditch flows past culvert. EFG24a; April 5, 2024.

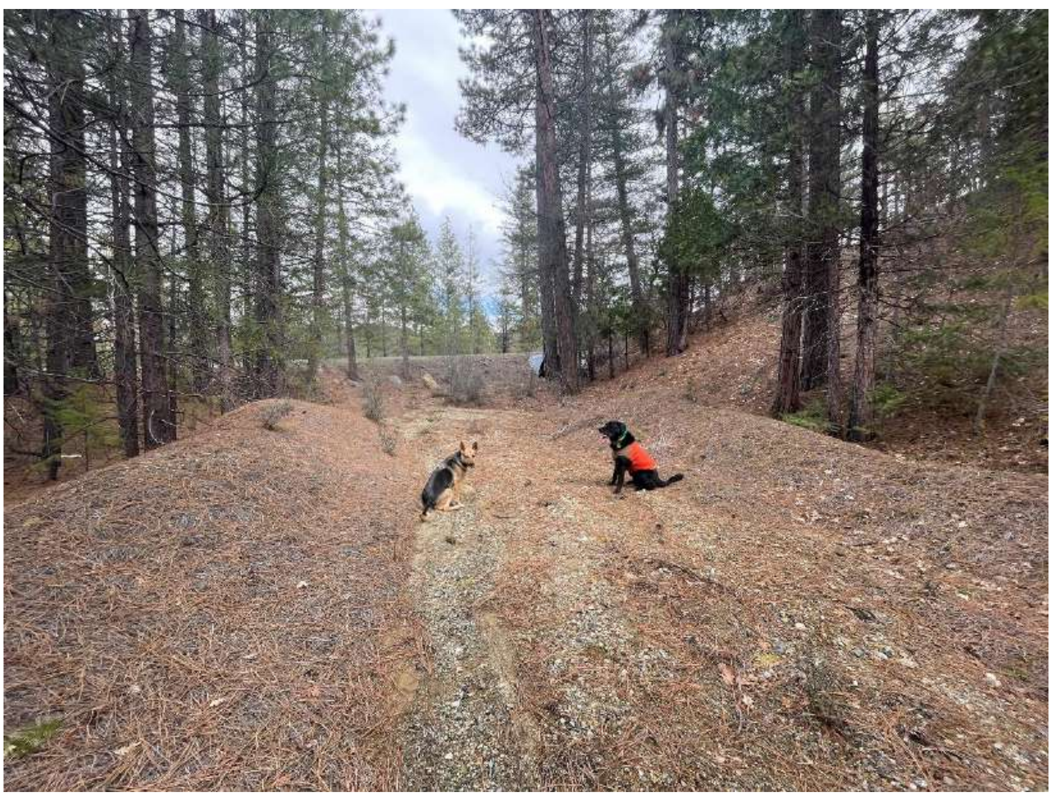


Photo 2.18: EFG 24 downstream of bypassed culvert. April 5, 2024.


Photos 2.19 and 2.20: EFG 24 below private road. EFG24b (left photo); EFG 24 discharges into Big Mill Creek. EFG24e (right photo). April 5, 2024.

Gully Complex 6

Gully Complex 6 (Table 2.10) begins slightly downslope of a berm on the downhill side of Highway 3 and bifurcates into two branches. Highway 3 does not appear to contribute to this gully system (Photo 2.21); there is no culvert or ditch. The thalweg of the gully is covered with a thick layer of duff (Photo 2.22), comparable to the forest floor around it, suggesting that it has not experienced recent erosion (Photo 2.23). It does not cause notable erosion when it crosses the dirt road. Perhaps this was a creek or swale that was cut off from its source by the construction of the highway.

Table 2.10: Gully Complex 6

Length	950 ft
Maximum cross-sectional area	40 ft^2
Number of associated road points	0
Erosion severity at road points	NA
Severity ranking	4

Photos 2.21 and 2.22: Beginning of EFGC 6; no visible cause EFG6.1a (left photo). Significant layer of duff. EFG6g (right photo). May 29, 2023.

Photo 2.23: Duff and vegetation in gully. EFG6e; May 29, 2023.

Highway 3 and Gullies

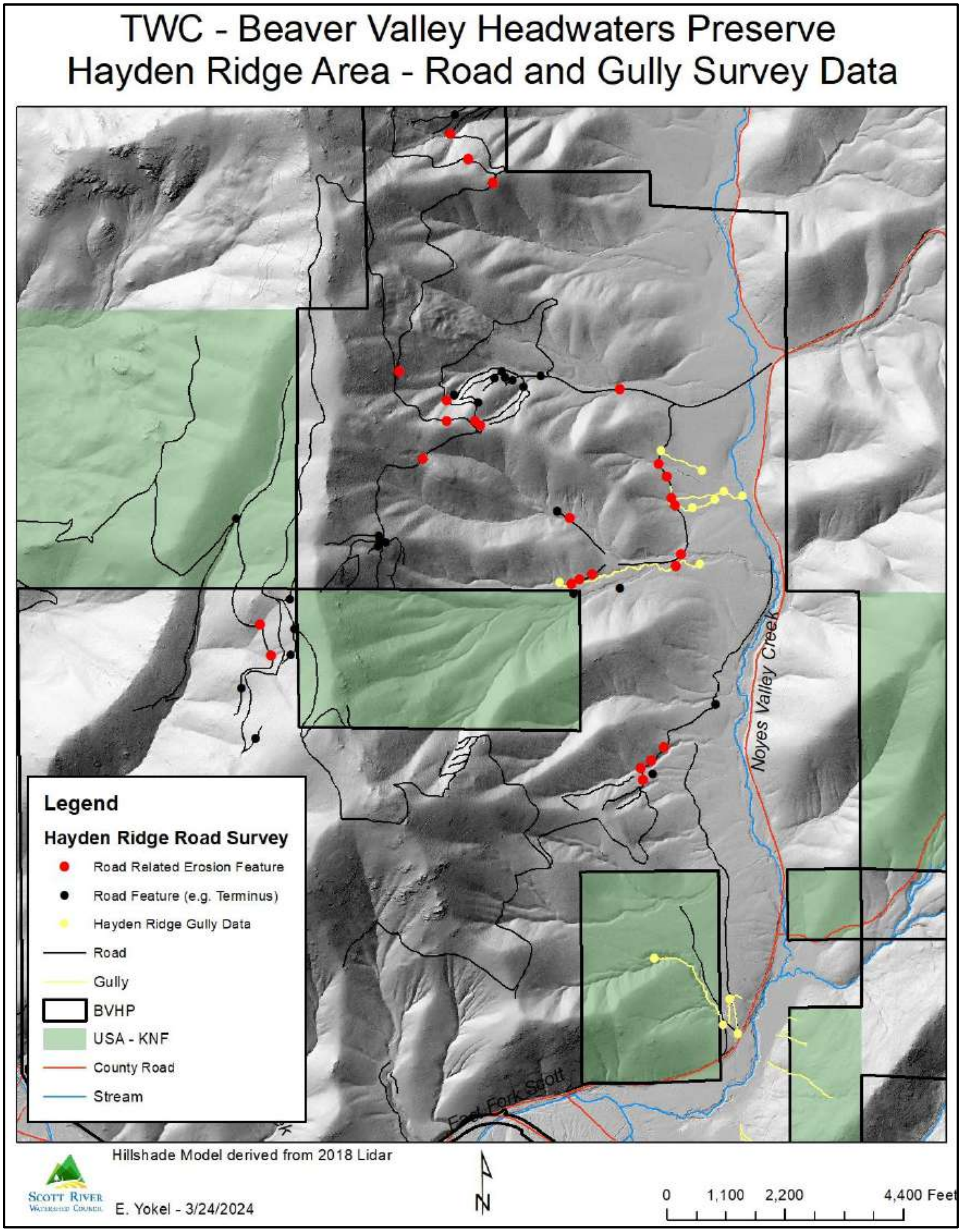
Water management related to Highway 3 causes, or exacerbates, erosion in almost all the high severity gullies and gully complexes. While it may not be feasible to improve water handling on Highway 3, methods to slow the flow--and hence decrease erosion--could reduce sediment delivery to the East Fork Scott River and protect the private roads from further damage.

2.4.2 Hayden Ridge Survey Area

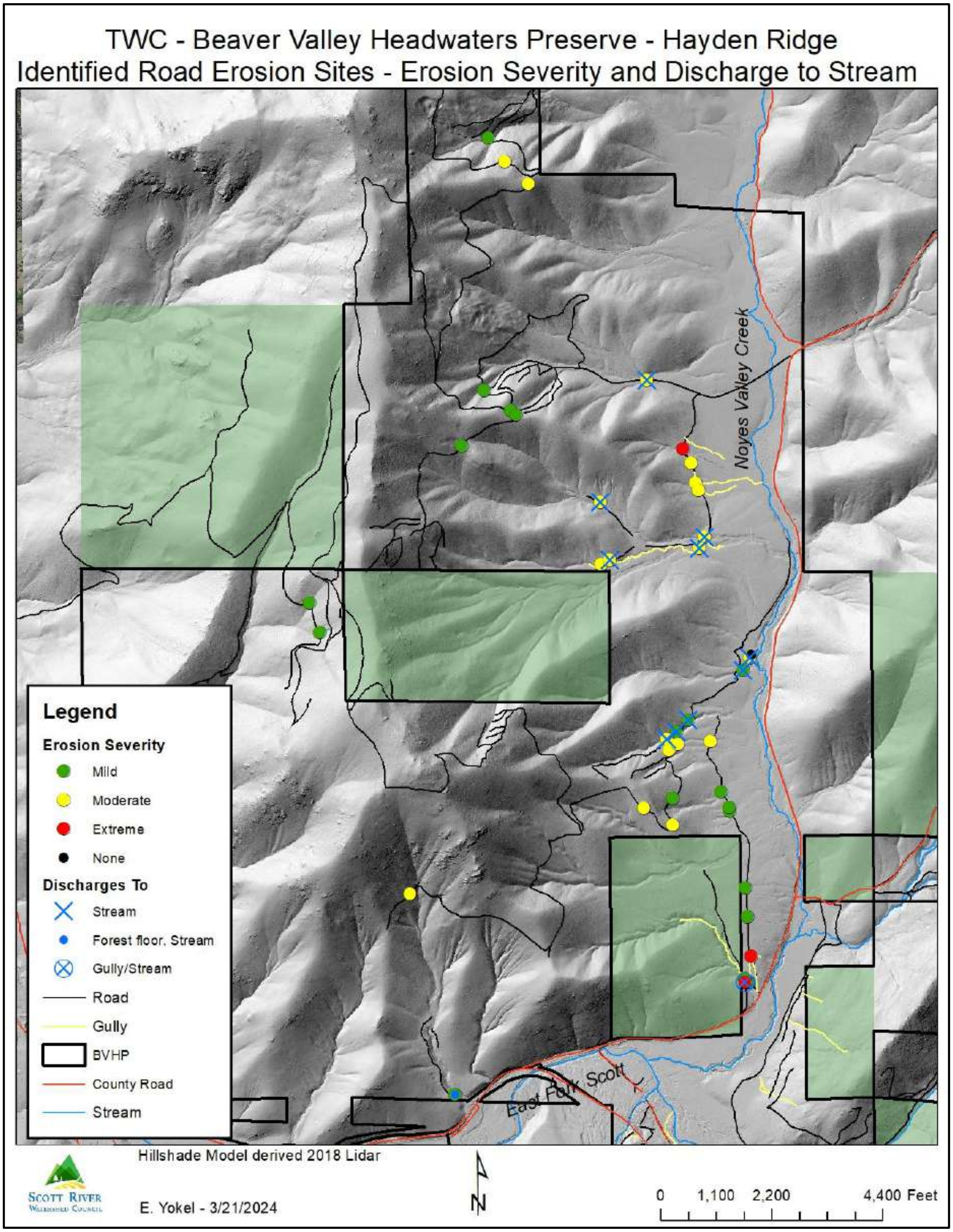
SRWC surveyed 20.2 miles of road in the Hayden Ridge Survey Area (Map 2.7). Forty-one (41) road erosion sites were identified and surveyed in the survey area (Map 2.8). Three road erosion sites had documented extreme erosion with nineteen sites with moderate erosion and nineteen sites with mild erosion. Eleven of the road erosion features were documented to discharge water and potential sediment to the stream (all features denoted as mild or moderate erosion severity) and seven road erosion features were documented to discharge water to gullies (two features denoted as extreme erosion severity).

Eight gullies (1.9 miles) were inventoried in the Hayden Ridge Survey Area.

The identified road erosion points and gullies that discharge water and potential sediment into the stream connect to a portion of Noyes Valley Creek more than 2 miles upstream of the East Fork Scott River. Noyes Valley Creek is a low gradient depositional stream between the road erosion and gully inputs and the East Fork Scott River, minimizing the risk of delivery of road and gully derived sediment to Lower Noyes Valley Creek (downstream of the Masterson Road low water crossing) and the East Fork Scott River.



Map 2.7: Road and Gully Survey results on the Hayden Ridge area.



Map 2.8: Hayden Ridge - Erosion severity and discharge to stream.

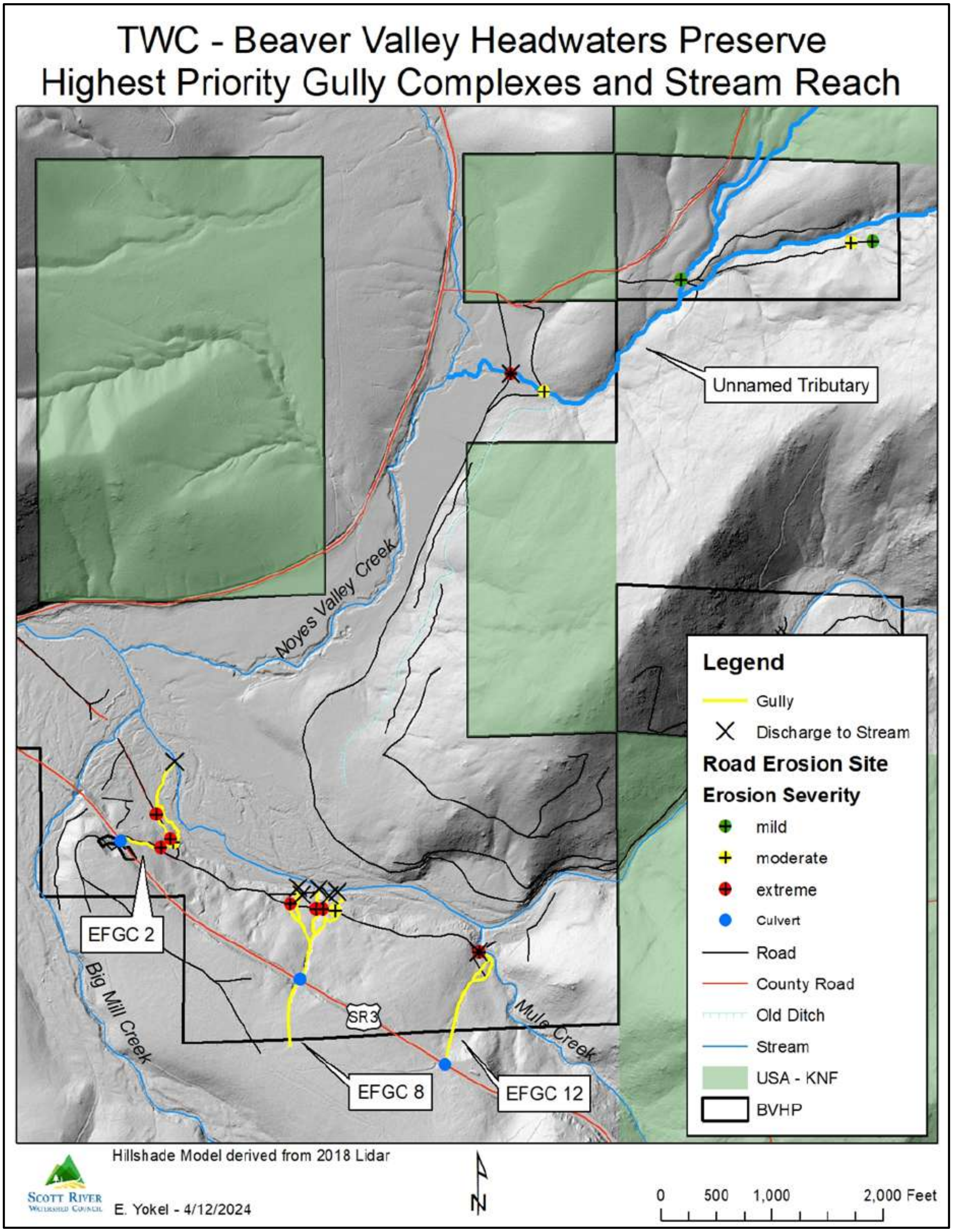
2.5 Conclusions

Remediating gullies takes precedence over addressing individual road erosion points because of the substantial volume of sediment they can directly deliver to streams. One indication of the magnitude of sediment gullies deliver is the presence of alluvium deposits where some of the gullies join the streams or the East Fork Scott River. The highest priority gullies for treatment are EFGC 2, EFGC 8 and EFGC 12 (Map 2.9).

Although not a gully, the unnamed tributary to Noyes Valley Creek has similar sediment potential; it is actively downcutting and delivering sediment directly to Noyes Valley Creek. Two extreme and one moderate road erosion points are stream crossings on this creek. (Map 2.9).

Though lower priority than the gullies identified above, Gully 24 discharges sediment directly into Big Mill Creek (Map 2.9) and appears to have a relatively simple fix. It will require the redirection of flow at a single location. Due to the relative simplicity of the solution, it is included here as a priority for treatment.

While some of the larger problems will require engineering design to address them, it may be possible to use low tech process-based approaches in the near term to reduce erosion until a more permanent solution can be implemented. Additionally, it would be useful to consider what locations lend themselves to simple, more inexpensive solutions. Even if they are not the major sediment sources, they may provide a decent return for the investment. A full copy of all the photos and photo points taken for this work can be found here: BVHP East Fork Roads and Gully_240501.



Map 2.9: Highest priority locations for treatment.

2.6 Bibliography

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2.7 Appendix

Appendix 2.1: Gully Photos

Chapter 3. Stream Discharge and Wetted Perimeter Monitoring

3.1 Introduction

Understanding stream discharge is fundamental for designing restoration actions that effectively restore stream ecosystems, improve habitat conditions for aquatic species, enhance water quality, and increase resilience to environmental stressors such as climate change. During the water year (WY) 2023, four continuous stream discharge (streamflow) stations were installed along the East Fork Scott River and its tributaries to systematically record and document the flow patterns throughout the year. A wetted perimeter station was set up to helps in assessing the flow characteristics within the East Fork, below China Cove Diversion (Scott River Decree Diversion 66 (Schedule E)), for a possible water leasing transaction.

3.2 Purpose

- To gain a better understanding of streamflow during baseflow with the East Fork of the Scott River, Big Mill and Noyes Valley Creeks, the data from these stations were used to help inform restoration designs for this project.
- Established a wetted perimeter analysis helps assess the potential environmental impacts of water leasing activities.

3.3 Methods

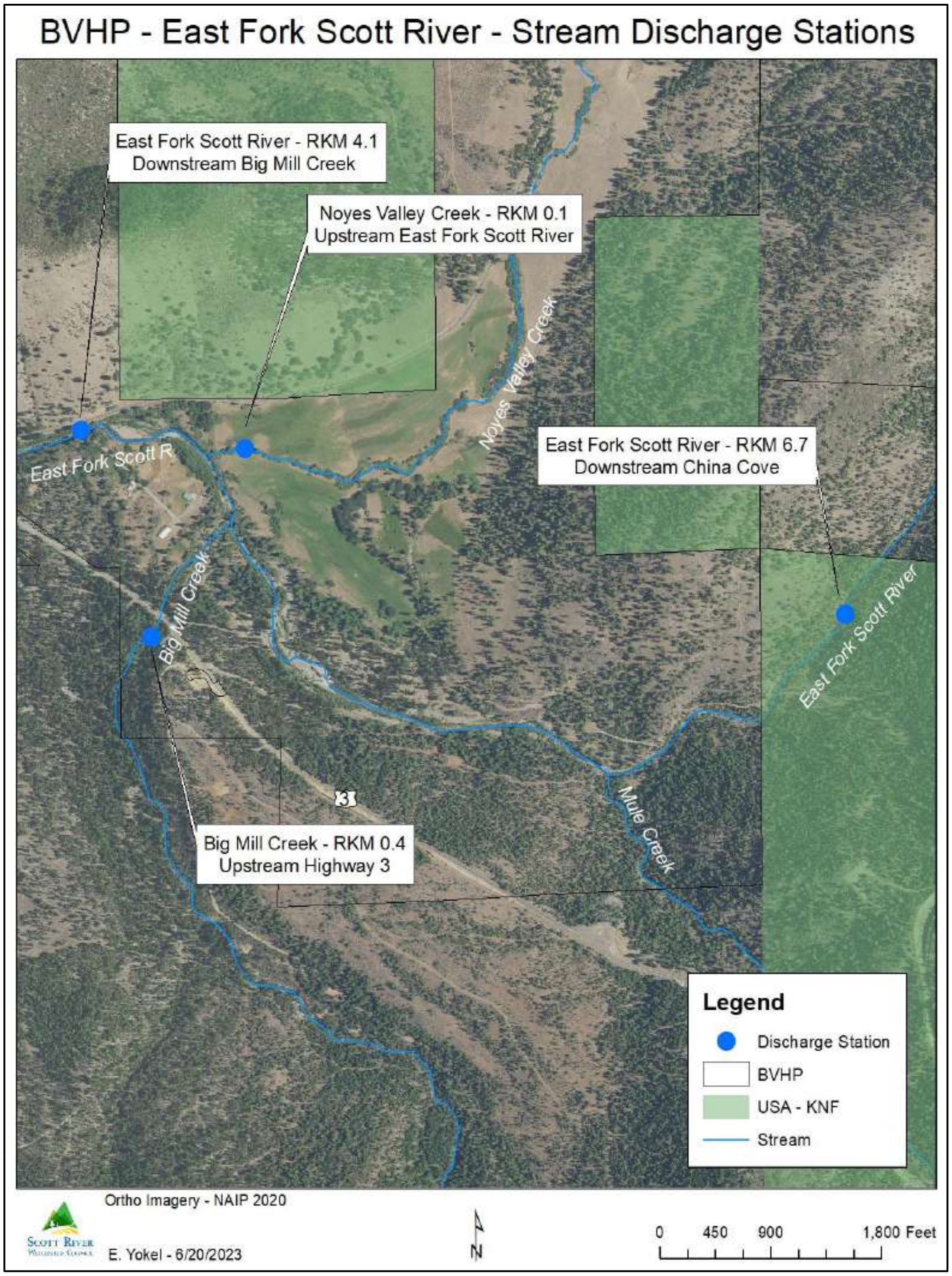
Four continuous stream discharge stations were established in the East Fork Scott River and tributaries to document the discharge during water year 2023 (Map 3.1). Two stations were established on the East Fork Scott River. The upstream East Fork Scott River station was established at RKM 6.7, downstream of the China Cove Diversion (Scott River Decree Diversion 66 (Schedule E)) and the downstream station was established at RKM 4.1 upstream of the Parker Pasture Diversion (Scott River Decree Diversion 81 (Schedule B7)).

A vented PVC stilling well was installed in a pool at each stream discharge station and an Onset Computer Corporation pressure transducer was deployed in the stilling well to document continuous (15 minute) water depth (stage) and temperature. Periodic discharge measurements were performed with a SonTek FlowTracker 2 Acoustic Dopler Velocity (ADV) meter at each station over a range of stream discharge to develop a rating equation to convert the continuous stage data to discharge data (Rantz, et al., 1982). Continuous discharge (cfs) was calculated for each station.

Table 3.1: Accumulated discharge (acre-ft) at the USGS gage - WY2011 - WY2023.

Accumulated Discharge (ac-ft) - October 1 - September 30		
Water Year	Accum. Discharge (ac-ft)	Driest Rank
2011	559,641	56
2012	310,758	33
2013	233,289	20
2014	122,156	7
2015	295,223	28
2016	507,984	52
2017	864,130	77
2018	191,048	12
2019	411,277	45
2020	120,137	5
2021	109,660	3
2022	139,420	8
2023	370,585	43
Average (82 years)	434,208	

Water Year 2023 was an average water year in the Scott River watershed, per analysis of the accumulated discharge (acre-ft) at the Scott River USGS gage (11519500) downstream of Fort Jones. The average accumulated discharge at the USGS gage over the 82-year period of record is 434,000 acre-ft and the accumulated discharge for WY2023 was 371,000 acre-ft - the 43rd driest water year for the period of record (Table 3.1). The previous three water years (WY2020 - WY2023) in the Scott River watershed were critical drought years with WY2021 having the third lowest accumulated discharge in the period of record.



Map 3.1: Location of stream discharge monitoring stations.

3.4 Results

3.4 East Fork Scott River - Downstream China Cove - RKM 6.7

The East Fork Scott River downstream of China Cove (RKM 6.7) stream discharge station was established on April 11, 2023. Twelve (12) periodic discharge measurements were performed from April 13 to September 13, 2023, documenting a range of 2.4 to 163.3 cfs (Table 3.2). The period of record ended on October 8, 2023.

Table 3.2: Periodic discharge measurements in cubic feet per second (cfs) - East Fork Scott River - RKM 6.7.

Date	Q (cfs)
4/13/2023	163.3
4/18/2023	140.4
4/20/2023	112.2
6/21/2023	49.0
7/3/2023	27.7
7/6/2023	19.1
7/17/2023	13.1
7/28/2023	7.0
8/3/2023	5.7
8/8/2023	4.9
8/17/2023	2.8
9/13/2023	2.4

The periodic discharge measurements were utilized to develop a rating curve. Continuous (15 minute) discharge (cfs) was calculated with the rating curve - discharge above 200 cfs was determined to be above the rating table (Figures 3.1 and 3.2). Daily average discharge was calculated from the continuous discharge (Figures 3.3 and 3.4).

The discharge at the East Fork Scott River at RKM 6.7 was above the rating curve for a significant amount of the time during the wet-season peak flow (spring snowmelt runoff) period. The spring recession flow period began on approximately June 15, 2023, with the dry-season (summer) base flow regime beginning on July 17, 2023, when the stream discharge fell below 10 cfs. The dry-season base flow period persisted through early October 2023. Daily average stream discharge was less than 5 cfs for greater than 62 days with a minimum daily average discharge of 2.2 cfs observed from September 19 - 21, 2023.

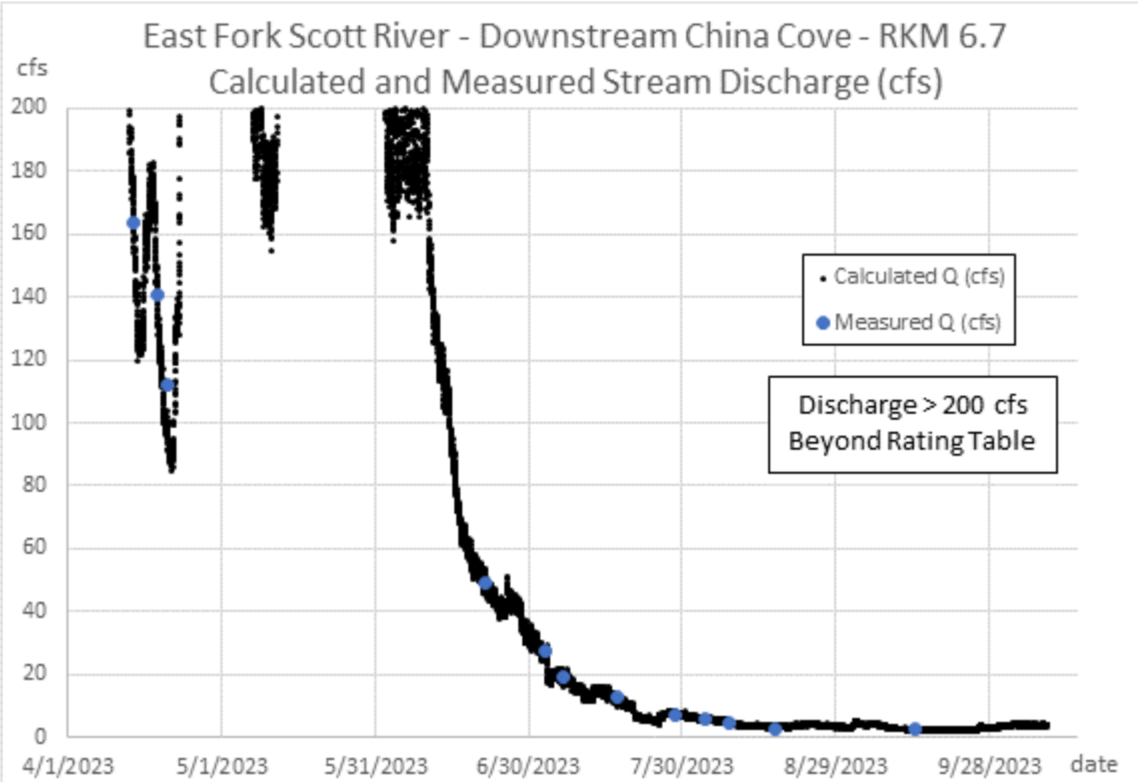


Figure 3.1: Continuous calculated and periodic measured discharge (cfs) – East Fork Scott RKM 6.7

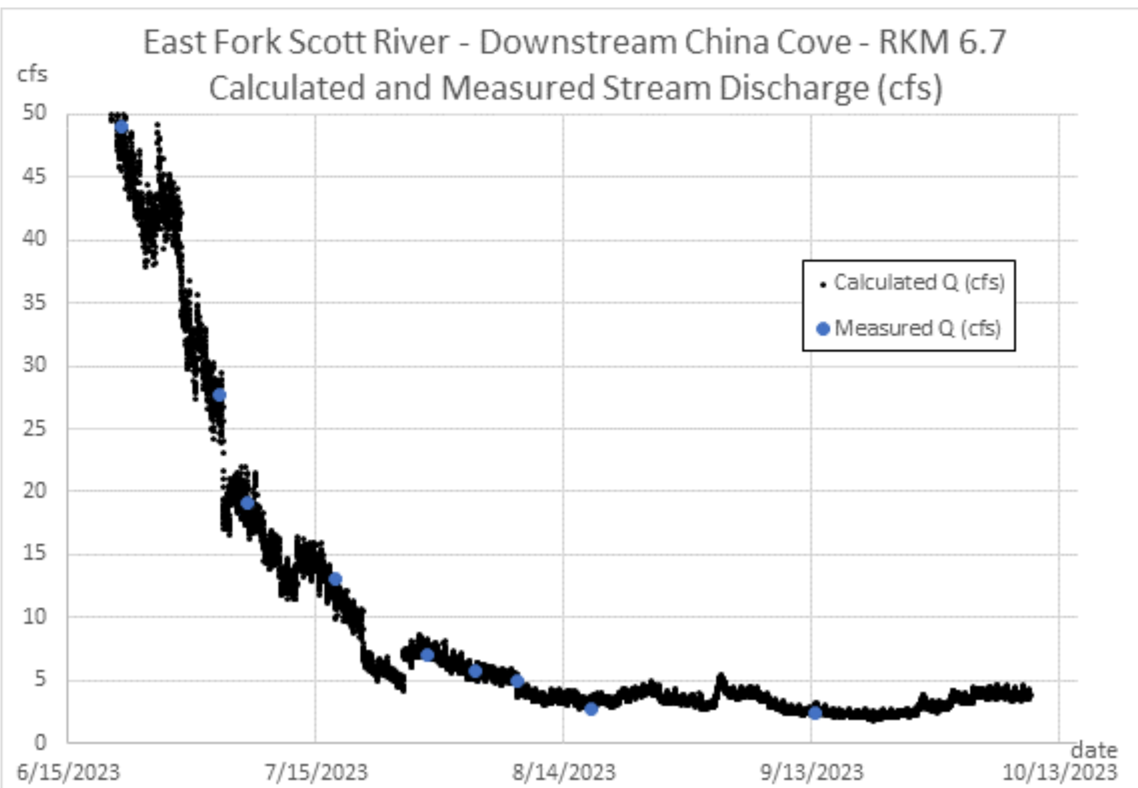


Figure 3.2: Continuous calculated and periodic measured discharge (cfs) – East Fork Scott RKM 6.7.

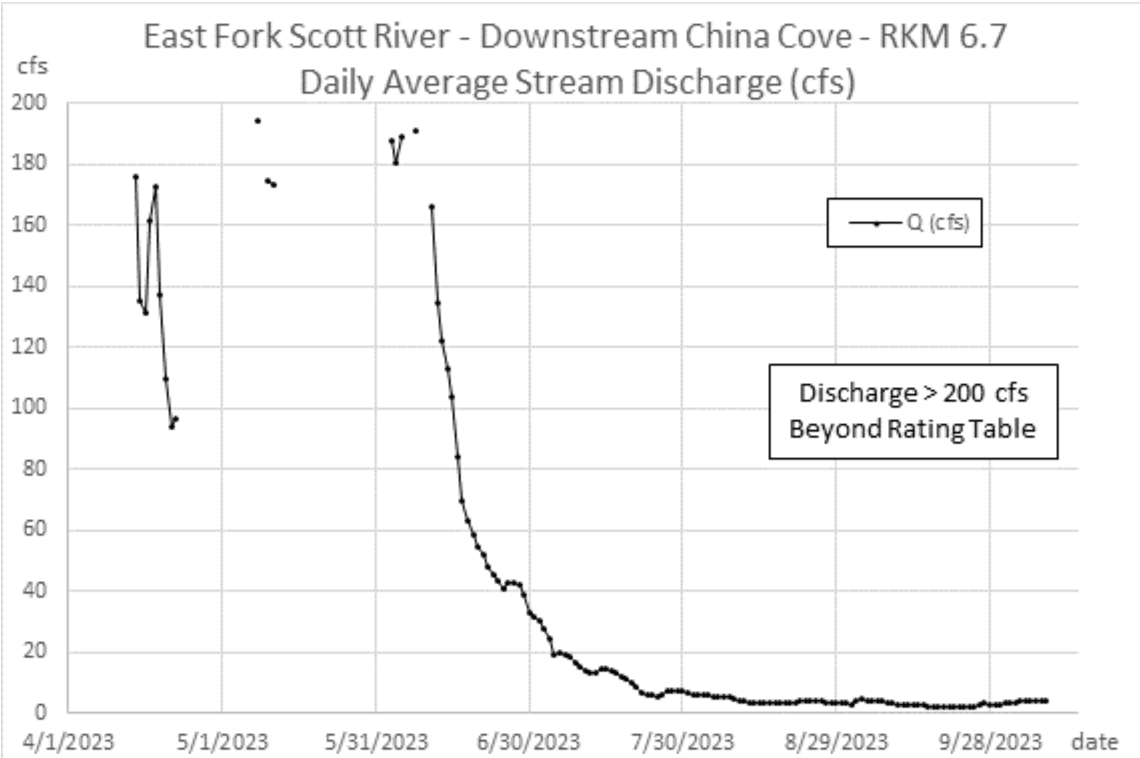


Figure 3.3: Daily average stream discharge (cfs) - East Fork Scott RKM 6.7.

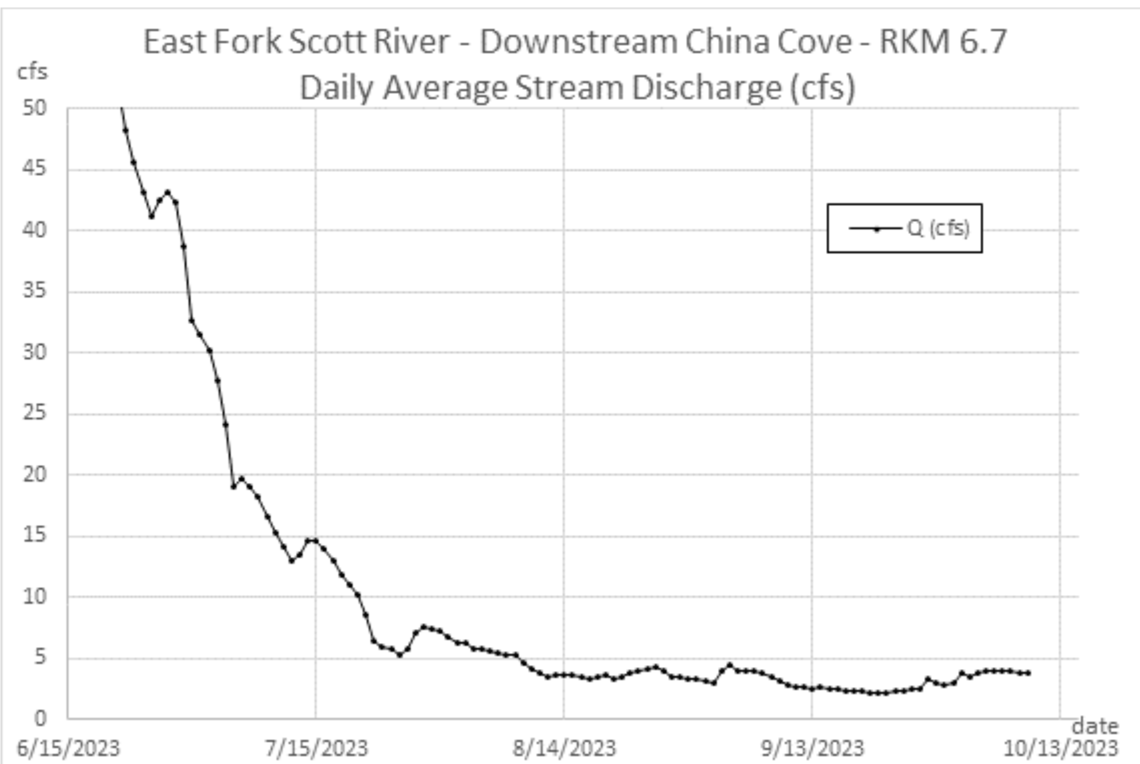


Figure 3.4: Daily average stream discharge (cfs) - East Fork Scott RKM 6.7.

3.4.2 Big Mill Creek – Upstream Highway 3 – RKM 0.4

The Big Mill Creek upstream of Highway 3 stream discharge station was established on July 6, 2023. Six (6) periodic discharge measurements were performed from July 6, 2023 to January 23, 2024, documenting a range of 1.8 to 51.7 cfs (Table 3.3).

Table 3.3: Periodic discharge measurements in cubic feet per second (cfs) - Big Mill Creek - RKM 0.4.

Date	Q (cfs)
7/6/2023	21.3
7/17/2023	11.4
8/3/2023	4.0
8/8/2023	3.7
8/29/2023	1.8
1/23/2024	51.7

The periodic discharge measurements were utilized to develop a rating curve. Continuous (15 minute) discharge (cfs) was calculated with the rating curve - discharge above 50 cfs was determined to be above the rating table (Figures 3.5 and 3.6). Daily average discharge was calculated from the continuous discharge (Figure 3.8).

The Big Mill Creek - RKM 0.4 discharge station was established after the spring recession flow period began in mid-June 2023. The dry-season base flow period began around July 25th, 2023, when discharge first fell below 5 cfs. Daily average discharge fell below 3 cfs on August 14, 2023, with ninety-two (92) of the one hundred ten (110) days between August 14 and December 1, 2023, having daily average discharge less than 3 cfs. A minimum daily average discharge of 1.0 cfs was documented on September 20 - 21, 2023. The fall pulse flow period began in Mid-November 2023, with a runoff event on November 18th – 19th creating daily average discharge greater than 10 cfs.

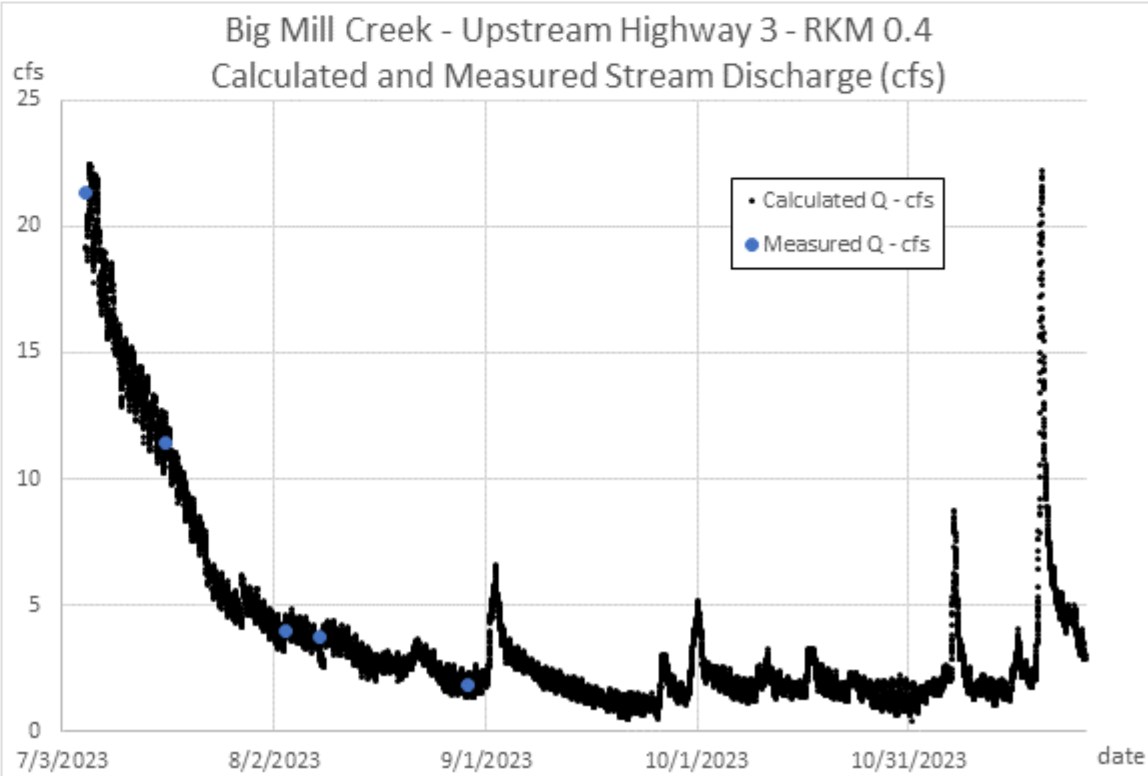


Figure 3.5: Continuous calculated and periodic measured discharge (cfs) - Big Mill Creek - RKM 0.4.

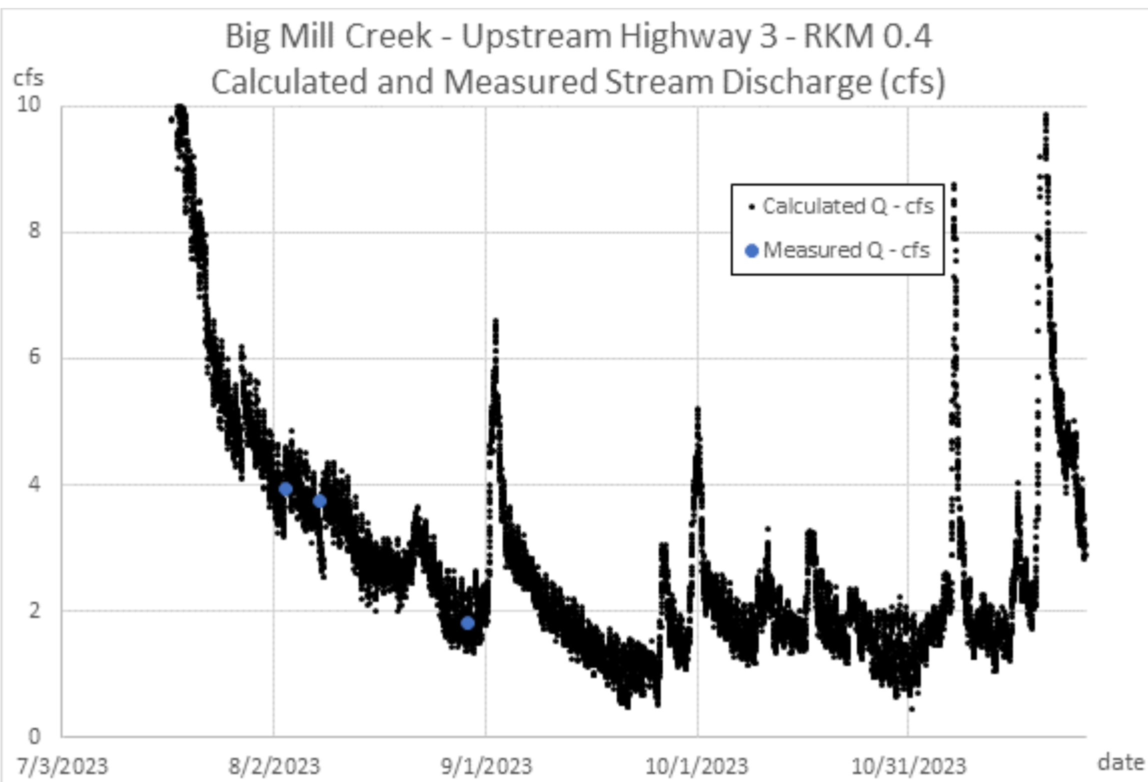


Figure 3.6: Continuous calculated and periodic measured discharge (cfs) - Big Mill Creek - RKM 0.4.

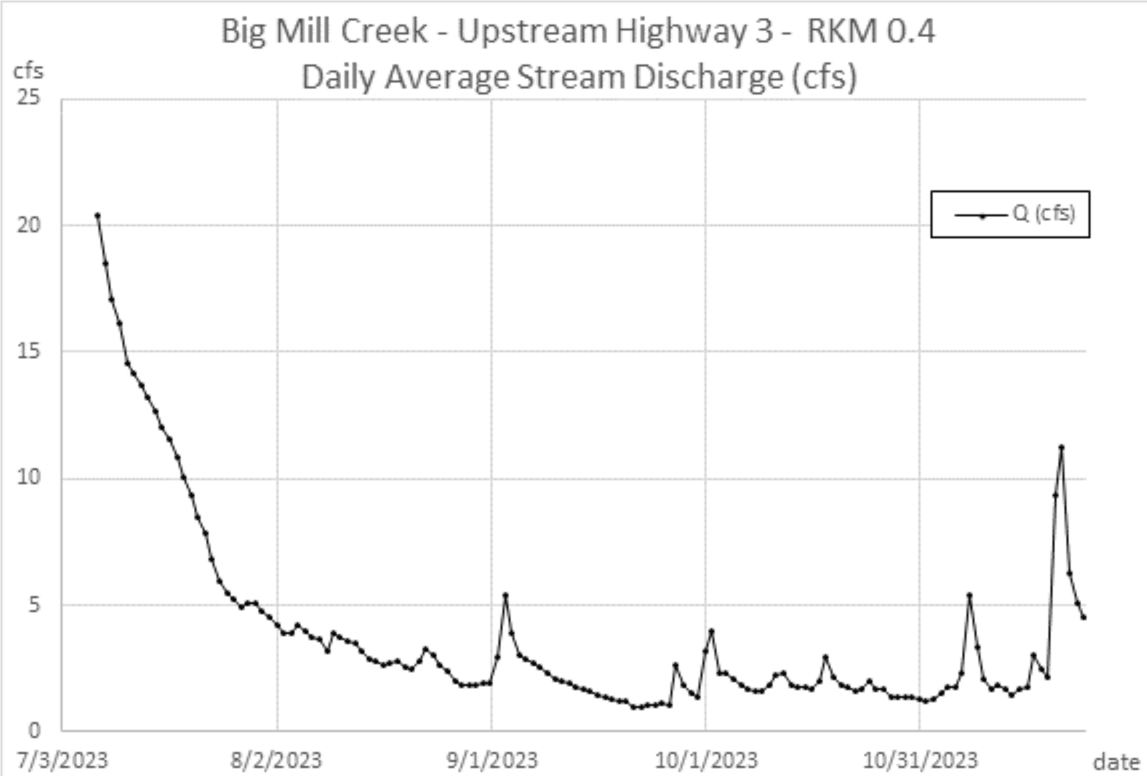


Figure 3.7: Daily average stream discharge (cfs) - Big Mill Creek - RKM 0.4.

3.4.3 Noyes Valley Creek - Upstream East Fork Scott River - RKM 0.1

The Noyes Valley Creek upstream of the confluence with the East Fork Scott River (RKM 0.1) stream discharge station was established on April 11, 2023. Ten (10) periodic discharge measurements were performed from April 12, 2023 to March 15, 2024, documenting a range of 0.4 to 16.5 cfs (Table 3.4).

Table 3.4: Periodic discharge measurements - Noyes Valley Creek - RKM 0.1.

Date	Q (cfs)
4/12/2023	5.3
4/19/2023	4.3
4/25/2023	3.6
6/21/2023	0.9
7/17/2023	0.7
8/3/2023	0.4
1/23/2024	9.3
3/6/2024	16.5
3/15/2024	9.8

The periodic discharge measurements were utilized to develop a rating curve. Continuous (15 minute) discharge (cfs) was calculated with the rating curve - discharge above 15 cfs was determined to be above the rating table (Figures 3.8 and 3.9). Daily average discharge was calculated from the continuous discharge (Figure 3.10).

The hydrology of Noyes Valley Creek has a different pattern than the hydrology observed in the East Fork Scott River and Big Mill Creek with the spring recession flow period starting before the establishment of the discharge station in April, several months before the spring recession flow period in the other monitored locations. The discharge at the Noyes Valley Creek discharge station first fell below 1.5 cfs on April 26, 2023, and below 1.0 cfs on May 22, 2023. The daily average discharge was equal to or less than 1.0 cfs for one hundred twelve (112) days from June 2, 2023 through September 23, 2023, with minimum calculated daily average discharge of 0.4 cfs.

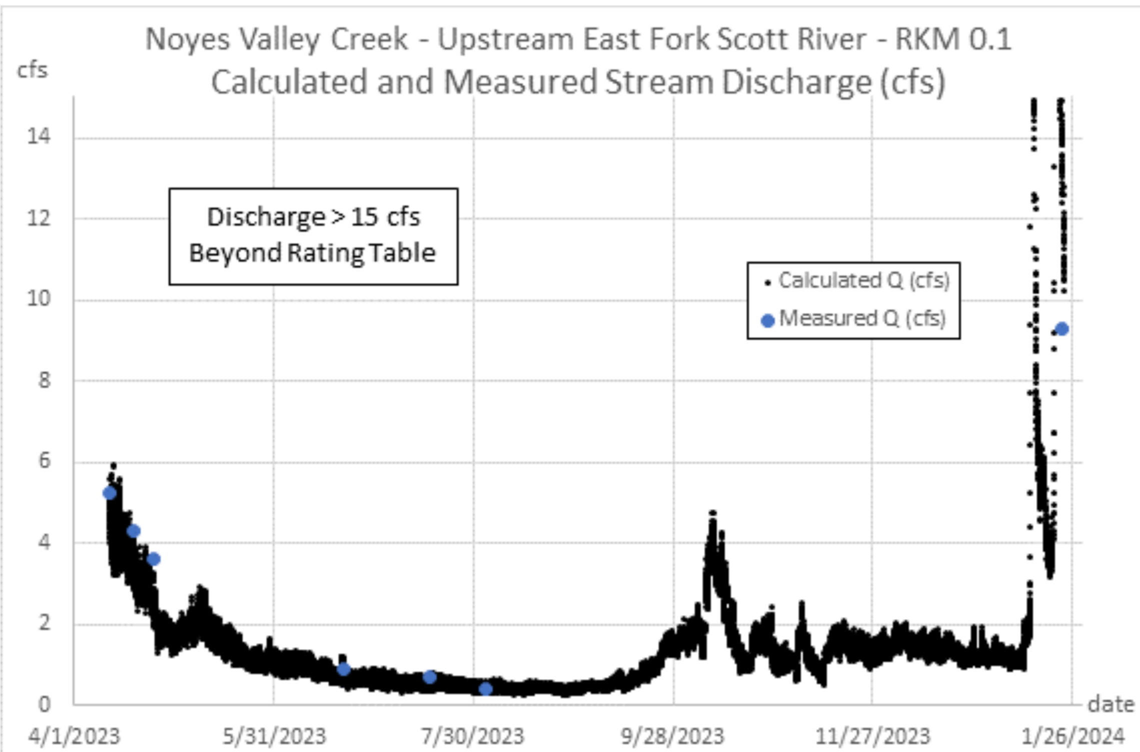


Figure 3.8: Continuous calculated & periodic measured discharge (cfs) - Noyes Valley Cr - RKM 0.1.

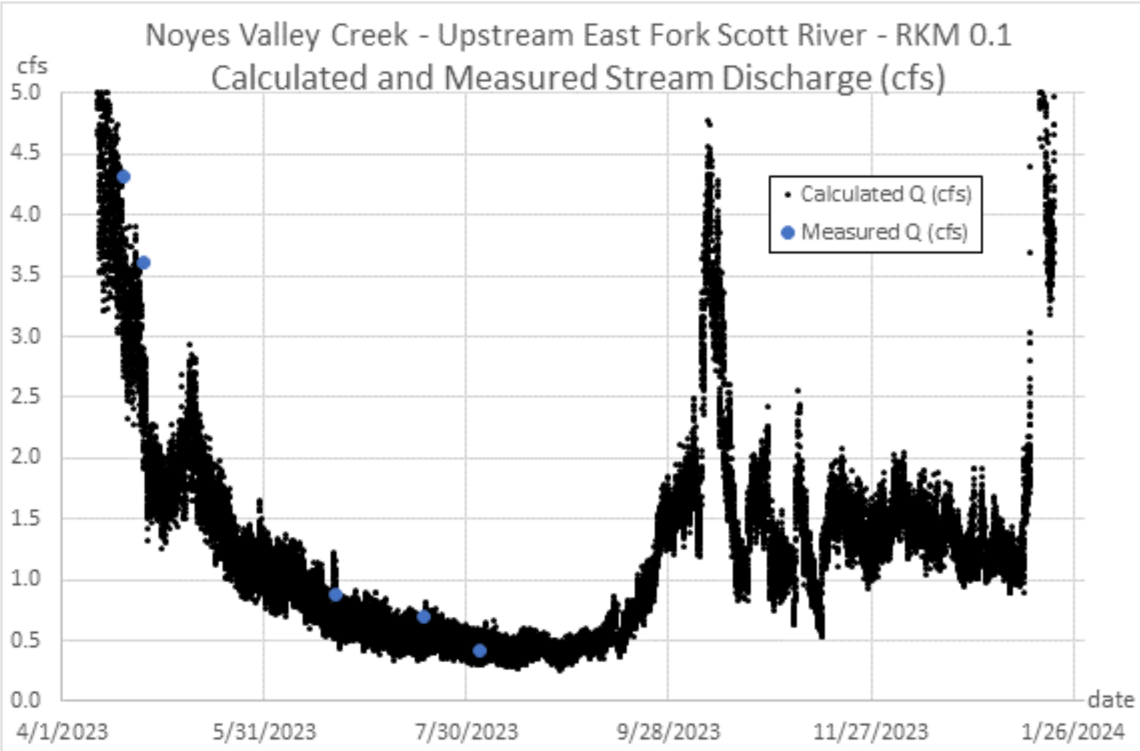


Figure 3.9: Continuous calculated & periodic measured discharge (cfs) - Noyes Valley Cr - RKM 0.1.

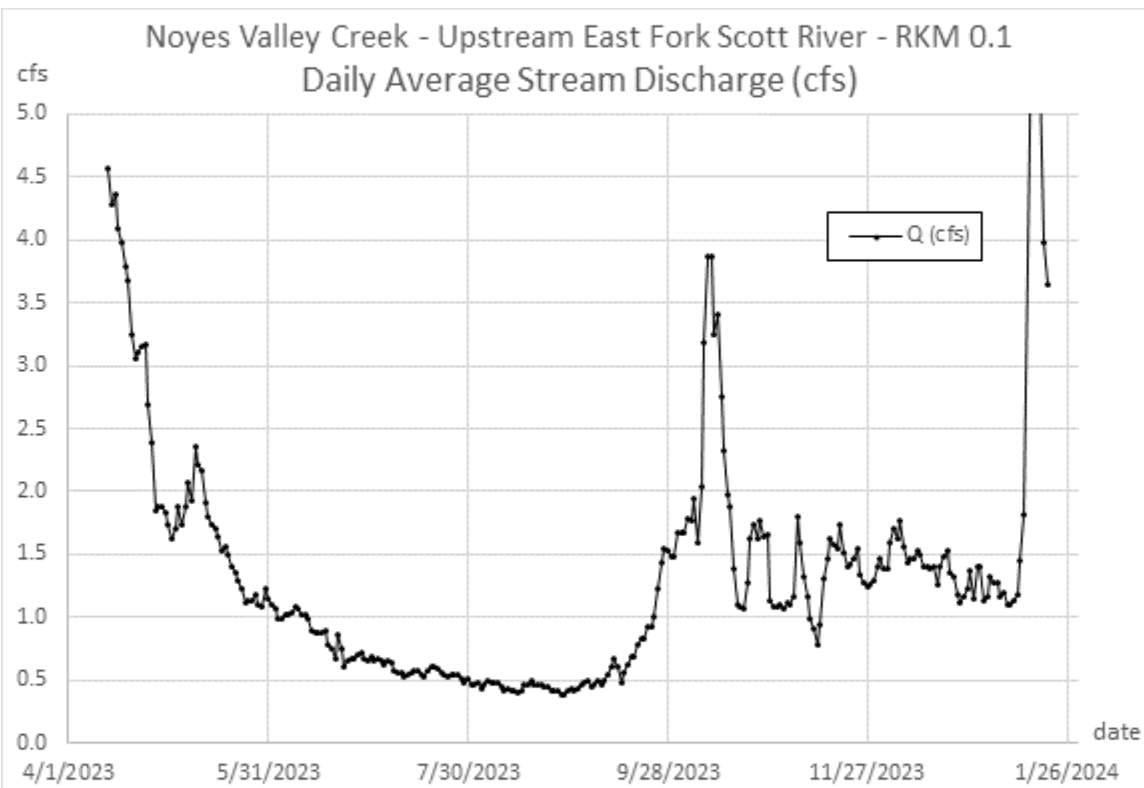


Figure 3.10: Daily average stream discharge (cfs) - Noyes Valley Creek - RKM 0.1.

3.4.4 East Fork Scott River - Downstream Big Mill Creek - RKM 4.2

The East Fork Scott River downstream of Big Mill Creek (RKM 4.2) stream discharge station was established on July 3, 2023. Seven (7) periodic discharge measurements were performed from July 3, 2023 to October 16, 2024, documenting a range of 6.5 to 63 cfs (Table 3.5).

Table 3.5: Periodic discharge measurements in cubic feet per second (cfs) - East Fork Scott River - RKM 4.2.

Date	Q (cfs)
7/3/2023	63.0
7/17/2023	25.8
7/18/2023	20.5
8/1/2023	11.7
8/8/2023	8.5
8/17/2023	6.5
10/16/2023	6.9

The periodic discharge measurements were utilized to develop a rating curve. Continuous (15 minute) discharge (cfs) was calculated with the rating curve - discharge above 63 cfs was determined to be above the rating table (Figures 3.11 and 3.12). Daily average discharge was calculated from the continuous discharge (Figures 3.13 and 3.14).

The East Fork Scott River downstream of Big Mill Creek discharge station was established after the spring recession flow period began in mid-June 2023. The dry-season base flow period began around July 30, 2023, when discharge first fell below 10 cfs. Daily average discharge fell below 5 cfs on September 10, 2023, with sixteen (16) days of daily average discharge less than 5 cfs from September 10, 2023, and September 25, 2023. A minimum daily average discharge of 4.2 cfs was documented on September 20 - 21, 2023. The fall pulse flow period began in Mid-November 2023 with runoff events on November 6, 2023, on November 18 – 19, 2023, creating daily average discharge greater than 10 cfs.

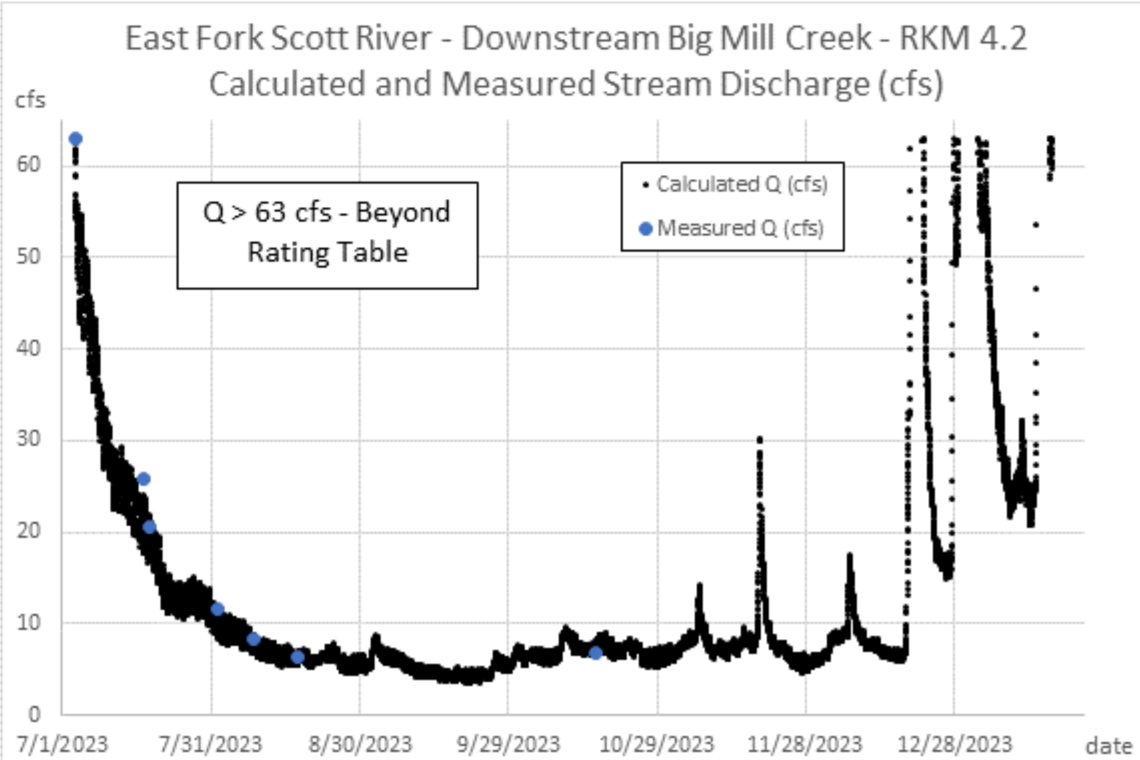


Figure 3.11: Continuous calculated and periodic measured discharge in cubic feet per second (cfs) - East Fork Scott RKM 4.2.

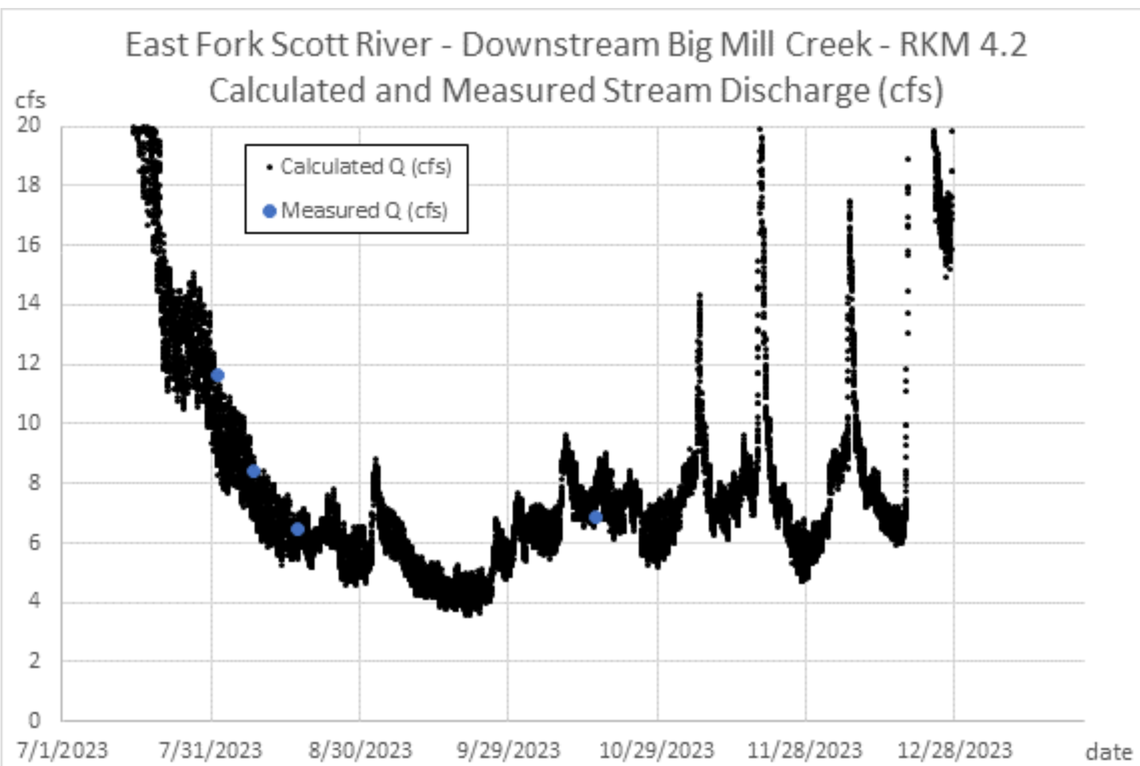


Figure 3.12: Continuous calculated and periodic measured discharge in cubic feet per second (cfs) - East Fork Scott RKM 4.2.

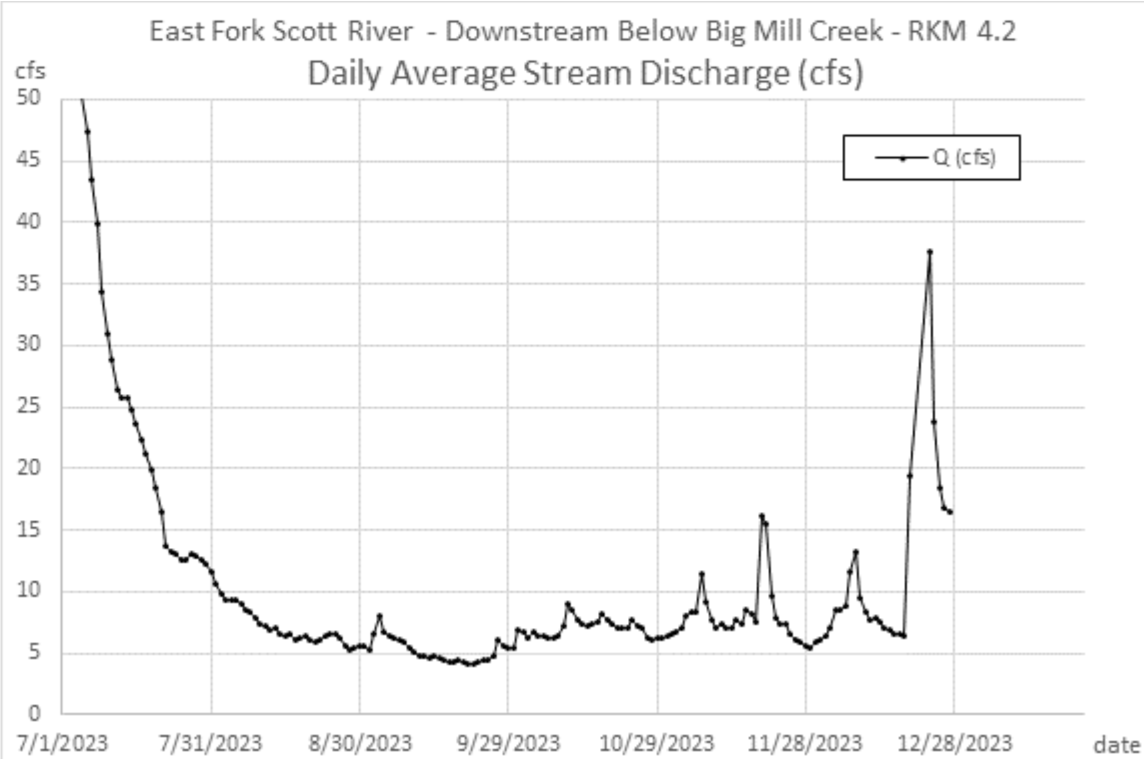


Figure 3.13: Daily average stream discharge in cubic feet per second (cfs) - East Fork Scott River RKM 4.2.

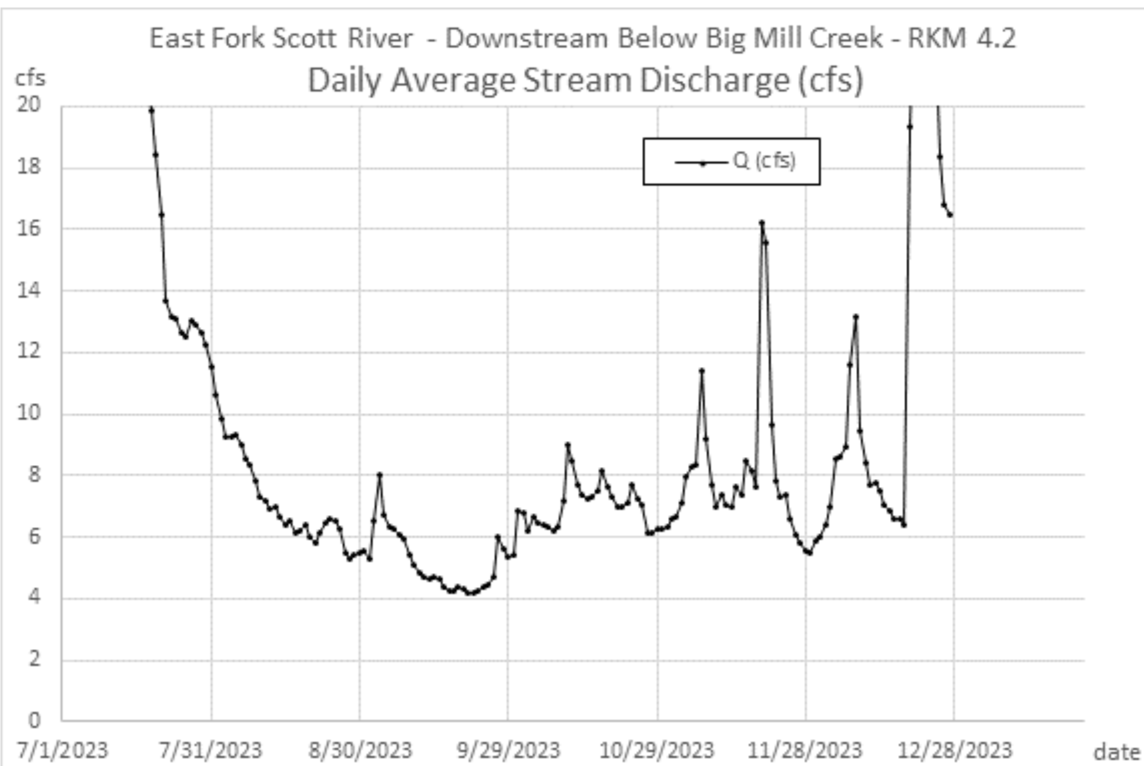


Figure 3.14: Daily average stream discharge in cubic feet per second(cfs) - East Fork Scott River RKM 4.2.

3.4.5 Wetted Perimeter Analysis - East Fork Scott River downstream China Cove

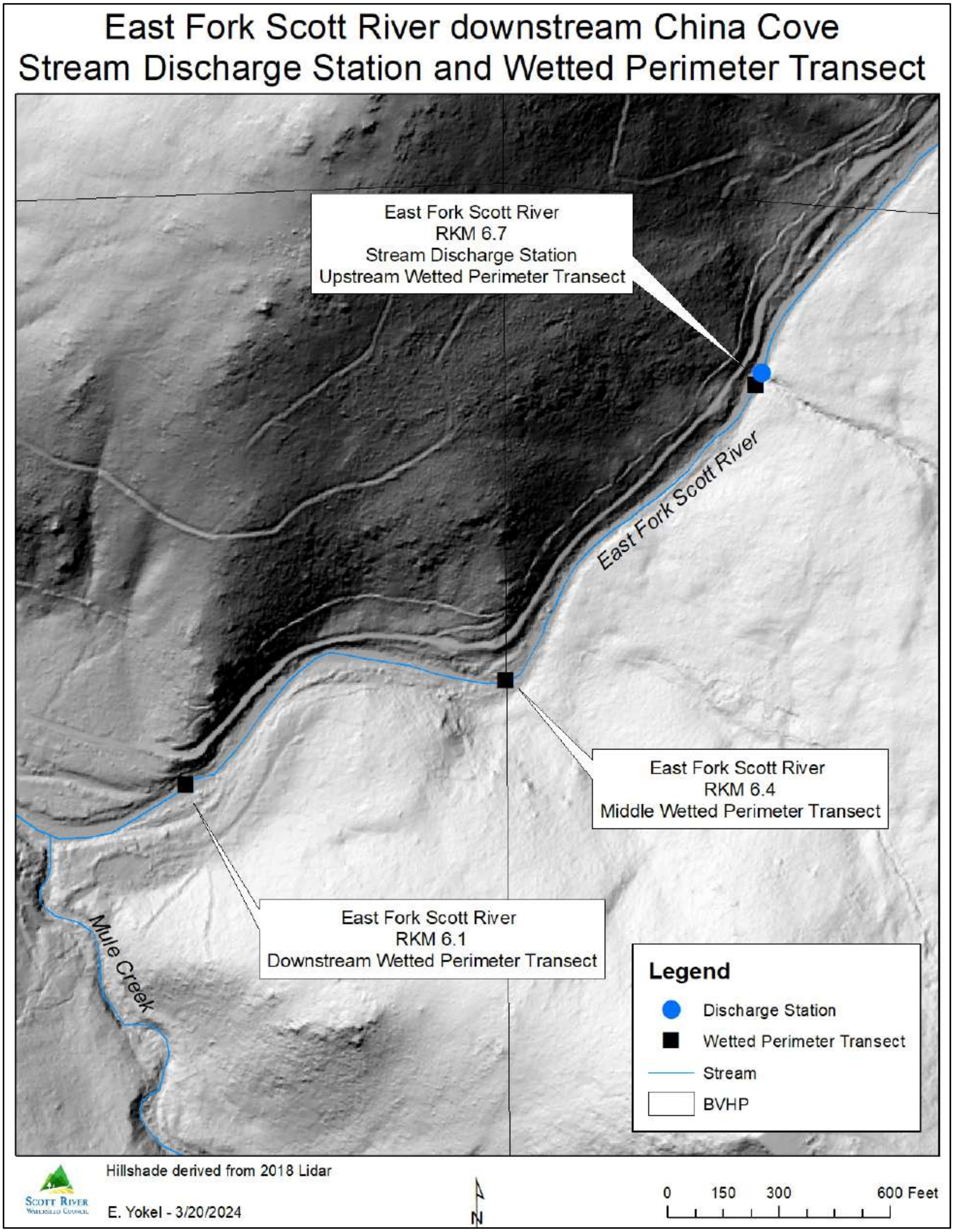
Wetted perimeter analysis was performed over a range of flow regimes at three transects downstream of the East Fork RKM 6.7 discharge station and upstream of Mule Creek in the canyon reach of the East Fork Scott River downstream of China Cove (Map 3.2). California Department of Fish and Wildlife protocol for the wetted perimeter method was followed in the performance of the wetted perimeter measurements and analysis of the relationship between the stream discharge and wetted perimeter “to identify dry-season low flows that protect productive riffle habitats … to maintain fish populations during the dry season” (California Department Fish Wildlife, 2013).

The upstream transect (East Fork Scott River RKM 6.7) was established at the hydraulic control at the upstream end of the riffle downstream of the gaged pool for the discharge station. At the upstream transect, eight wetted perimeter measurements were performed from July 3, 2023 to September 6, 2023, over a stream discharge range of 2.8 - 27.7 cfs (Table 3.6).

The middle transect (East Fork Scott River RKM 6.4) was established at the hydraulic control at the upstream end of a riffle on July 26, 2023. At the middle transect, six wetted perimeter measurements were performed from July 26, 2023 to September 6, 2023 over a stream discharge range of 2.8 - 7.6 cfs (Table 3.7).

The downstream transect (East Fork Scott River RKM 6.1) was established at the hydraulic control at the upstream end of a riffle on August 3, 2023. At the middle transect, five wetted perimeter measurements were performed from August 3, 2023 to September 6, 2023, over a stream discharge range of 2.8 - 5.7 cfs (Table 3.8).

For each transect, the wetted perimeter values for each survey effort were calculated and graphs were created to illustrate the relationship between the wetted perimeter (ft) and discharge (cfs) (Figures 3.15 - 3.17). Analysis of the relationship between wetted perimeter and discharge and identification of breakpoints allows for identification of discharge thresholds that indicate inflection points at which significant decreases in aquatic habitat production result from decreasing stream flows.



Map 3.2: Location of wetted perimeter transects.

Wetted perimeter measurements were performed at the upstream transect over the largest discharge range (2.8 - 27.7 cfs) of the WY2023 study. Analysis of the relationship between discharge and wetted perimeter illustrates a breakpoint at a discharge of 7 cfs with the slope increasing significantly as the discharge declines below 7 cfs (Figure 3.16). The steep decline of wetted perimeter during discharge regimes below 7 cfs indicates that aquatic productivity and fish condition likely decreases significantly in the period when flows decrease below 7 cfs.

Table 3.7: Wetted perimeter measurements at upstream transect.

Date	7/3/2023	7/17/2023	7/28/2023	8/3/2023	8/8/2023	8/17/2023	8/29/2023	9/6/2023
Discharge (cfs)	27.7	13.1	7.0	5.7	4.9	2.8	3.5	3.8
Average depth (ft)	0.80	0.55	0.58	0.39	0.37	0.33	0.32	0.37
Wetted width (ft)	36.8	33.0	33.4	31.2	31.5	29.8	28.8	28.1
Wetted Perimeter (ft)	38.40	34.11	34.56	31.92	32.24	30.42	29.44	28.83

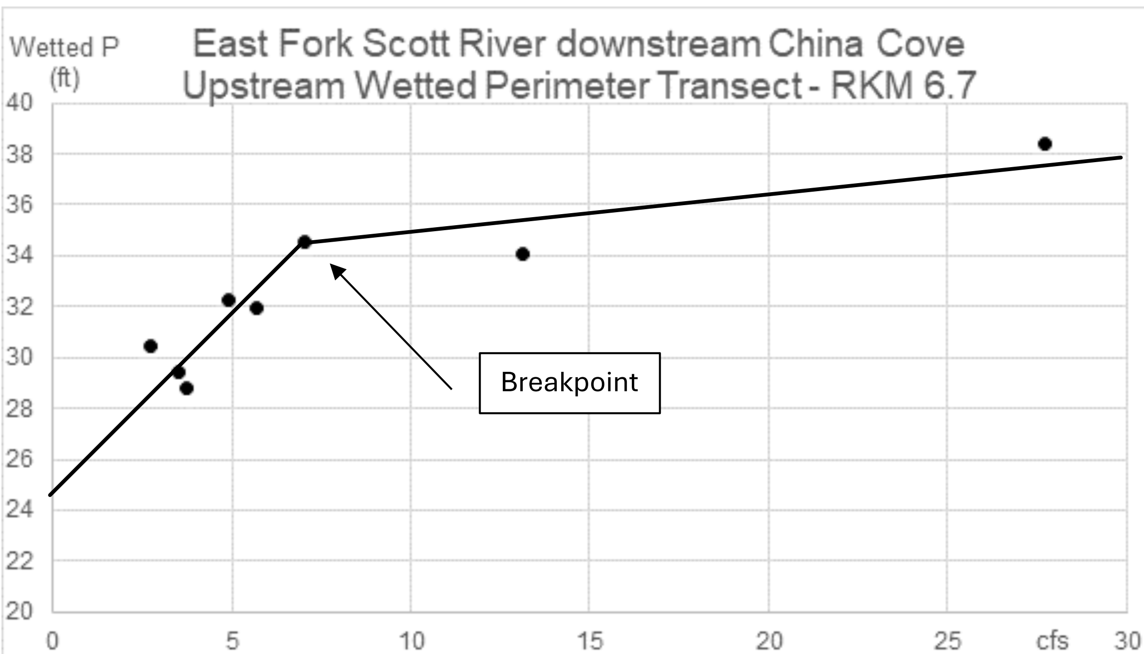


Figure 3.15: Wetted perimeter vs stream discharge - Upstream Transect.

At the middle-wetted perimeter transect the highest discharge measurement at which a survey was performed was 7.6 cfs. Analysis of relationship between the wetted perimeter and the discharge at the middle transect illustrates a significant decrease in wetted perimeter between 7.6 cfs and 5.7 cfs with the slope of the decrease decreasing between 5.7 and 2.8 cfs (Figure 3.17).

Table 3.8: Wetted perimeter measurements at middle transect.

Date	7/26/2023	8/3/2023	8/8/2023	8/17/2023	8/29/2023	9/6/2023
Discharge (cfs)	7.6	5.7	4.9	2.8	3.5	3.8
Average depth (ft)	0.79	0.52	0.50	0.54	0.48	0.57
Wetted width (ft)	21.9	21.0	21.1	21.0	20.6	21.0
Wetted Perimeter (ft)	23.48	22.04	22.09	22.07	21.56	22.14

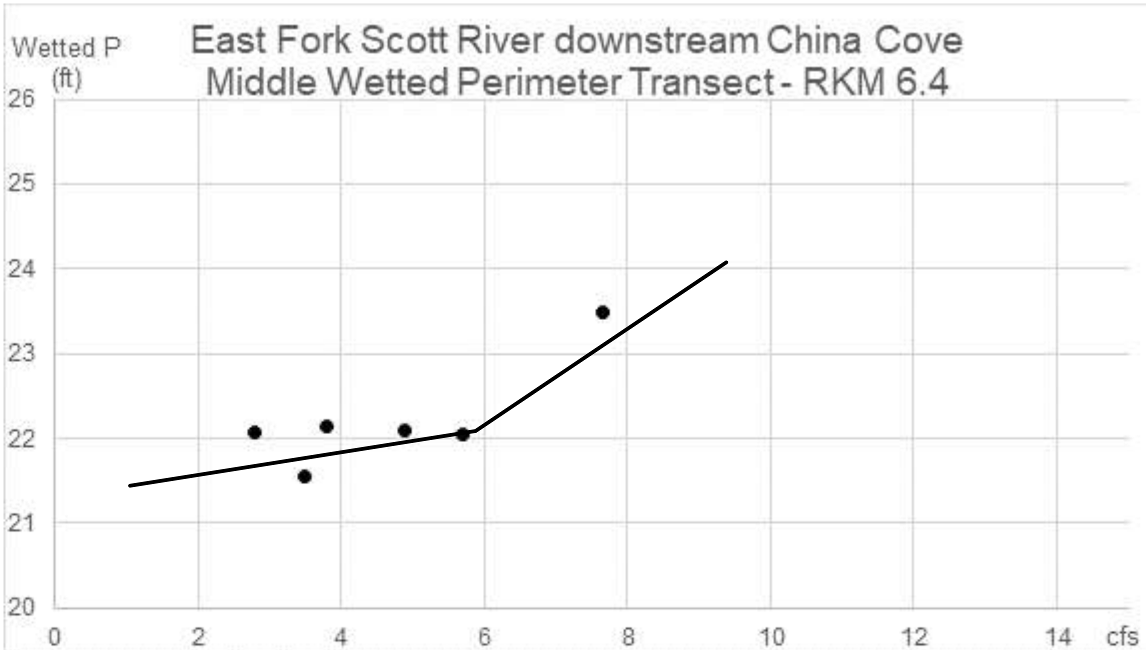


Figure 3.16: Wetted perimeter vs stream discharge - Middle Transect.

At the downstream wetted perimeter transect the highest discharge measurement at which a survey was performed was 5.7 cfs. Analysis of relationship between the wetted perimeter and the discharge at the upstream transect illustrates a significant decrease in wetted perimeter as the discharge decreases from 5.7 cfs to 2.8 cfs.

Table 3.9: Wetted perimeter measurements at downstream transect.

Date	8/3/2023	8/8/2023	8/17/2023	8/29/2023	9/6/2024
Discharge (cfs)	5.7	4.9	2.8	3.5	3.8
Average depth (ft)	0.50	0.51	0.44	0.50	0.56
Wetted width (ft)	32.9	31.2	27.1	26.9	26.1
Wetted Perimeter (ft)	33.89	32.22	27.97	27.84	27.21

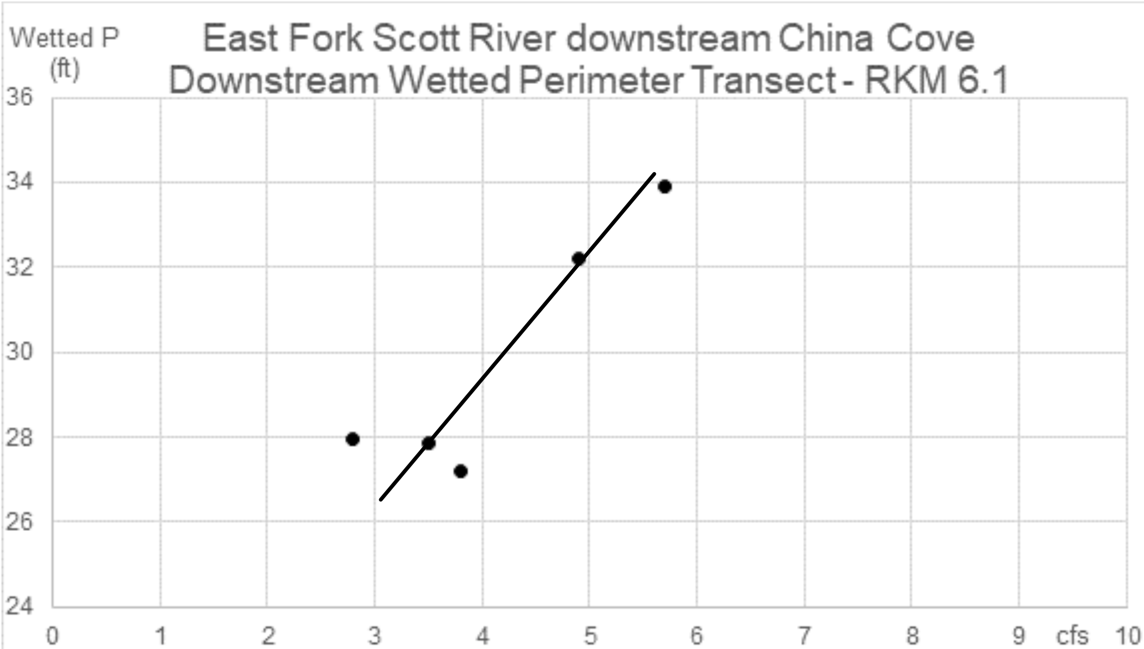


Figure 3.17: Wetted perimeter vs stream discharge - Downstream Transect>

3.5 Conclusion

Analysis of the flow regime at the four stream discharge stations in the East Fork Scott River and tributaries illustrates that the hydrology of the East Fork Scott River and Big Mill Creek have similar trends, while the hydrology of Noyes Valley Creek is significantly different (Figure 3.18). The spring recession period occurred significantly earlier in Noyes Valley Creek and many of the increases in discharge from precipitation driven runoff events observed in the East Fork and Big Mill Creek are not observed at Noyes Valley Creek. The discharge observed at the East Fork Scott River downstream of Big Mill Creek is approximately equal to the accumulated discharge at the three upstream stations indicating that there is not a significant gain or loss in surface water flows between the monitoring stations.

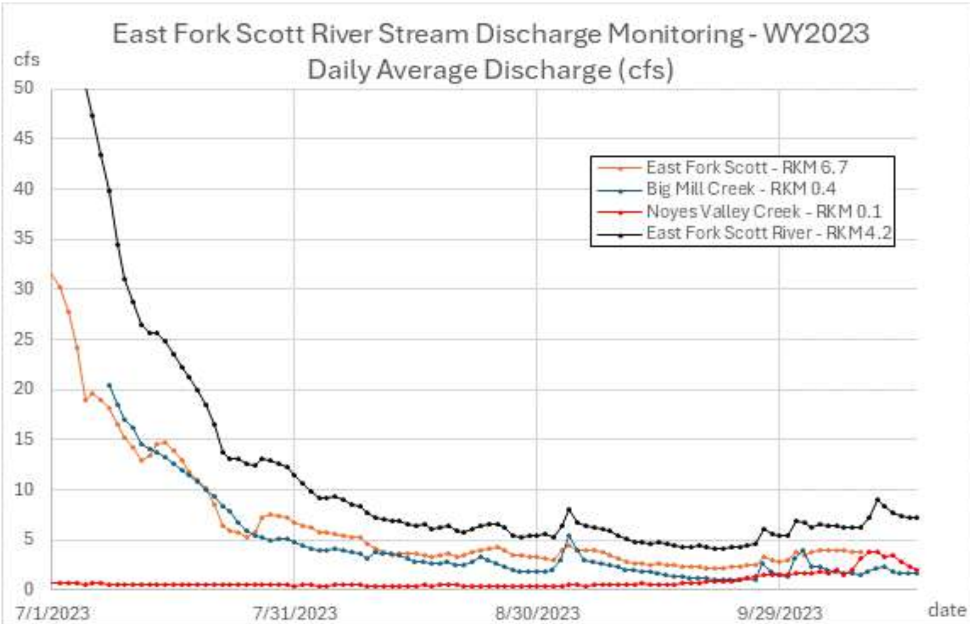


Figure 3.18: Daily average discharge in cubic feet per second (cfs) at discharge stations.

Analysis of wetted perimeter was conducted across various flow conditions at three transects, revealing notable decreases in wetted perimeter at all locations when stream discharge fell below a threshold of about 7 cfs.

3.6 Bibliography

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Chapter 4. East Fork Scott River and Tributary Water Temperature - WY2023

4.1 Introduction

Due to elevated sediment levels and elevated water temperature, the Scott River water quality is listed as “impaired” under Section 303(d) of the Clean Water Act from the U.S. Environmental Protection Agency (National Marine Fisheries Service, 2014). In response, the North Coast Regional Water Quality Control Board (NCRWQCB) implemented the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads (TMDL). The plan seeks to achieve the TMDLs, thereby improving water quality for the migration, spawning, and reproduction of salmonids (NCRWQCB, 2005). As such, the East Fork of the Scott River has commonly been known to have higher temperatures during some periods of time of the year, mainly late summer to early fall. Coho Salmon are particularly sensitive to high temperatures, having been shown to not persist in areas where the maximum weekly average temperature (MWAT) exceeds 16.7 °C (Welsh et al., 2001).

4.2 Purpose

- Document the temperature regime within the East Fork Scott River with an emphasis on understanding the impacts of the smaller tributaries: Mule, Big Mill and Noyes Valley Creeks. This information can be used to inform future restoration actions aimed to improve conditions for aquatic species such as coho salmon.

4.3 Methods

Sixteen (16) water temperature stations were operated in the East Fork Scott River and tributaries during the base flow period of WY2023 to document the thermal regime throughout the TWC Beaver Valley Headwaters Preserve holdings (Map 4.1). Three tributaries to the East Fork Scott River (Mule Creek, Big Mill Creek and Noyes Valley Creek) were bracketed with temperature stations (stations in the East Fork Scott River upstream and downstream of the tributary and a station in the tributary upstream of the confluence with the East Fork) to document the effects of the tributary on the thermal regime of the East Fork Scott River. The China Cove surface water diversion (Scott River Decree Diversion 66 (Schedule E)) was bracketed with temperature stations to document the effect of the extraction of water on the thermal regime. Eleven (11) temperature stations were established in the East Fork Scott River from RKM 7.5 to RKM 2.5.

Daily average water temperatures (°C) were calculated from the continuous (15 minute) water temperature for each station. Moving weekly average temperature (MWAT) was calculated for each station. The maximum MWAT and date of occurrence for each station was calculated (Table 4.1).

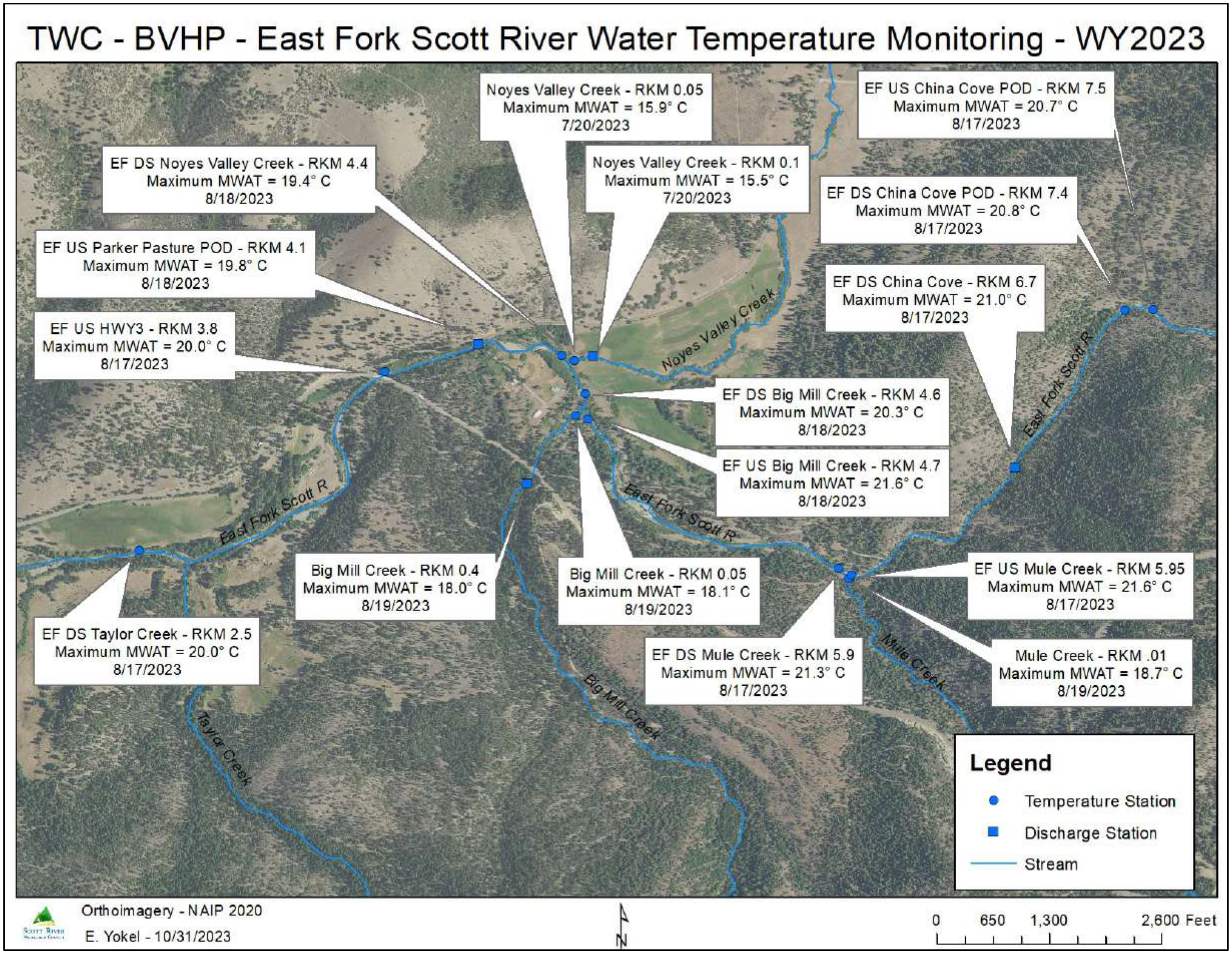
4.4 Results

The maximum MWAT occurred during the period of August 17 to August 19, 2023, at all stations, except for the Noyes Valley Creek station, at which it occurred on July 20, 2023. Noyes Valley

Creek became disconnected upstream of the temperature stations in late July - early August resulting in the surface water at the temperature stations having a temperature signal characteristic of significant groundwater inputs.

Analysis of the maximum MWAT in the East Fork Scott River illustrates a warming trend from RKM 7.5 (Upstream China Cove POD) to RKM 5.95 (Upstream Mule Creek) with cooling due to the input of cold water at Mule Creek (RKM 5.9) followed by warming from RKM 5.9 to RKM 4.7 (Upstream Big Mill Creek) (Figure 4.1). A significant cooling effect (1.3°C) is observed in the East Fork Scott River between the Upstream Big Mill Creek (RKM 4.7) and Downstream Big Mill Creek (RKM 4.6) stations. Further cooling in the East Fork is observed at the input of Noyes Valley Creek (RKM 4.4) followed by warming from the RKM 4.4 station to the RKM 3.8 (East Fork upstream Highway 3 Bridge) station. Water temperatures in the East Fork Scott River are stable from the RKM 3.8 station to the downstream RKM 2.5 stations.

Analysis of the average daily water temperatures (°C) in the East Fork Scott River illustrates the differences between the temperature regimes during the period of record - Figures 2 and 3. The temperature regimes at the confluence of Mule Creek, Big Mill Creek and Noyes Valley Creek are illustrated in Figures 4, 5 and 6, respectively.



Map 4.1: Location of water temperature stations with maximum MWAT and date of occurrence.

Table 4.1: Maximum MWAT and date of occurrence of water temperature stations in the East Fork Scott River and tributaries.

Location	Stream	RKM	Maximum MWAT °C	Date
East Fork Upstream China Cove POD	East Fork Scott River	7.5	20.7	8/17/2023
East Fork Downstream China Cove POD	East Fork Scott River	7.4	20.8	8/17/2023
East Fork Downstream China Cove - Discharge Station	East Fork Scott River	6.7	21.0	8/17/2023
East Fork Upstream Mule Creek	East Fork Scott River	5.95	21.6	8/17/2023
Mule Creek - Upstream East Fork Scott River	Mule Creek	0.01	18.7	8/19/2023
East Fork Downstream Mule Creek	East Fork Scott River	5.9	21.3	8/17/2023
East Fork Upstream Big Mill Creek	East Fork Scott River	4.7	21.6	8/18/2023
Big Mill Creek - Discharge Station	Big Mill Creek	0.4	18.0	8/19/2023
Big Mill Creek - Upstream East Fork Scott River	Big Mill Creek	0.05	18.1	8/19/2023
East Fork Downstream Big Mill Creek	East Fork Scott River	4.6	20.3	8/18/2023
Noyes Valley Creek - Discharge Station	Noyes Valley Creek	0.1	15.5	7/20/2023
Noyes Valley Creek - Upstream East Fork Scott River	Noyes Valley Creek	0.05	15.9	7/20/2023
East Fork Downstream Noyes Valley Creek	East Fork Scott River	4.4	19.4	8/18/2023
East Fork Upstream Parker Pasture POD - Discharge Station	East Fork Scott River	4.1	19.8	8/18/2023
East Fork Upstream Highway 3	East Fork Scott River	3.8	20.0	8/17/2023
East Fork Downstream Taylor Creek - Parker Pasture	East Fork Scott River	2.5	20.0	8/17/2023

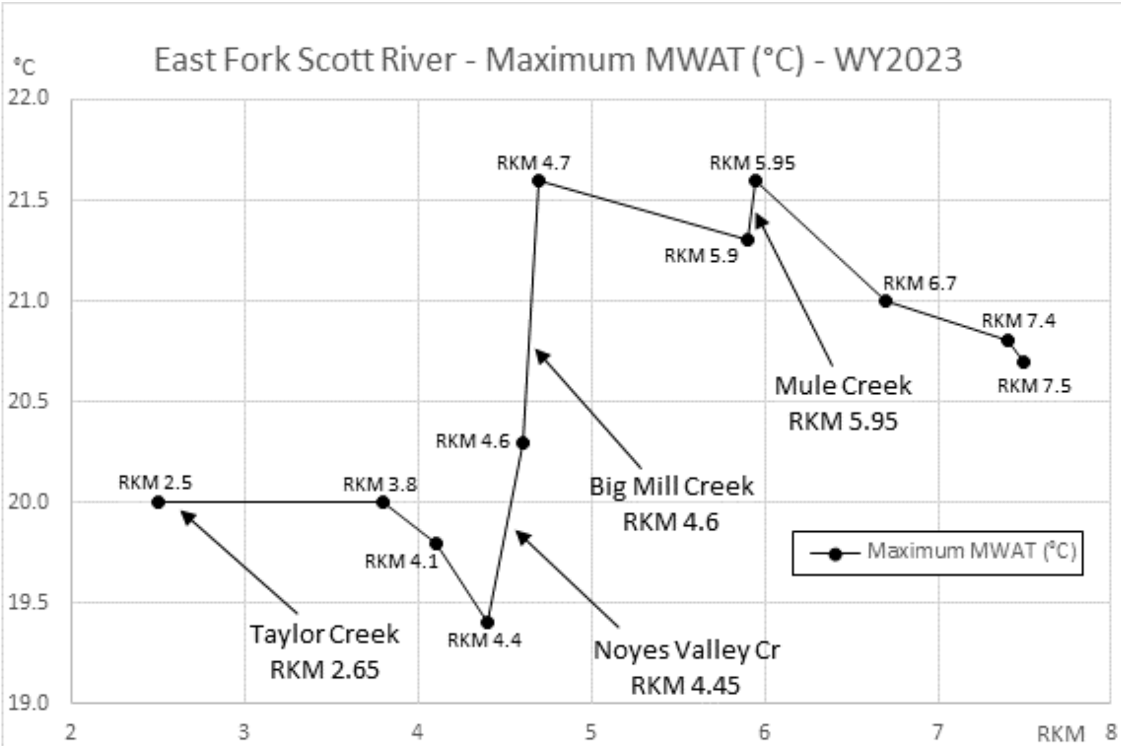


Figure 4.1: Maximum MWAT (°C) in the East Fork Scott River by RKM.

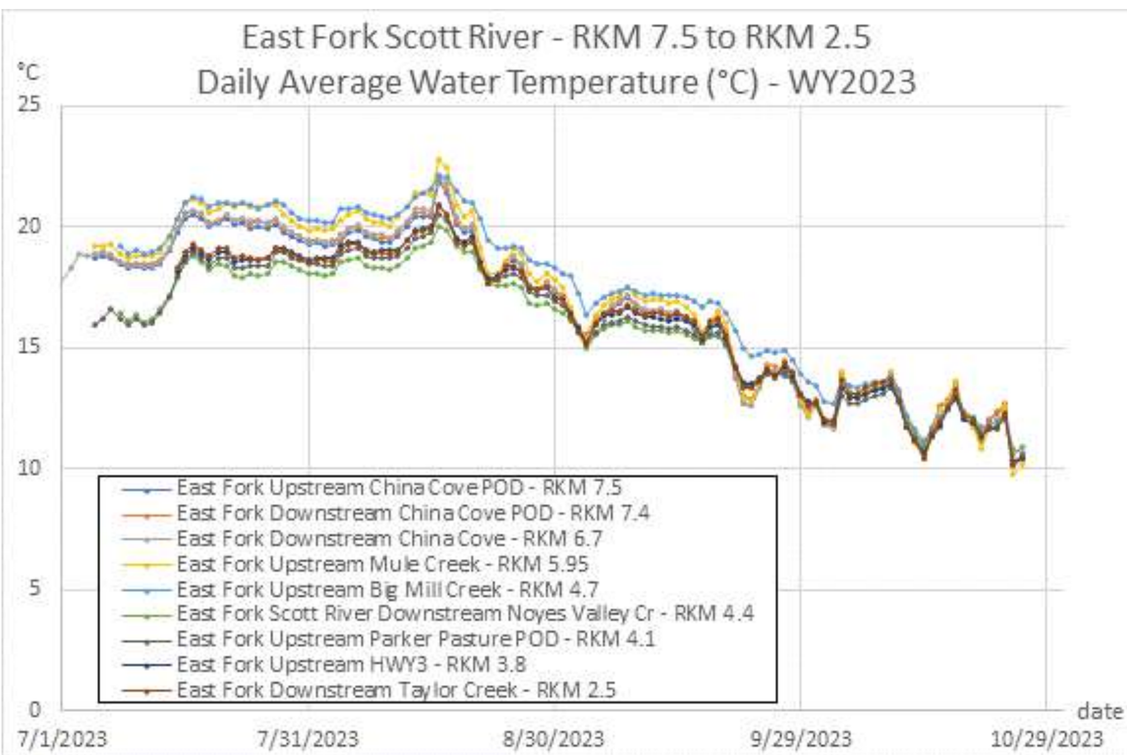


Figure 4.2: Daily average water temperature (°C) at all stations in the East Fork Scott River.

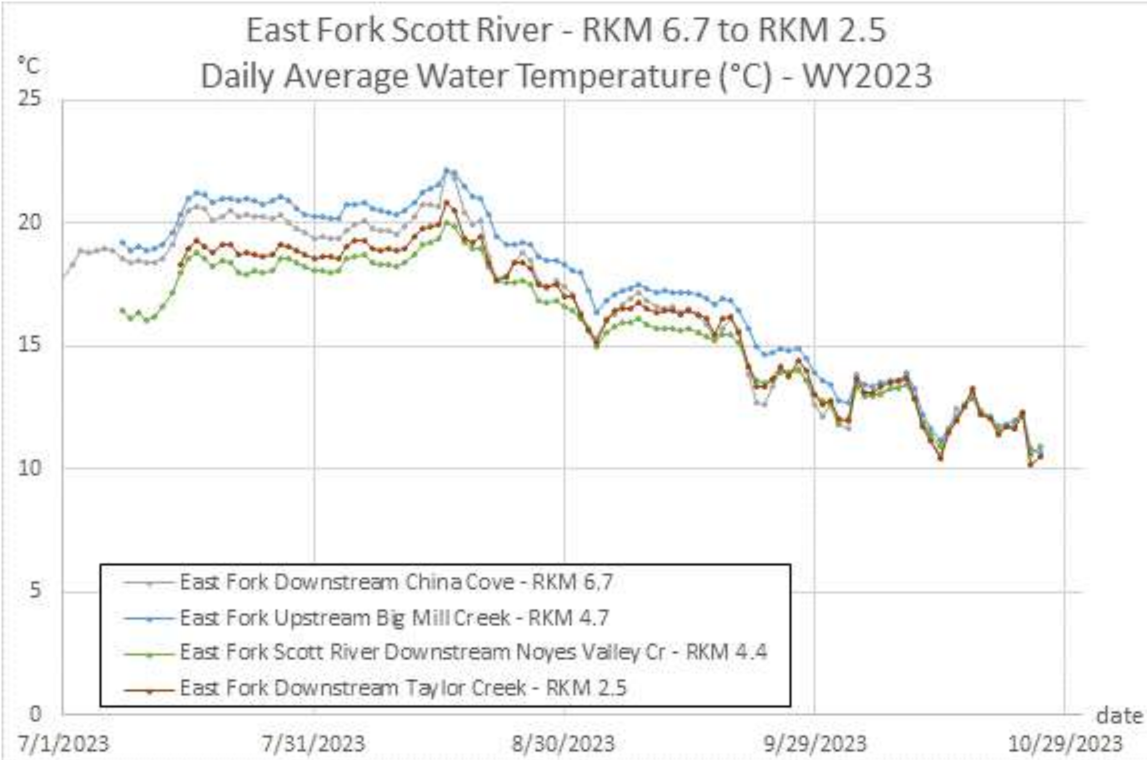


Figure 4.3: Daily average water temperature (°C) - East Fork Scott River RKM 6.7, RKM 4.7, RKM 4.4 and RKM 2.5.

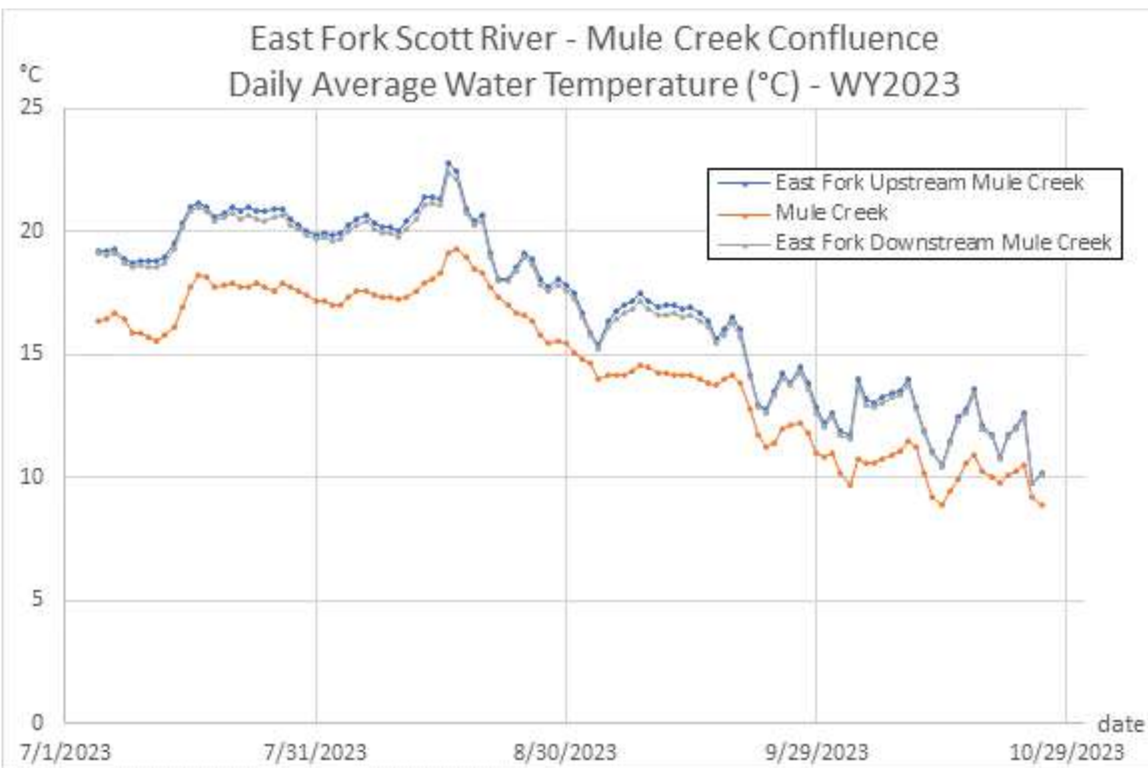


Figure 4.4: Daily average water temperature (°C) - East Fork Scott River and Mule Creek at Confluence.

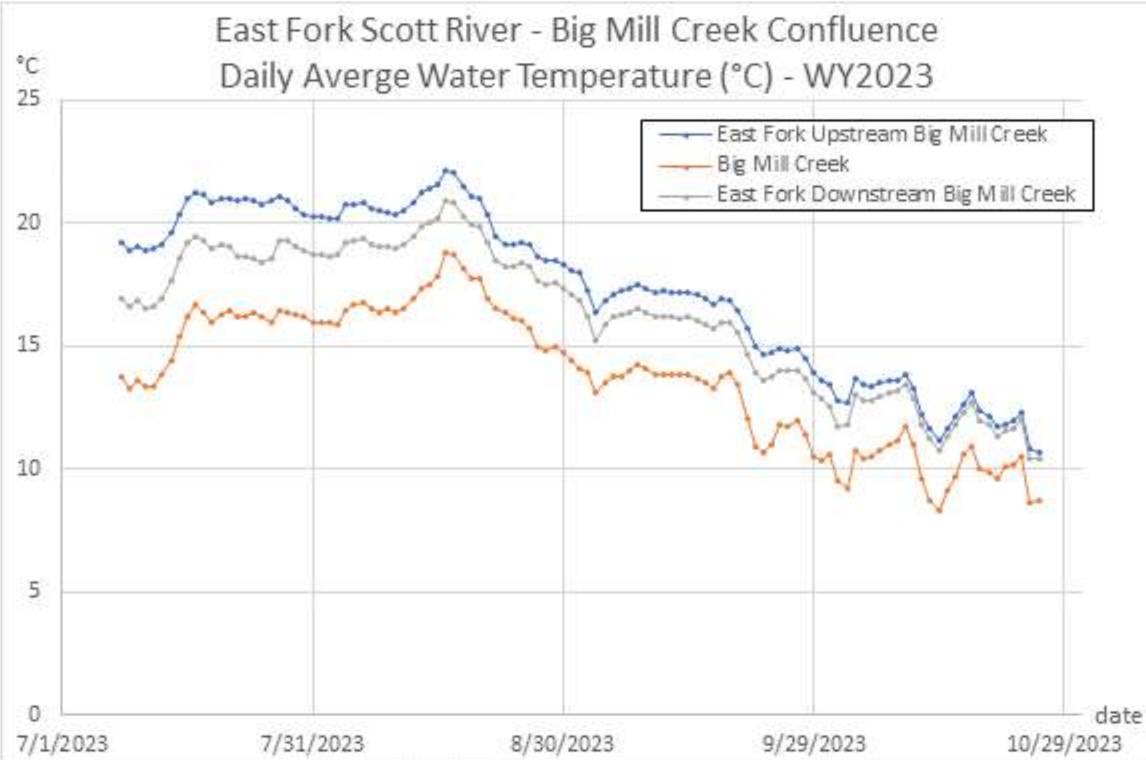


Figure 4.6: Daily average water temperature (°C) - East Fork Scott River and Big Mill Creek at Confluence.

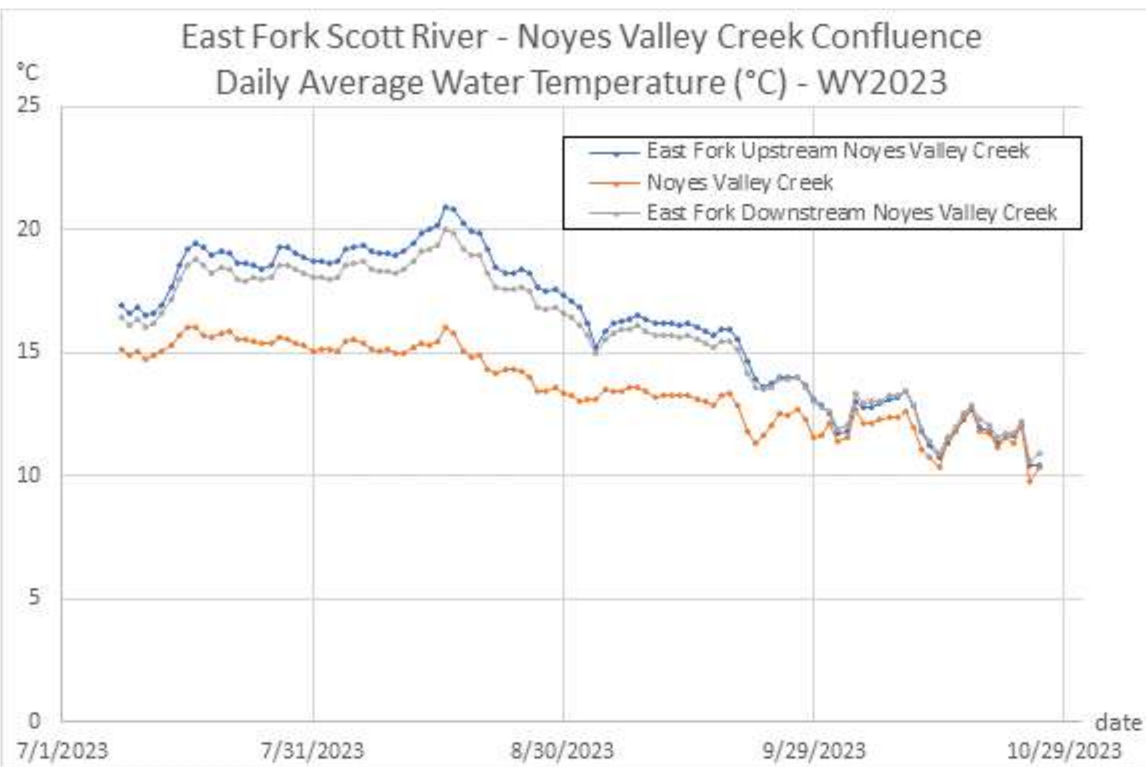
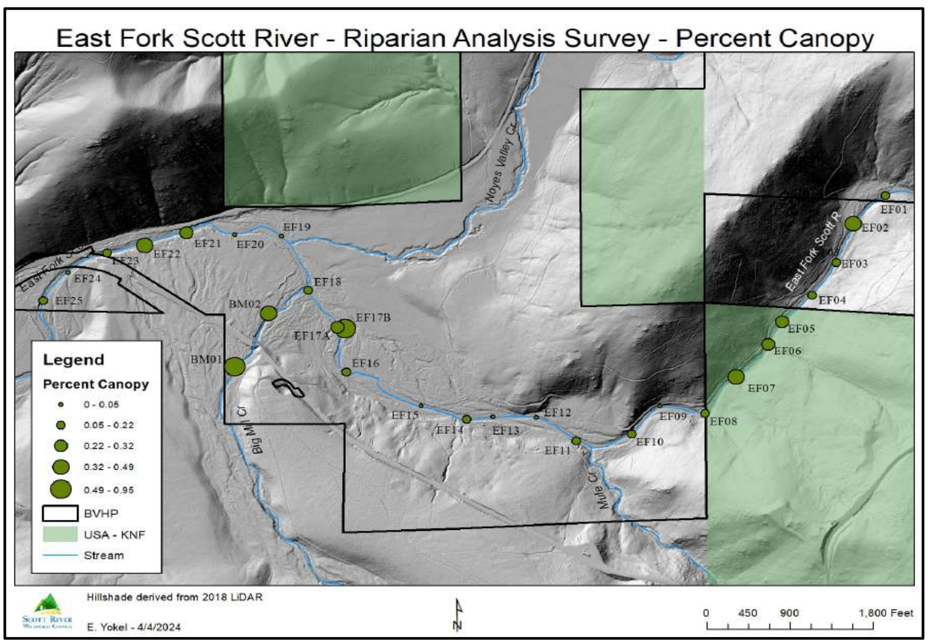


Figure 4.7: Daily average water temperature (°C) - East Fork Scott River – Noyes Valley Creek at Confluence.

4.5 Conclusion

The MWAT along various points of the East Fork Scott River changes spatially along the river course. There is a general warming trend in MWAT from RKM 7.5 to RKM 5.95, indicating that as you move downstream from China Cove POD to Mule Creek, water temperatures tend to increase. There is a notable cooling effect at RKM 5.9, attributed to the input of cold water from Mule Creek. This suggests that Mule Creek contributes colder water to the East Fork Scott River, likely due to factors such as elevation or flow characteristics. After the cooling effect at RKM 5.9, there's a subsequent warming trend observed from RKM 5.9 to RKM 4.7 (Upstream Big Mill Creek). However, a significant cooling effect (1.3°C) is noted between upstream Big Mill Creek (RKM 4.7) and downstream Big Mill Creek (RKM 4.6), indicating a localized cooling influence, possibly due to factors specific to this stretch of the river.

Downstream Big Mill Creek, additional cooling is observed at the input of Noyes Valley Creek (RKM 4.4), indicating another point where colder water is introduced. However, this is followed by a warming trend from RKM 4.4 to RKM 3.8 (East Fork upstream Highway 3 Bridge), suggesting that despite the cooling influence of Noyes Valley Creek, the overall trend along this section of the river is towards warmer temperatures. This could be a result of solar exposure based on the relatively reduced riparian zone directly downstream of the Noyes Valley Creek confluence (Map 4.2.), as documented in Chapter 1 of this report.



Map 4.2: Existing riparian canopy estimated with the use of a densiometer.

Finally, water temperatures appear stable from RKM 3.8 to downstream RKM 2.5 stations, indicating that there are no significant temperature changes observed in this section. Overall, this analysis provides valuable insights into the spatial variation of water temperatures along the East Fork Scott River, highlighting the influence of tributaries and local conditions on temperature dynamics. Going forward, SRWC intends to continue to monitor the water temperature, using similar methodology.

4.6 Bibliography

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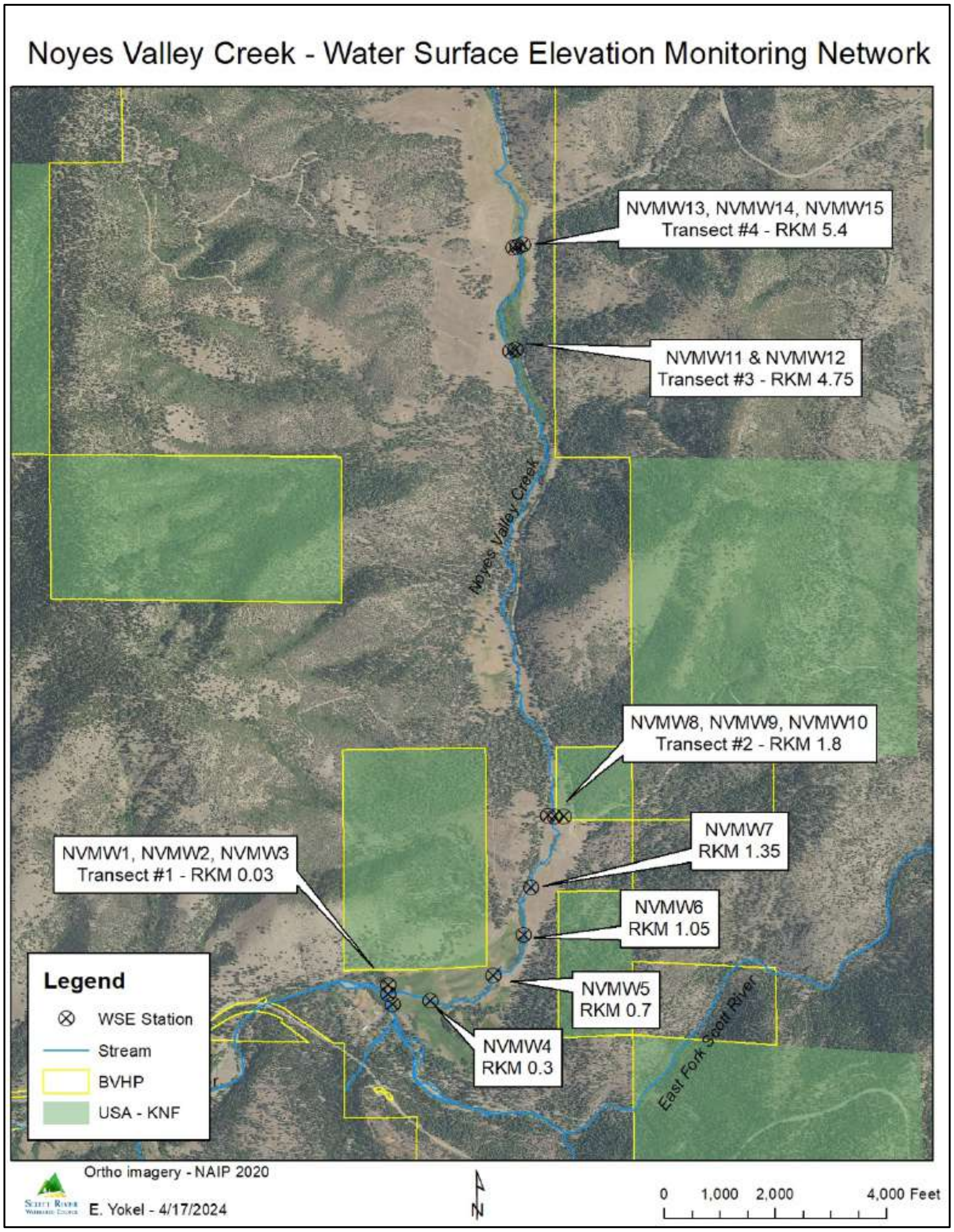
Welsh, H., Hodgson, G., Harvey, B., Roche, M. 2011. Distribution of Juvenile Coho Salmon in Relation to Water Temperatures in Tributaries of the Mattole River, California. North American Journal of Fisheries Management Volume 21, Issue 3 p. 464-470

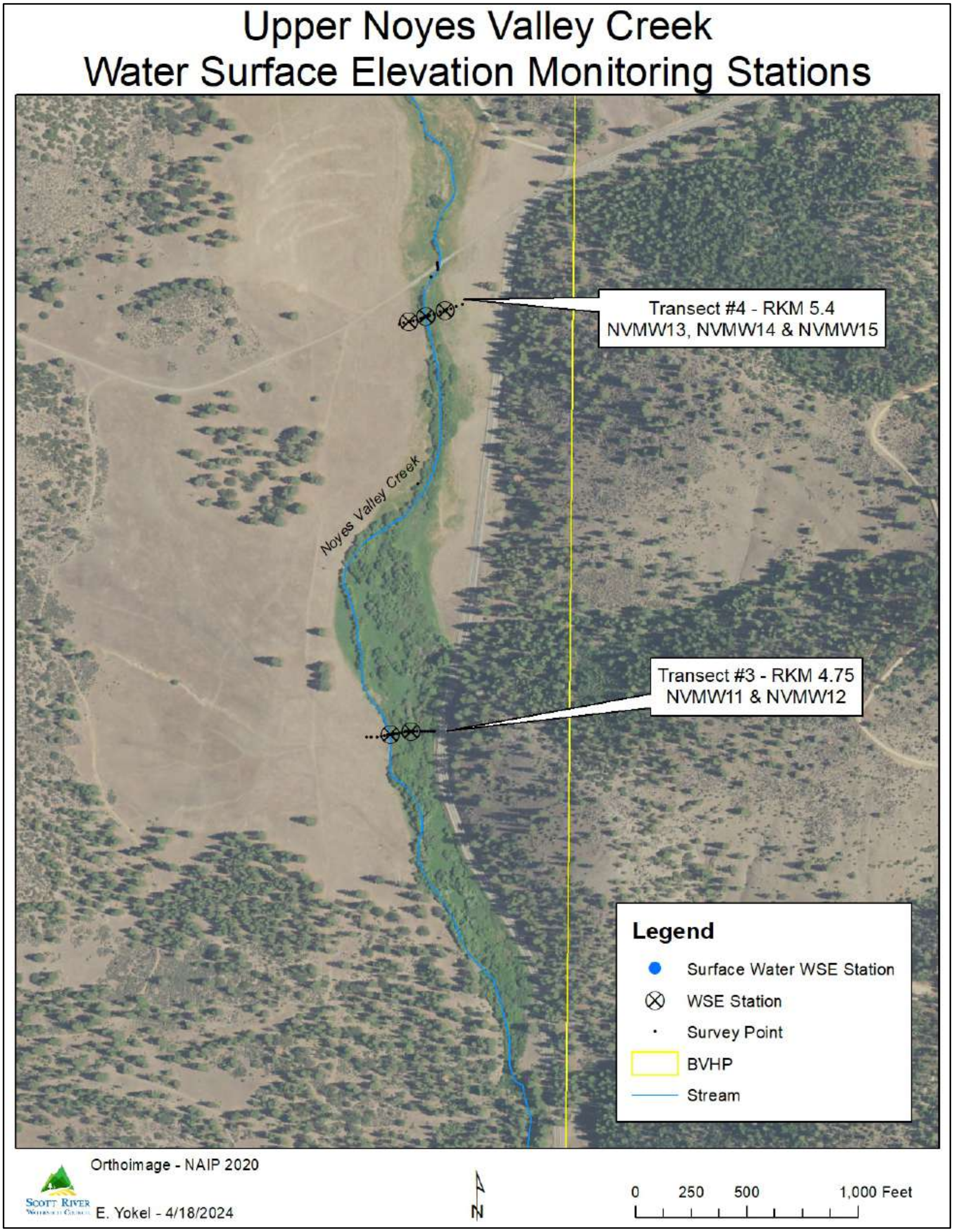
Chapter 5. Water Surface Elevation Monitoring

5.1 Introduction

Fifteen water surface elevation (WSE) stations were established in Noyes Valley Creek on December 13, 2022 (Map 5.1). Four transects of three stations (Transects #1, #2 and #4) or two WSE stations (Transect #3) and four individual stations along the stream center line were established in the Lower and Upper Noyes Valley Creek reaches (Map 5.2). Three station transects consist of one WSE station in (or near) the thalweg of the stream and two stations on the river right and river left floodplain.



Map 5.1: Horizontal coordinates (SPC 401 - NAD83) and elevation (NAVD88) of the WSE stations.



Map 5.2: Upper Noyes Valley Creek water surface elevation (WSE) station transects.

5.2 Purpose

- Comprehending the interaction between groundwater and surface water is crucial for guiding restoration design efforts and assessing whether water availability affects riparian health, a critical element of overall stream function.

5.3 Methods

Onset Computer Corporation U20L pressure transducers were placed in each WSE station documenting continuous (15 minute) water depth and temperature. A nearby barometric logger is used to correct the sensor depth for atmospheric pressure influence. The station's reference point (RP) and ground elevation (mean sea level - NAVD88) were documented using a RTK GNSS survey system (Table 5.1). Periodic manual measurements of the distance to water from the reference point were performed. The continuous WSE for each station was calculated using the sensor depth, reference point elevation and periodic empirical measurements of the distance from the reference point to the WSE.

Table 5.1: Horizontal coordinates (SPC 401 - NAD83) and elevation (NAVD88) of the WSE stations.

Station	SPC 401 - N (ft)	SPC 401 - E (ft)	RP Elev. (ft)	Ground Elev. (ft)
NVMW1	2361814	6352808	3262.6	3260.5
NVMW2	2361652	6352806	3257.2	3255.4
NVMW3	2361470	6352875	3259.9	3258.6
NVMW4	2361523	6353564	3273.1	3270.3
NVMW5	2361965	6354700	3291.9	3289.3
NVMW6	2362698	6355258	3303.7	3301.6
NVMW7	2363554	6355401	3314.6	3311.8
NVMW8	2364833	6355715	3337.7	3334.7
NVMW9	2364822	6355844	3331.6	3329.0
NVMW10	2364818	6355995	3332.9	3331.4
NVMW11	2373225	6355133	3456.1	3453.9
NVMW12	2373241	6355225	3457.3	3454.9
NVMW13	2375083	6355216	3493.1	3490.7
NVMW14	2375106	6355292	3488.5	3485.7
NVMW15	2375134	6355379	3491.5	3489.8

Stream cross sections were surveyed at each WSE station location to document the topography of the streambed, stream bank and adjacent floodplain. Continuous calculated WSE is illustrated with the stream cross section to illustrate the distance from the ground to water during the period of record.

Average daily WSE for each WSE station in a transect is illustrated to show the relative elevation of the water in the stream bed and the adjacent floodplain. Water temperature is illustrated to show the different thermal regime at the logger location for each station and transect.

The WSE stations were installed after a series of three critically dry years (WY2020 - WY2022) when Noyes Valley Creek was disconnected with many of the station logger locations being dry.

After significant runoff events in late December 2022 and mid-January 2023, Noyes Valley Creek became reconnected, and the WSE rapidly increased.

5.4 Results

5.4.1 Upper Noyes Valley Creek

Two water surface elevation (WSE) transects were established in the Upper Noyes Valley Creek project area (Map 5.2). A transect of three WSE stations (Transect #4 - NVMW15, NVMW14 and NVMW13) was established at Noyes Valley Creek RKM 5.4. The channel of Noyes Valley Creek is moderately entrenched at the location of Transect # 4 with the ground elevation at the right terrace (NVMW13) and left terrace (NVMW15) stations approximately four feet higher than the elevation at instream station (NVMW14) - Figure 5.1.

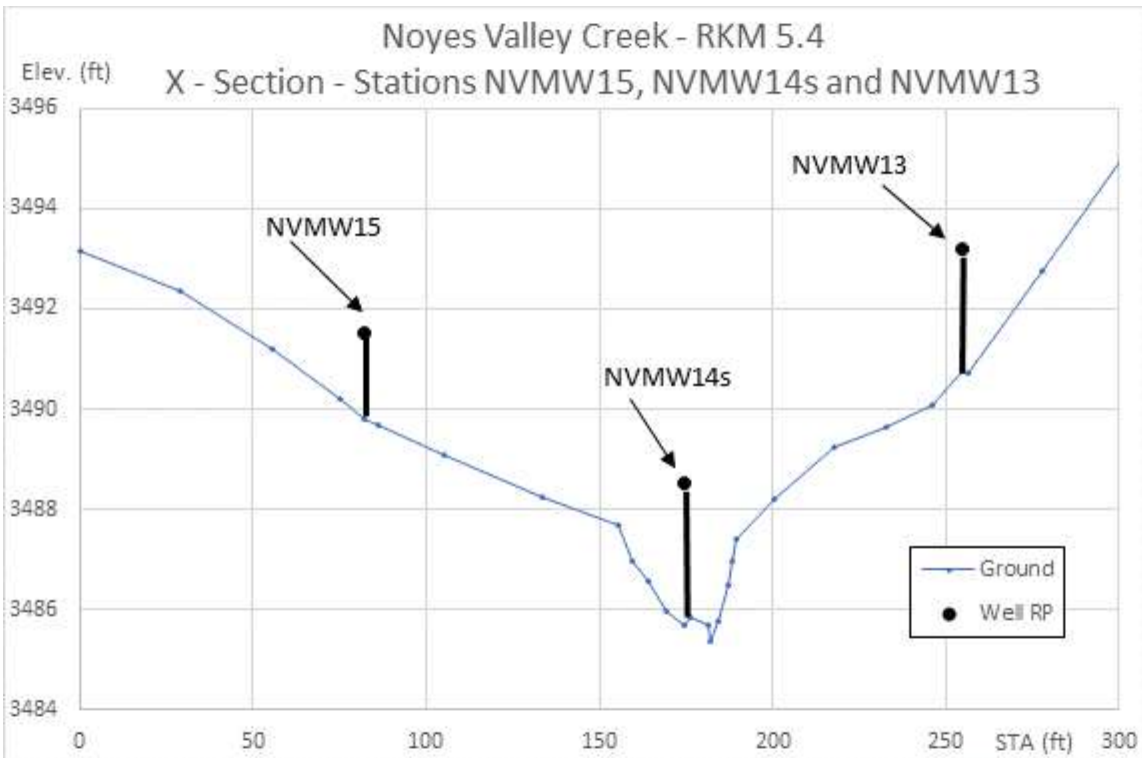


Figure 5.1: Transect #4 - NVMW15, NVMW14s and NVMW13 - Cross section and WSE station location.

Noyes Valley Creek was dry when the water surface elevation (WSE) stations were installed on December 13, 2022. The sensor location (bottom of casing) of NVMW13 and NVMW 14 were dry when the stations were first installed and the WSE at NVMW15 was approximately eleven (11) feet below the channel thalweg elevation at 3,477' (Figures 5.2 - 5.4).

Noyes Valley Creek reconnected after a series of precipitation events resulted in runoff and a rapid increase in water surface elevation (Figure 5.3). Noyes Valley maintained connectivity through the summer base flow period of WY2023 at Transect #4. Analysis of the daily average water surface elevation at the three stations at Transect #4 illustrates that the WSE on the river left terrace is lower (approximately 1 ft) than the WSE in the channel (Figure 5.5). The WSE on the river right terrace is higher than the WSE in the channel for the short periods in which the

NVMW13 station has water in the casing. The daily average water temperature for the three stations in Transect #4 are illustrated in Figure 5.6.

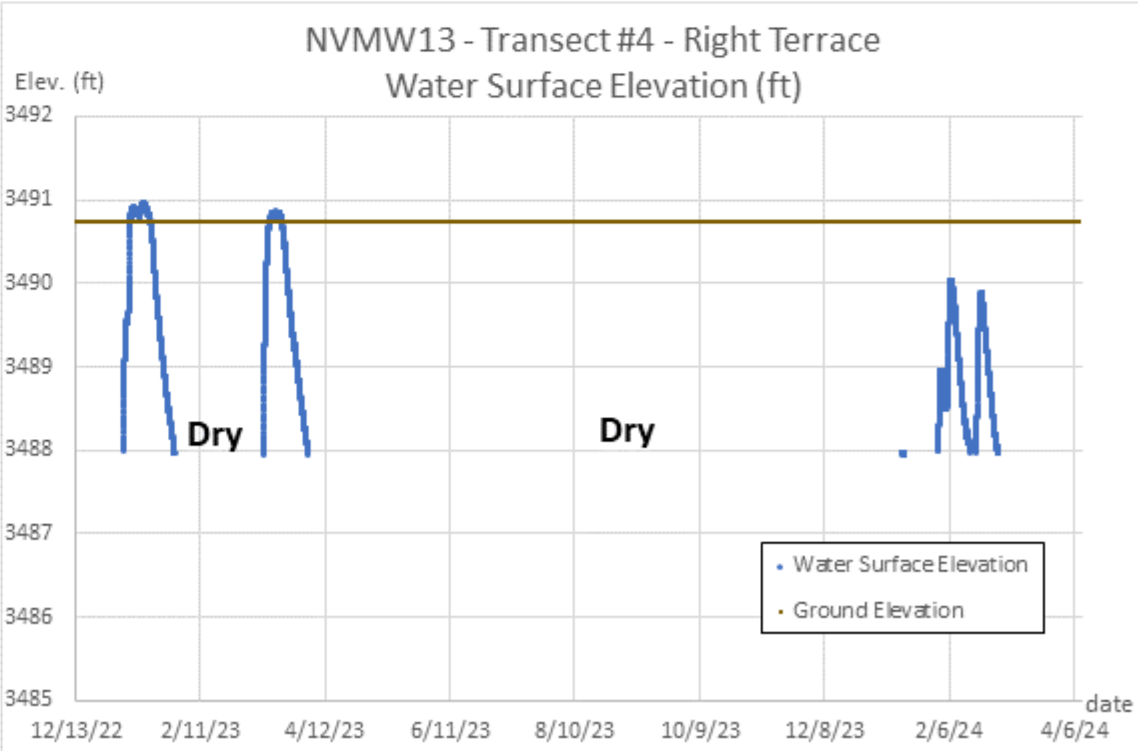


Figure 5.2: NVMW13 - Continuous WSE and ground elevation (ft).

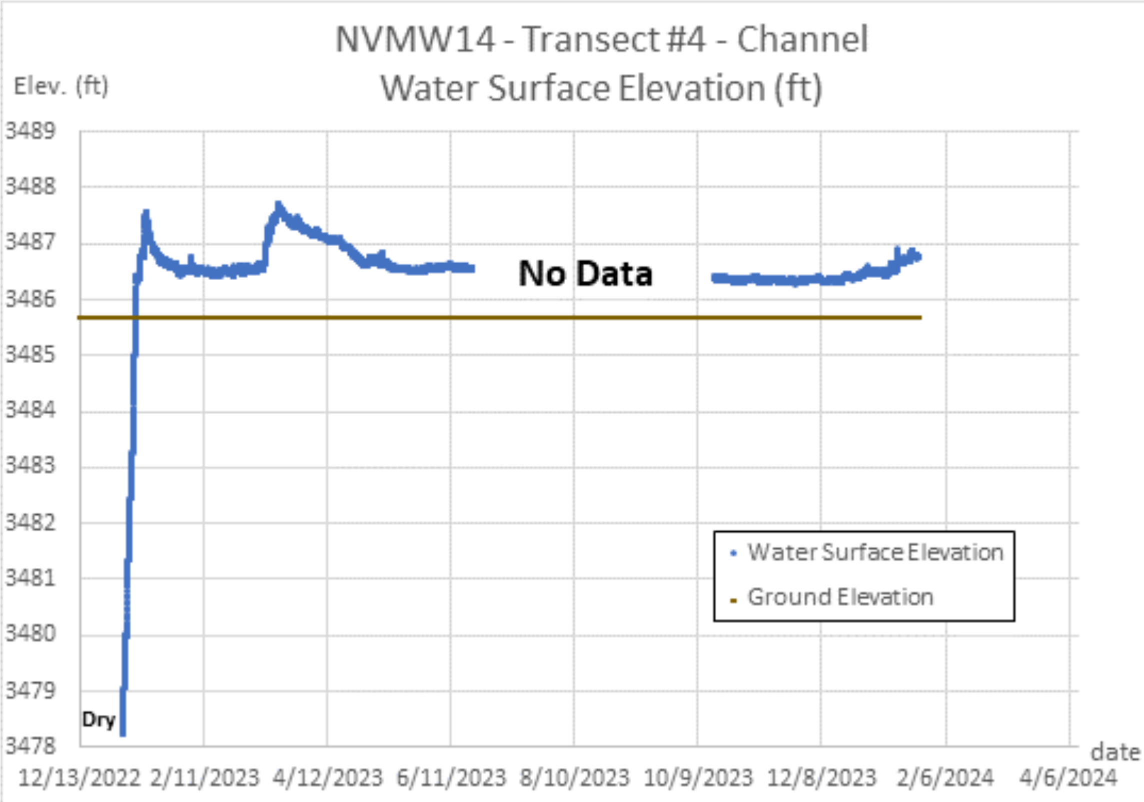


Figure 5.3: NVMW14 - Continuous WSE and ground elevation (ft).

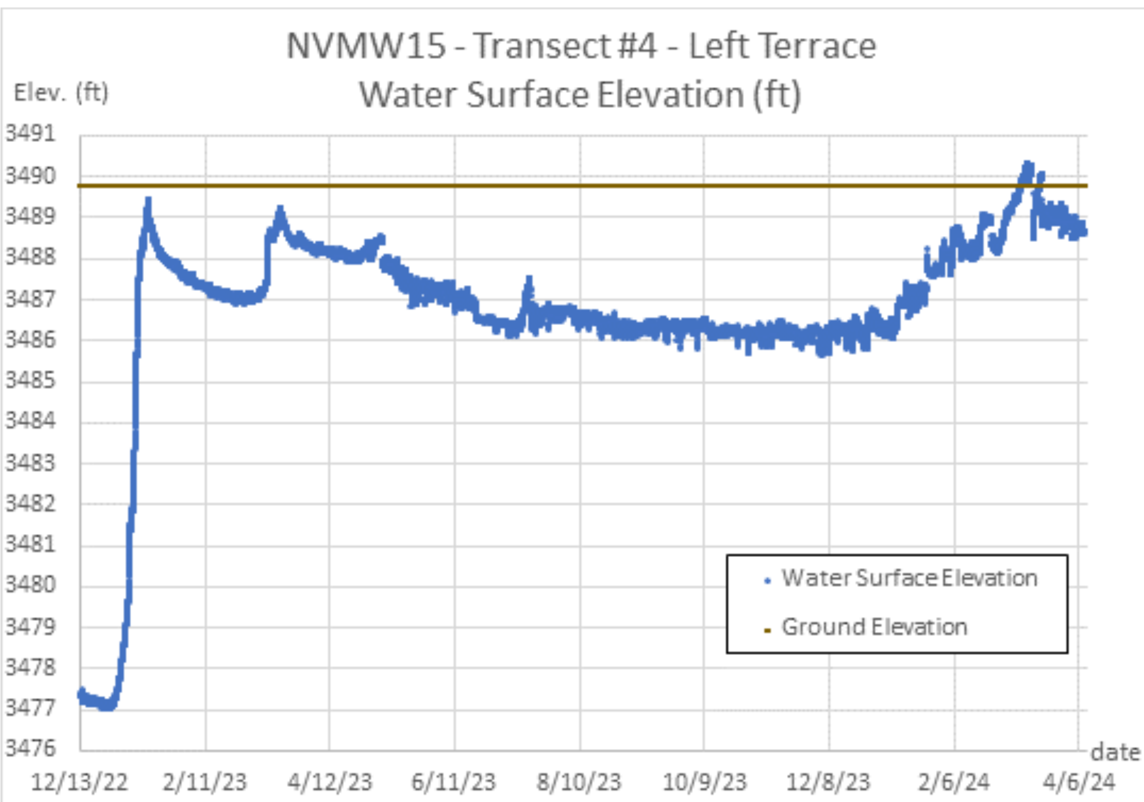


Figure 5.4: NVMW15 - Continuous WSE and ground elevation (ft).

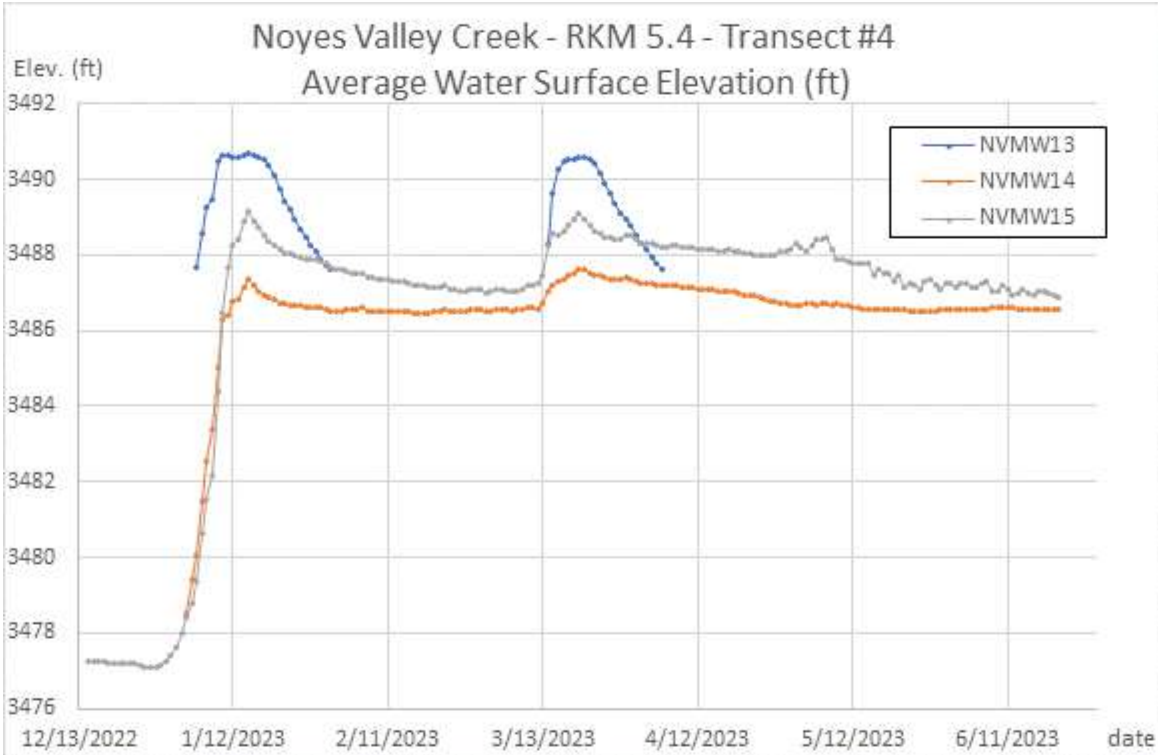


Figure 5.5: Transect #4 - Daily average WSE (ft).

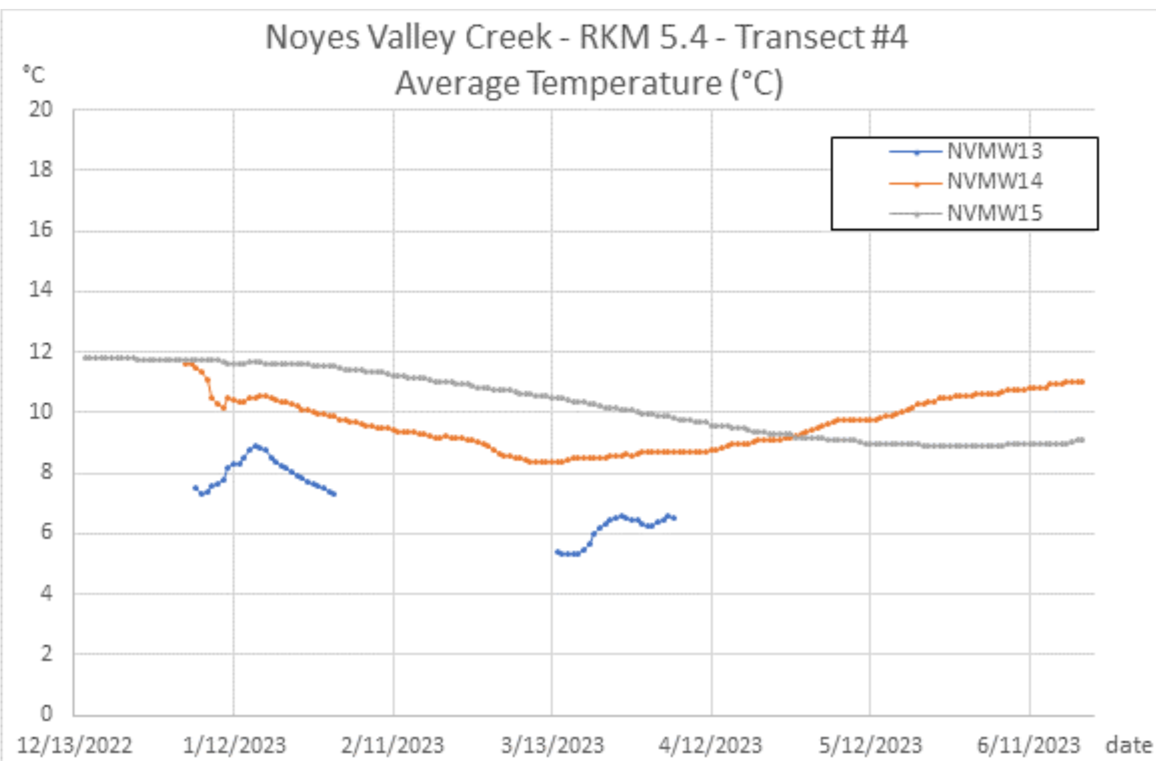


Figure 5.6: Transect #4 - Daily average temperature (°C).

Two WSE stations (NVMW12 and NVMW11) were established in Noyes Valley Creek at RKM 4.75 (Transect #3) in an area with vegetation characteristic of wetlands. The two stations were established in the main channel (NVMW11) and a side channel (NVMW12) with the ground elevation of the main channel approximately one foot lower than the ground elevation of the side channel (Figure 5.7).

5.4.2 Lower Noyes Valley Creek

Noyes Valley Creek was dry during the installation of the WSE stations with the WSE less than half a foot below the surface at the main channel station (Figures 5.8 and 5.9). Noyes Valley Creek reconnected after the precipitation events in late 2022 and early 2023 and remained connected through the summer base flow period at Transect #3. Analysis of the daily average WSE at the two stations in Transect #3 illustrates that the WSE in the main channel is approximately one half to one foot lower than the WSE in the side channel location (Figure 5.10) and the water temperature in the main channel location is slightly warmer than the side channel location (Figure 5.11).

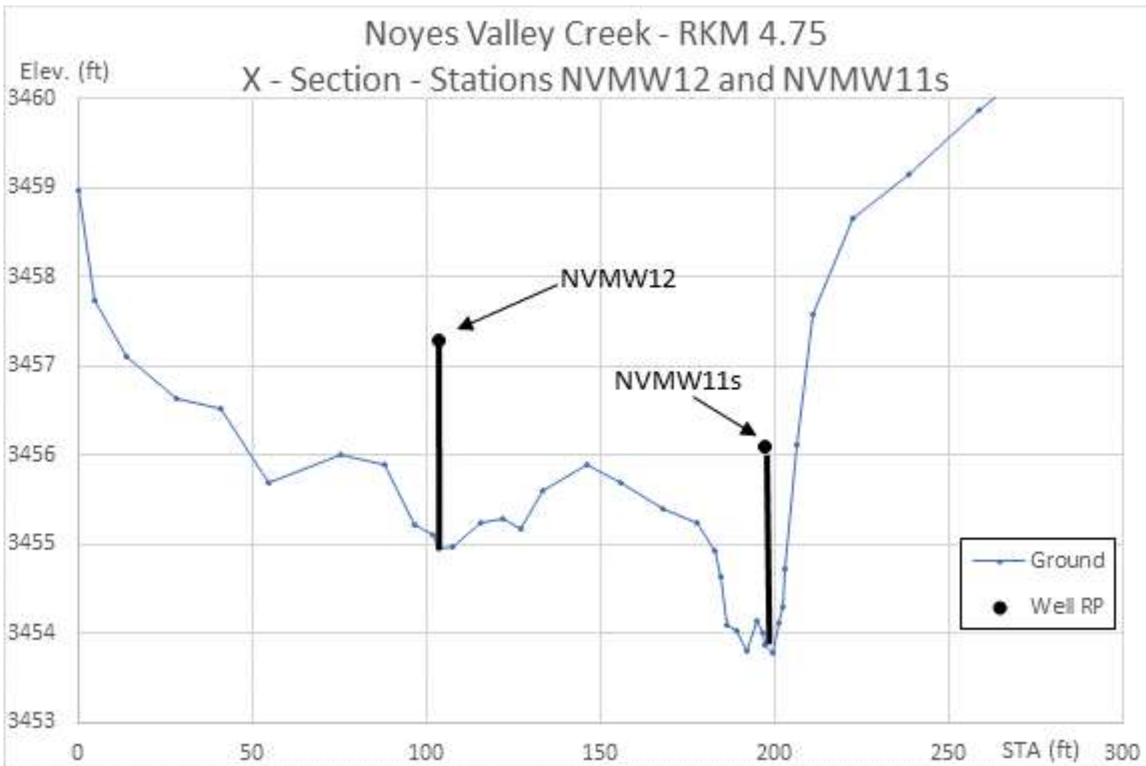


Figure 5.7: Transect #3 - NVMW12 and NVMW11 - Cross section and WSE station location.

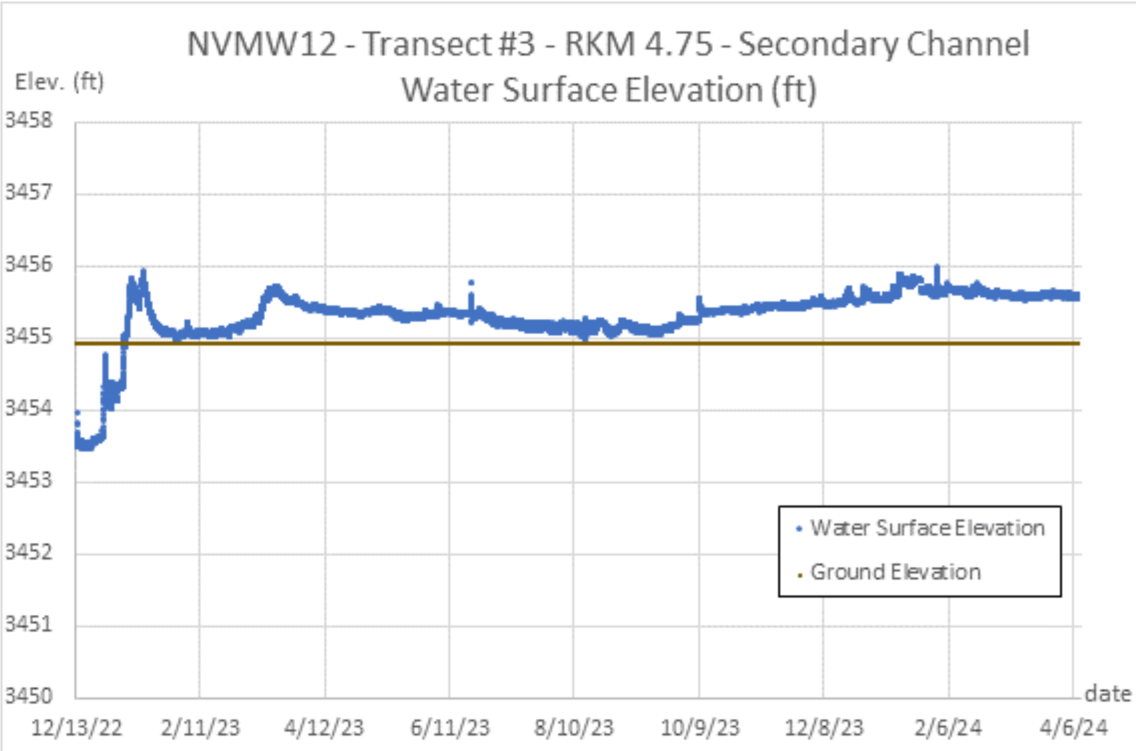


Figure 5.8: NVMW12 - Continuous WSE and ground elevation (ft).

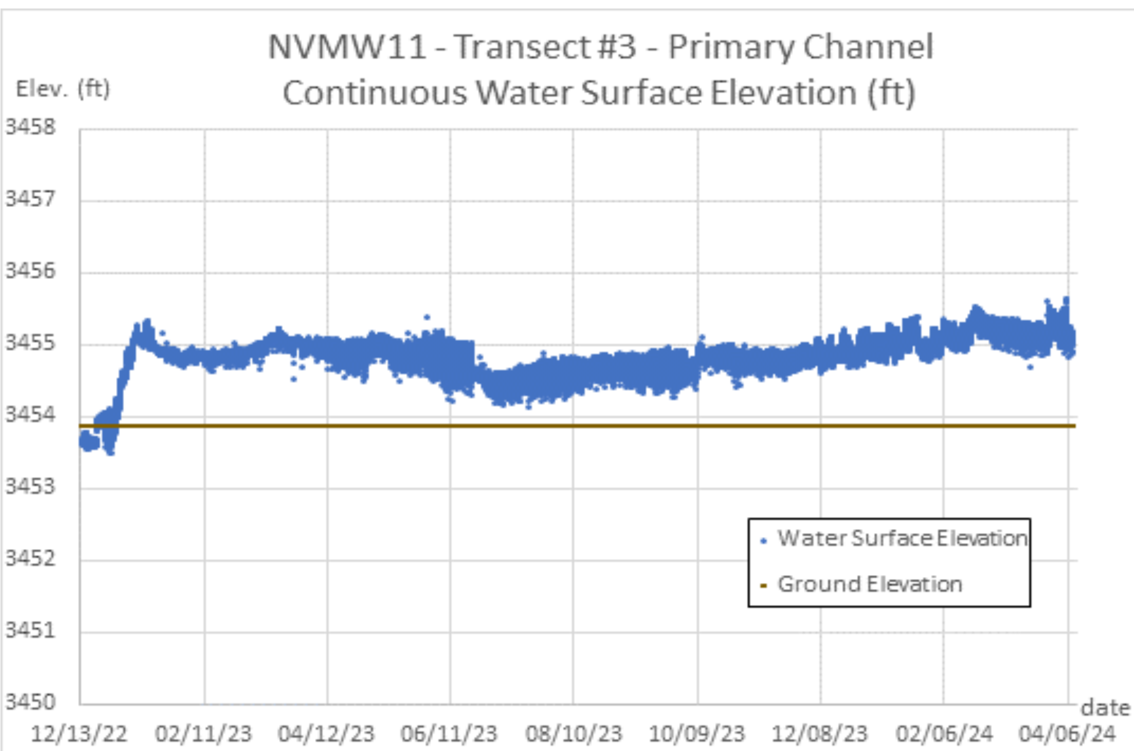


Figure 5.9: NVMW11 - Continuous WSE and ground elevation (ft).

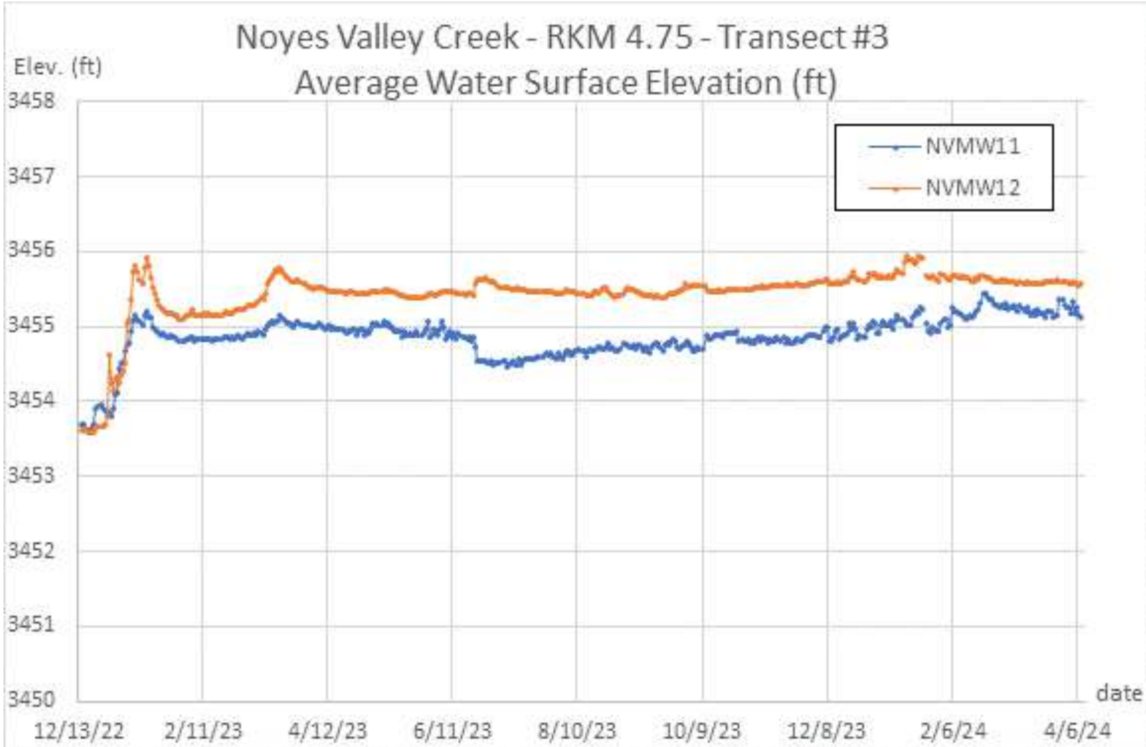


Figure 5.10: Transect #3 - Daily average WSE (ft).

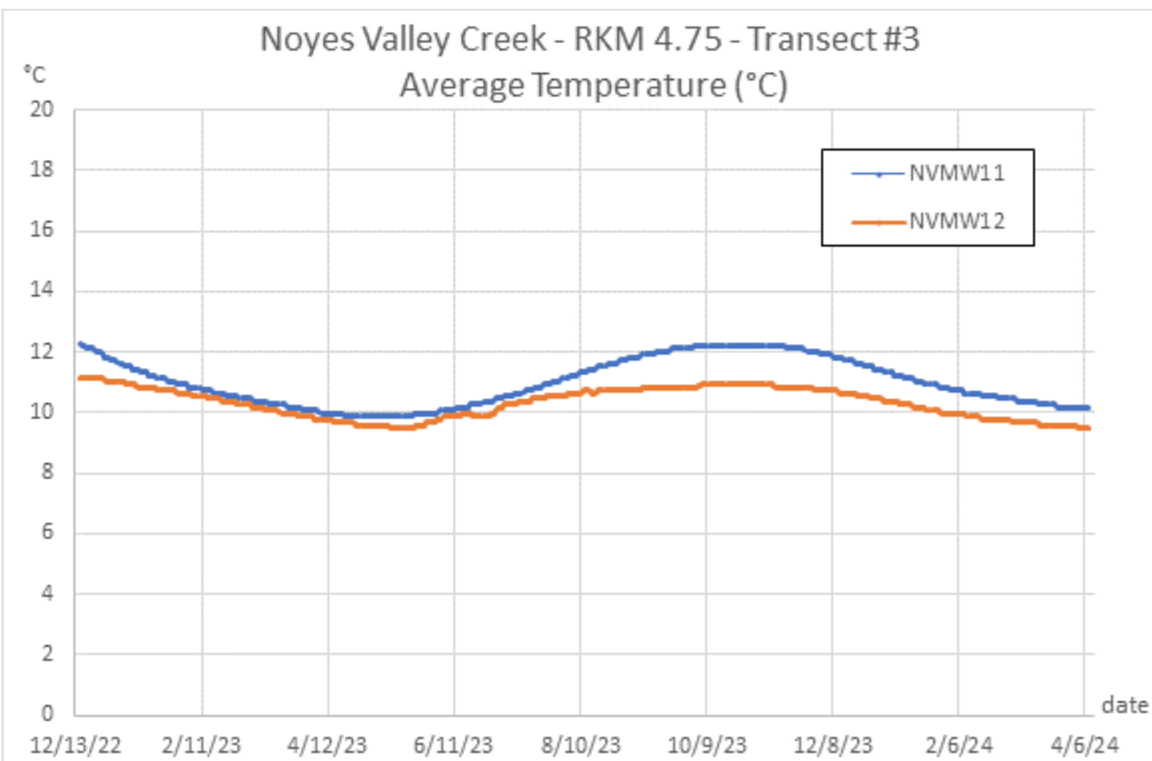
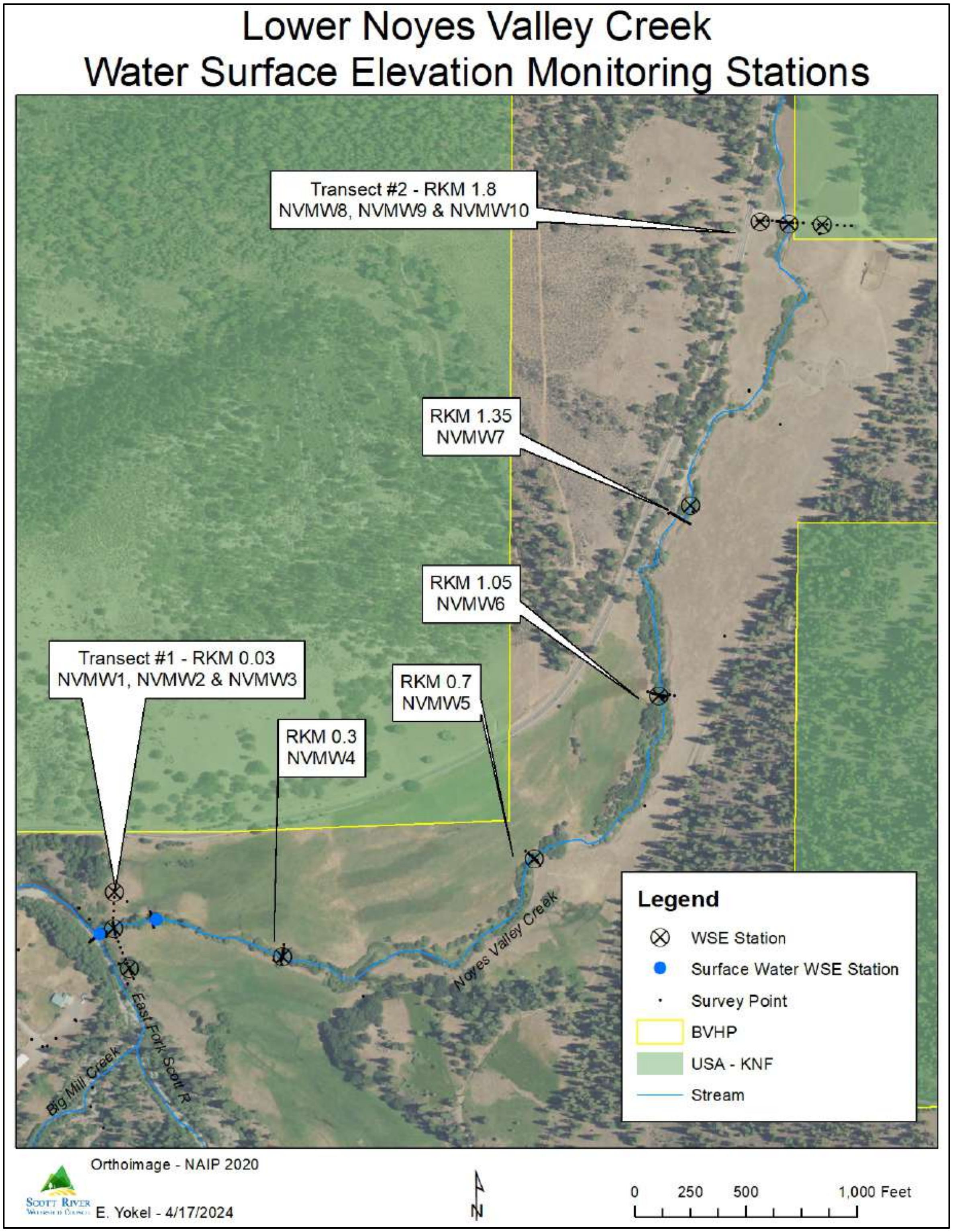


Figure 5.11: Transect #3 - Daily average temperature (°C).

Two water surface elevation (WSE) transects and four individual WSE stations in or near the channel thalweg were established in the Lower Noyes Valley Creek project reach (Map 3).

Three WSE stations (NVMW10, NVMW9 and NVMW8) were established downstream of the low water crossing at Masterson Road at Noyes Valley Creek RKM 1.8. The ground surface elevation at the thalweg station (NVMW9) is approximately two feet lower than the ground elevation at the river left station (NVMW10) and six feet lower than the ground elevation at the river right station (Figure 5.12).

Noyes Valley Creek was dry during the installation of the WSE stations on December 13, 2022 (Figures 5.13 - 5.15). The WSE was approximately eight (8) feet below the channel elevation before rapidly rising upon the runoff events of late December 2022 and early January 2023 (Figure 5.14). The channel remained connected during the winter and spring runoff period and then disconnected in May 2023, during the spring recession flow period. The WSE was approximately nine (9) feet lower than the channel bed during the 2023 summer base flow period with the ground recharging and reconnecting in early January 2024 after precipitation and runoff. Analysis of the daily average WSE of the three stations in Transect #3 illustrates that the WSE at the channel (NVMW9) and river left (NVMW10) stations were equivalent with the WSE at the river right station (NVMW8) being higher during runoff events (Figure 5.16). Daily average water temperatures at the three stations indicate surface water temperature signals at the NVMW9 and NVMW8 stations with the NVMW10 temperature signal characteristic of groundwater (Figure 5.17).



Map 5.3: Lower Noyes Valley Creek water surface elevation (WSE) station transects.

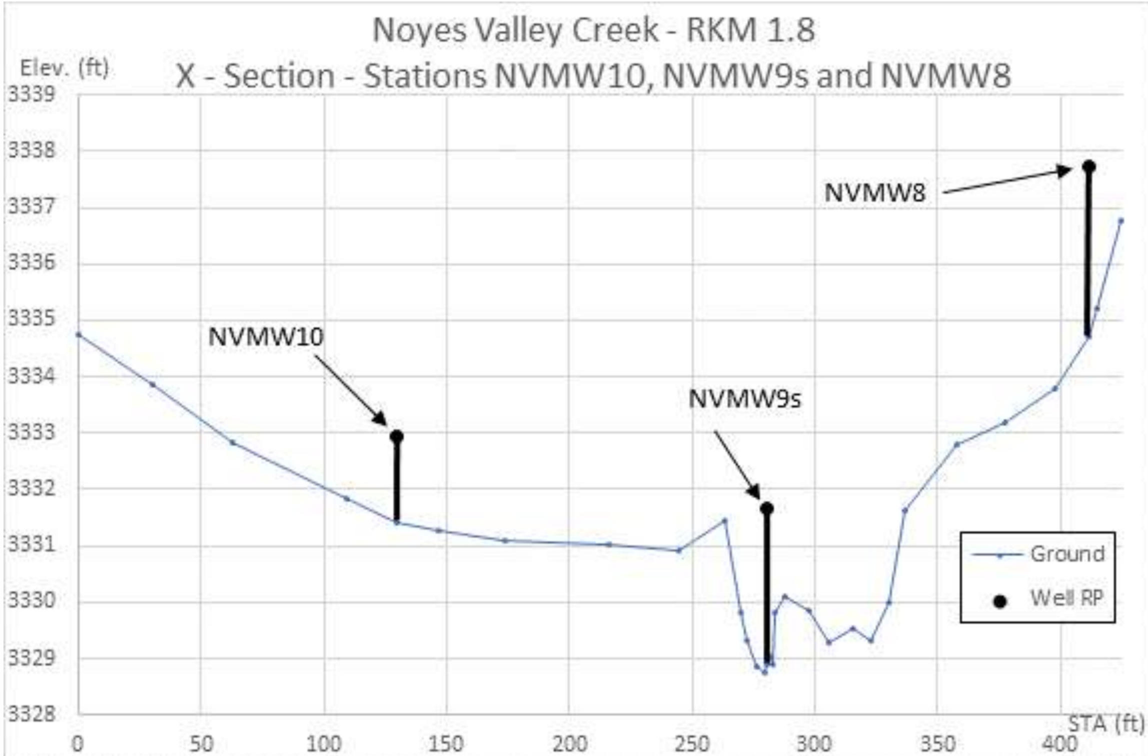


Figure 5.12: NVMW10, NVMW9s and NVMW8 - Cross section and WSE station location.

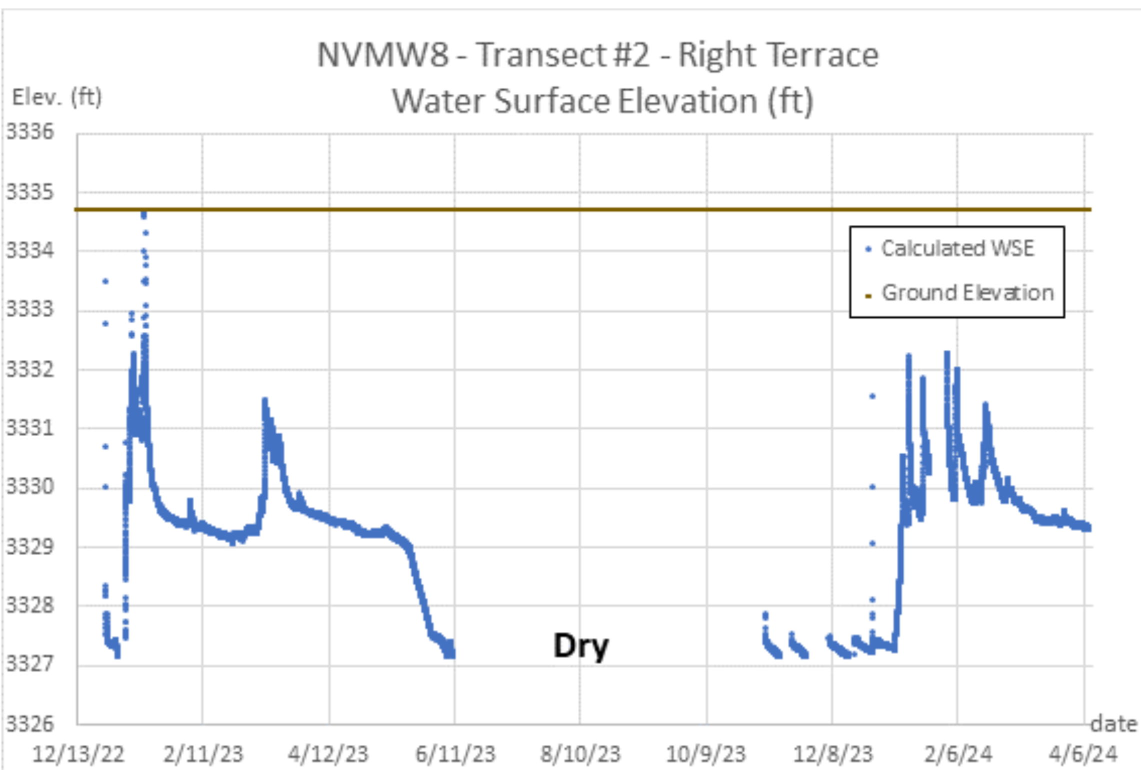


Figure 5.13: NVMW8 - Continuous WSE and ground elevation (ft).

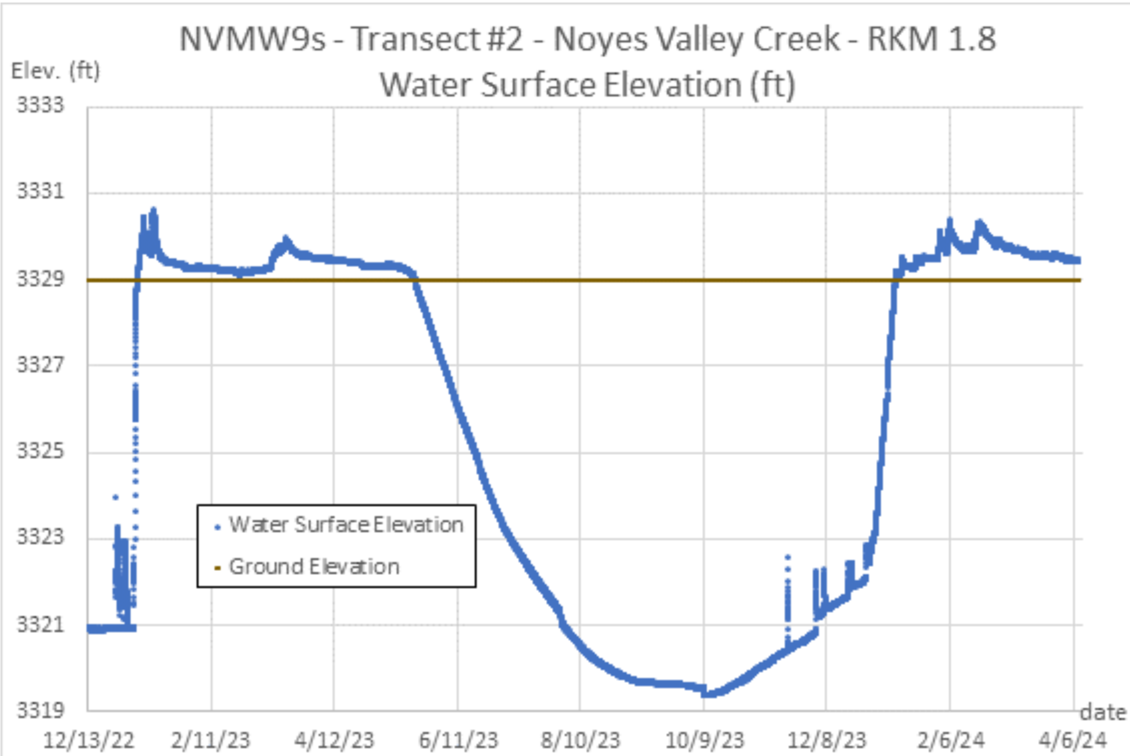


Figure 5.14: NVMW9s - Continuous WSE and ground elevation (ft).

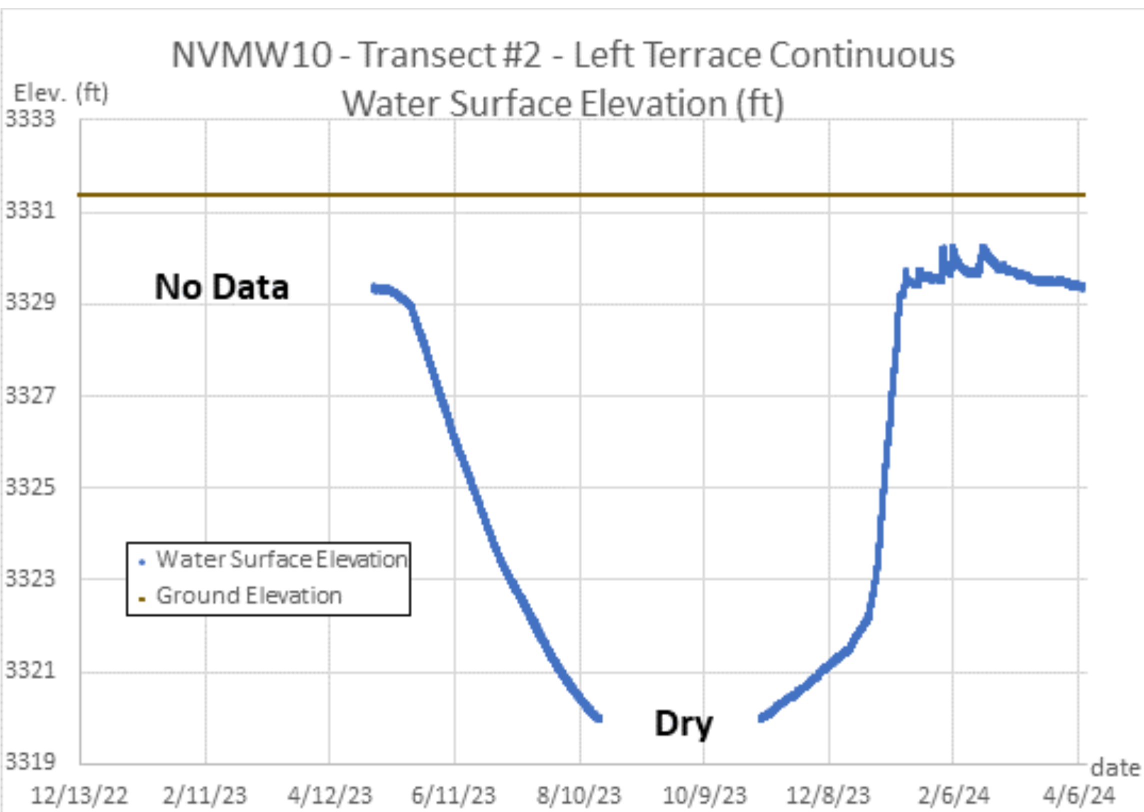


Figure 5.15: NVMW10 - Continuous WSE and ground elevation (ft).

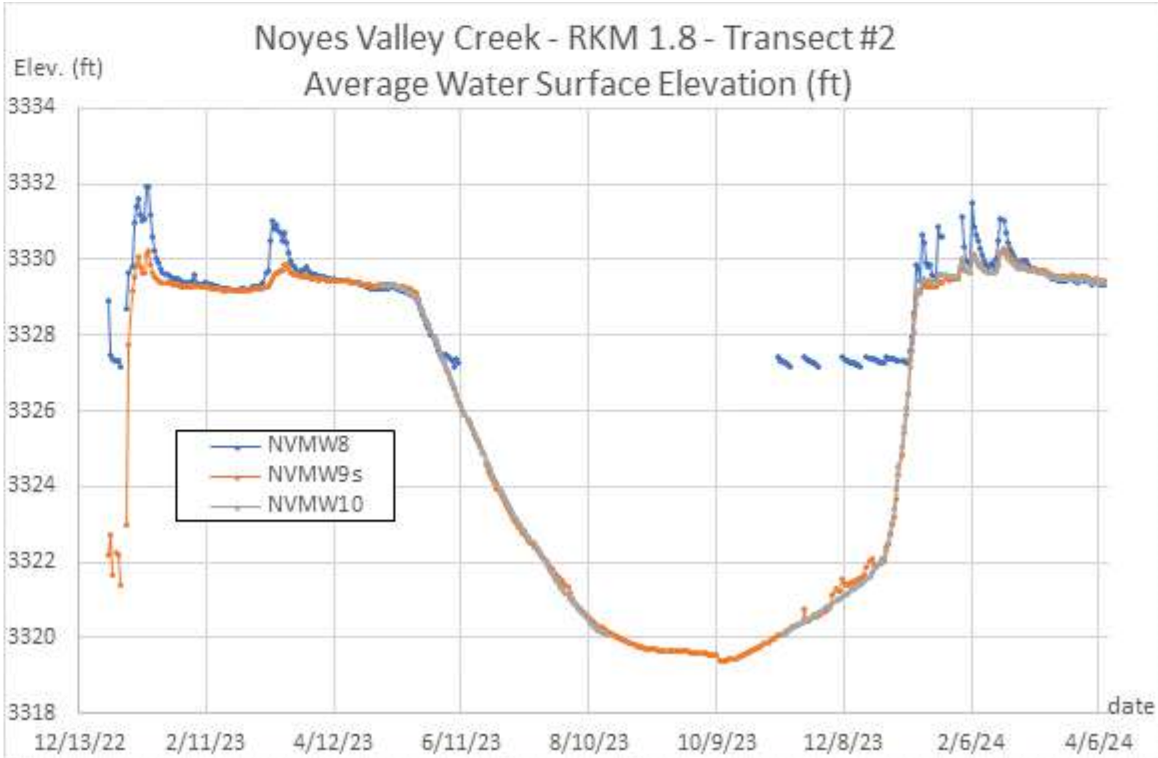


Figure 5.16: Transect #2 - Daily average WSE (ft).

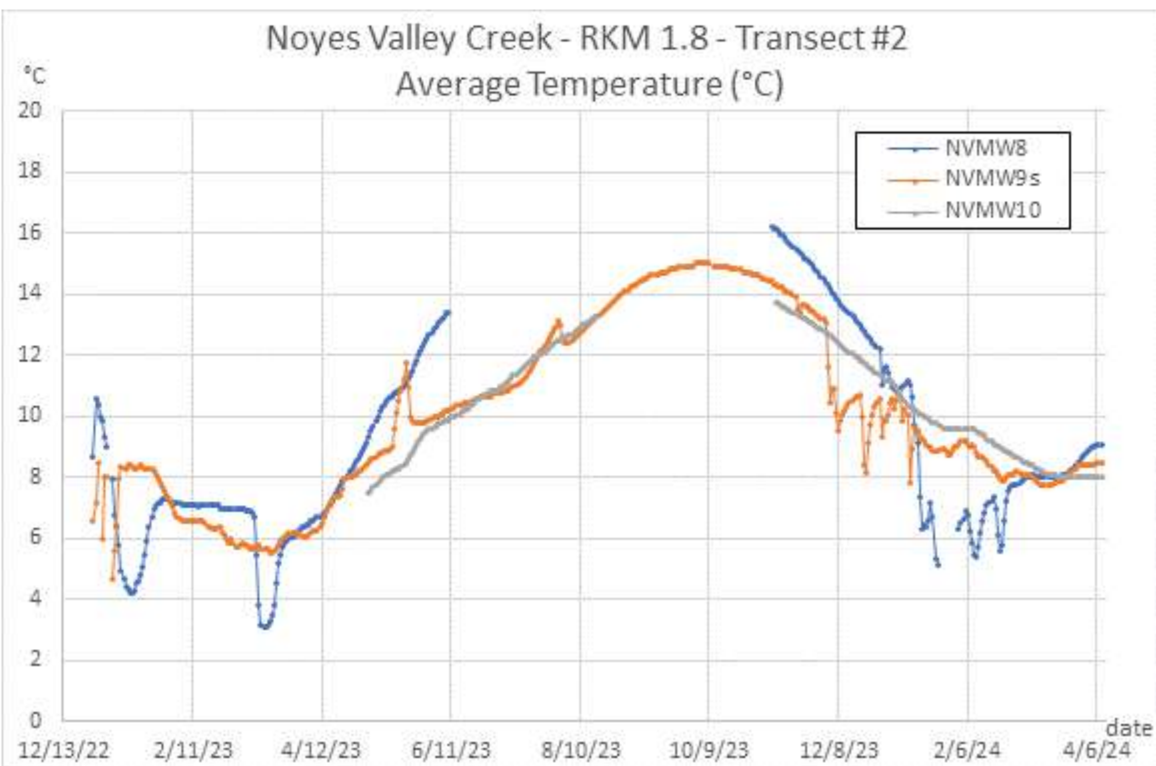


Figure 5.17: Transect #2 - Daily average temperature (°C).

A WSE station (NVMW7) was installed in an off-channel location that is lower elevation than the main channel of Noyes Valley Creek at RKM 1.35 (Figure 5.18). The main channel of Noyes Valley Creek has visible bedrock at the surface in this location and it was assumed that it would be impossible to install the casing for the WSE station in the main channel. A survey of a cross section approximately 100 ft downstream of the WSE station illustrates that the main channel and side channel elevation are the same at this location (Figure 5.19).

Noyes Valley Creek was disconnected during the installation of the station on December 13, 2022 and became reconnected during the runoff events of late December 2022 and early January 2023, (Figure 20). Similar to the upstream WSE transect, Noyes Valley Creek and the off-channel location became disconnected during the summer base flow period with the WSE three (3) ft lower than the off-channel bed elevation, and approximately seven (7) ft lower than the adjacent main channel bed elevation.

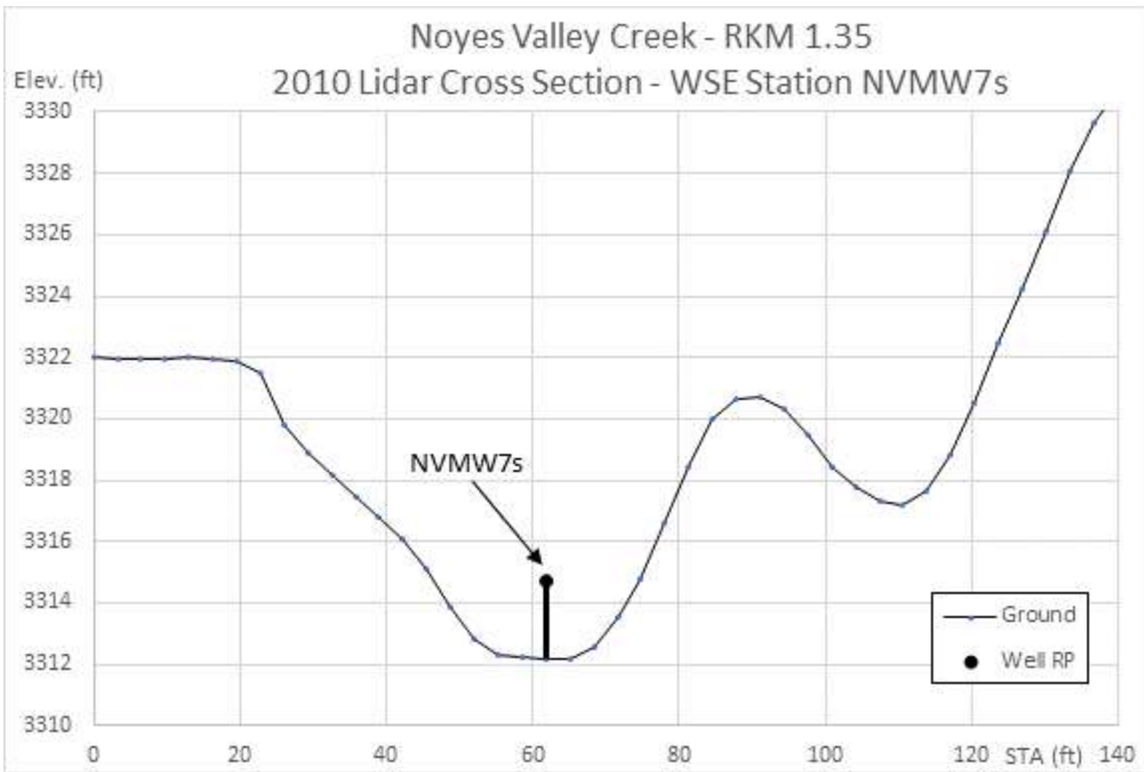


Figure 5.18: NVMW7s - Cross section and WSE station location.

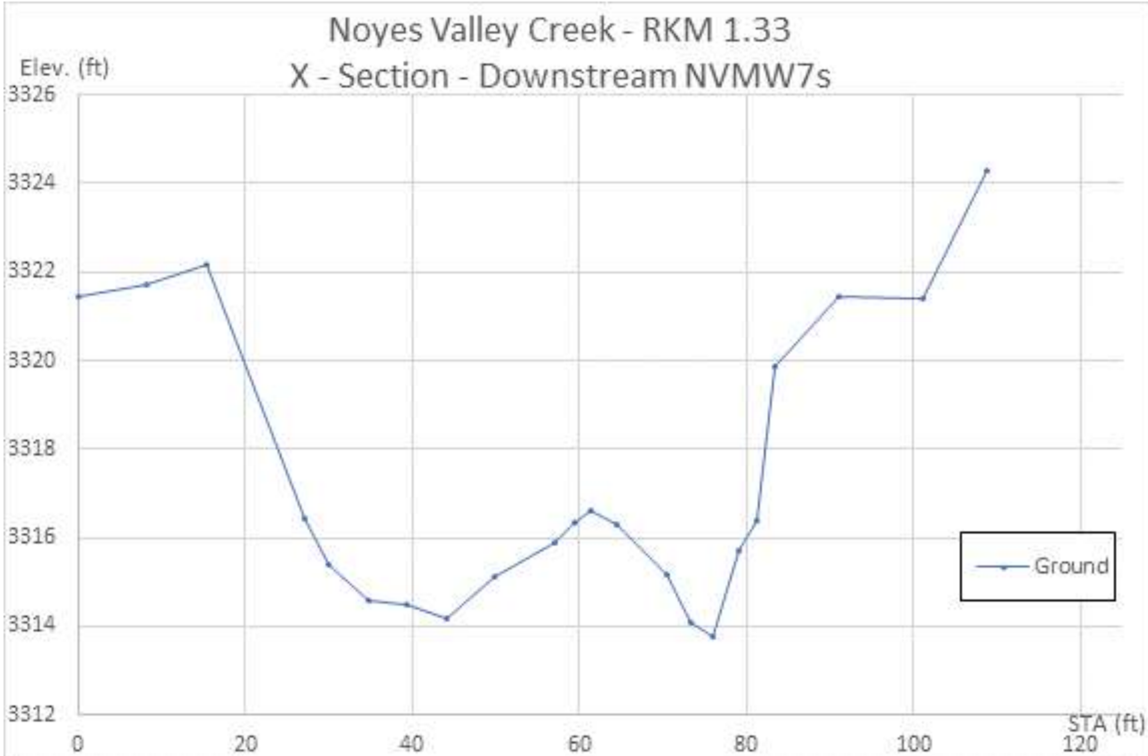


Figure 5.19: Surveyed cross section downstream WSE station location.

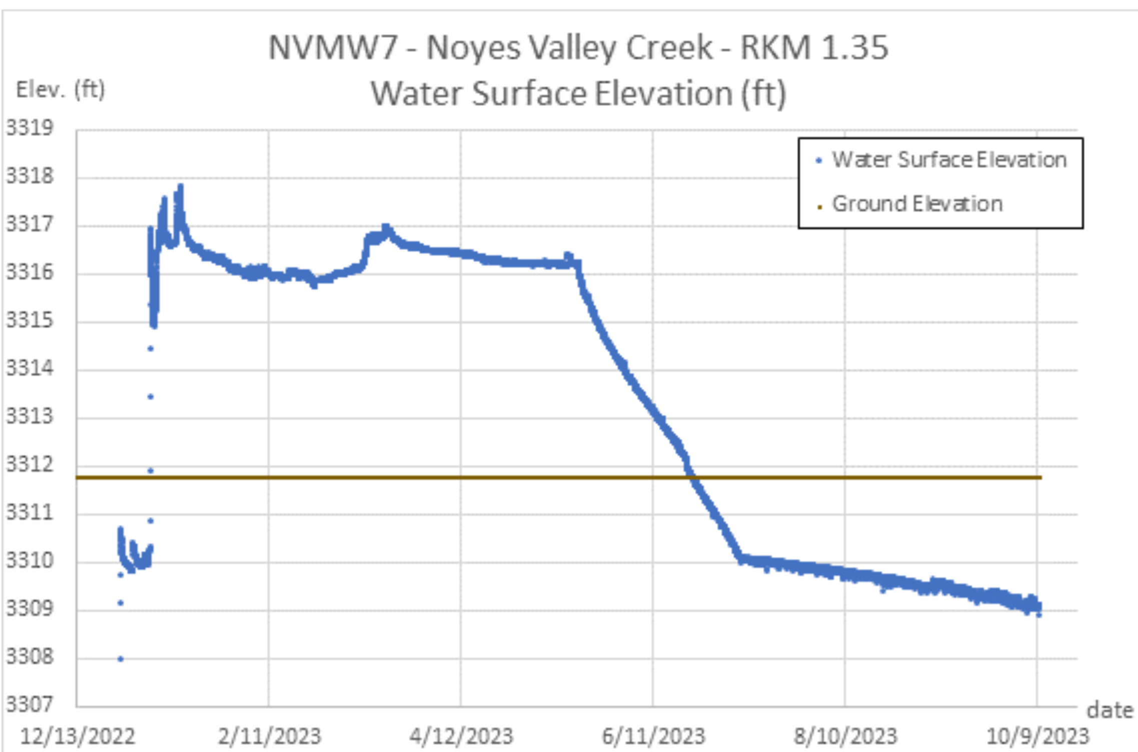


Figure 5.20: NVMW7s - Continuous WSE and ground elevation (ft).

A WSE station (NVMW6) was established on the floodplain terrace adjacent to the channel at Noyes Valley Creek at RKM 1.05. The ground elevation at the WSE station is approximately 1.5 feet higher than the channel bed elevation (Figure 5.21). The river left bank of Noyes Valley Creek is twelve (12) feet higher than the stream bed elevation with a vertical stream bank. The river right bank has several low elevation floodplain and terrace surfaces with the top of bank eight (8) feet higher than the stream bed elevation.

Noyes Valley Creek was disconnected during the installation of the WSE station on December 13, 2022, with the WSE greater than six (6) feet below the channel bed elevation (Figure 5.22). Noyes Valley Creek reconnected during the winter runoff of WY2023, and the floodplain terrace on which the WSE station was located, was inundated during much of the wet season base flow and peak flow periods of WY2023 and WY2024. Noyes Valley Creek at the NVMW6 WSE station became disconnected during a short period during the summer base flow period of WY2023 with the WSE less than half a foot below the channel bed elevation.

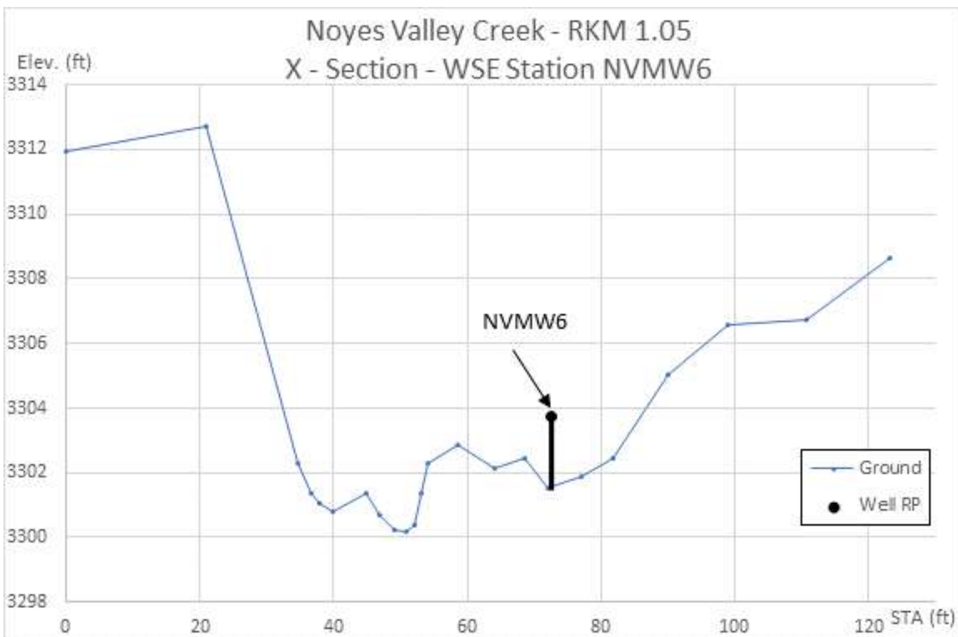


Figure 5.21: NVMW7s - Cross section and WSE station location.

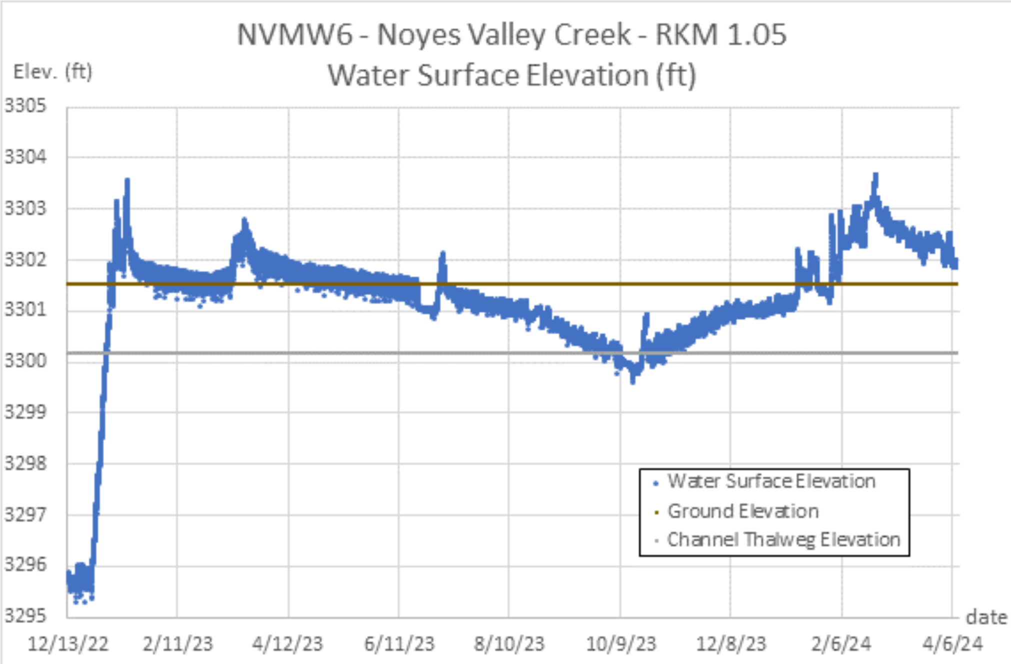


Figure 5.22: NVMW6 - Continuous WSE and ground elevation (ft).

A WSE station was established in the channel bed at confined area of Noyes Valley Creek at RKM 0.7 (Figures 23 and 24).

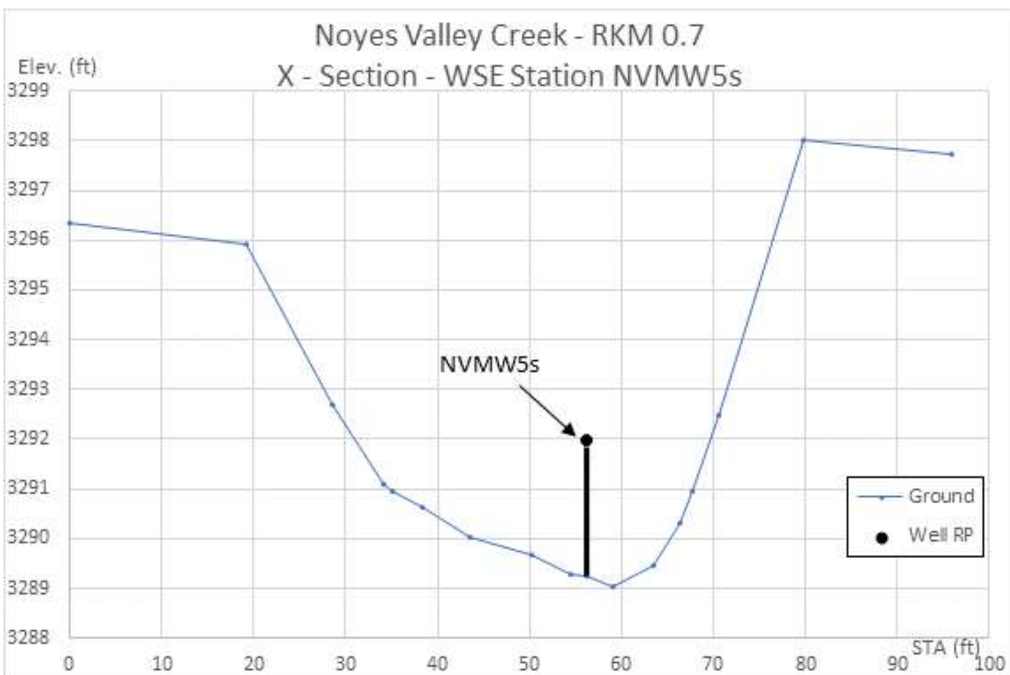


Figure 5.23: NVMW5s – Cross section and WSE station location.

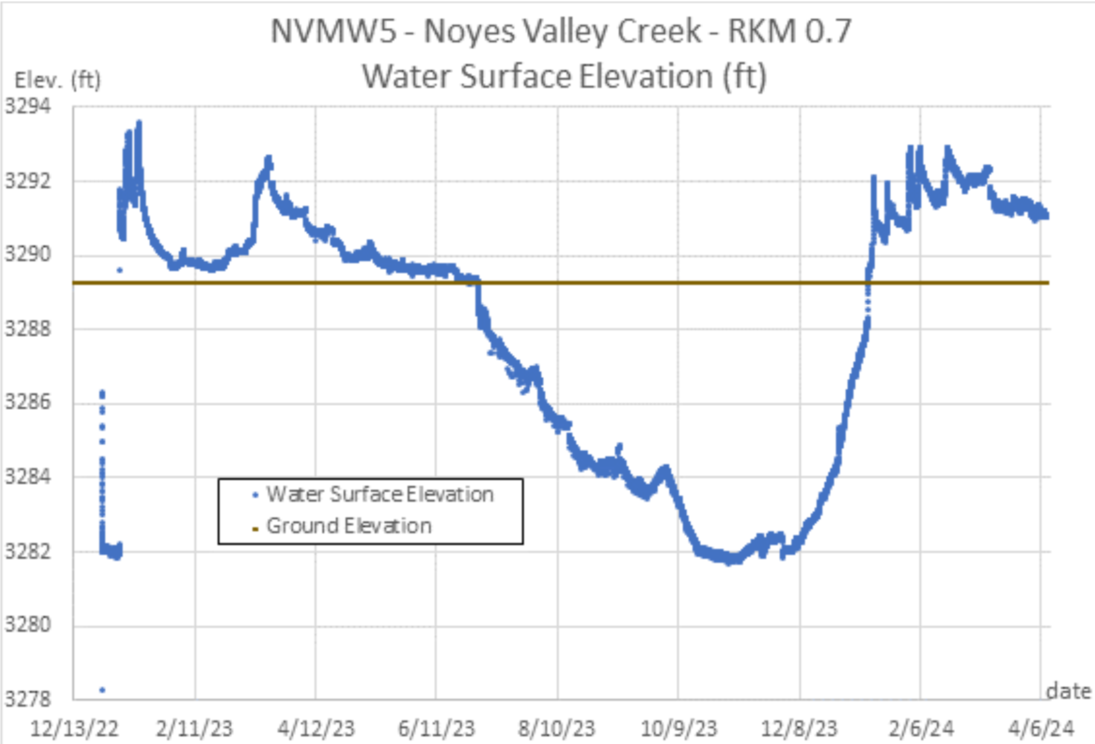


Figure 5.24: NVMW5s - Continuous WSE and ground elevation (ft).

A WSE station (NVMW4) was installed at the top of bank of the main channel on the floodplain approximately two (2) feet above the channel bed elevation at Noyes Valley Creek RKM 0.3 (Figure 5.25). The tops of the river left and river right banks are approximately ten (10) feet higher than the channel bed elevation with a steep bank on river left and a low elevation floodplain/ terrace surfaces on river right. Noyes Valley Creek was connected during the installation of the WSE station on December 13, 2022, and remained connected through the period of record (Figure 5.26). The floodplain terrace on which the NVMW4 station was located became inundated periodically during periods of significant runoff during the wet season peak flow period of WY2023 and WY2024.

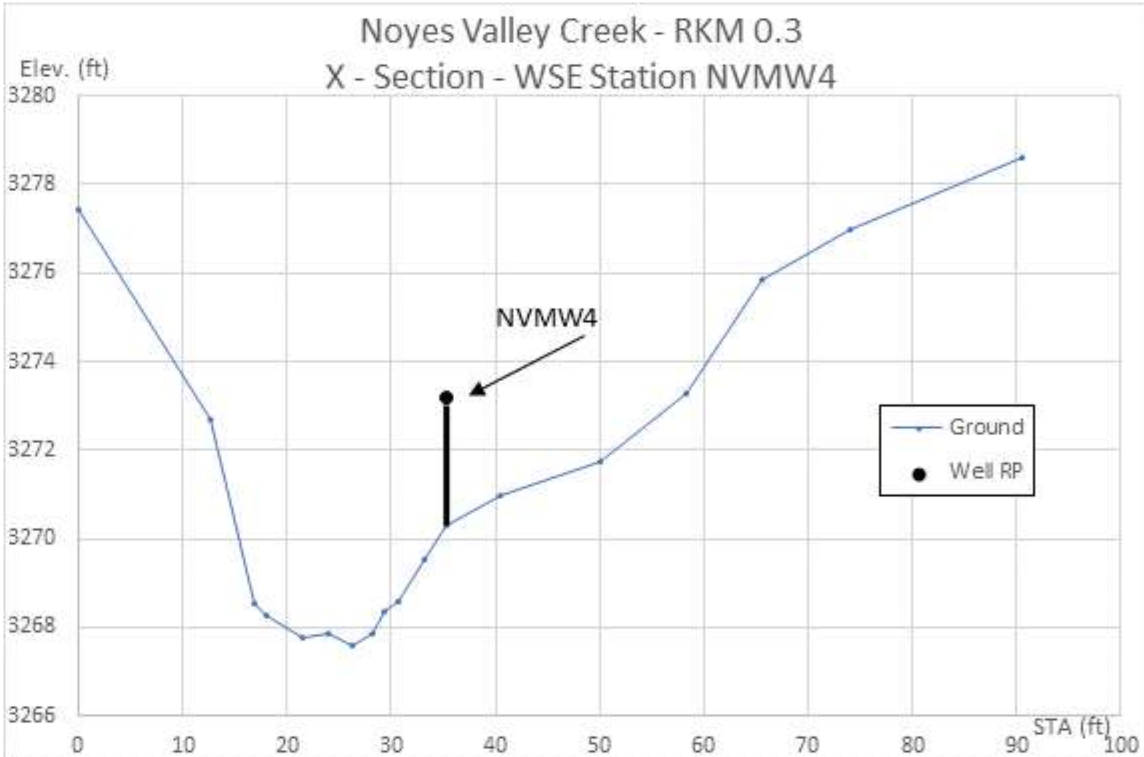


Figure 5.25: NVMW4 - Cross section and WSE station location.

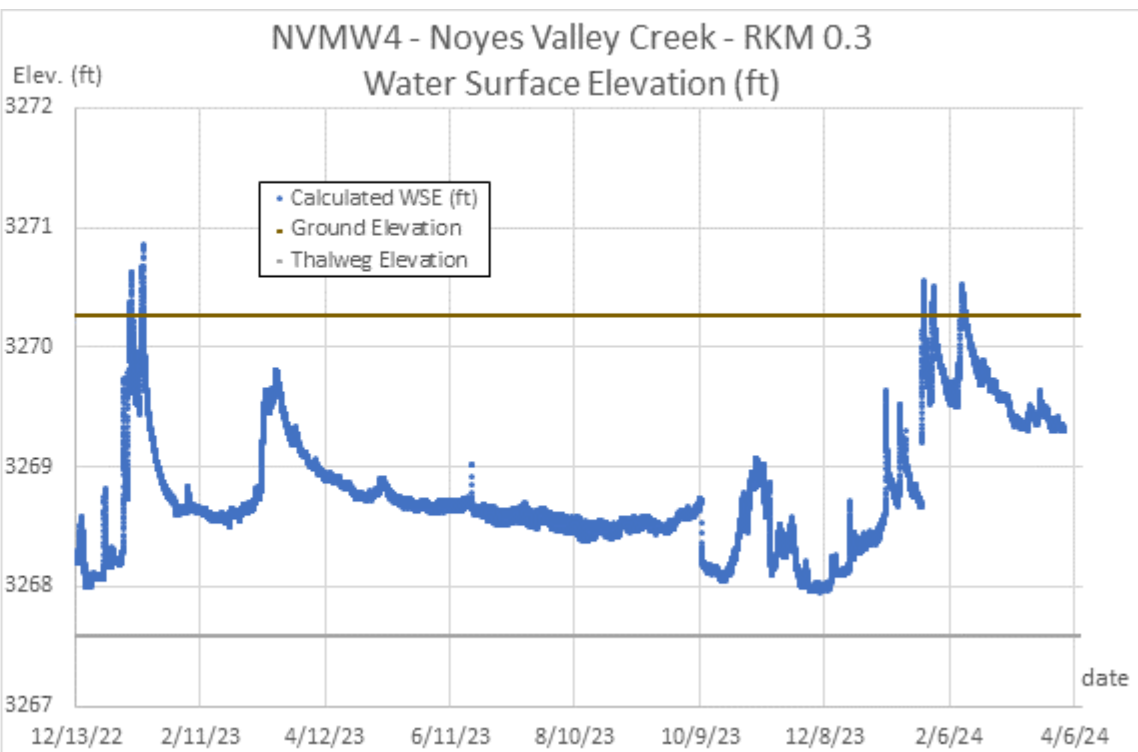


Figure 5.26: NVMW4 - Continuous WSE and ground elevation (ft).

Three WSE stations (NVMW1, NVMW2 and NVWM3) were established at the downstream transect (Transect #1) of Noyes Valley Creek at RKM 0.03 upstream of the confluence with the East Fork Scott River. Noyes Valley Creek is significantly confined in this location with the top of bank elevations approximately six (6) feet higher than the channel bed elevation. The river left WSE station (NVMW3) was installed in a depression with a ground elevation three (3) feet higher than the stream bed elevation and the river right WSE station (NVMW10) was installed in a location with the ground elevation five (5) feet higher than the stream bed elevation.

The WSE observed at the river left station has a pattern that deviates significantly from the WSE pattern observed in the other stations along Noyes Valley Creek due to the influence of the East Fork Scott River on this station (Figures 5.27 - 5.30). The effect of the East Fork Scott River on the river left (upstream East Fork location) is additionally illustrated in the comparison of the daily average WSE for the three stations of Transect #1 (Figure 5.31). Analysis of the daily average water temperature indicates a groundwater signal at the river right WSE station (NVMW1), a surface water signal at the Noyes Valley Creek WSE station (NVMW2) and a complicated signal at the river left WSE station (NVMW3) (Figure 5.32). The significant increase in temperature observed at the NVMW3 station that was not observed at any other station is hypothesized to be attributed to an influx of warm irrigation water into the ground at the station location.

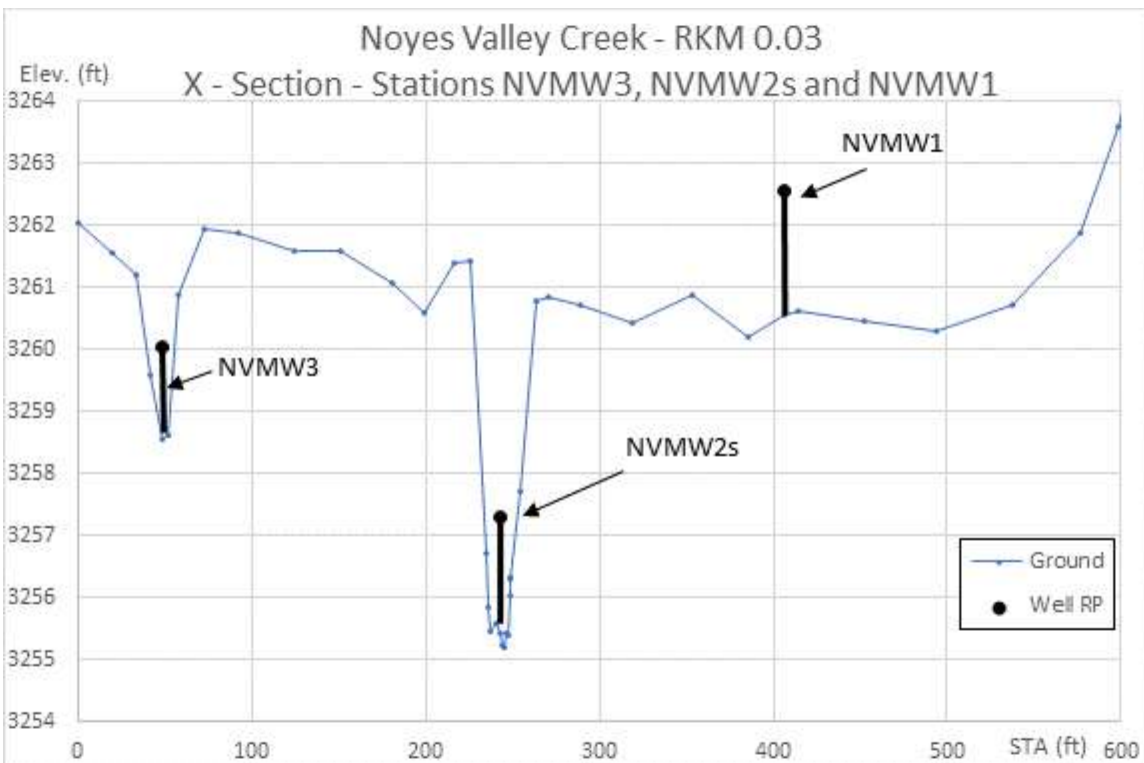


Figure 5.27: Transect #1 - NVMW3, NVMW2s and NVMW1 - Cross section and WSE station location.

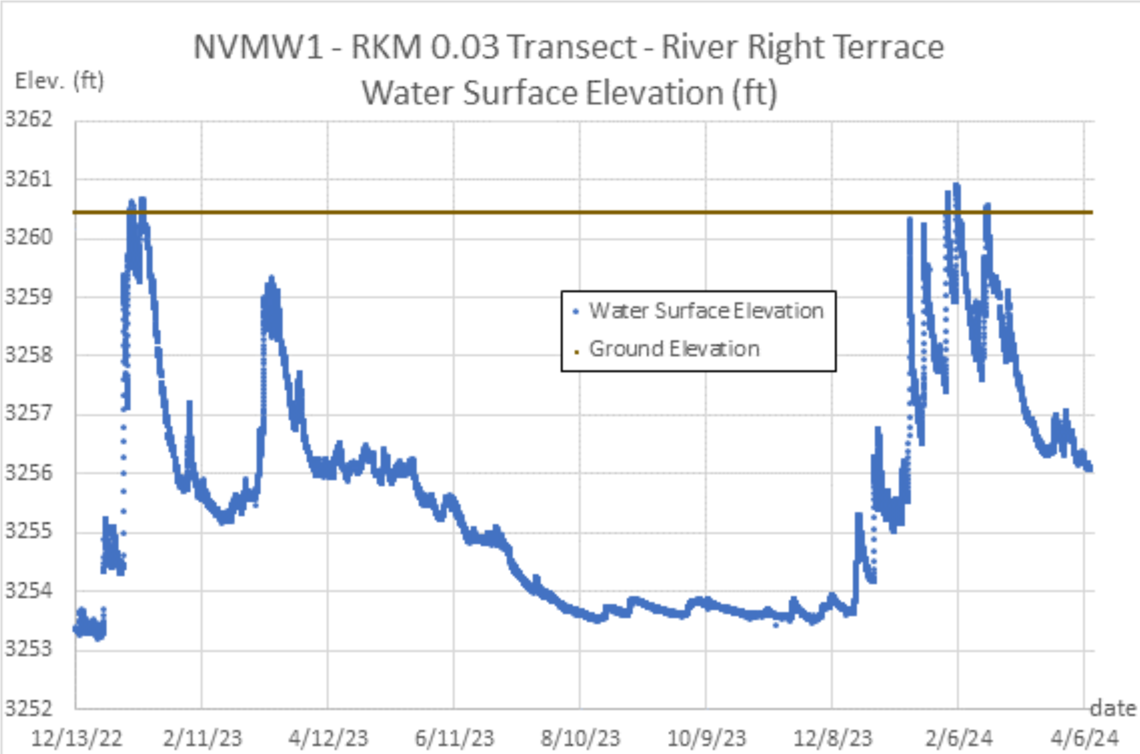


Figure 5.28: NVMW1 - Continuous WSE and ground elevation (ft).

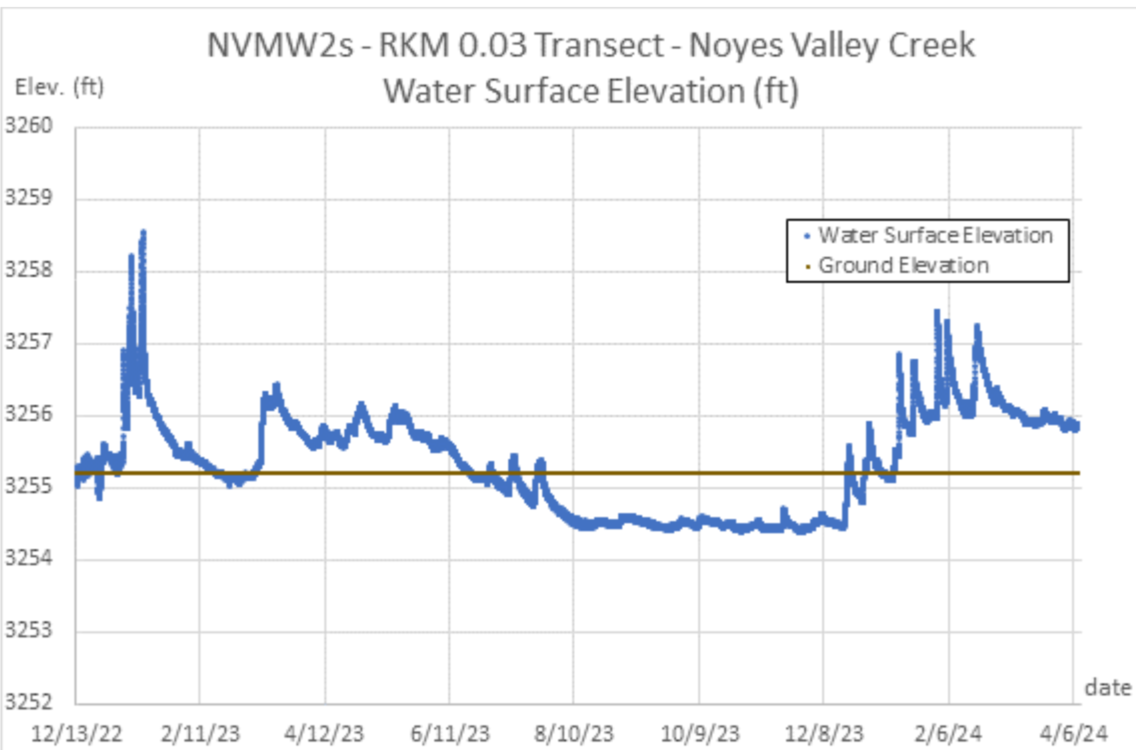


Figure 5.29: NVMW2s - Continuous WSE and ground elevation (ft).

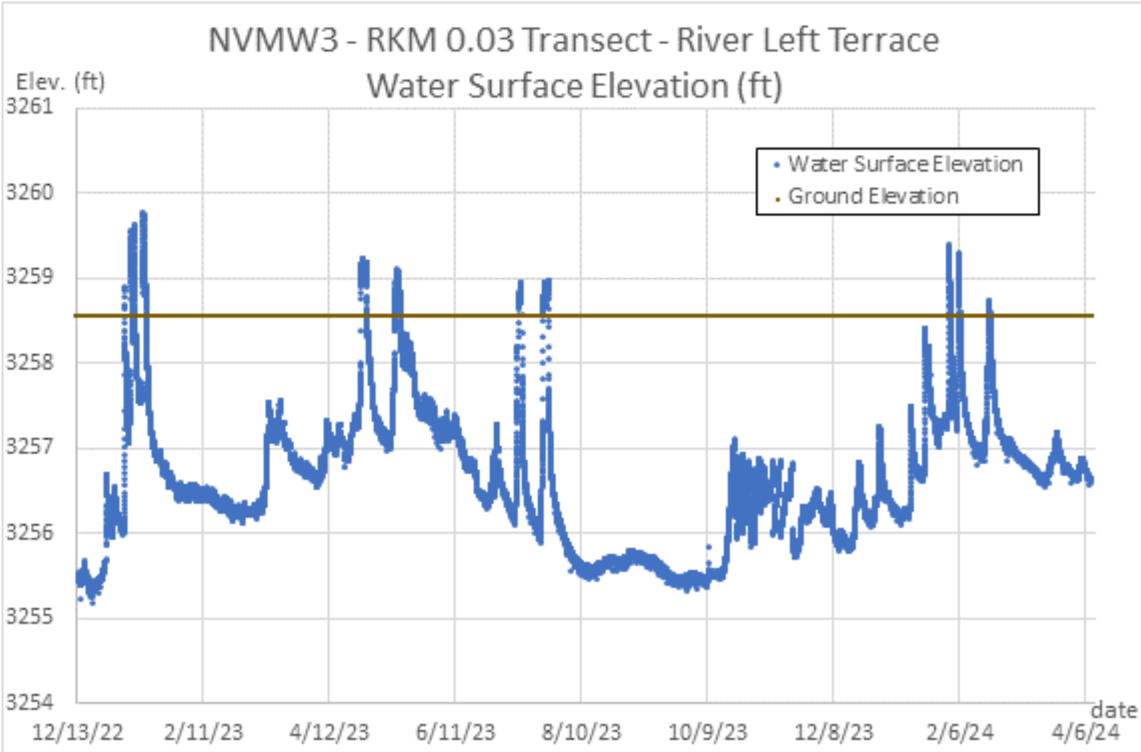


Figure 5.30: NVMW3 - Continuous WSE and ground elevation (ft).

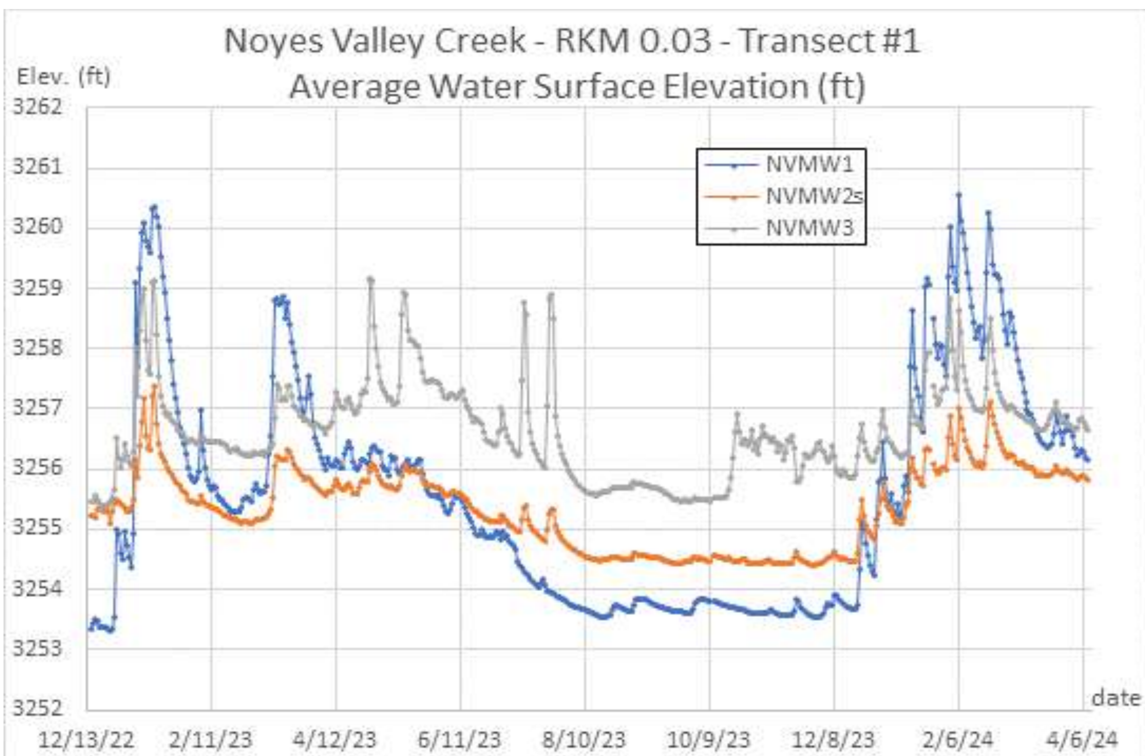


Figure 5.31: Transect #1 - Daily average WSE (ft).

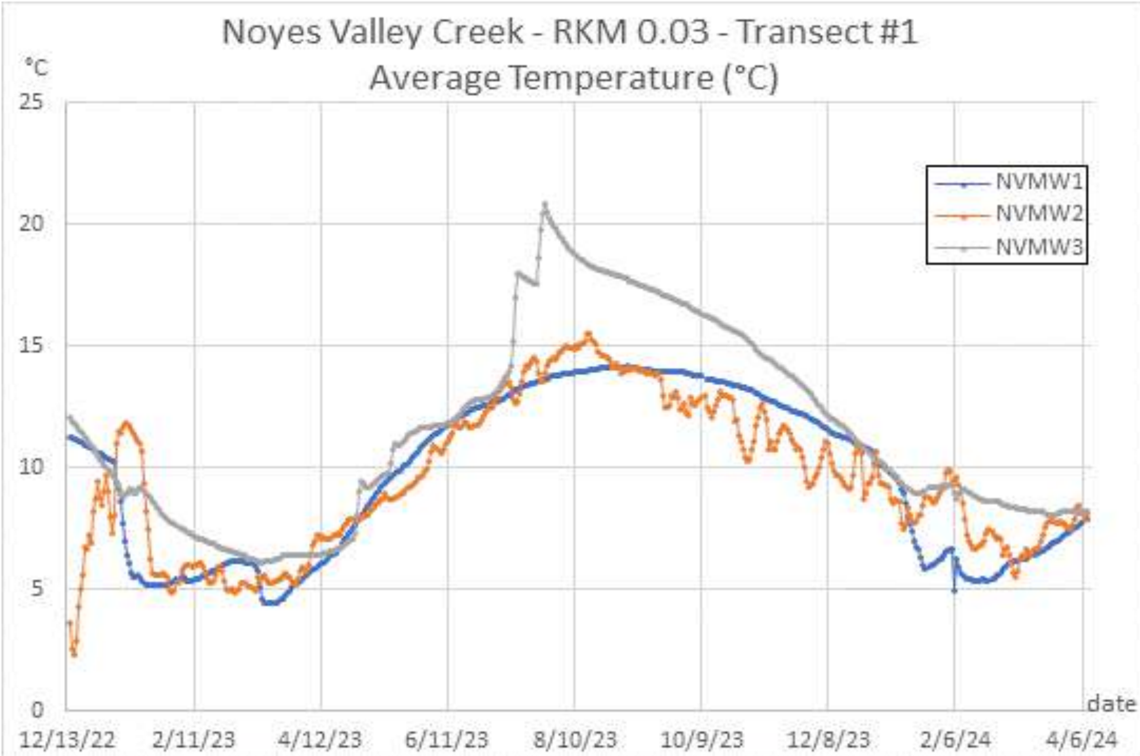


Figure 5.32: Transect #1 - Daily average temperature (°C).

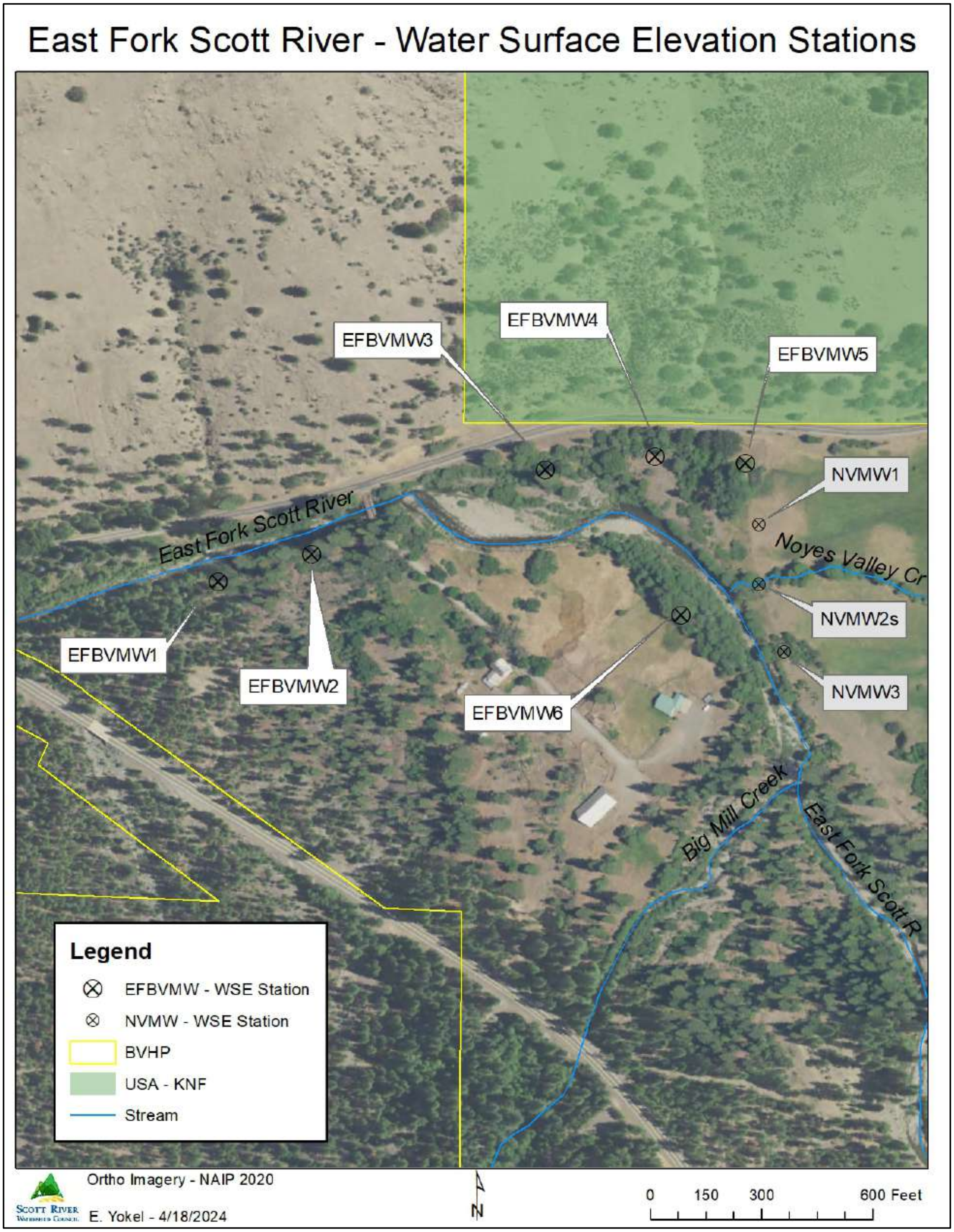
5.4.3 East Fork Beaver Valley (EFBV) Water Surface Elevation Stations

Locations for additional water surface elevation stations along the East Fork Scott River were identified during the restoration design process. Six water surface elevation stations were installed in locations of shallow groundwater adjacent to the East Fork Scott River on March 19, 2024 (Map 5.4).

Onset Computer Corporation U20L pressure transducers were placed in each WSE station documenting continuous (15 minute) water depth and temperature. The station's reference point (RP) and ground elevation (mean sea level - NAVD88) were documented using a RTK GNSS survey system (Table 5.2).

Table 5.2: Horizontal coordinates (SPC 401 - NAD83) and elevation (NAVD88) of the EFBV WSE stations.

Station	SPC 401 - N (ft)	SPC 401 - E (ft)	RP Elev. (ft)	Ground Elev. (ft)
EFBVMW1	2361660	6351350	3246.5	3244.7
EFBVMW2	2361734	6351602	3247.8	3246.3
EFBVMW3	2361985	6352192	3250.2	3249.3
EFBVMW4	2361998	6352527	3257.1	3255.2
EFBVMW5	2361980	6352772	3259.9	3257.9
EFBVMW6	2361570	6352597	3261.4	3259.8



Map 5.4: Location of EFBV and NVMW WSE stations.

5.5 Conclusion

The objective of future restoration actions are twofold within Noyes Valley Creek: Increase the seasonality of surface water. This could be done by promoting groundwater recharge within this low gradient subbasin of the East Fork Scott River. Additionally, increase the presence of beaver within Noyes Valley Creek and its low gradient valley morphology. Historical accounts document the presence of beaver and therefore indicate a likelihood that under favorable conditions, reoccupation is possible.

The restoration designs include the use of process based, beaver mimicry techniques. These are considered low tech and can be constructed using local youth, including students from the Quartz Valley Indian Reservation, the Karuk Tribe and SRWC's Youth Environmental Summer Studies (YESS) program. Material for these structures can be locally harvested and integrated into the overall forest management plan that is aimed at enhancing the biodiversity of BVHP and ensuring a more fire resilient landscape.

Chapter 6. Noyes Valley Creek - Restoration Planning and Design

6.1 Introduction

Beavers play a vital role in shaping and sustaining the intricate ecosystems of streams and wetlands, fostering rich biodiversity (Pollock, 2014). By mimicking the impact of beaver dams, Beaver Dam Analogs (BDAs) hold promise for initiating restoration efforts that encourage natural beaver colonization and the formation of new dam complexes (Charnley, 2018). The aim of BDAs is to create suitable habitats for beavers or enhance the success of reoccupation, thereby leading the recovery of stream environments (Castro, 2018).

BDAs promote sediment deposition and organic matter buildup behind dams, raising streambed levels, and reconnecting incised channels with their historic floodplains. SRWC has implemented a series of BDAs in other locations within the Scott River watershed. The sturdy construction of BDAs allows for their use in early stream succession stages, preventing breaches by high-velocity flows that would typically occur in natural beaver-built dams.

Beavers show a preference for constructing dams in small- to medium-sized streams within unconfined valleys, typically starting with the lowest gradient sites (slope < 1-2%) (Castro, 2018). Like numerous regions in the Scott Valley, Noyes Valley Creek is characterized by its low gradient, lying within a valley floor. Today, beaver signs have been documented in the lower reach, close to the confluence with the East Fork Scott River. Over the past few decades, significant beaver activity, including the construction of large dams, ponds, and tree chewing, has been observed in the upper section of Noyes Valley Creek (Photo 6.1).

Photo 6.1: Footprint of a formal beaver pond. The dam has broken down over time, but evidence of its structure remains. Beaver chewed a conifer that once stood in ponded water behind the beaver dam (Gilmore 2024). April 28, 2024.

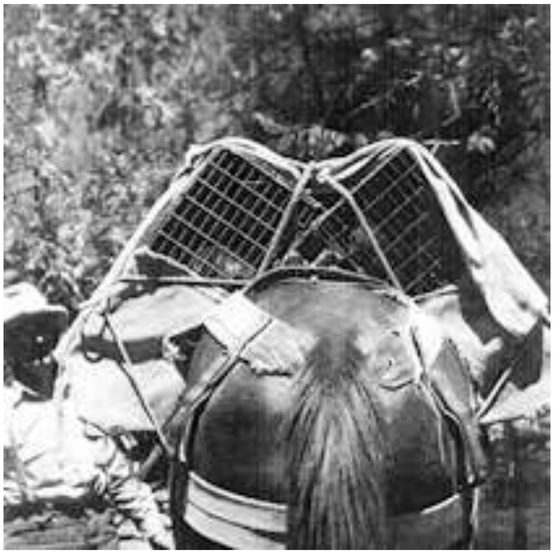
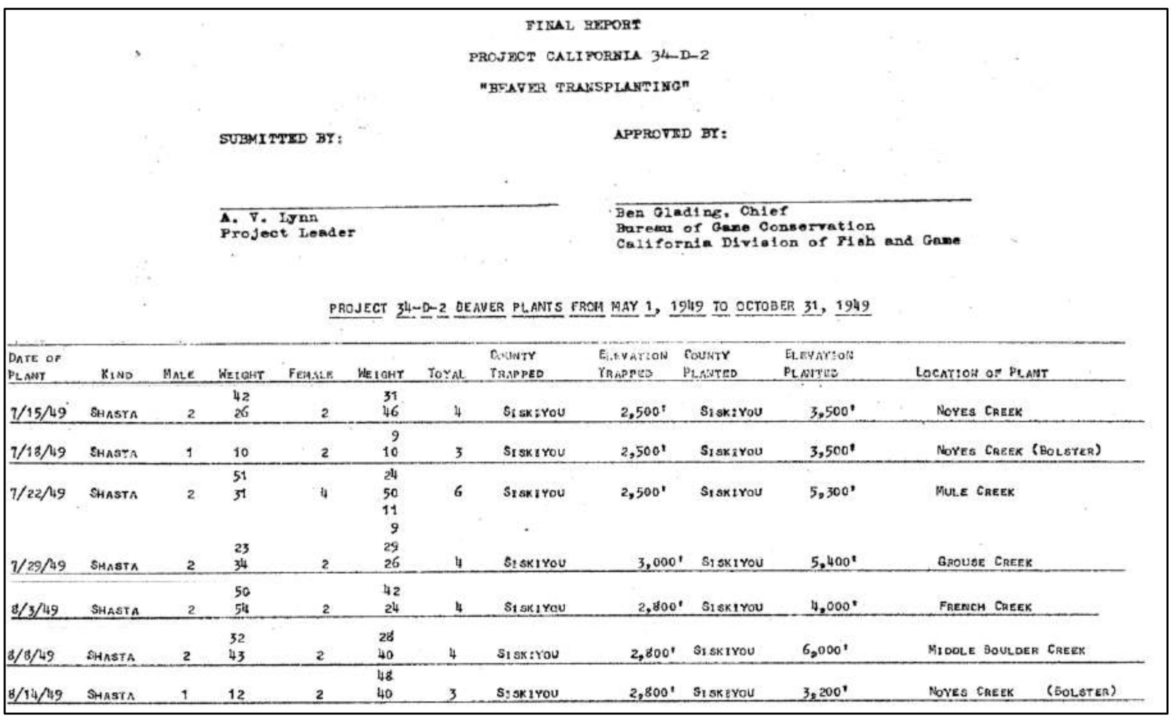


Photo 6.2: Clyde Fowler packs live beaver into the mountains near Callahan, circa 1940s (Siskiyou History Alliance 2024).

Clyde Fowler's documentation of relocation efforts in the Callahan area (Photo 6.2) offers a fascinating insight into the dynamic history of environmental management and conservation in the region.

Historical record reveals a compelling narrative of beaver transplantation in Noyes Valley Creek, tracing back to 1949 (Lundquist et al., 2013). This documentation provides evidence of a deliberate attempt to bolster local ecosystems through the introduction of beavers. Specifically, between July 15 and August 14, 1949, a total of ten beavers, comprising four males and six females, were carefully translocated to Noyes Valley Creek, marking a pivotal moment in the region's conservation history.

There are historical records that document these relocation efforts (Figure 6.1). Such endeavors not only highlight the foresight of conservationists, but also underscore the ongoing commitment to the importance of beaver.



FINAL REPORT

PROJECT CALIFORNIA 34-D-2

"BEAVER TRANSPLANTING"

SUBMITTED BY:

A. V. Lynn
Project Leader

APPROVED BY:

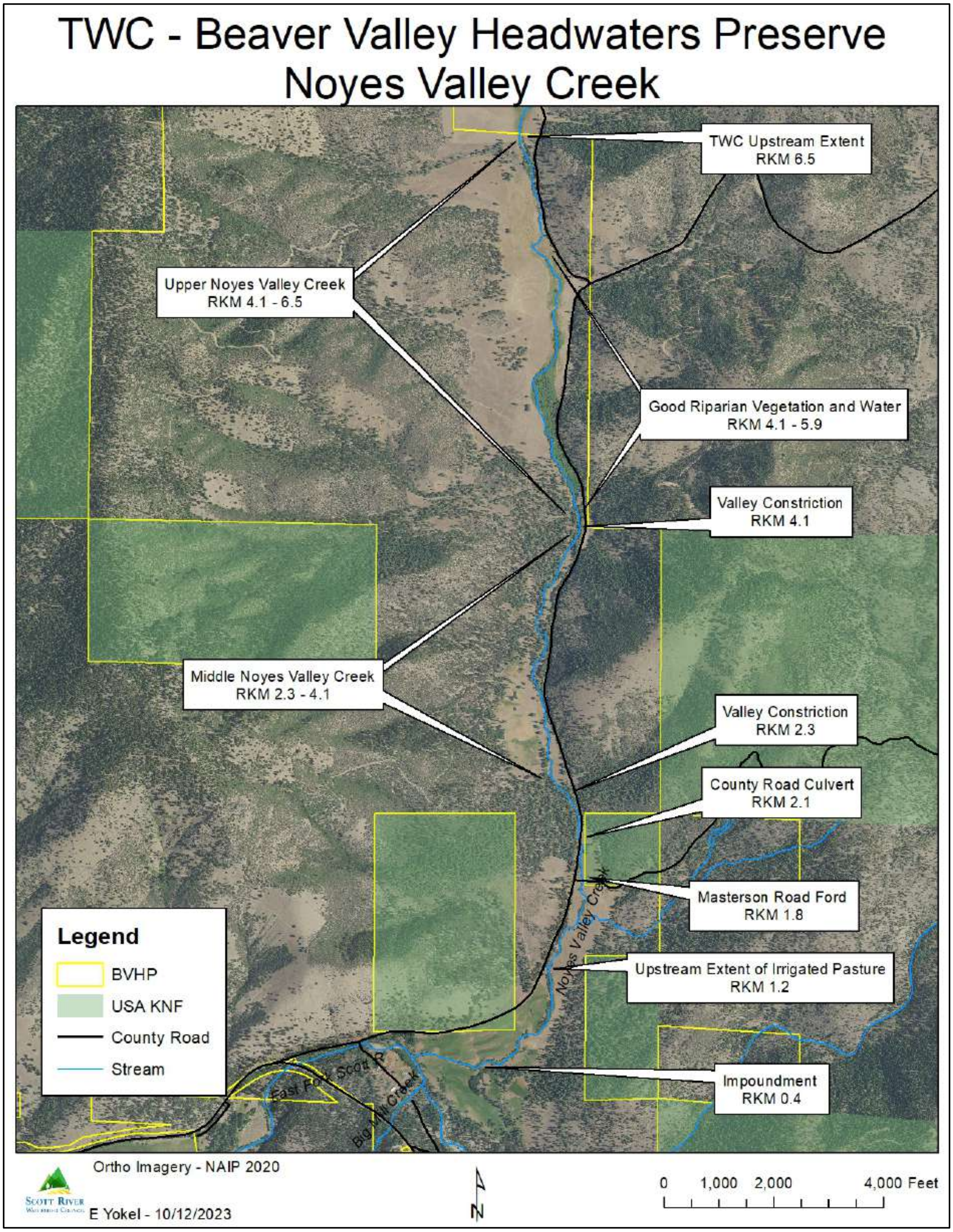
Ben Glading, Chief
Bureau of Game Conservation
California Division of Fish and Game

PROJECT 34-D-2 BEAVER PLANTS FROM MAY 1, 1949 TO OCTOBER 31, 1949

DATE OF PLANT	KIND	MALE	WEIGHT	FEMALE	WEIGHT	TOTAL	COUNTY TRAPPED	ELEVATION TRAPPED	COUNTY PLANTED	ELEVATION PLANTED	LOCATION OF PLANT
7/15/49	SHASTA	2	42 26	2	31 46	4	SISKIYOU	2,500'	SISKIYOU	3,500'	NOYES CREEK
7/18/49	SHASTA	1	10	2	9 10	3	SISKIYOU	2,500'	SISKIYOU	3,500'	NOYES CREEK (BOLSTER)
7/22/49	SHASTA	2	51 31	4	24 50 11 9	6	SISKIYOU	2,500'	SISKIYOU	5,300'	MULE CREEK
7/29/49	SHASTA	2	23 34	2	29 26	4	SISKIYOU	3,000'	SISKIYOU	5,400'	GROUSE CREEK
8/3/49	SHASTA	2	50 54	2	42 24	4	SISKIYOU	2,800'	SISKIYOU	4,000'	FRENCH CREEK
8/8/49	SHASTA	2	32 43	2	28 40	4	SISKIYOU	2,800'	SISKIYOU	6,000'	MIDDLE BOULDER CREEK
8/14/49	SHASTA	1	12	2	48 40	3	SISKIYOU	2,800'	SISKIYOU	3,200'	NOYES CREEK (BOLSTER)

Figure 6.1: Excerpts from the Historic Range of Beaver in the North Coast of California: A Review of the Evidence (Lundquist et al 2013) regarding transported beaver in 1949 within Scott Valley, including Noyes Valley Creek.

The Noyes Valley Creek encompasses 4.0 miles (6.5 kilometers) from the confluence with the East Fork Scott River to the upstream extent at the property boundary (Map 6.1).



Map 6.1: Noyes Valley Creek.

6.2 Purpose

- Provide restoration designs utilizing process-based restoration techniques, specifically beaver dam analogs (BDAs), as seen in other areas where SRWC has employed this restoration method within the watershed since 2014. The anticipated benefits are to encourage groundwater recharge, potentially enhancing summer baseflow conditions improved water quality in the East Fork of the Scott River and reoccupation of beaver.

6.3 Methods

An analysis of the existing conditions of the stream channel and floodplain elevations, the density, height and condition of the riparian vegetation and surface water and groundwater elevations was performed in Noyes Valley Creek using remote sensing products and on the ground monitoring to identify restoration opportunities and guide restoration planning and design.

Three restoration reaches were identified in Noyes Valley Creek: Upper Noyes Valley Creek (RKM 4.1 - 6.5) from the upstream property boundary to a point of valley constriction, Middle Noyes Valley Creek (RKM 2.3 - 4.1) between two points of valley constriction and Lower Noyes Valley Creek (RKM 0 - 1.8) from the Masterson Road low water crossing to the confluence with the East Fork Scott River. The reach between RKM 1.8 and 2.3 was not considered for restoration planning due to the county road infrastructure adjacent to Noyes Valley Creek.

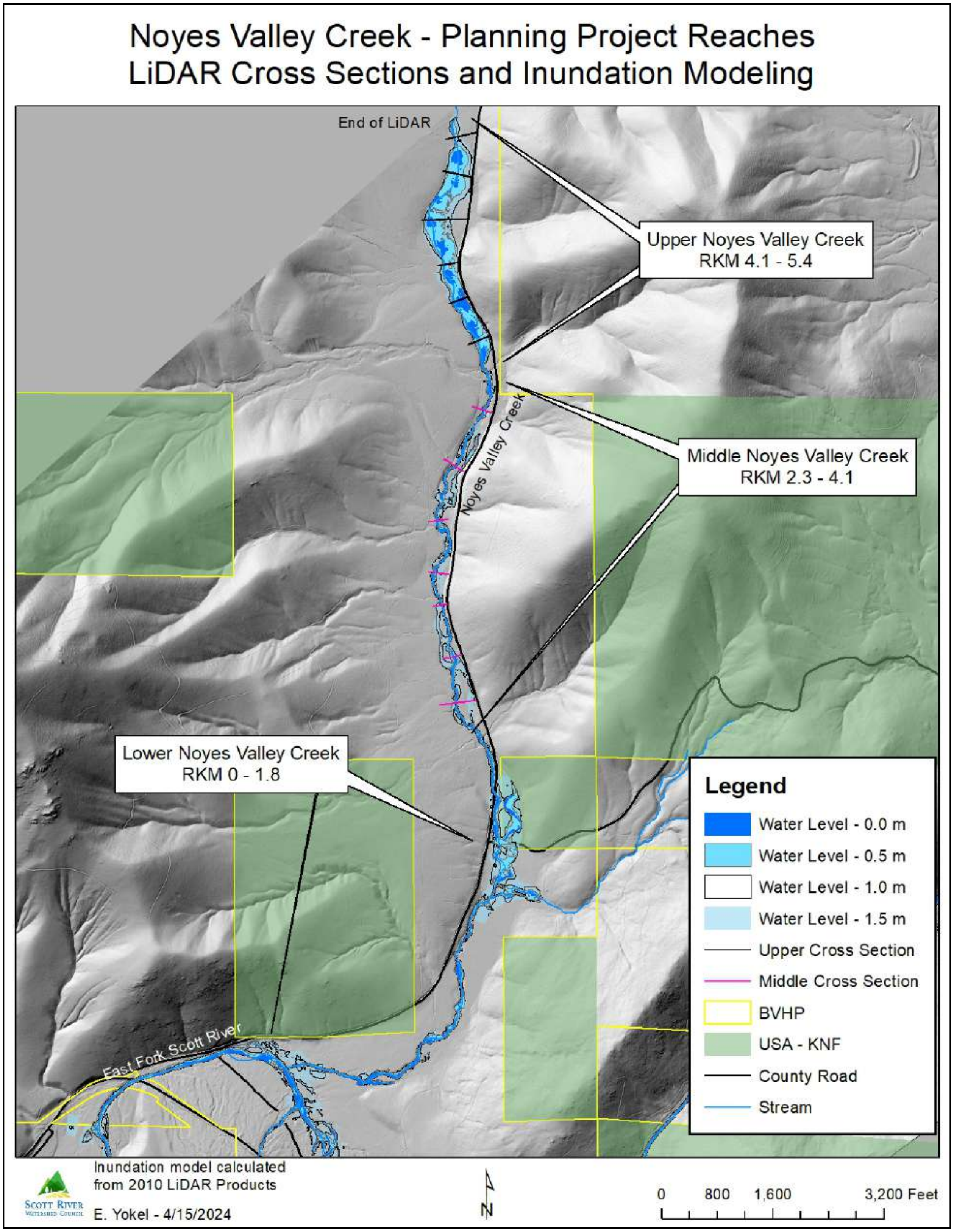
Inundation modelling of the Noyes Valley Creek floodplain was performed in the River Bathymetry Toolkit using the 2010 LiDAR bare earth DEM to illustrate the areas of relatively low elevation floodplain terraces adjacent to the stream channel (Map 6.2). Classified canopy heights were calculated using the 2010 LiDAR bare earth DEM and highest hits DSM for a 600 ft wide corridor (300 ft on each side of the stream) to illustrate the vegetation density and height adjacent to the stream channel (Map 6.3).

A longitudinal profile of Noyes Valley Creek was generated from the 2010 LiDAR bare earth DEM for the extent of the LiDAR (Noyes Valley Creek RKM 5.4) to the confluence with the East Fork Scott River (Figure 6.1). The gradient for the entire reach (1.3%) and for the three planning reaches was calculated (Table 6.1). The Upper Reach is higher gradient (1.7%) than the Middle Reach (1.1%) and Lower Reach (1.2%).

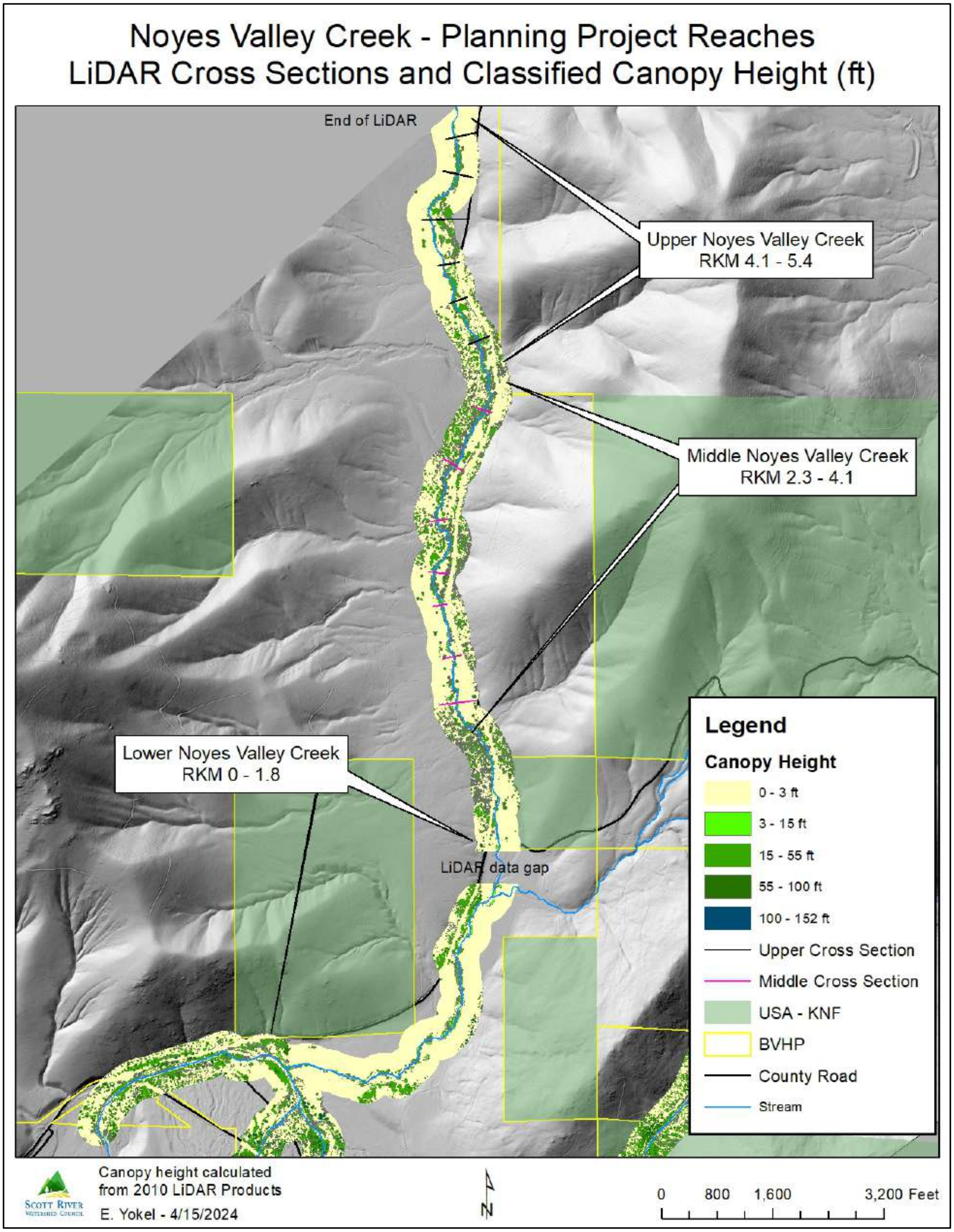
The SRWC established ten water surface elevation (WSE) stations in the Lower Reach and five WSE stations in the Upper Reach to document the WSE of the surface water and adjacent shallow groundwater. The results of the WSE monitoring are reported in Chapter 5.

Noyes Valley Creek has areas with high density of riparian vegetation (primarily willow) and areas of sparse to no riparian vegetation. Most of the extent riparian vegetation is mature to decadent with little recruitment of new vegetation observed. Noyes Valley Creek runs through areas of pasture with no fencing to exclude grazing within the stream, floodplain and riparian corridors. The area of available floodplain and low elevation terraces in Noyes Valley Creek varies from a wide floodplain in the Upper Reach to a confined narrow stream with limited floodplain in the Middle and Lower Reaches. Multiple sites of actively eroding vertical banks were observed in the Lower and Middle Reaches.

The SRWC has developed a stream restoration and protection plan for Noyes Valley Creek that includes riparian exclusion fencing, and alternative stock water systems in the Upper, Middle and Lower Reaches and instream structures in the Upper and Middle Reaches (Map 6.4). The SRWC proposes a low tech processed based restoration approach to the design and implementation of the instream structures. Cascade Stream Solutions, the SRWC and the project partners developed engineered stream restoration designs for the Lower Reach. Cascade Stream Solutions acquired LiDAR bare earth DEMs of Lower Noyes Valley Creek reach on September 14, 2023, and the Middle and Upper reaches on April 8, 2024, for use as base maps in the design process (Map 6.5).



Map 6.2: Inundation model of Noyes Valley Creek.



Map 6.3: Classified canopy height of Noyes Valley Creek.

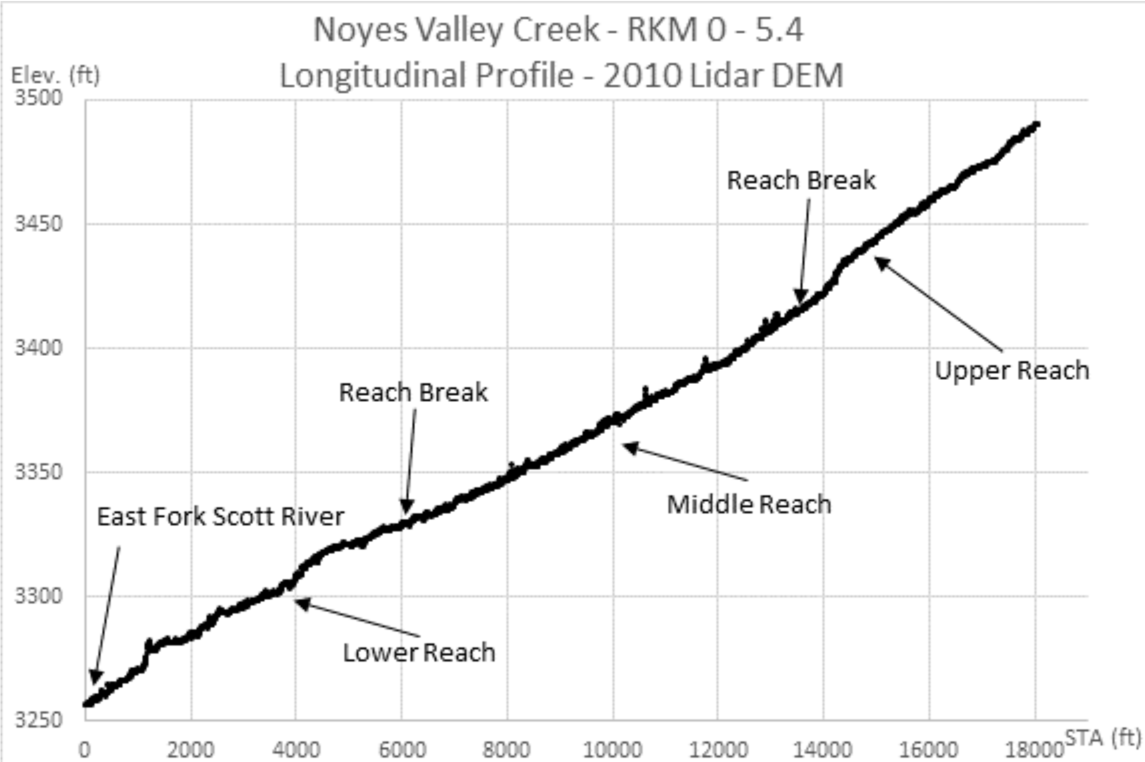
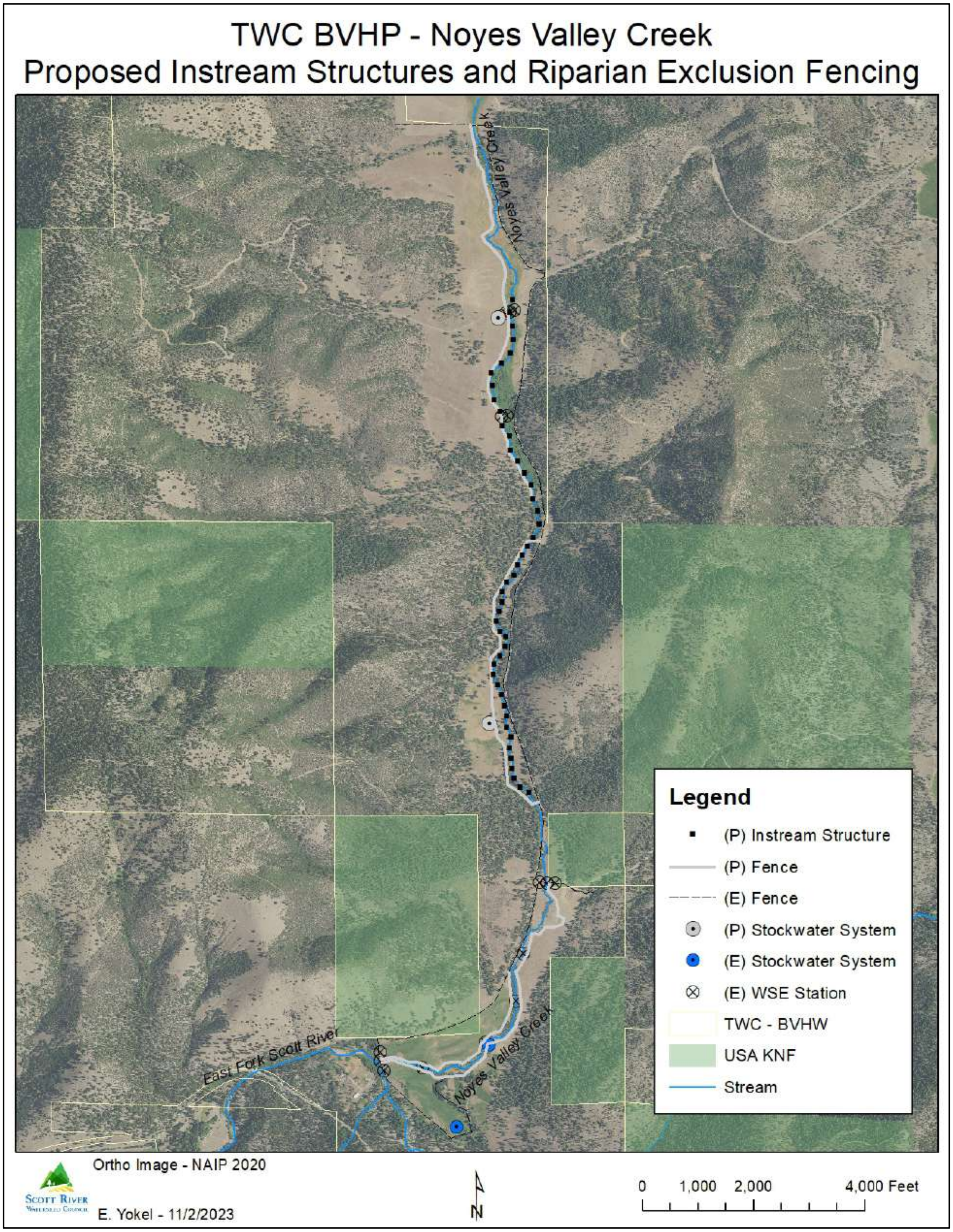


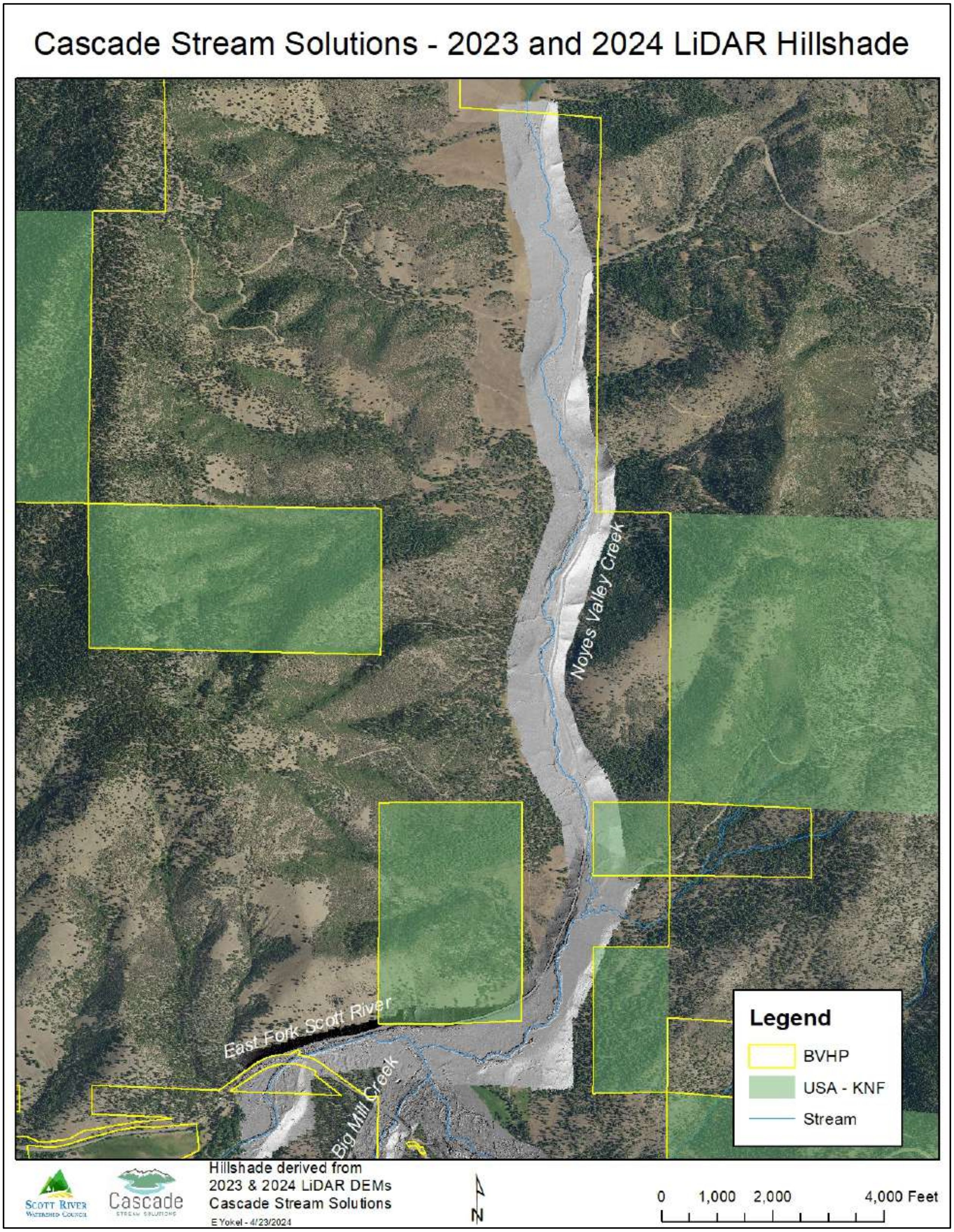
Figure 6.1: Longitudinal profile for 2010 Lidar DEM – Noyes Valley Creek - RKM 0 - 5.4.

Table 6.1: Stream gradient by reach.

Reach	RKM From	RKM To	Percent Gradient
Noyes Valley Creek	0	5.4	1.3%
Lower Reach	0	1.8	1.2%
Middle Reach	1.8	4.1	1.1%
Upper Reach	4.1	5.4	1.7%



Map 6.4: Proposed fencing, stock water systems and instream structures - Noyes Valley Creek.



Map 6.5: LiDAR hillshade model of Noyes Valley Creek and East Fork Scott River.

6.4 Results

6.4.1 Upper Noyes Valley Creek Reach

Photo 6.1: Upper Noyes Valley Creek - looking downstream (left) and upstream (right). April 16, 2024

The Upper Reach of Noyes Valley Creek (RKM 4.1 - 5.4) is a higher gradient (1.7%) stream (Figure 6.2) than the lower two reaches with the largest potential floodplain area per the inundation modeling (Map 6.6). The vegetation of the Upper Reach is a band of riparian vegetation (predominantly willow) of varying width adjacent to the stream and within the floodplain surrounded by irrigated pasture grasses (Map 6.7). Analysis of the classified canopy height illustrates that most of the riparian vegetation falls in the 15 - 55 ft class with areas of 3 - 15 ft tall vegetation. Most of the riparian vegetation is mature to senescent with little natural recruitment observed. There is no riparian exclusion fencing in the Upper Reach allowing cattle to graze throughout the riparian corridor and traverse across the stream bed and banks.

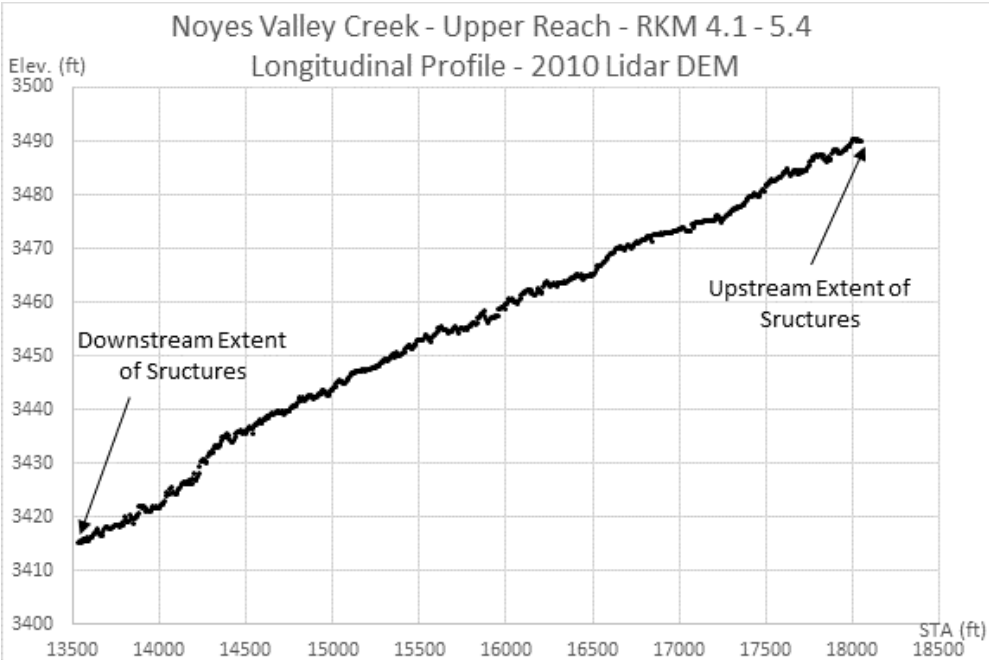
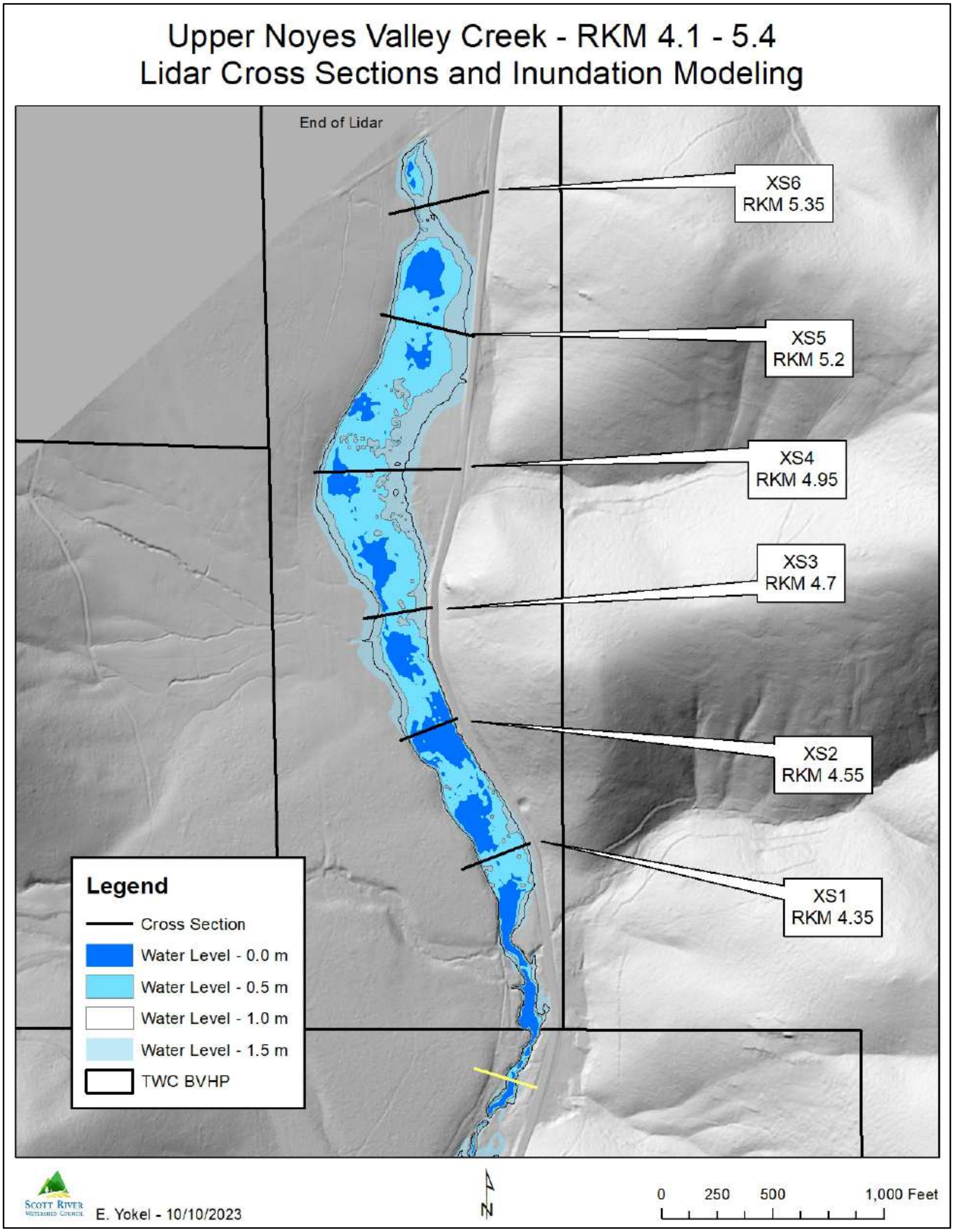
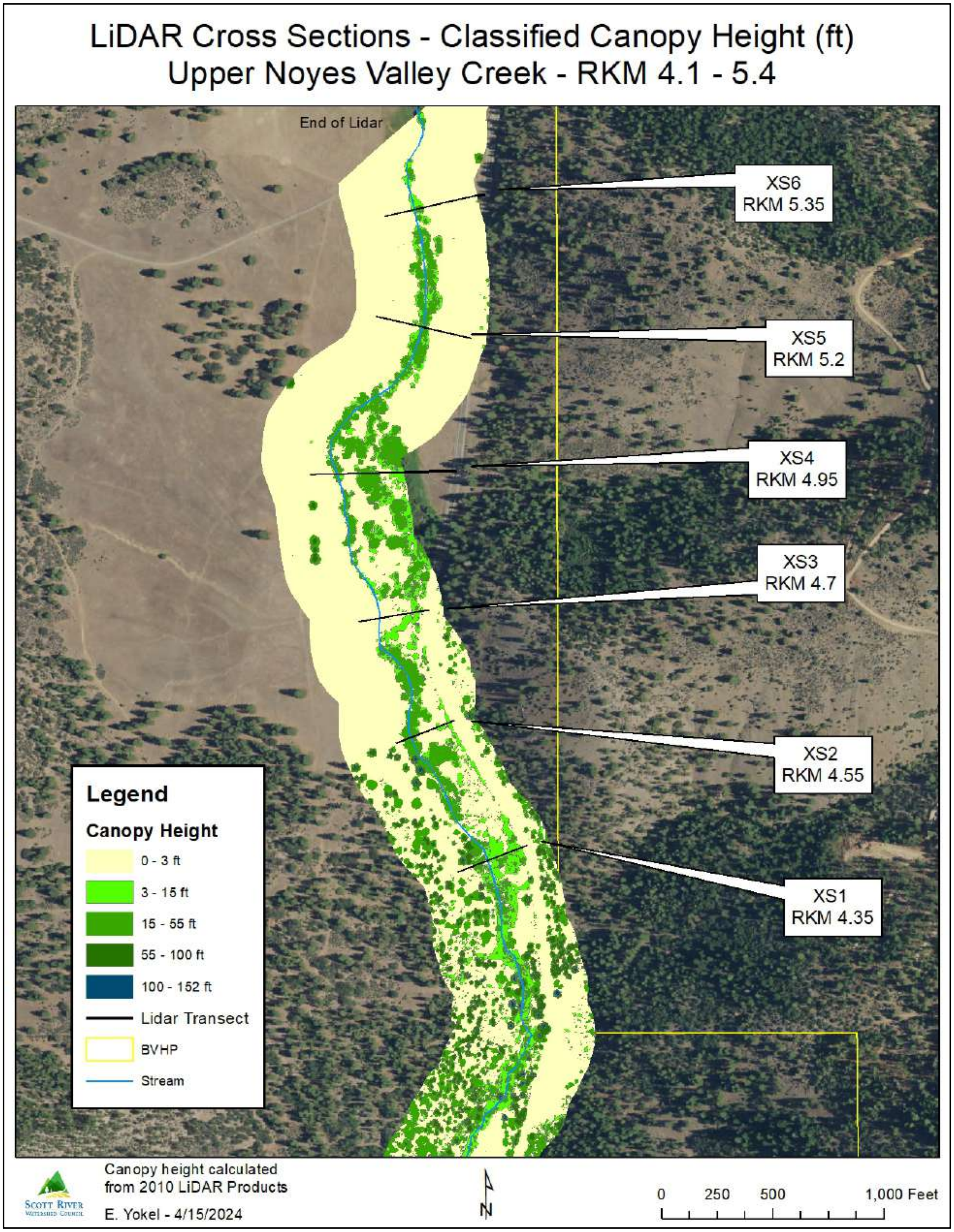


Figure 6.2: Longitudinal profile of Noyes Valley Creek (RKM 4.1-5.4) showing the gradient (1.7%).

The 2010 LiDAR bare earth DEM was utilized to analyze six representative cross sections in the Upper Reach (Figures 6.3 - 6.8). The approximate width of a two-foot-high channel spanning structure was calculated for each cross section. In the approximately 4,500 ft long Upper Reach of Noyes Valley Creek eighteen (18) two-foot-high instream structures are proposed with a spacing of approximately 250 feet. The average structure width is approximately 200 feet. A two-foot-high structure could backwater almost 120 ft of the upstream stream. In addition to the structures, riparian exclusion fencing and a stock water system is proposed to remove the impacts of grazing in the riparian area and stream channel (Map 6.8).



Map 6.6: Inundation model and location of LiDAR cross sections - Upper Noyes Valley Creek.



Map 6.7: Classified canopy height and LiDAR cross sections - Upper Noyes Valley Creek.

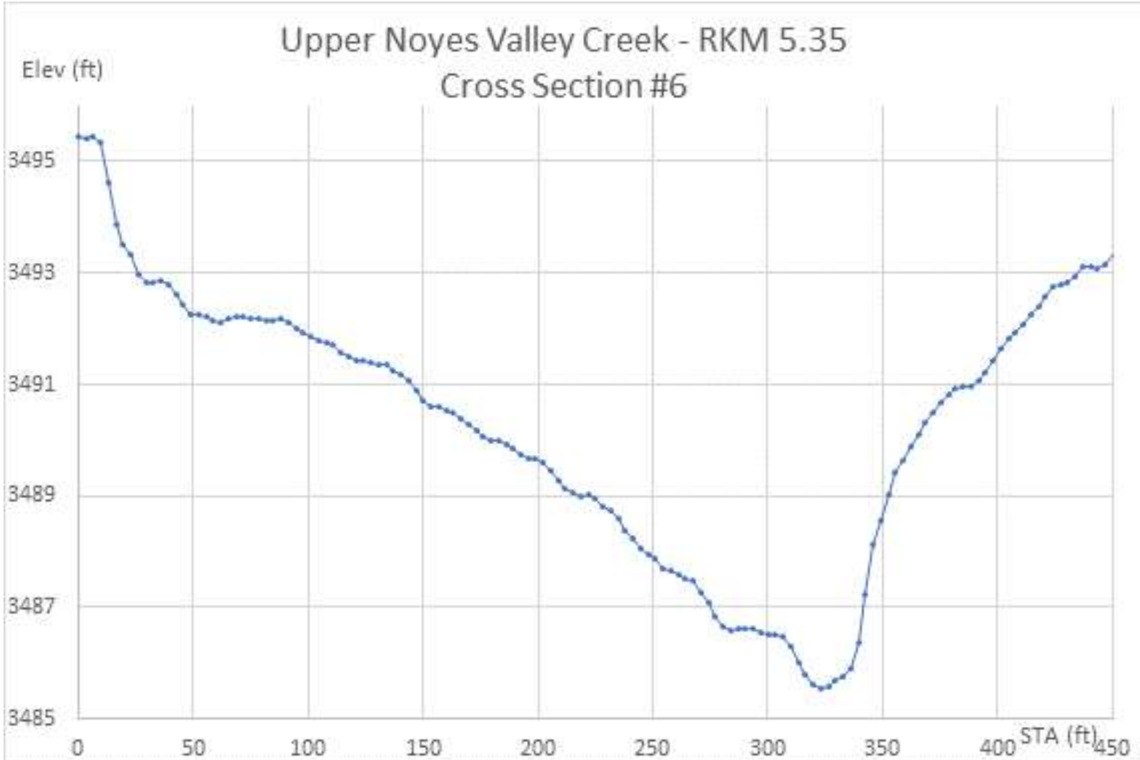


Figure 6.3: Upper Noyes Valley Cross Section #6 - RKM 5.35 - 2 ft high structure - 90 ft width.

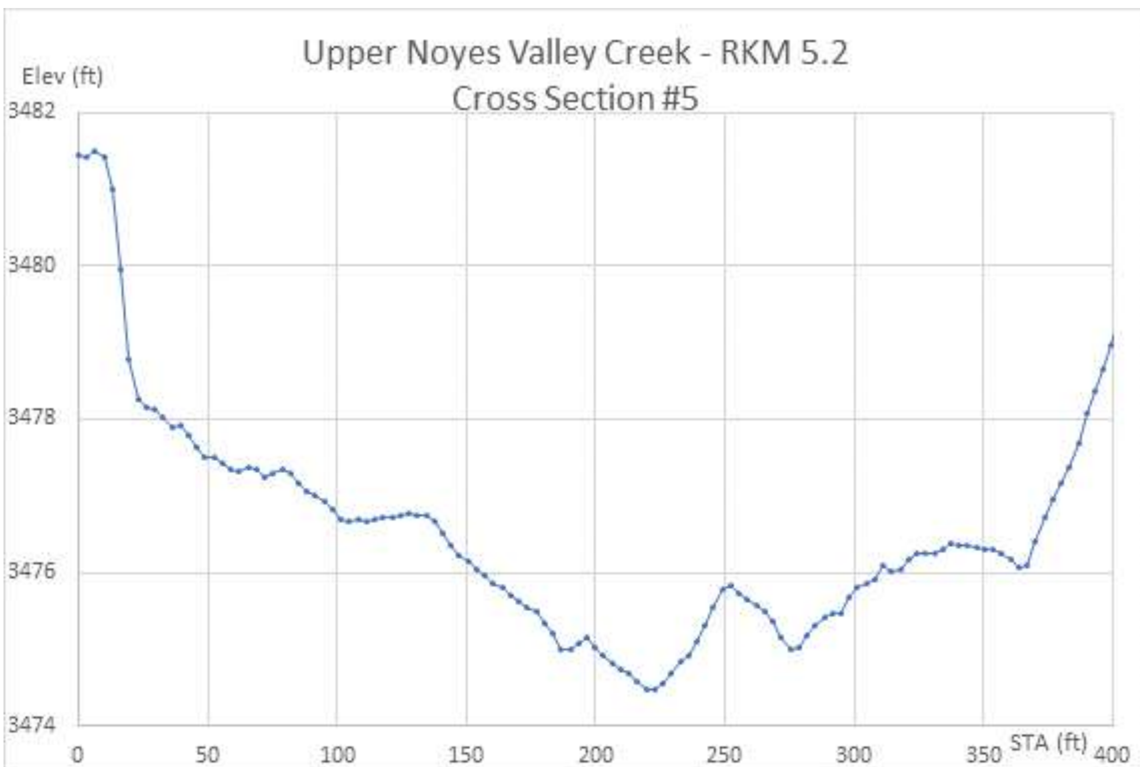


Figure 6.4: Upper Noyes Valley Cross Section #5 - RKM 5.2 - 2 ft high structure - 230 ft width.

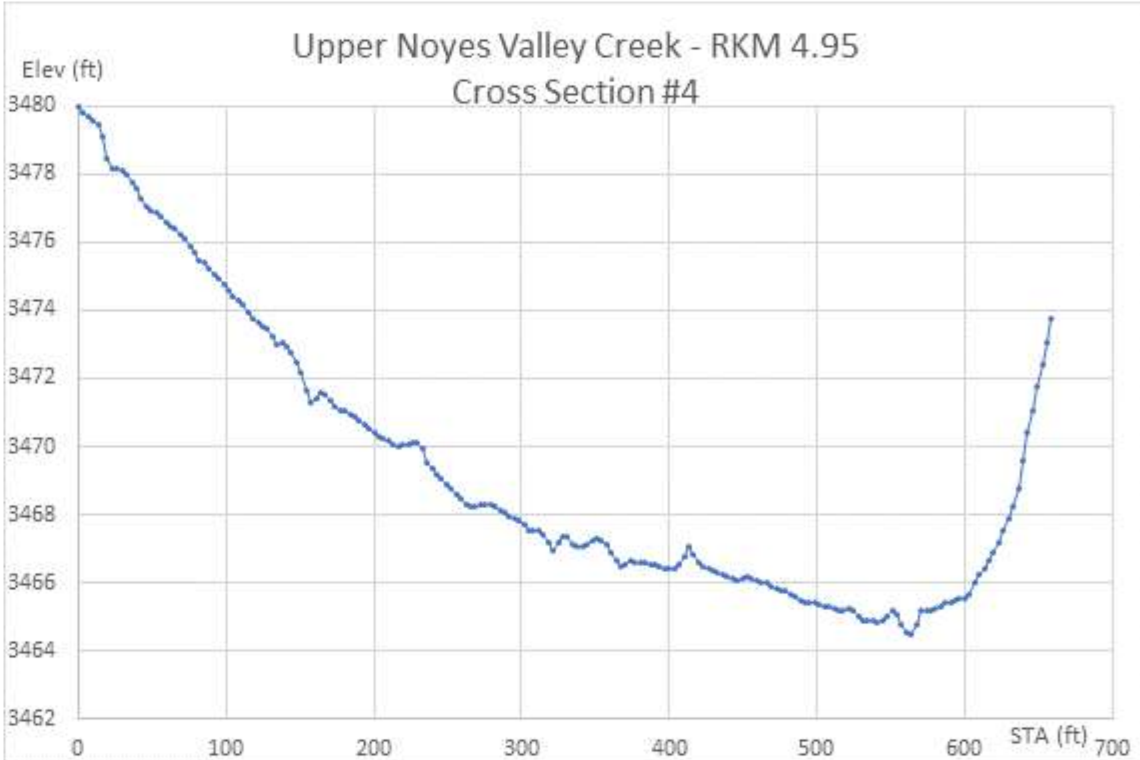


Figure 6.5: Upper Noyes Valley Cross Section #4 - RKM 4.95 - 2 ft high structure - 200 ft width.

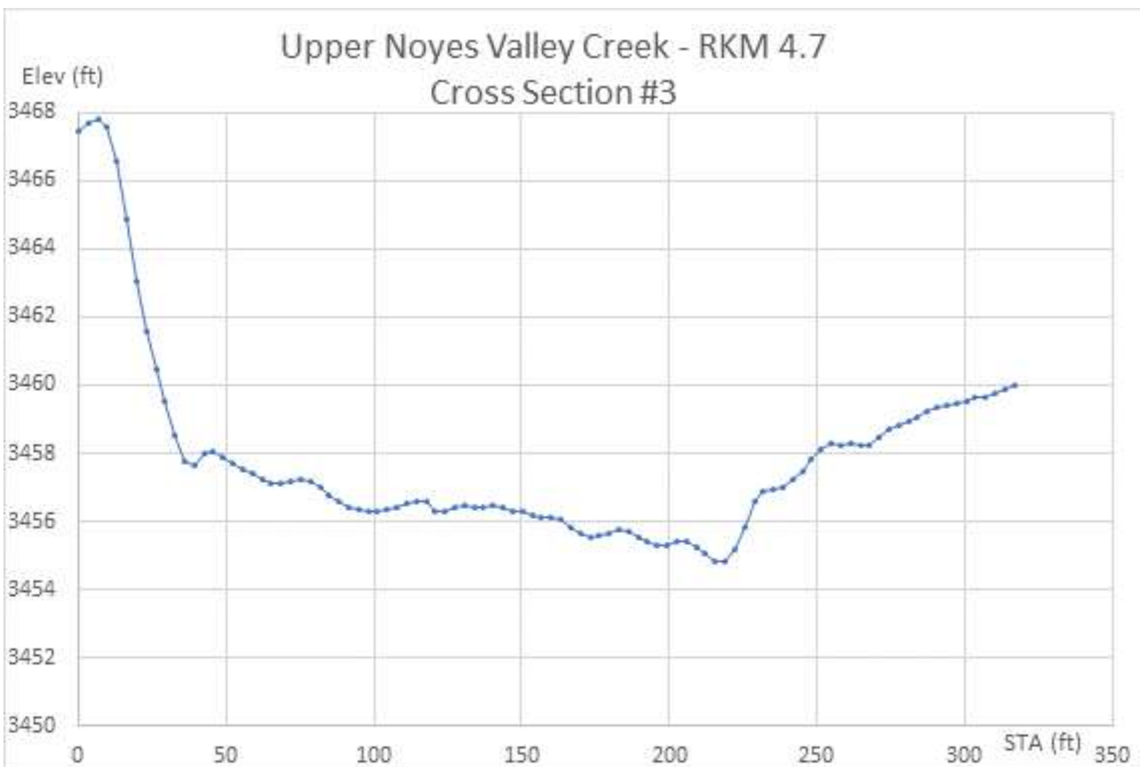


Figure 6.6: Upper Noyes Valley Cross Section #3 - RKM 4.7 - 2 ft high structure - 150 ft width.

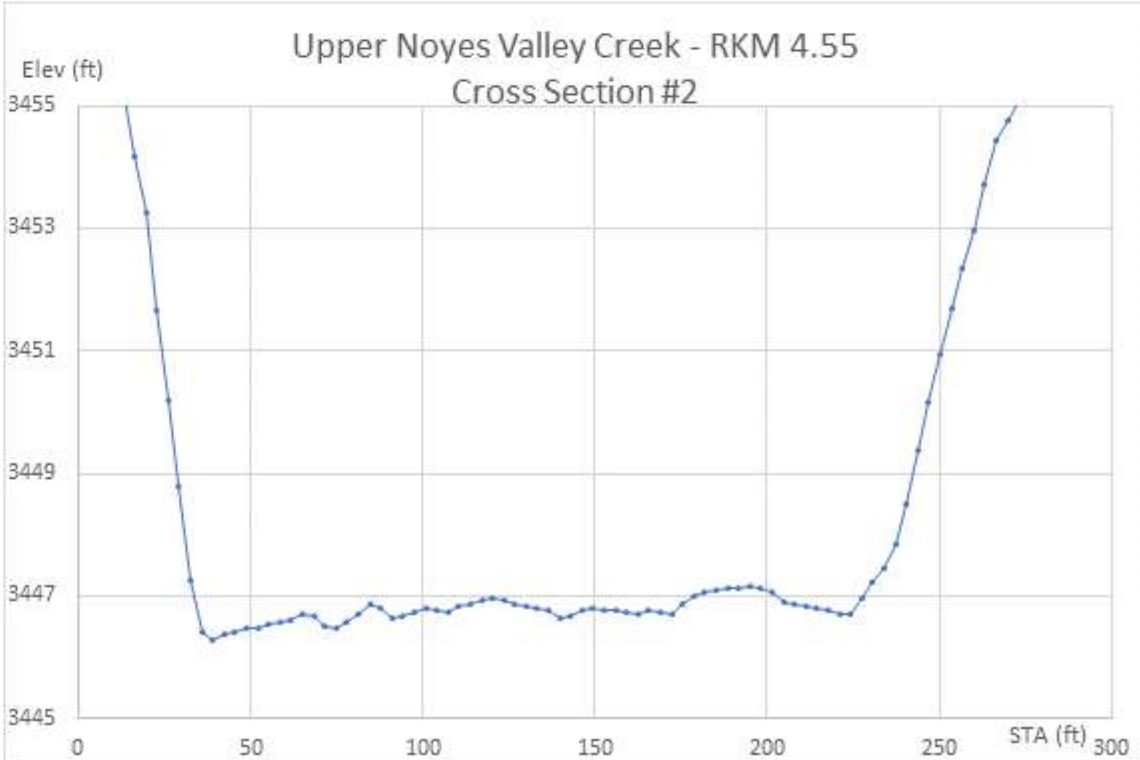


Figure 6.7: Upper Noyes Valley Cross Section #2 - RKM 4.55 - 2 ft high structure - 210 ft width.

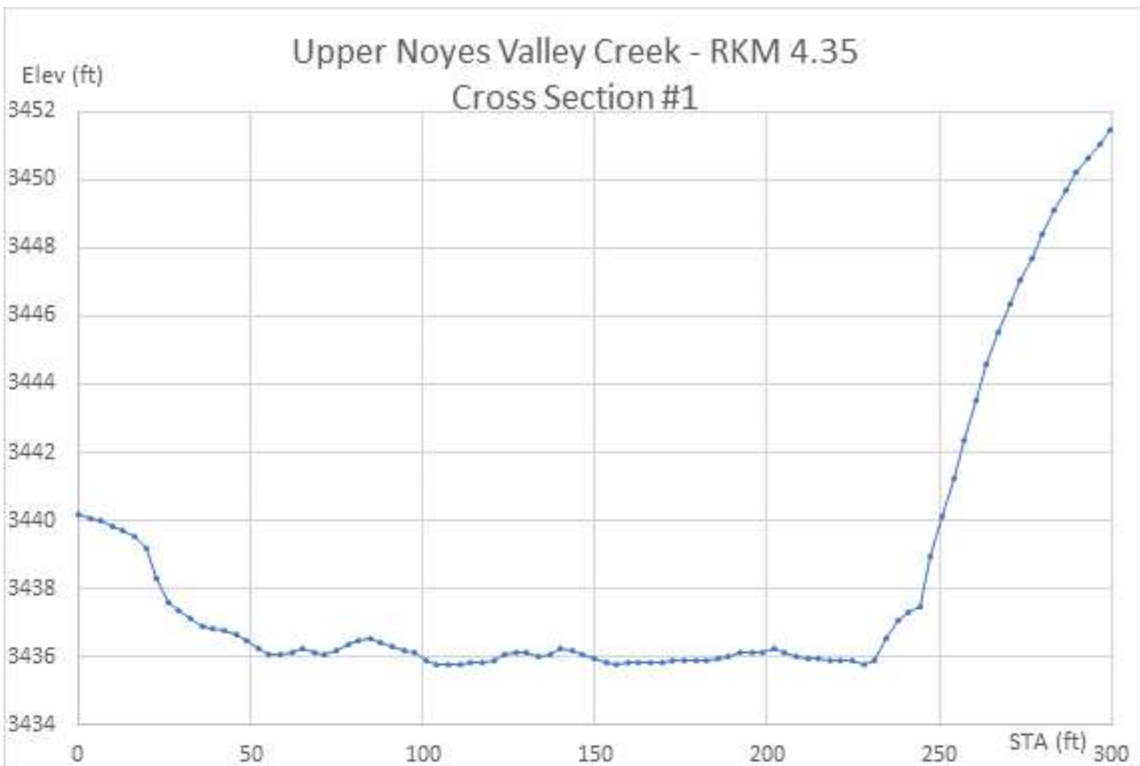
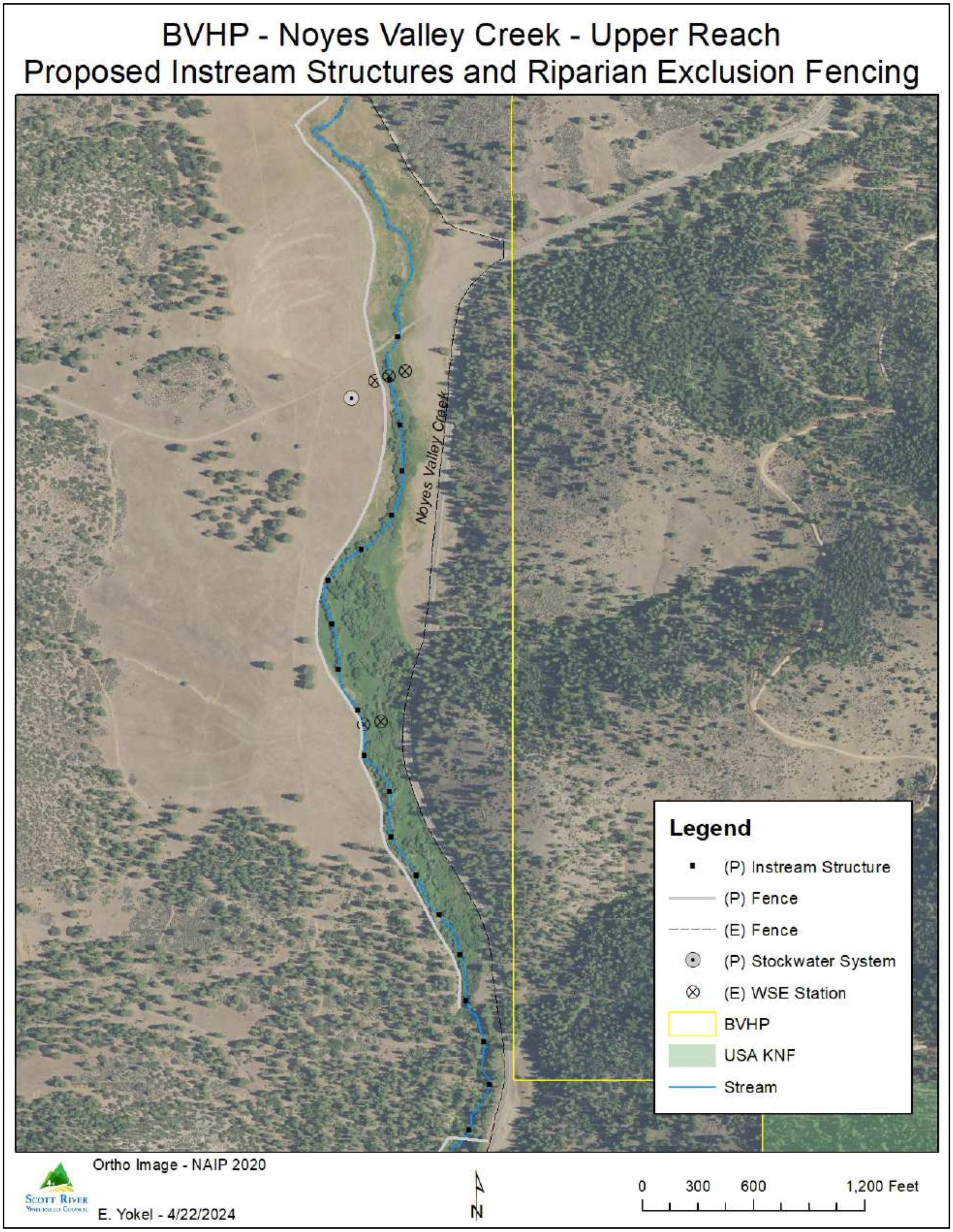


Figure 6.8: Upper Noyes Valley Cross Section #1 - RKM 4.35 - 2 ft high structure - 220 ft width.



Map 6.8: Proposed fencing, stock water system and instream structure locations - Upper Reach.

6.4.2 Middle Noyes Valley Creek Reach

Photo 6.2 and 6.3: Eroding stream bank – Middle Noyes Valley Creek (left photo) and looking downstream (right photo). April 16, 2024.

The stream channel and floodplain morphology in the Middle Reach is significantly different than the morphology in the Upper Reach (Photos 6.2 and 6.3). Most of the stream channel in the Middle Reach is confined with areas of steep banks and a limited floodplain. Analysis of the inundation model of the Middle Reach illustrates narrow areas of inundation around the majority of the channel with locations of lower elevation surfaces from presumed historic channel alignments (Map 6.9). The vegetation assemblage adjacent to the stream in the Middle Reach is also different from that observed at the Upper Reach with a narrow band of riparian vegetation in the stream channel and banks adjacent to large conifers and grazed pasture (Map 6.10).

Noyes Valley Creek in the Middle Reach has the gentlest gradient (1.1%) of the three reaches (Figure 6.9). Analysis of representative cross sections illustrates the confined morphology of Noyes Valley Creek in the Middle Reach and the steep high banks (Figures 6.10 - 6.15). In the approximately 5,600 ft long Middle Reach of Noyes Valley Creek, twenty-eight (28) two-foot-high instream structures are proposed with a spacing of approximately 200 feet. The average structure width is approximately 35 feet. A two-foot-high structure could backwater approximately 180 ft of the upstream stream. In addition to the structures, riparian exclusion fencing and a stock water system is proposed to remove the impacts of grazing in the riparian area and stream (Map 6.11).

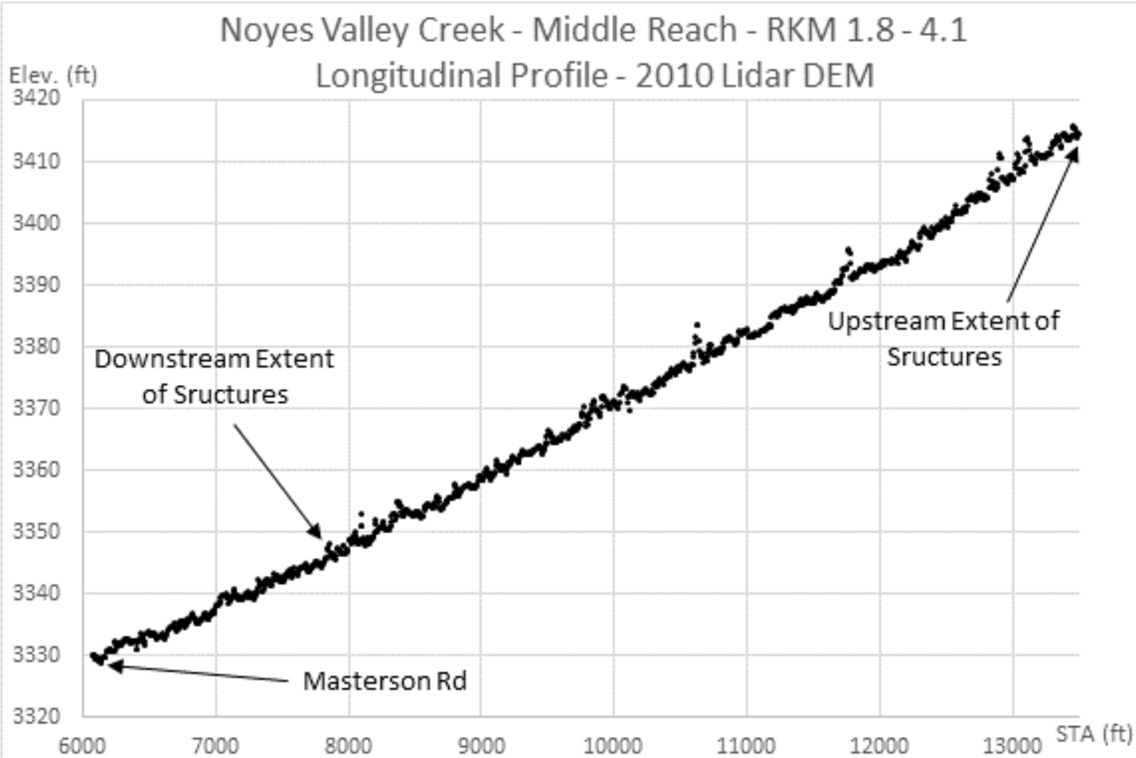
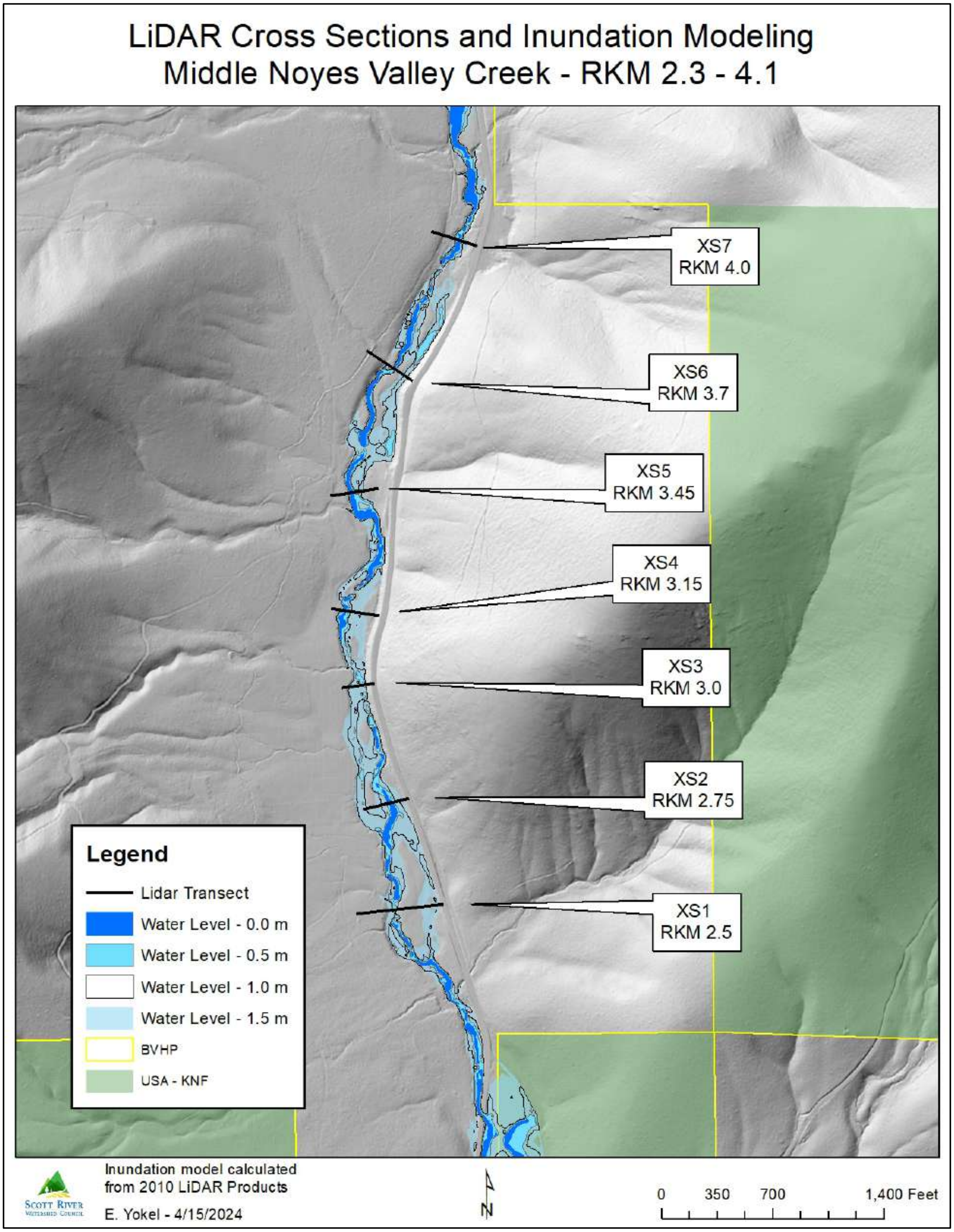
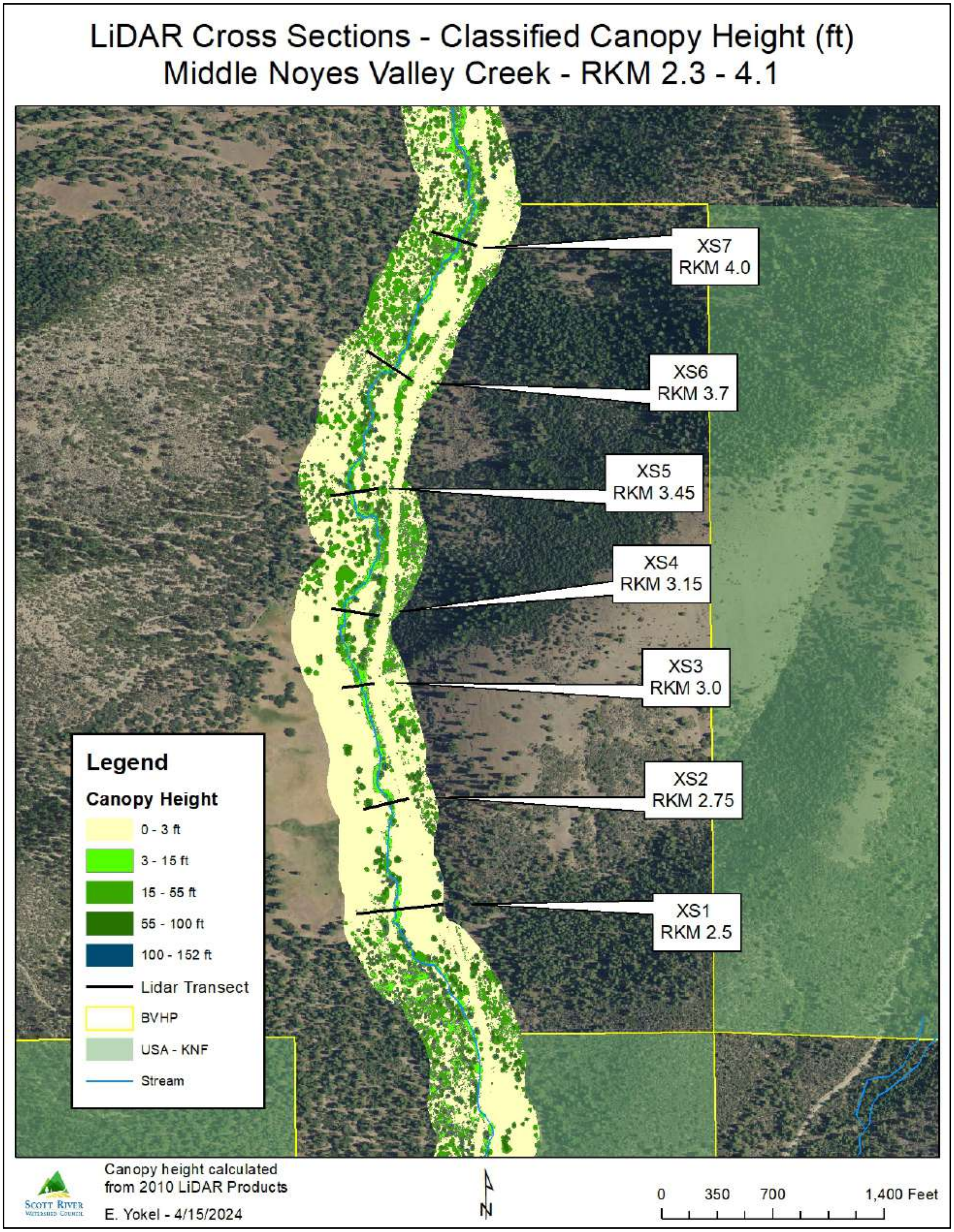


Figure 6.9: Longitudinal profile for 2010 Lidar DEM - Middle Noyes Valley Creek Reach - RKM 1.8 - 4.1.



Map 6.9: Inundation model and location of LiDAR cross sections - Middle Noyes Valley Creek.



Map 6.10: Classified canopy height and LiDAR cross sections - Middle Noyes Valley Creek.

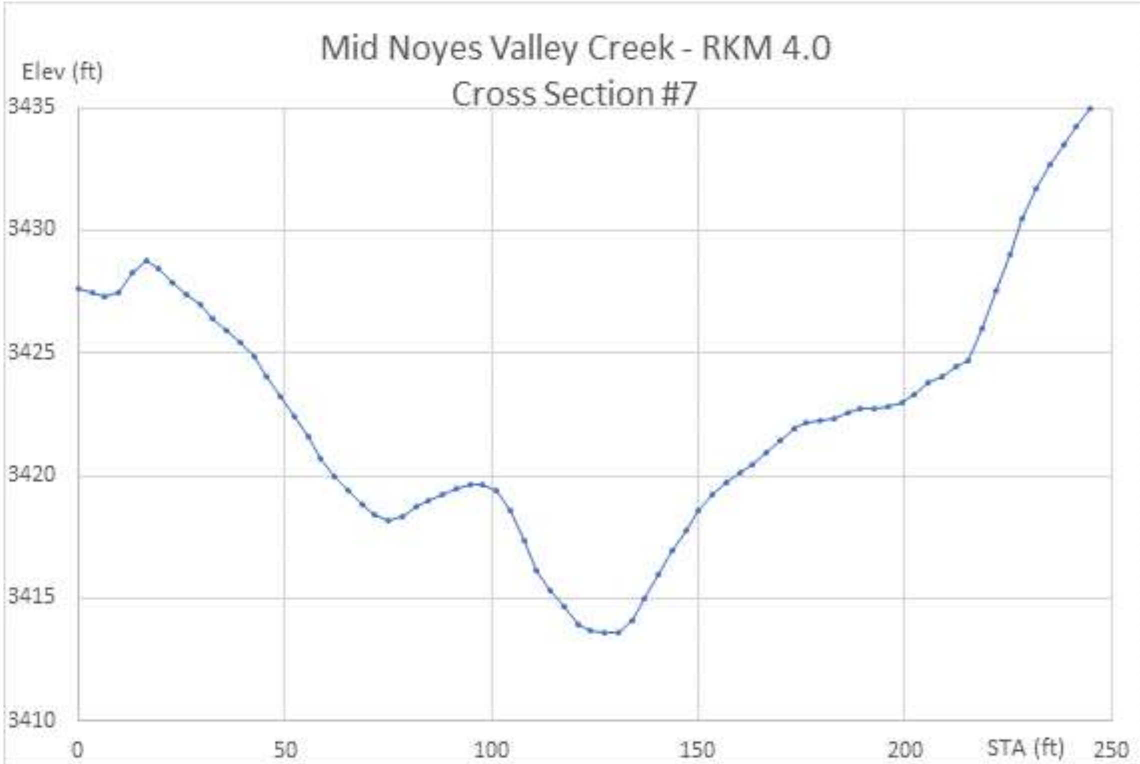


Figure 6.10: Middle Noyes Valley Cross Section #7 – RKM 4.0 - 2 ft high structure - 30 ft width.

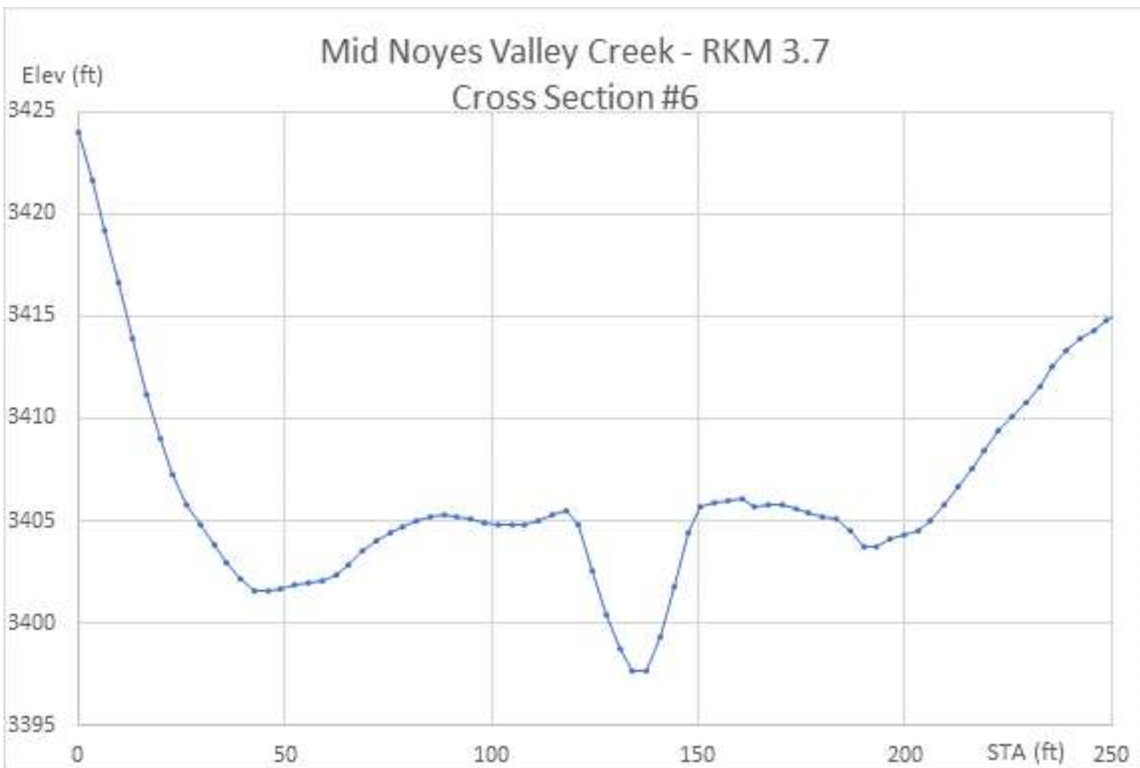


Figure 6.11: Middle Noyes Valley Cross Section #6 – RKM 3.7 - 2.5 ft high structure - 16 ft width.

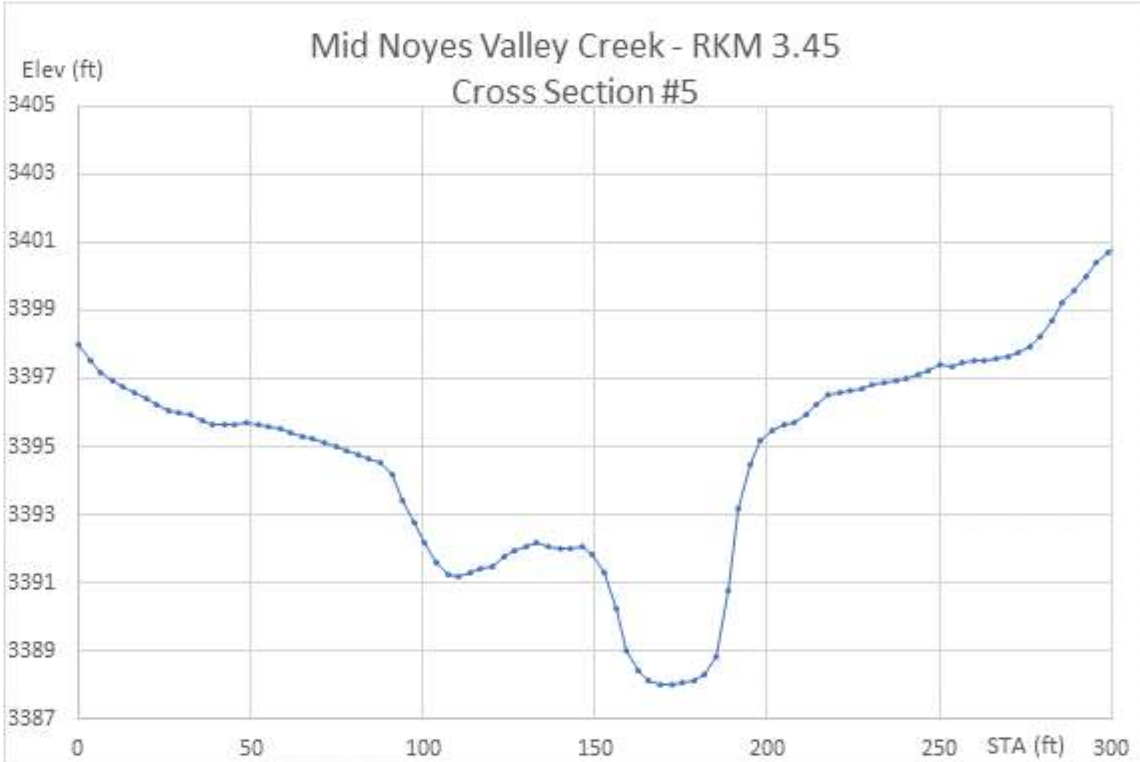


Figure 6.12: Middle Noyes Valley Cross Section #5 – RKM 3.45 - 2 ft high structure - 30 ft width.

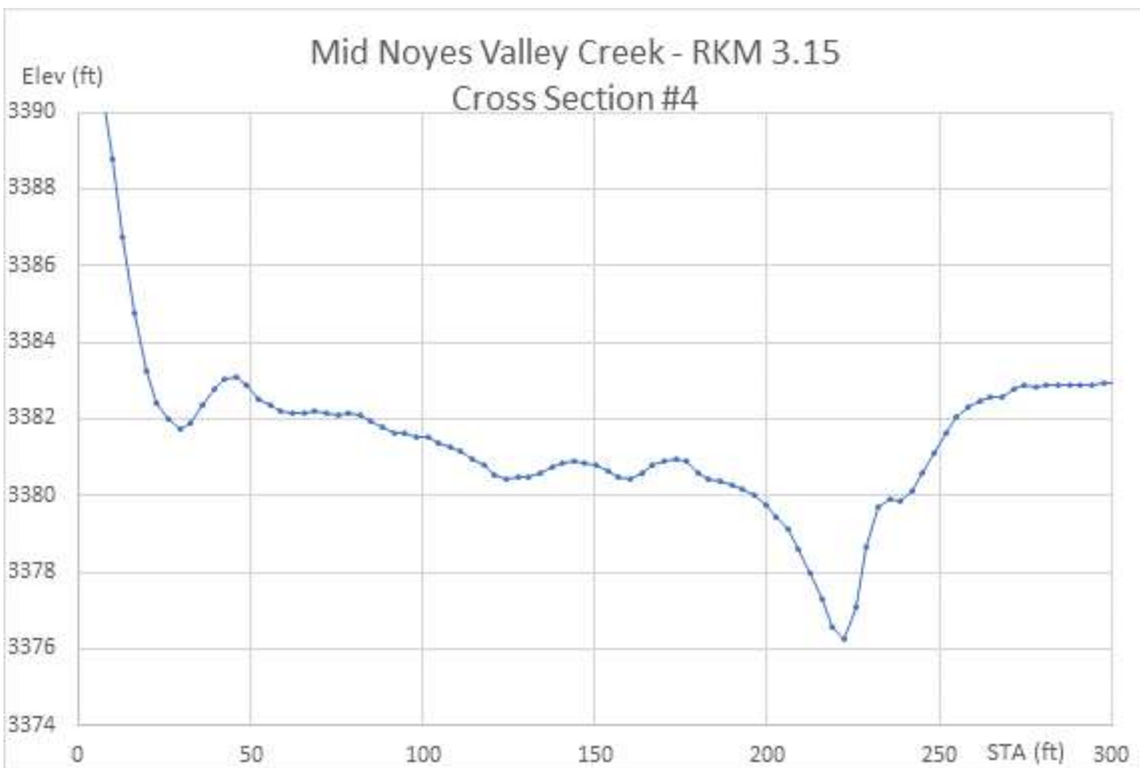


Figure 6.13: Middle Noyes Valley Cross Section #4 – RKM 3.15 - 2 ft high structure - 20 ft width.

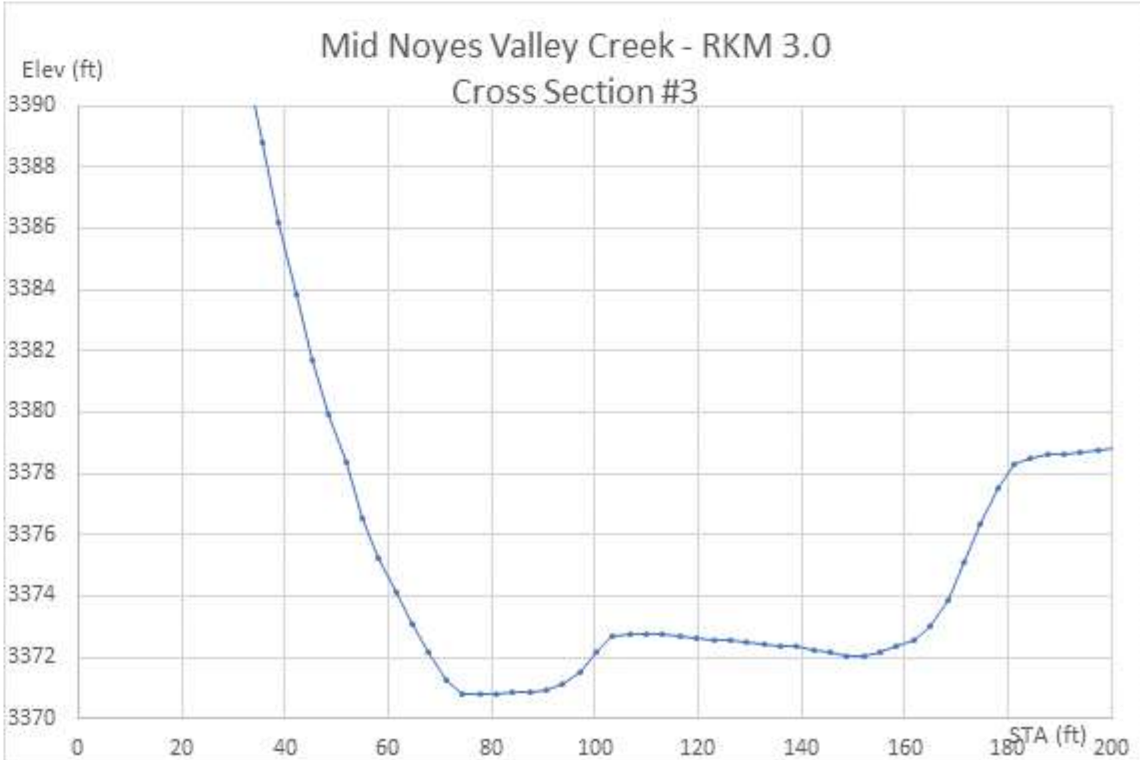


Figure 6.14: Middle Noyes Valley Cross Section #3 – RKM 3.0 - 2 ft high structure – 100 ft width.

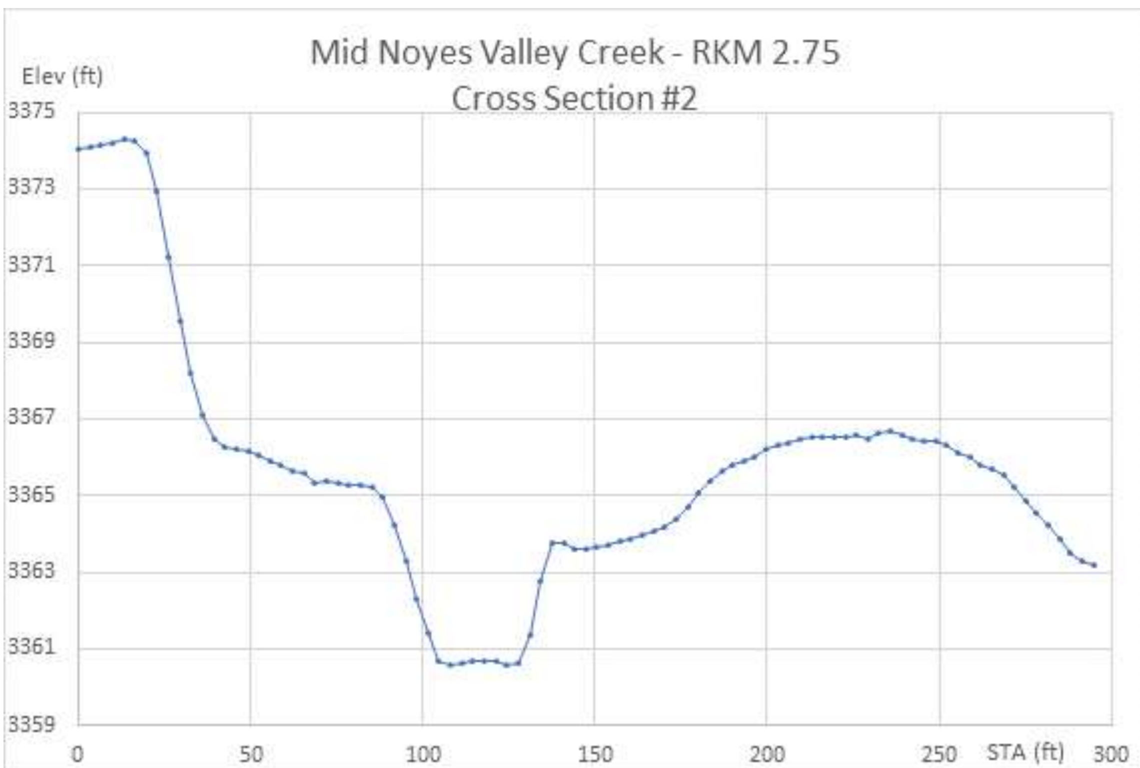


Figure 6.15: Middle Noyes Valley Cross Section #2 – RKM 2.75 - 2 ft high structure – 40 ft width.

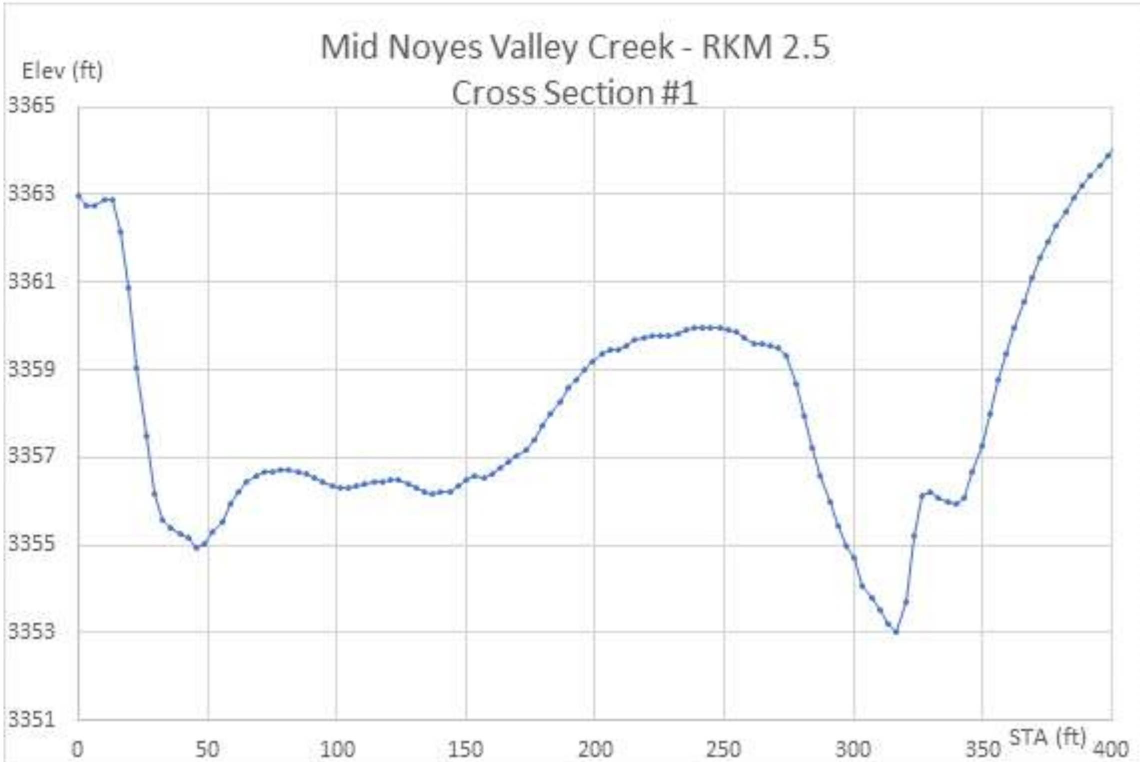
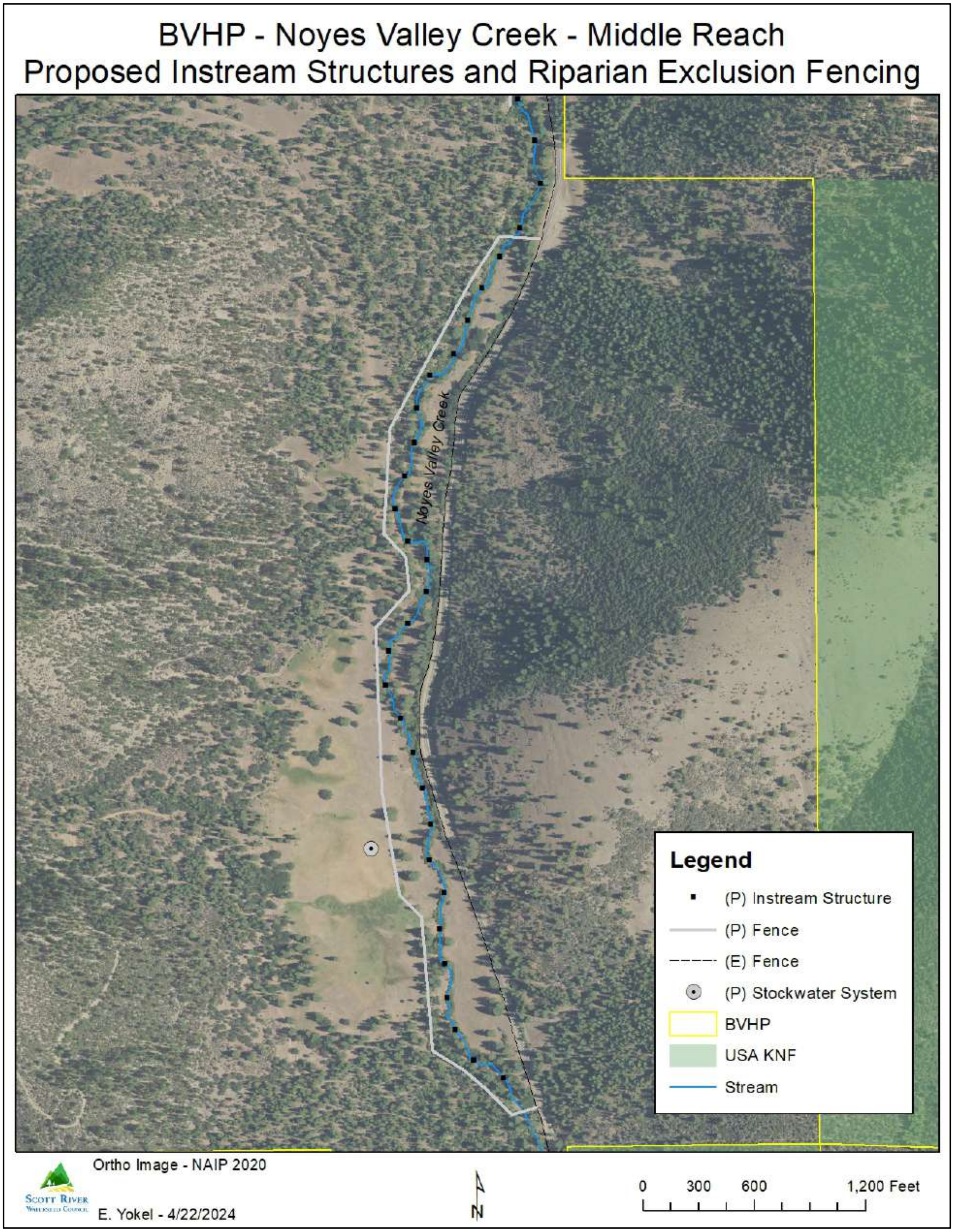


Figure 6.16: Middle Noyes Valley Cross Section #1 - RKM 2.5 - 2 ft high structure - 30 ft width.

Photo 6.4: Noyes Valley Creek - Middle Reach - Looking Upstream. April 16, 2024.



Map 6.11: Proposed fencing, stock water system and instream structure locations - Middle Reach.

6.4.3 Lower Noyes Valley Creek Reach

The Lower Noyes Valley Creek Reach (RKM 0 - 1.8) extends from the low water crossing at Masterson Road to the confluence with the East Fork Scott River. Noyes Valley Creek is a 1.2% gradient reach (Figure 6.16) with an unnamed tributary entering from the east. The inundation model illustrates an area of low elevation floodplain at the upstream end of the reach to downstream of the confluence of the unnamed tributary with a more confined channel in the downstream two thirds of the reach (Map 6.12). Analysis of the classified canopy height illustrates a narrow band of riparian vegetation (predominantly willow) throughout most of the reach (Map 6.13). On the ground surveys documented that the riparian vegetation is mostly mature to senescent with little natural recruitment observed. Areas of Himalayan blackberry along the stream and stream bank were observed. In addition to the blackberry, large amounts of yellow star thistle were observed in the western end of the pasture.

The entire Lower Reach is in grazed pasture with no riparian exclusion fencing. Before the installation of the stock water systems in the fall of 2022, Noyes Valley Creek was the only source of water for the cattle. Multiple locations of active stream bank erosion were documented in the Lower Reach. Ten water surface elevation (WSE) stations were installed in the Lower Reach in December 2022, to document the relative elevation of surface water and groundwater. The results of the WSE monitoring are detailed in Chapter 5. Analysis of channel morphology, floodplain elevations, riparian vegetation density and condition, irrigation patterns and surface water connectivity during the summer base flow period of 2023 illustrates several distinct sub-reaches in the Lower Reach (Map 6.14).

Photo 6.5: Mature alders - Lower Noyes Valley Creek - looking downstream. June 21, 2023.

Photo 6.6: Limited riparian vegetation with blackberry encroachment and actively eroding stream bank. June 21, 2023.

Photo 6.7: Unfenced Noyes Valley Creek with limited vegetation - looking downstream. June 21, 2023.

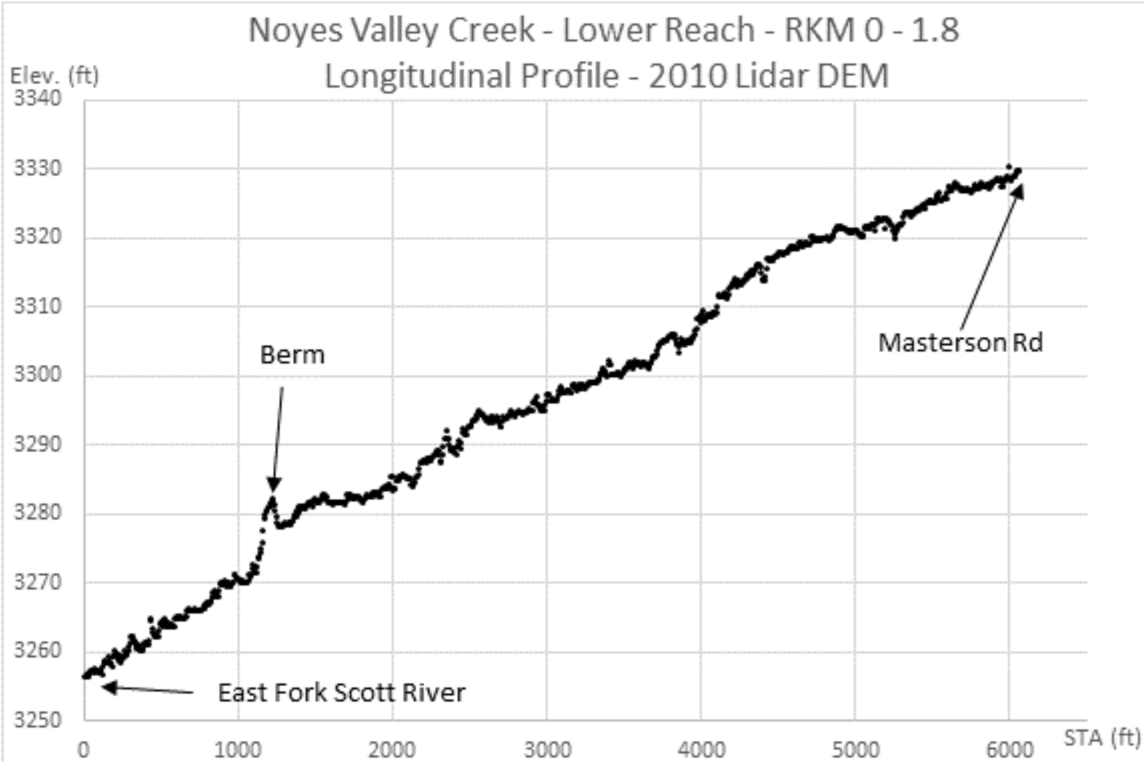
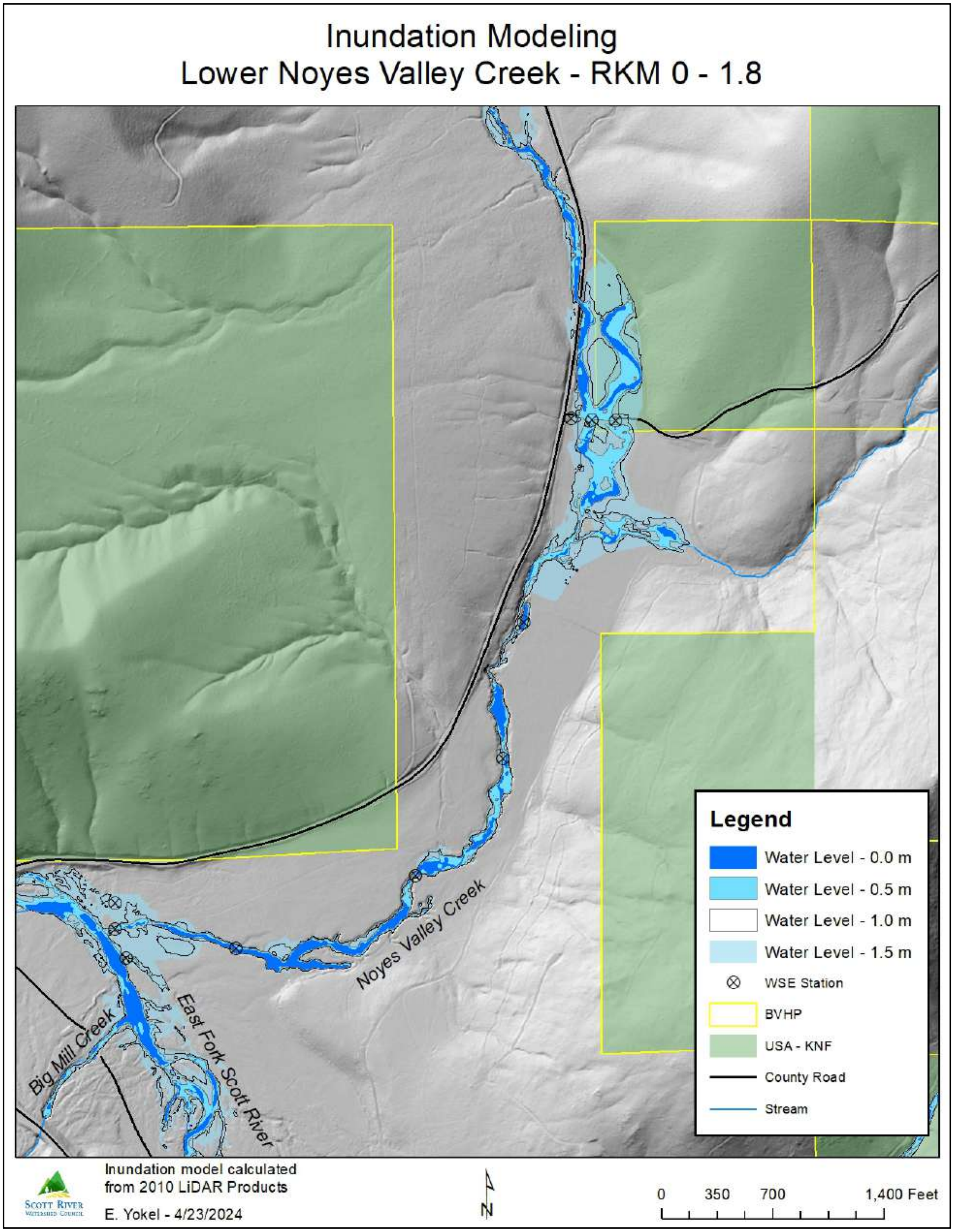


Figure 6.17: Longitudinal profile for 2010 Lidar DEM - Lower Noyes Valley Creek Reach - RKM 0 - 1.8.

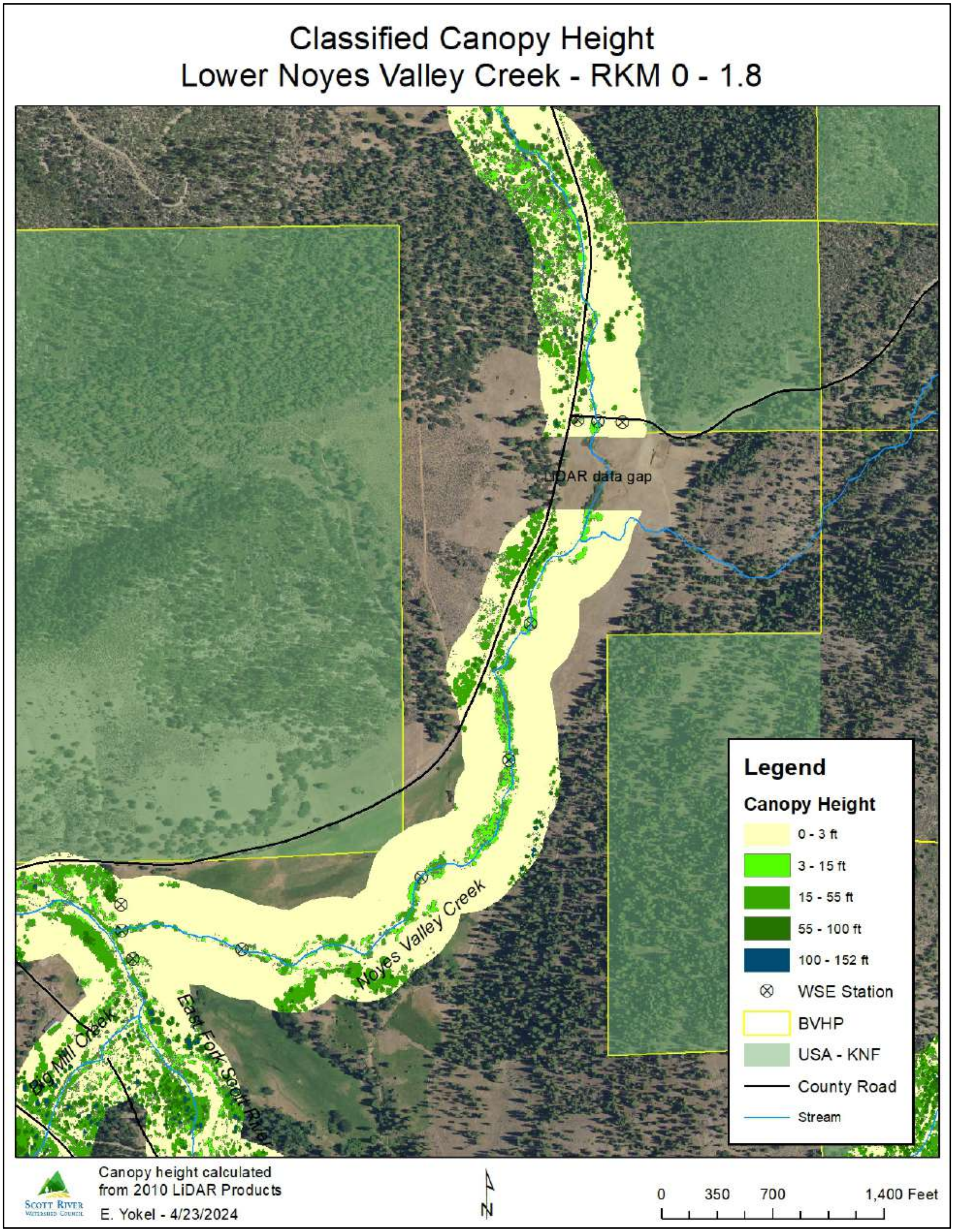
Noyes Valley Creek downstream of Masterson Road was disconnected during the summer base flow period of 2023. Analysis of the WSE data at the station (NVMW9) in the channel downstream of Masterson Road illustrates a significant fluctuation of WSE from the wet-season and spring recession flow regimes to the summer base flow regime (Figure 6.17). The WSE was greater than nine (9) feet below the ground elevation during the summer. The WSE rose rapidly in December 2023 and January 2024, after precipitation and runoff events to restore connectivity to Noyes Valley Creek.

In 2023, the upstream one third of the pasture at the Lower Noyes Valley Creek Reach was not irrigated while the lower two thirds of the pasture was irrigated with sprinkler systems. The area of irrigation corresponds with the areas of connectivity of Noyes Valley Creek (Map 6.14). The downstream 0.6 miles of Noyes Valley Creek was connected through the summer base flow period. Stream discharge was documented upstream of the confluence and is reported in Chapter 3.

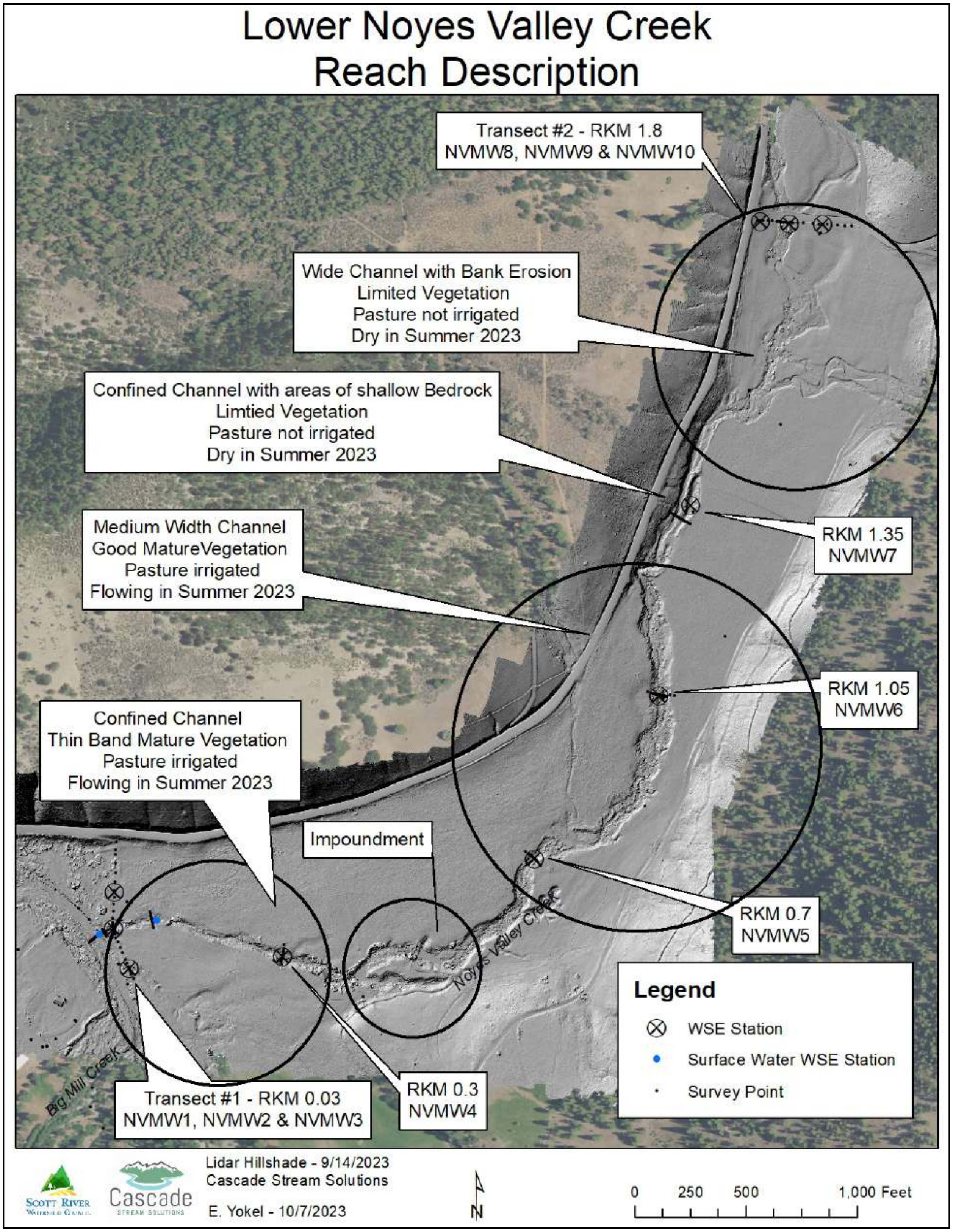
The SRWC installed cattle exclusion fencing along the East Fork Scott River and two stock water systems in the fall of 2022. Cattle exclusion fencing along Noyes Valley Creek is proposed (Map 6.15). Restoration designs are being developed for Lower Noyes Valley Creek with a potential realignment of the downstream section and confluence with the East Fork Scott River.



Map 6.9: Inundation model and location of LiDAR cross sections - Lower Noyes Valley Creek.



Map 6.10: Classified canopy height and LiDAR cross sections - Lower Noyes Valley Creek.



Map 6.11: Lower Noyes Valley Creek reach.

Photo 6.7: Noyes Valley Creek at Masterson Road - Looking downstream. March 23, 2023.

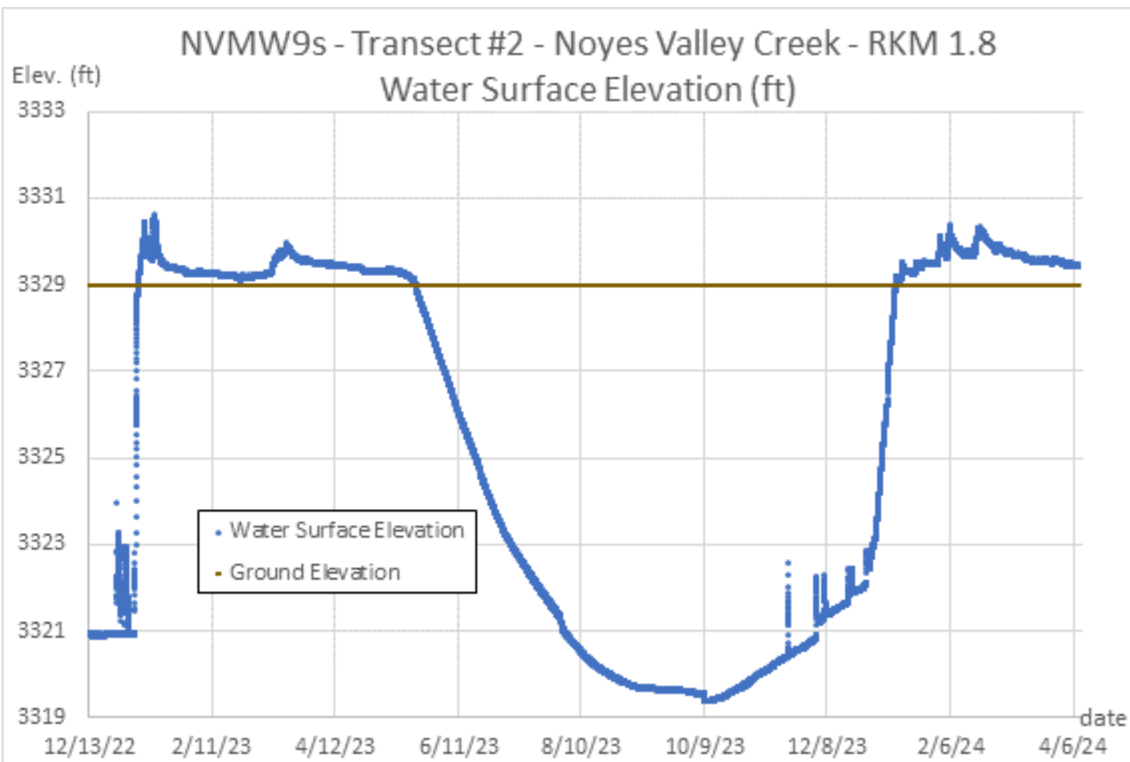
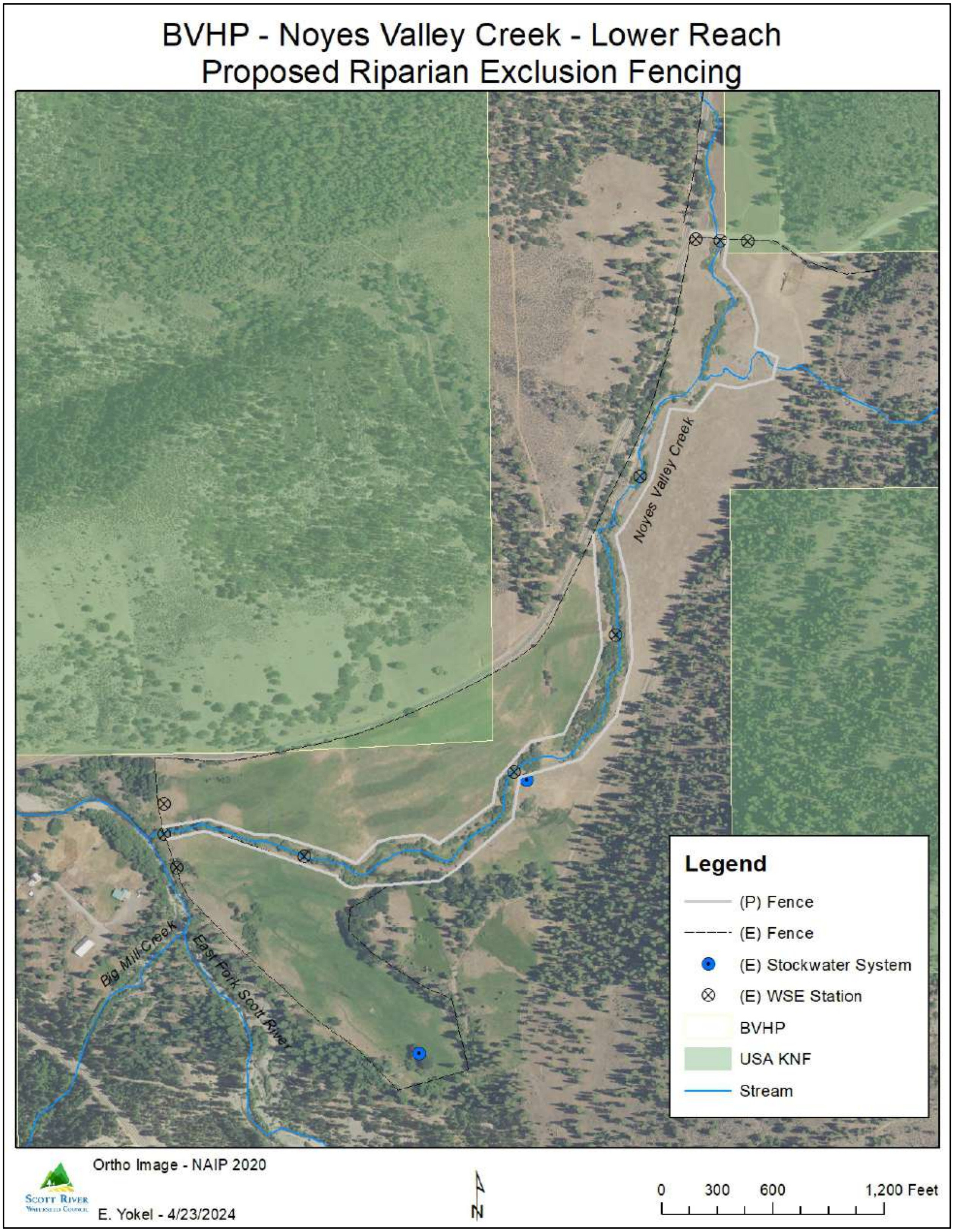


Figure 6.18: Water surface elevation at Noyes Valley Creek RKM 1.8.

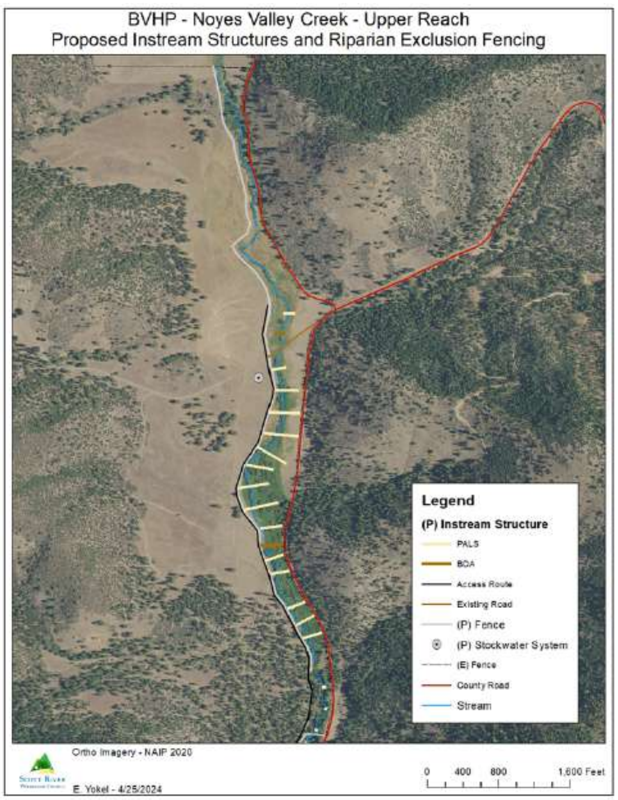


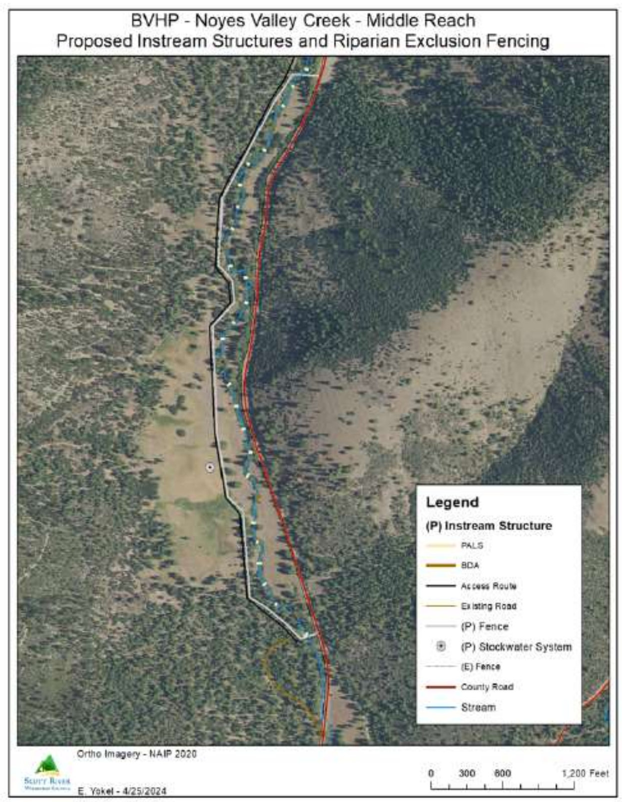
Map 6.12: Proposed riparian exclusion fencing - Lower Reach.

6.5 Conclusion

The project designs strive to enhance the seasonal flow of surface water by fundamentally promoting groundwater recharge. Achieving this goal can be done by slowing the water, spreading across the low gradient valley floor and giving it the time necessary to sink into the adjacent groundwater. Historical records indicate the past presence of beaver, suggesting that under favorable circumstances, their return is feasible.

The use of BDAs as a primary tool to slow the water and extend its duration time could effectively facilitate groundwater in Noyes Valley Creek, potentially prolonging the presence of surface water in the area. Using a combination of remote sensing tools, on-the-ground surveys and historic locations of beaver dams, SRWC developed a site design plan that includes the installation 50 BDAs or similar structures in the upper and middle reaches (Maps 6.13 and 6.14). Additionally, to ease pressure on the existing willow and other riparian vegetation, 2.5 miles of cattle exclusionary fencing is being recommended.





Map 6.13 and 6.14: Upper Reach of Noyes Valley Creek and proposed structures and exclusion fencing (left). Middle Reach of Noyes Valley Creek and proposed structures and exclusion fencing (right).

6.6 Bibliography

Castro, Janine, Michael Pollock, Chris Jordan, and Gregory Lewallen (2018). “US Fish and Wildlife Service National Oceanic and Atmospheric Administration University of Saskatchewan US Forest Service Woodruff,” n.d., 228.

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6.7 Appendix

Appendix 6.1 Noyes Valley Creek Stream Conditions Analysis

Chapter 7. Forest Management Opportunities

7.1 Introduction

Forest stands on BVHP have been severely impacted by drought and as a result have experienced a high rate of mortality (Figure 7.1). This has contributed to extreme fuel loading in areas and increases the potential for stand-replacing wildfires. Multiple factors are contributing to the decline of forest stands on BVHP including increasing temperatures, drought, insects and encroachment of conifers onto marginal sites. Climate is the main driver of this mortality with other contributing factors intensifying its effects (Bennett and Adlam 2023).

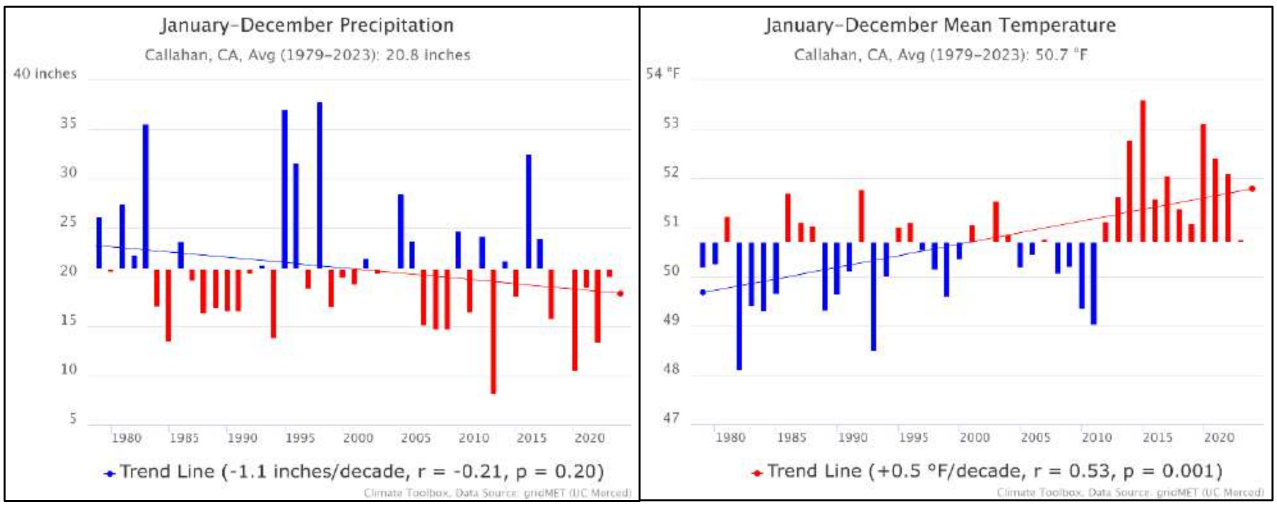


Figure 7.1: Decreasing precipitation and increasing temperatures are driving the decline of forest stands on marginal sites. (Climatetoolbox.org 2024).

Funding from various sources has supported efforts to achieve the following objectives: The United States Fish and Wildlife Service is collaborating with Lomakatsi and SRWC to remove conifers in critical oakwood habitats. NCRP provided technical assistance through BB&W Associates to initiate efforts addressing conifer tree mortality across the ownership of TWC. California Trout, funded by CalTrans, played a role in identifying the future restoration needs for large wood.

7.2 Purpose

- Salvage dead and dying trees to reduce hazardous fuel loads.
- Promote regeneration of species that are more tolerant of drought and fire.
- Integrate, support, and enhance oak woodland restoration projects currently underway.
- Identify trees to be utilized for the East Fork instream restoration project that also meet criteria for removal under the drought mortality exemption.
- Develop a forest management plan for BVHP with a focus on creating a more fire resilient landscape and ecological uplift.

7.3 Methods

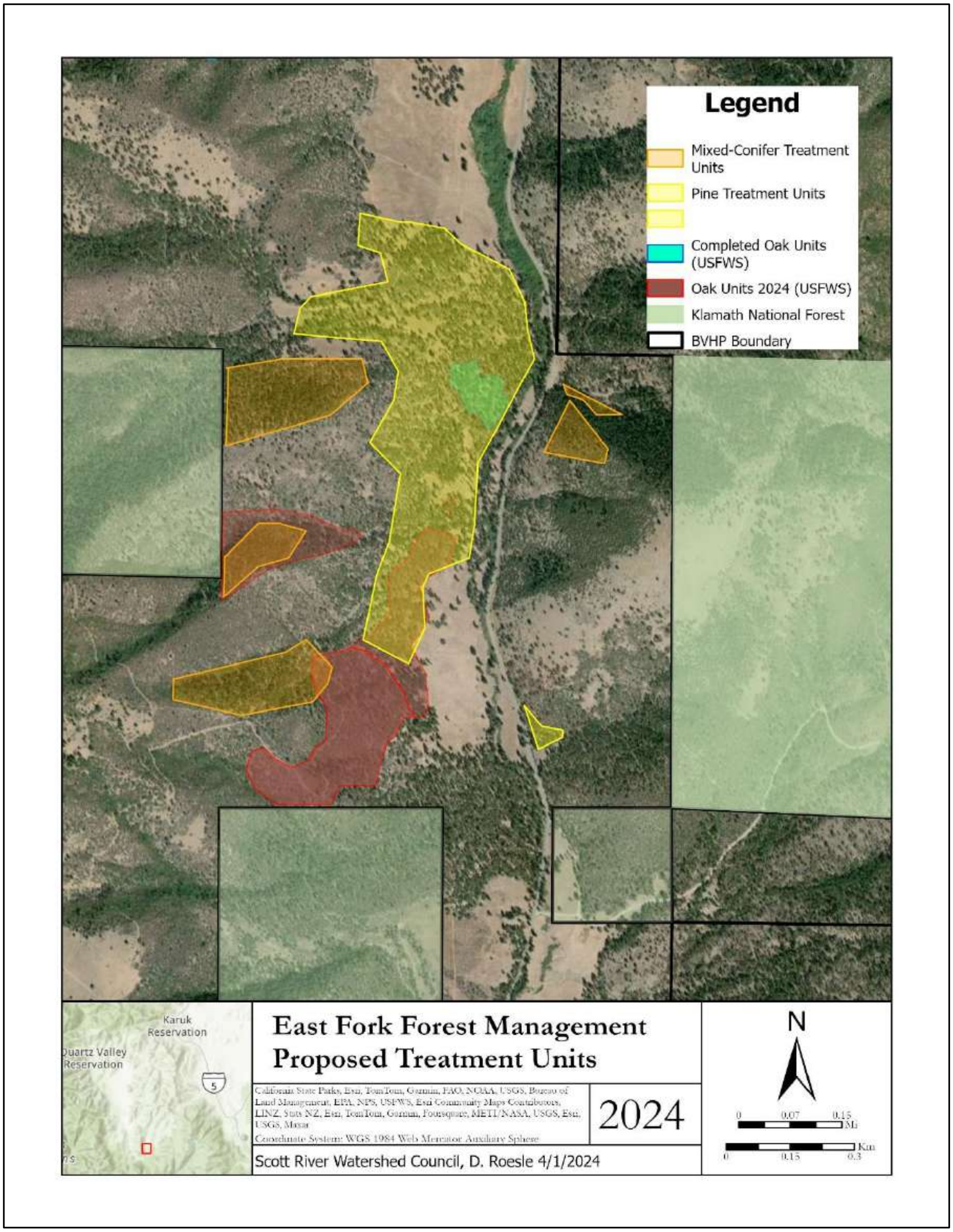
SRWC initiated the start of developing a comprehensive forest management plan for BVHP. This effort couples several ongoing and future forest management strategies that aim to provide ecological uplift while trying to mitigate the impacts of extensive drought and a century of fire suppression.

A complete overview of the BVHP landownership as completed as it relates to the topography, elevations, existing road networks, slope, aspect, soil types, geology setting, vegetation types and historic fire regimes. This information was integrated into an inventory of tree stands which included the species composition, tree sizes and stand density and overall stand health. SRWC worked with TWC and other project partners to determine some of the best practices and initial management strategy for a first entry to remove some of the significant dead and dying conifer (Photo 7.1).

Photo 7.1: Dead and dying Douglas fir in proposed drought mortality treatment unit. March 25, 2024.

7.4 Results

In addition to the work supported by this project, SRWC received an additional grant for technical assistance through North Coast Resource Partnership (NCRP) to employ BBW & Associates (BBWA). With BBWA assistance, work was done to develop a harvest plan and permits for removal of dead and dying trees in the lower elevation stands on BVHP. Implementation is expected to begin this spring. In areas where it is possible these operations will overlap with the US Fish and Wildlife Service's (USFWS) oak woodland restoration units as shown in Figure 7.1. This overlap will make it possible to remove the large dead and dying trees that would have been left in the stand with hand piling operations alone. Two to four snags per acre will be left throughout these units to provide wildlife habitat.



Map 7.1: Map of proposed treatment units for drought mortality and USFWS oak restoration units.

Photo 7.2: Dead and dying conifer in proposed drought mortality treatment unit. March 25, 2024.

Photo 7.3: More drought tolerant oak and pine are thriving on sites where Douglas-fir is dying. Photo credit: Mark Lancaster, BBWA, March 18, 2024.

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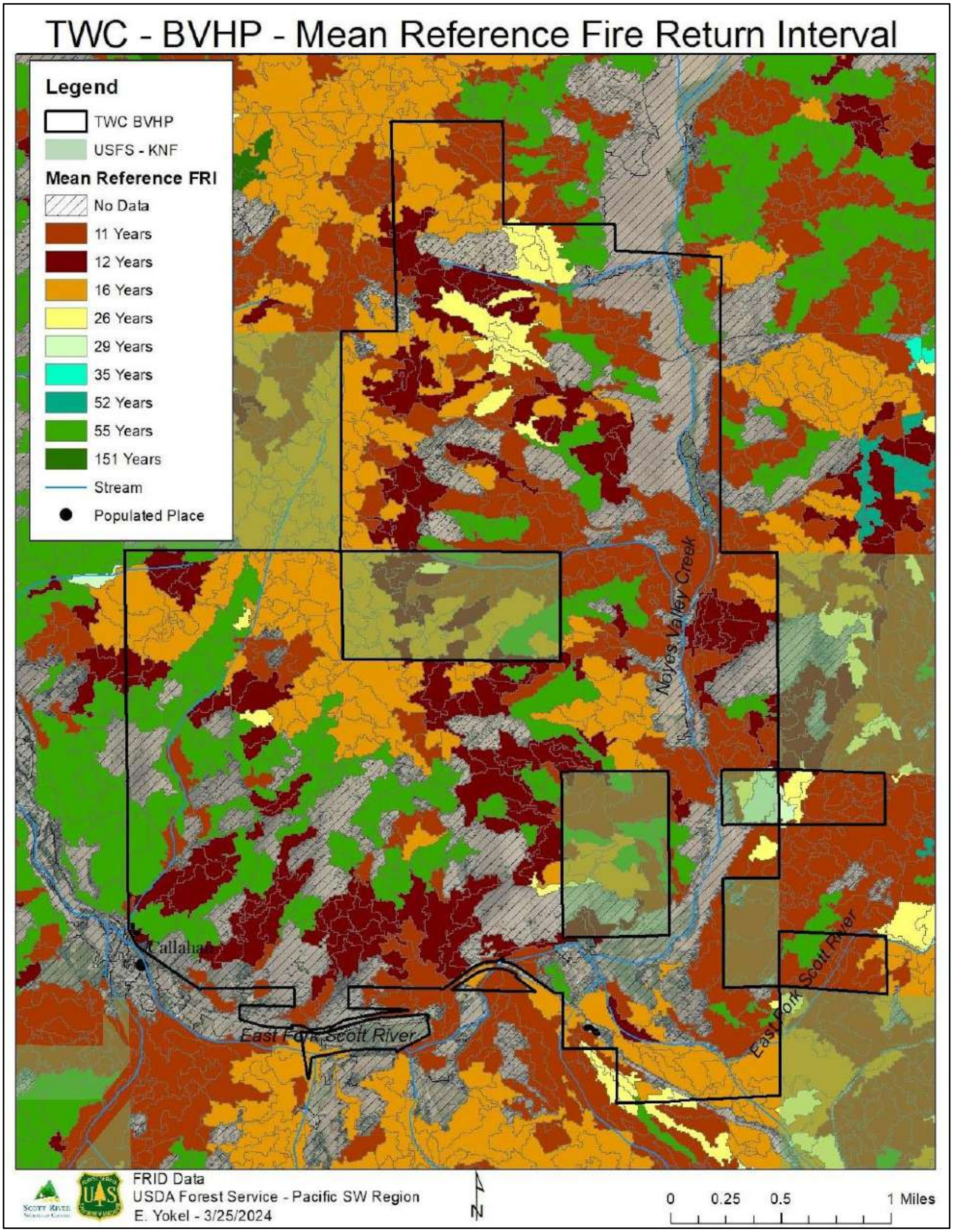
Douglas-fir dominant mixed-conifer forests in the East Fork watershed are experiencing tremendous rates of mortality in areas near and below 3,500 feet in elevation. Plot data collected shows that approximately 83% of mature Douglas-fir trees within the proposed treatment units are either dead or dying (Photo 7.2). Stands on north-facing aspects are experiencing high levels of mortality in Douglas-fir while pine and oak, which are more tolerant of drought conditions, remain viable (Photo 7.3). Treatment is proposed for 63 acres in mixed conifer stands and only dead or dying trees will be removed. The resulting stand post-treatment in these areas will be a more open pine-oak association with scattered Douglas-fir. Douglas-Fir that regenerates on these sites will likely die when it grows to a size where water is a limiting factor (Bennett and Adlam 2023). Historically, frequent low intensity fires would have kept Douglas-fir from regenerating in these areas (Photo 7.4).

Scattered mortality in pine stands has been observed in the valley floor with high rates of mortality observed on southern facing aspects above the valley floor. Conditions of these pine stands can be seen in Photo 7.4. Treatment of approximately 129 acres is proposed to remove dead and dying pine from these areas. Trees that are no longer merchantable will be chipped and sent to a biomass facility. There is a significant oak component throughout the pine treatment unit that will benefit from the removal of pines that are suppressing oak canopies.

Trees to be used for instream restoration projects will be designated concurrent with timber marking operations for drought mortality treatment units.

Figure 7.4: Aerial view of dying pines in Noyes Valley. March 25, 2024.



Map 7.2: Map represents presumed historical fire regime with the project area outlined in red.

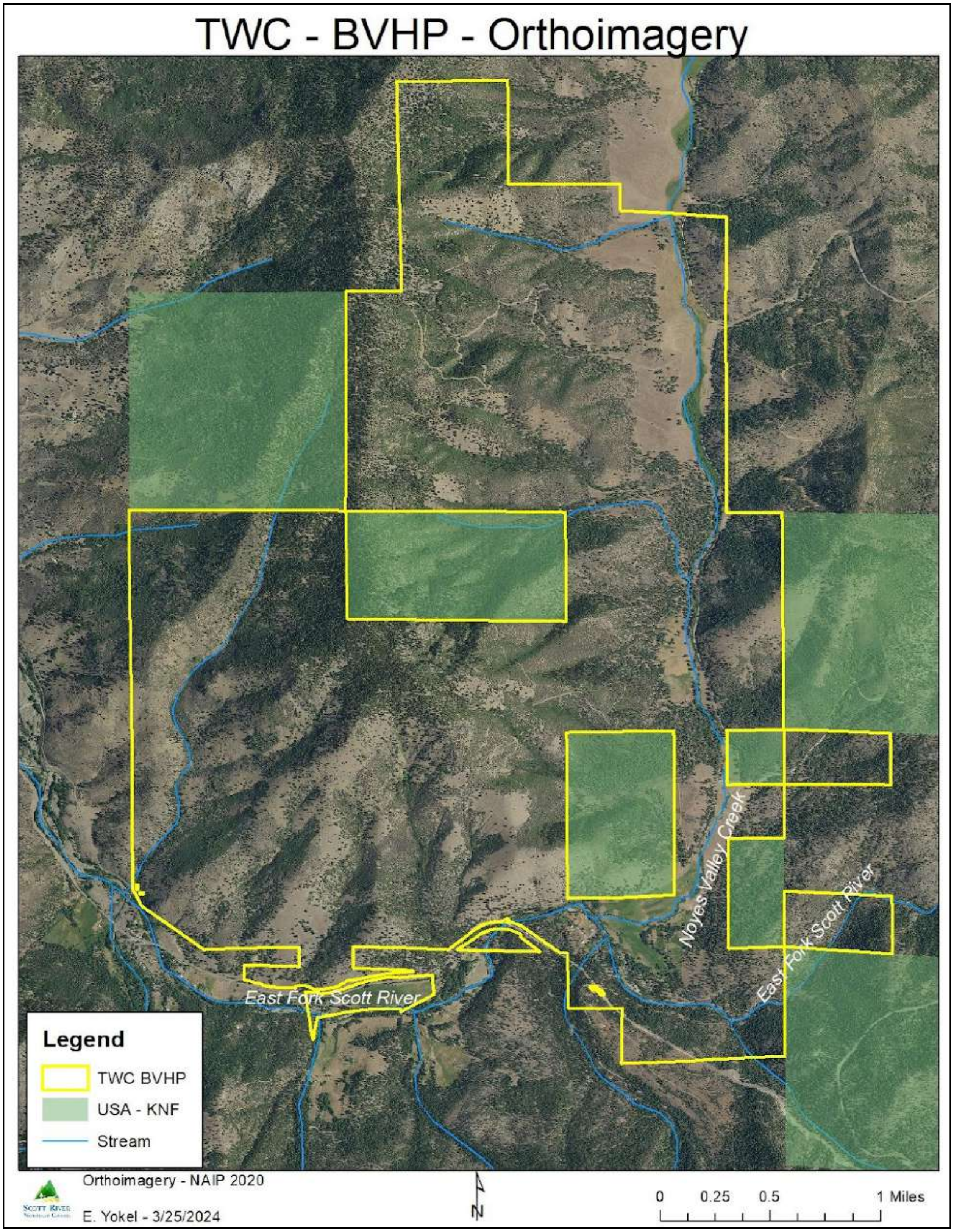
7.5 Forest Management Plan Exhibits

SRWC utilized available remote sensing products to produce a series of maps detailing the topography and vegetation variations across the BVHP area, crucial for crafting a comprehensive Forest Management Plan. Situated along the East Fork Scott River and Noyes Valley Creek within the Scott River Watershed (Map 7.3). The BVHP spans approximately 5,270 acres, with elevations ranging from 3,000 to 5,500 feet (Map 7.4).

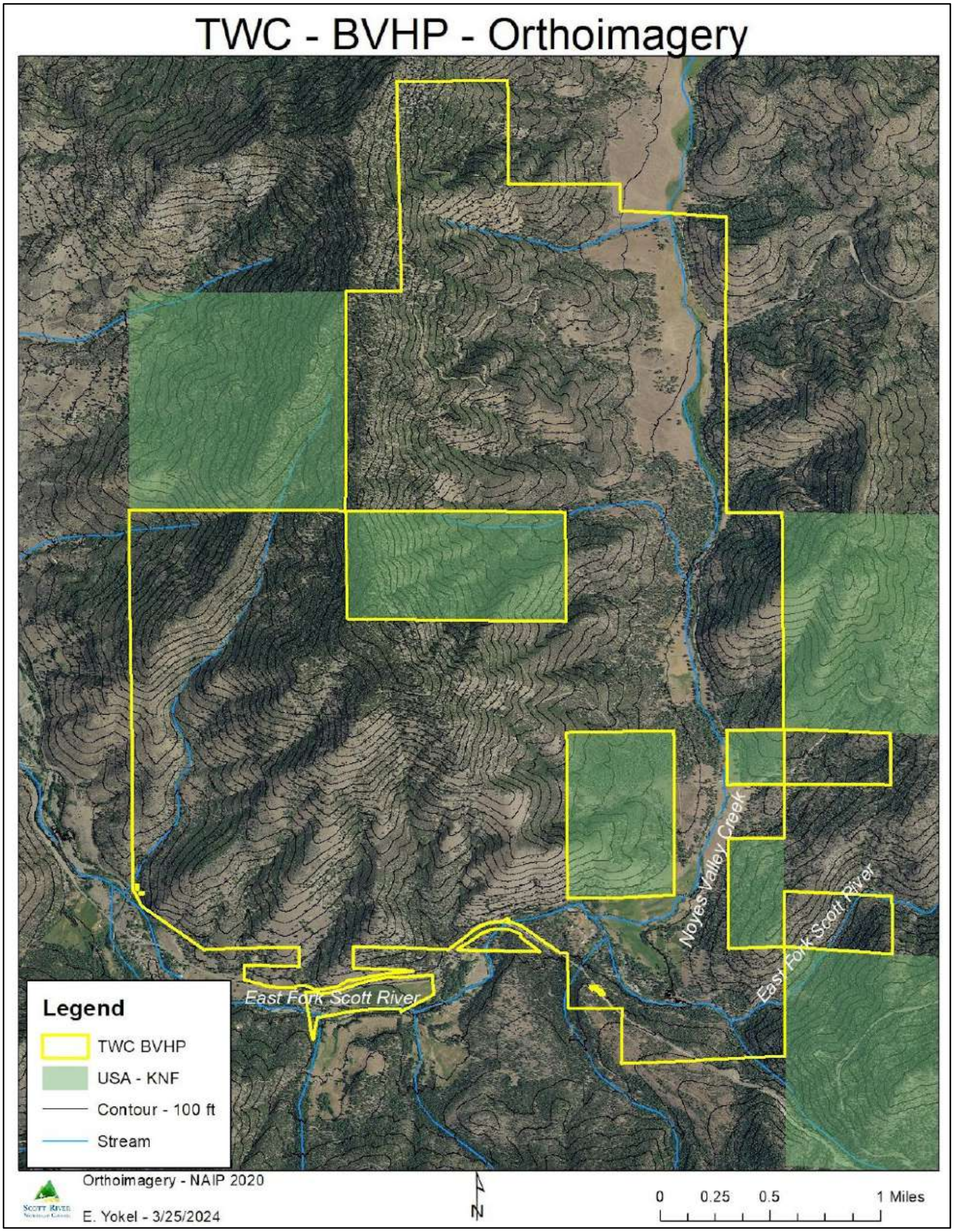
Employing the 2018 LiDAR bare earth DEM, a hillshade model (Map 7.5) was generated and 100-foot contours (Map 7.6) for the project area. The road network, including private, USFS/private, and county roads, is depicted in Map 7.7. Additionally, utilizing the same LiDAR DEM, we created slope (Maps 7.8 and 7.9) and aspect models (Maps 7.10 and 7.11) of the project area.

The soil type distribution across the BVHP is presented in Map 7.12 and Table 7.1, while the geology is illustrated using the Geologic Map of California - Version 2.0 (Maps 7.13 and 7.14, Table 7.2). Vegetation types are depicted using the Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG) Existing Vegetation Dataset (Maps 7.15 and 7.16, Table 7.3), along with sub-vegetation types specific to the TWC-BVHP property (Tables 7.3 and 7.4, Map 7.18).

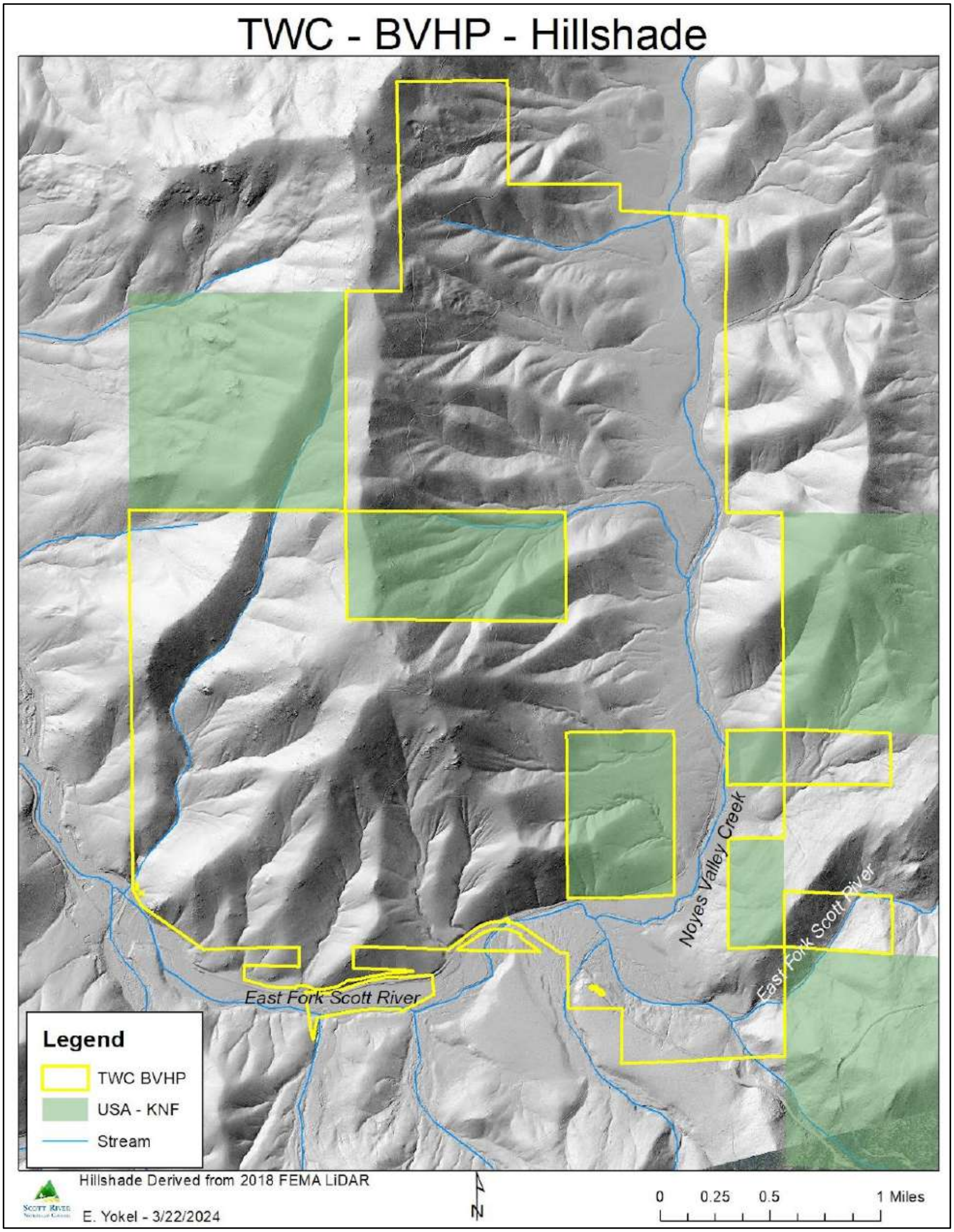
Fire regime information, including pre-settlement fire regime (Maps 7.19 and 7.20) and Mean Reference Fire Return Interval (Map 7.21) for the TWC-BVHP property, is derived from the Fire Return Interval Divergence (FRID) dataset. Historic fire activity surrounding the project area is shown in Map 7.22.



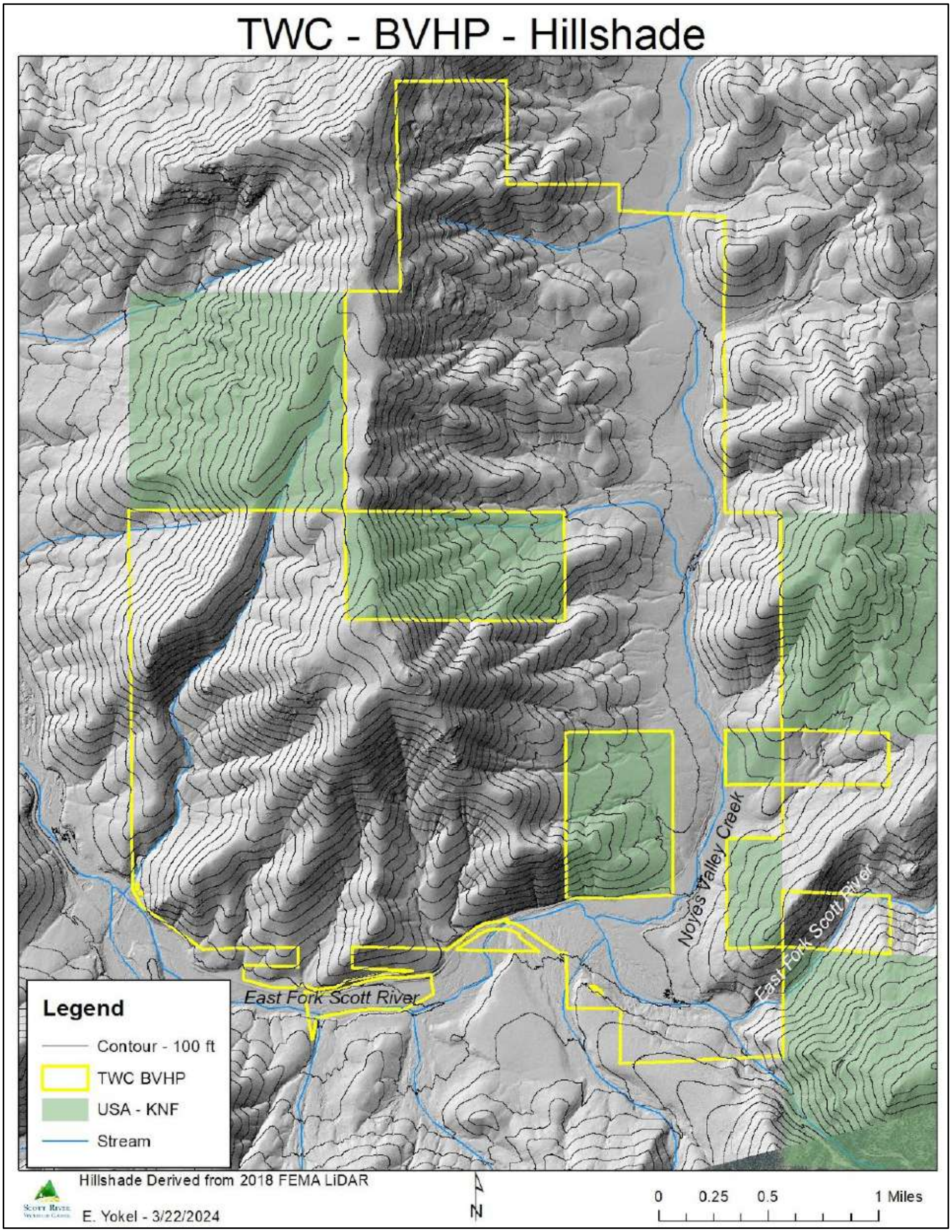
Map 7.3: Ortho imagery of TWC – BVHP Property.



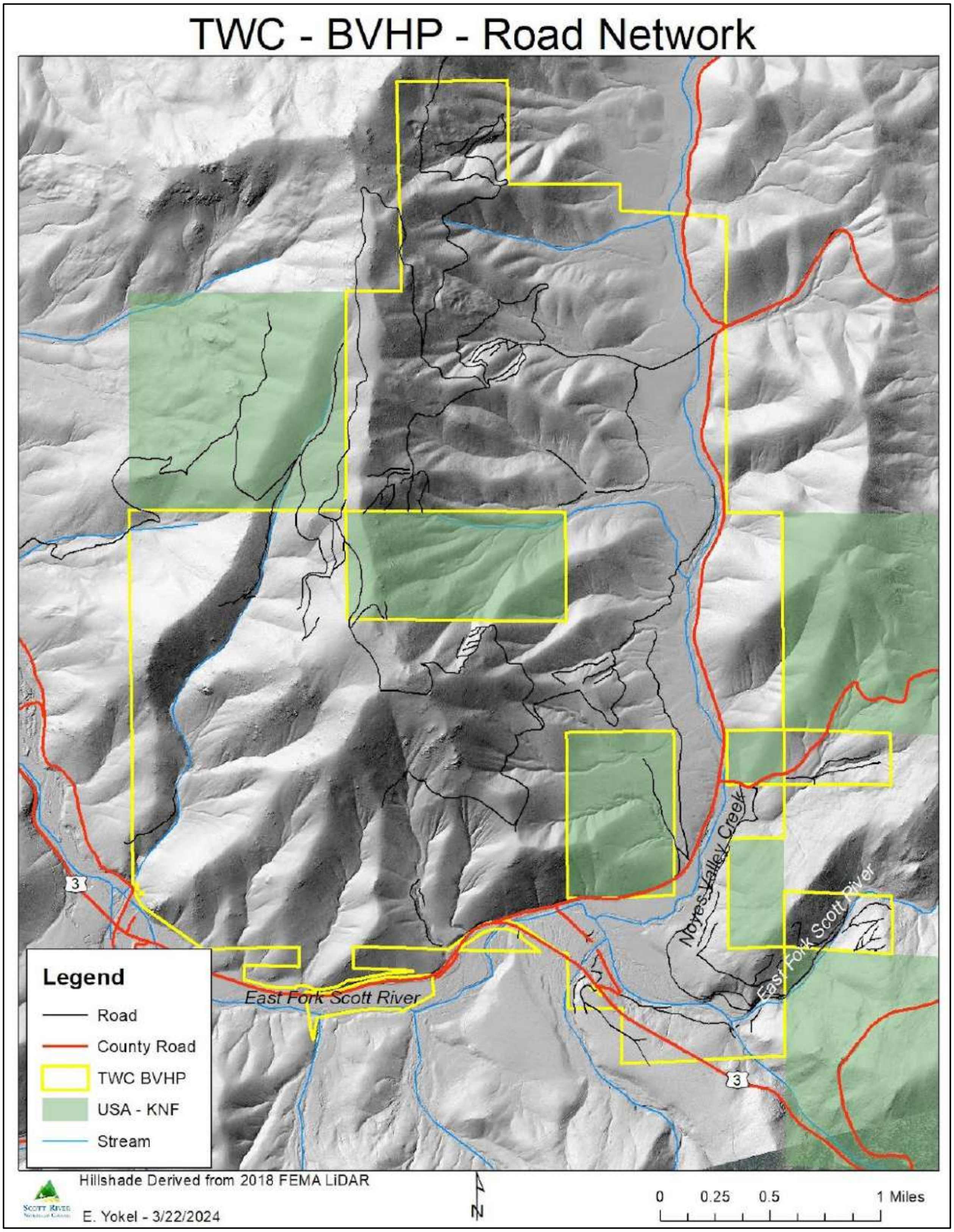
Map 7.4: Ortho imagery of TWC – BVHP Property with 100 ft contours.



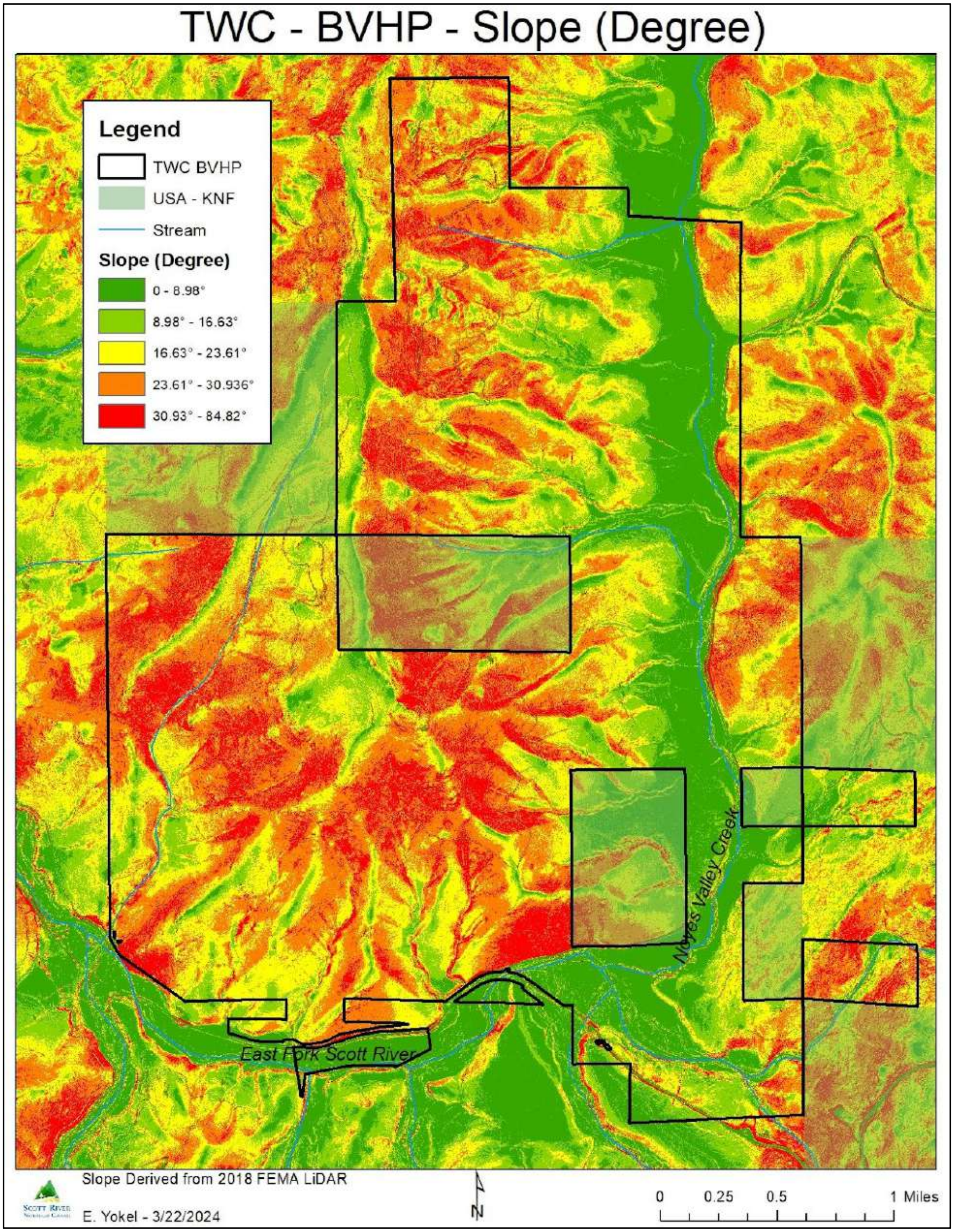
Map 7.5: Hillshade model of TWC – BVHP Property.



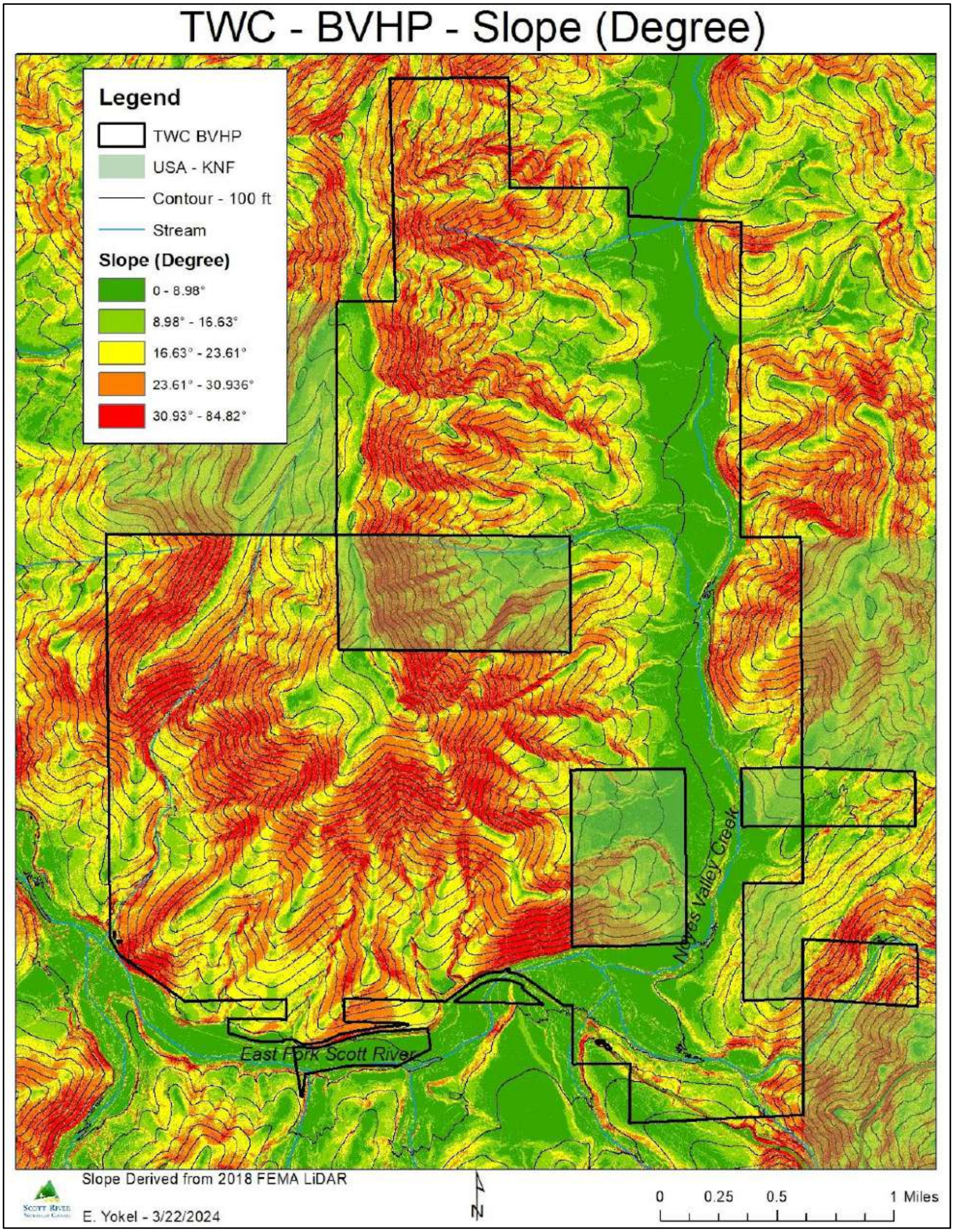
Map 7.6: Hillshade model of TWC – BVHP Property with 100 ft contours.



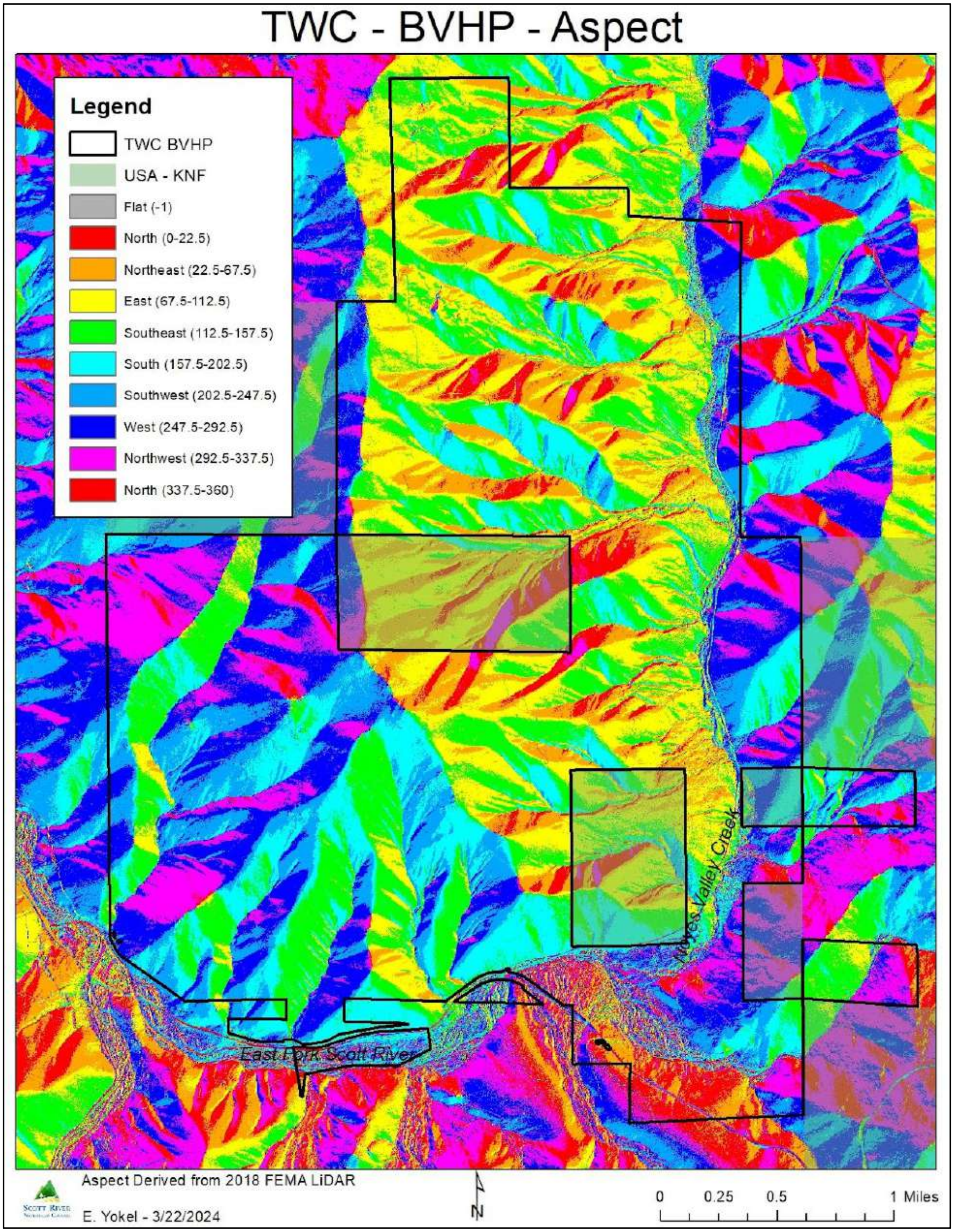
Map 7.7: Hillshade model of TWC – BVHP Property with road network.



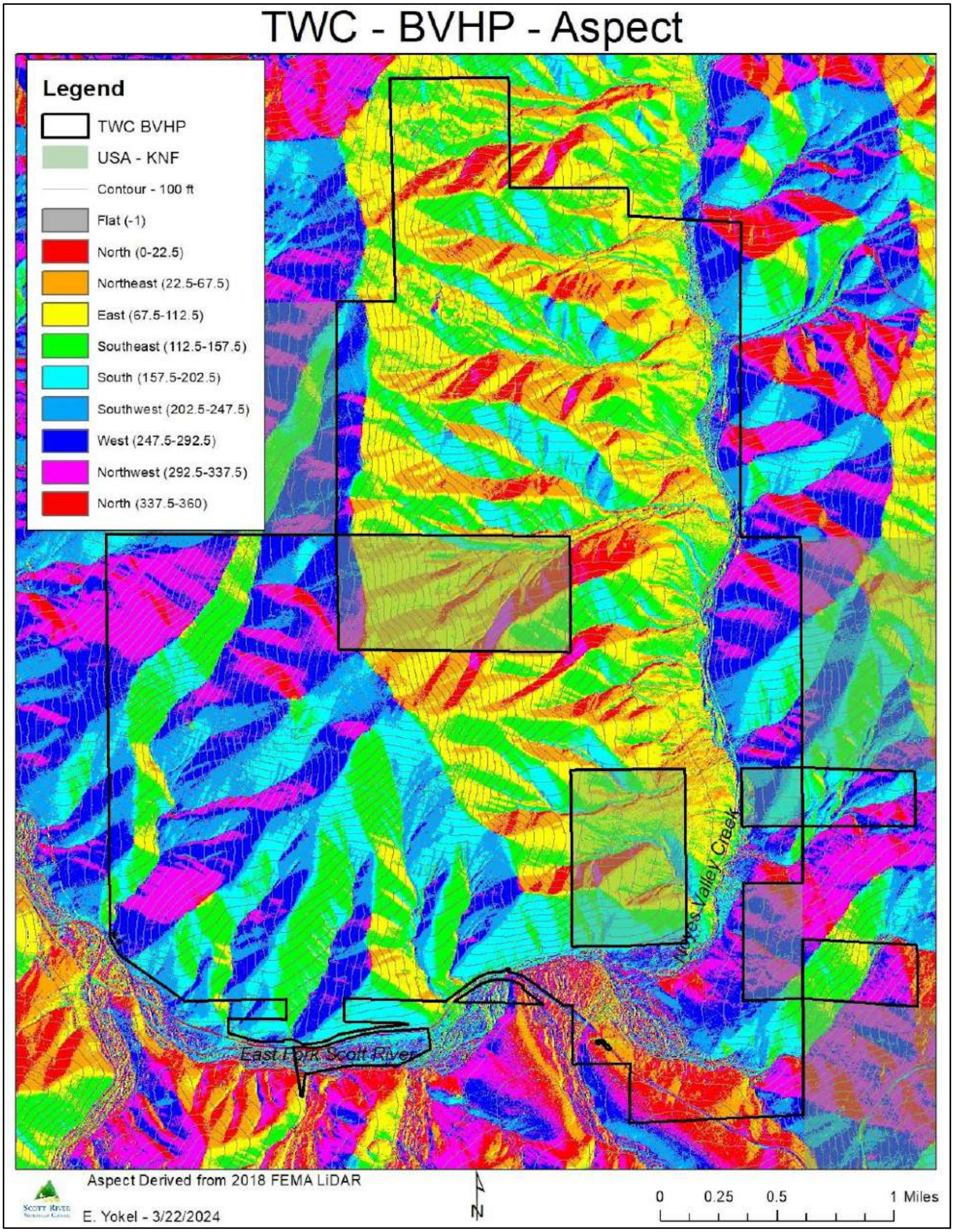
Map 7.8: Slope (degree) of TWC – BVHP Property.



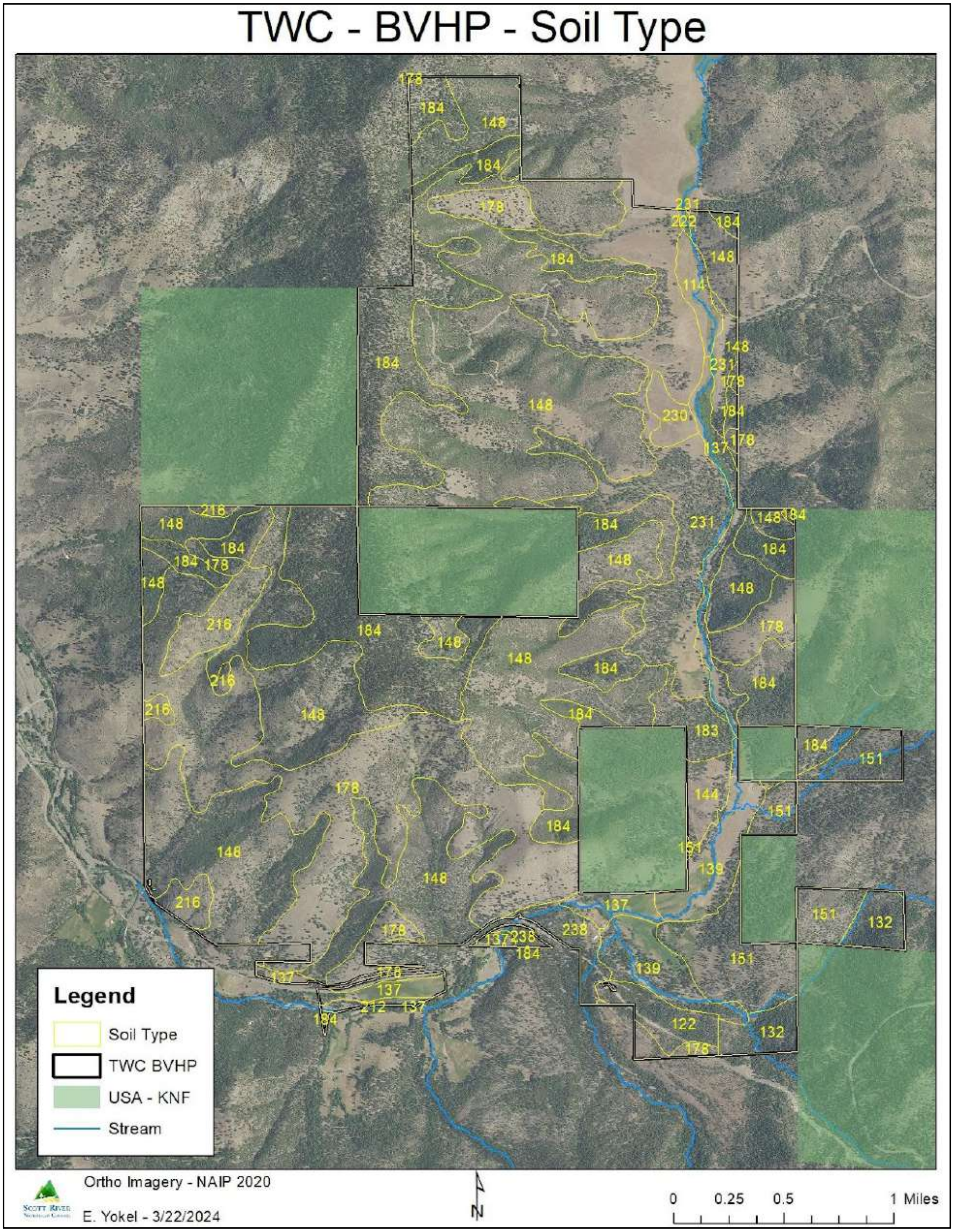
Map 7.9: Slope (degree) of TWC – BVHP Property with 100 ft contours.



Map 7.10: Aspect of TWC – BVHP Property.



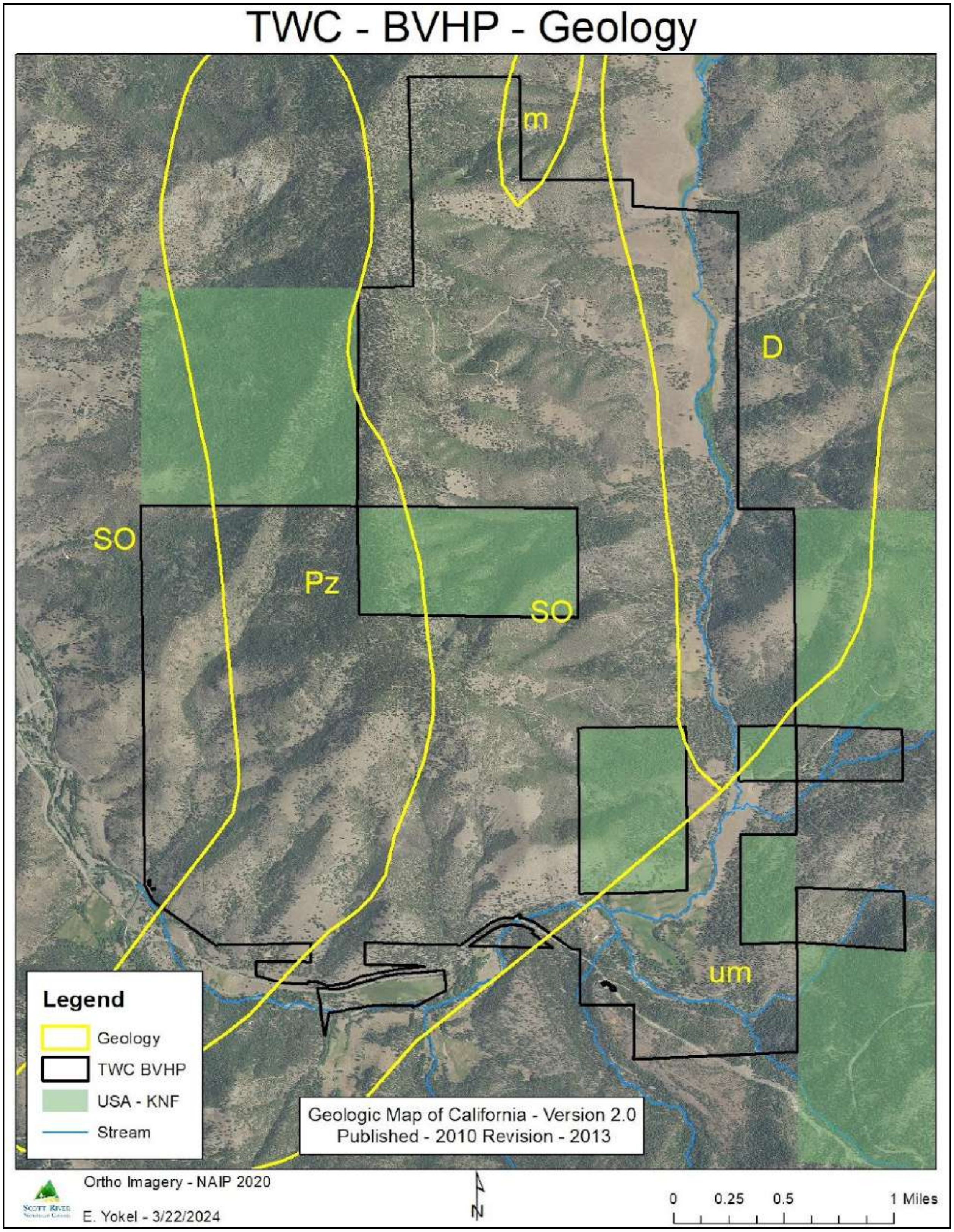
Map 7.11: Aspect of TWC – BVHP Property with 100 ft contours.



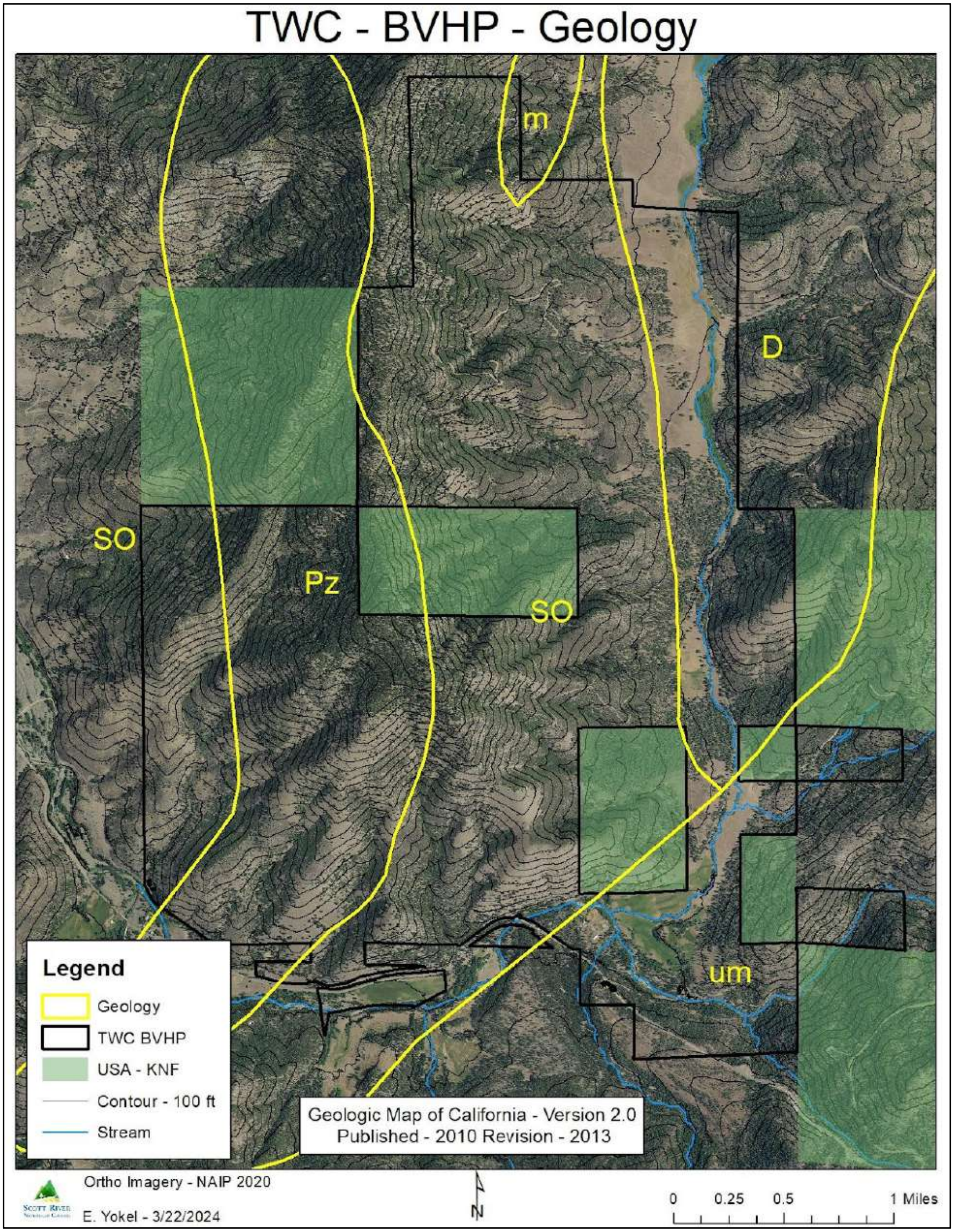
Map 7.12: Soil type of TWC – BVHP Property.

Table 7.10: TWC – BVHP Soil Types

Soil ID	Soil Type	Acres	Percent Area
114	Bonnet gravelly loam, 2 to 5 percent slopes	36	0.7%
122	Dubakella family, 30 to 70 percent slopes.	53	1.0%
132	Goldridge, gravelly-Clallam, deep-Prather families association, 30 to 90 percent slopes.	81	1.5%
137	Diyou loam, drained	141	2.7%
144	Holland-Skalan families association, 30 to 70 percent slopes.	213	4.1%
148	Duzel-Jilson-Facey complex, 15 to 50 percent slopes	2,024	38.4%
151	Kang-Beaughton families association, 9 to 90 percent slopes.	241	4.6%
178	Lithic Xerorthents-Rock outcrop complex, 0 to 65 percent slopes*	839	15.9%
184	Marpa-Kinkel-Boomer, cool complex, 15 to 50 percent slopes	981	18.6%
212	Riverwash	11	0.2%
216	Rock outcrop	105	2.0%
222	Settlemeyer loam, 0 to 2 percent slopes	3	0.1%
230	Stoner gravelly sandy loam, 2 to 5 percent slopes	29	0.5%
231	Stoner gravelly sandy loam, 5 to 15 percent slopes	456	8.7%
238	Xerofluvents, nearly level	54	1.0%
	Total	5,269	



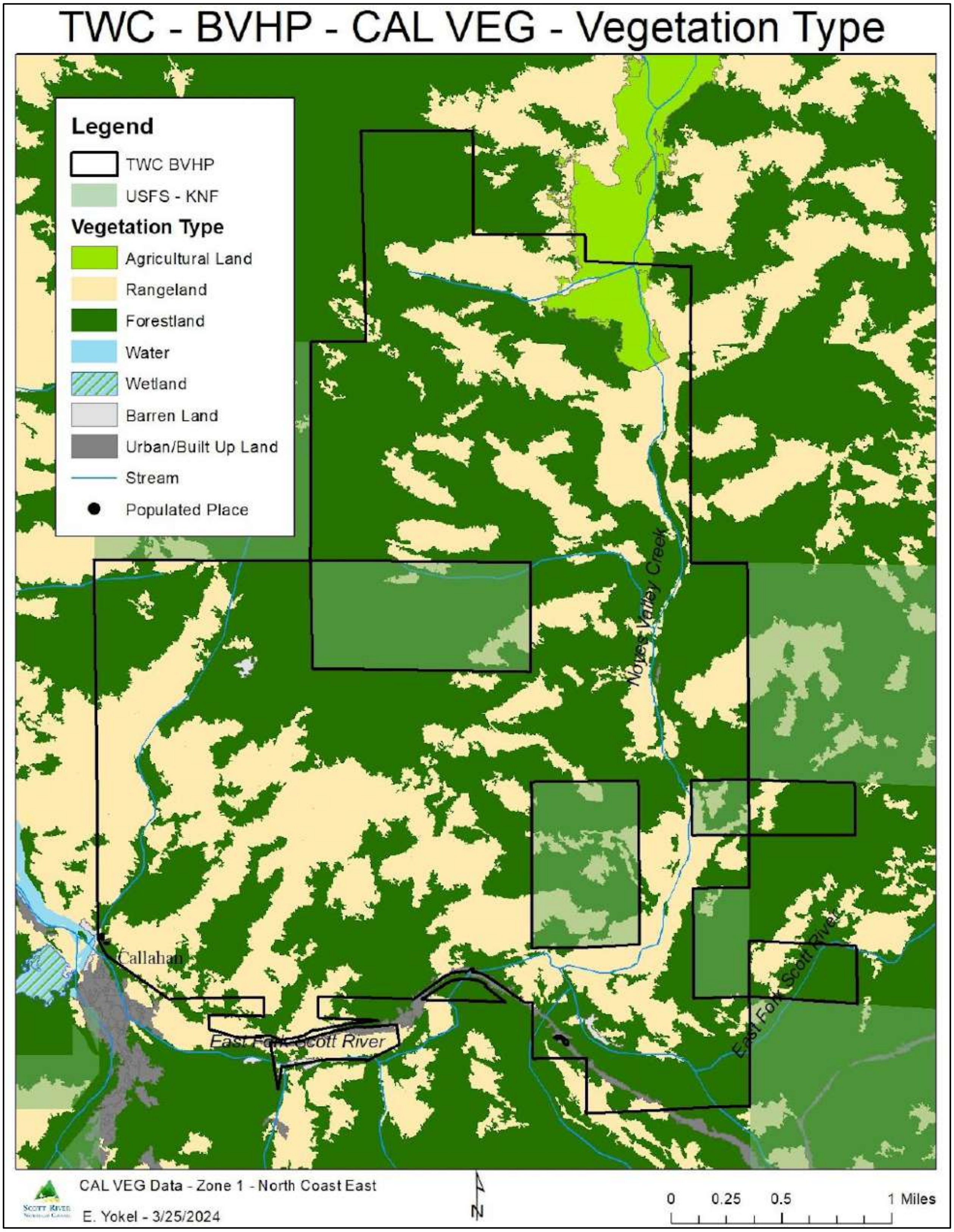
Map 7.13: Geology of TWC - BVHP



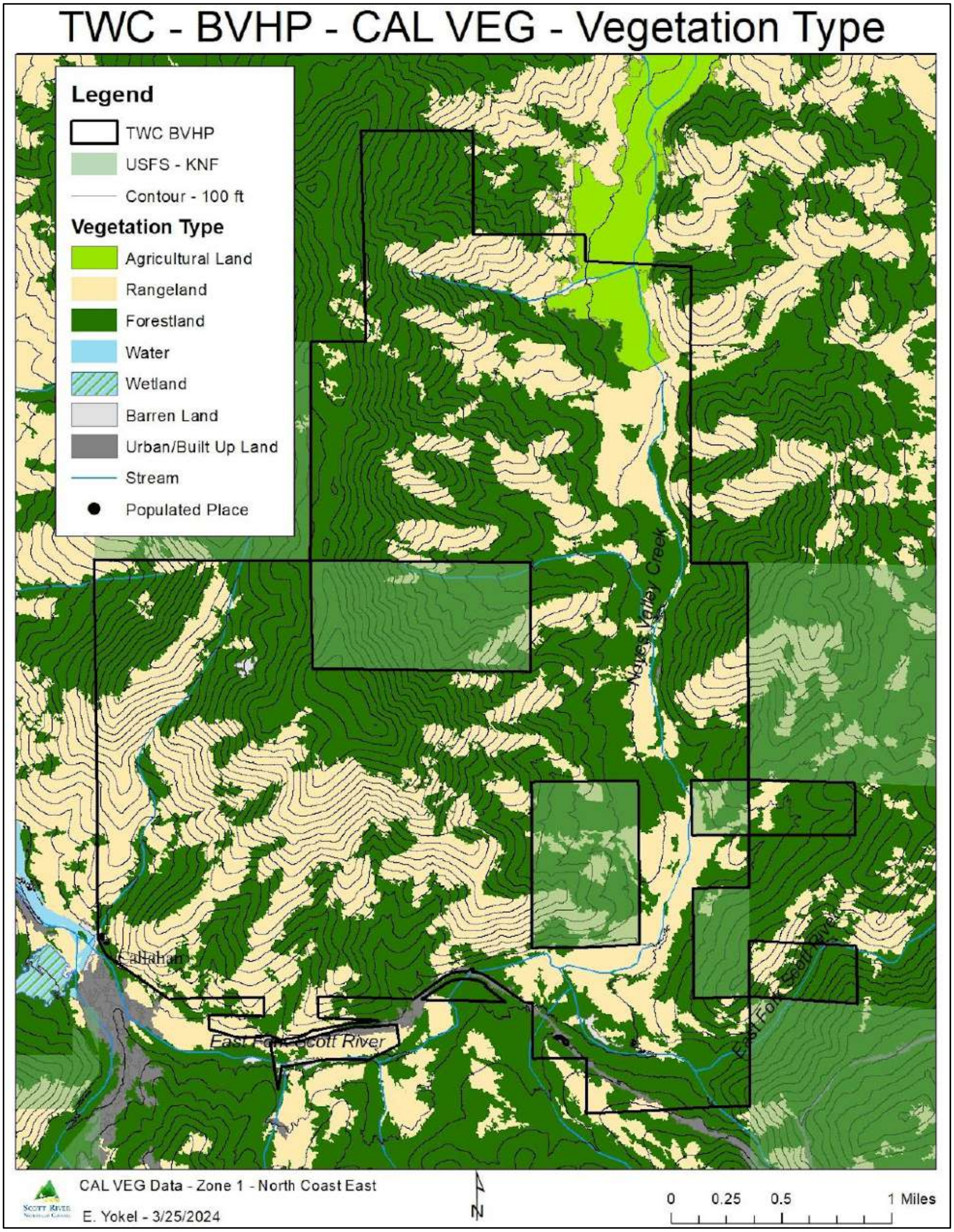
Map 7.14: Geology of TWC – BVHP with 100 ft contours.

Table 7.2: Geology types for BVHP holdings (Department of Conservation, California Geological Survey 2013).

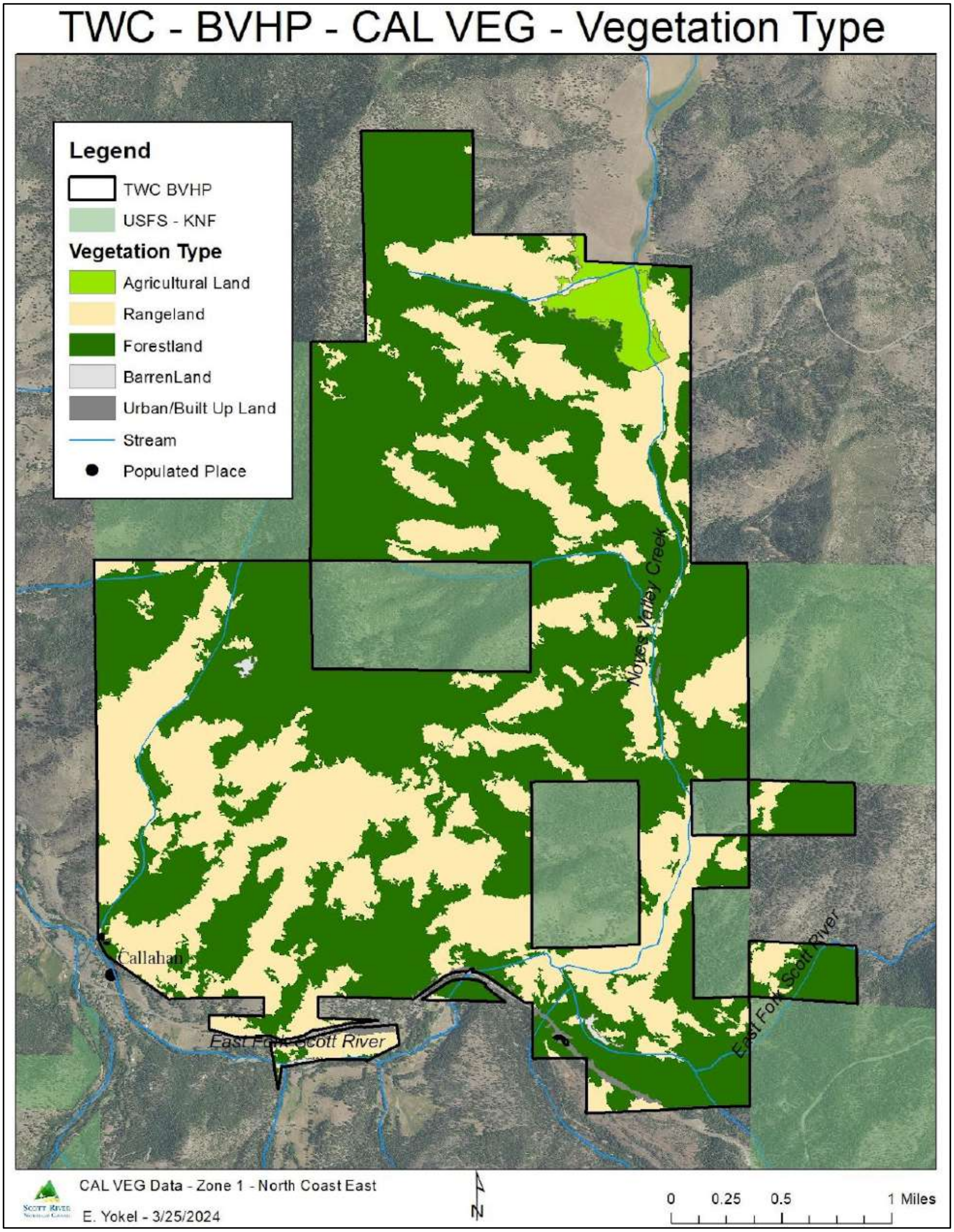
D	*Marine sedimentary and metasedimentary rocks (Devonian) - Limestone and dolomite, sandstone and shale; in part tuffaceous.*
m	*Mixed rocks (pre-Cenozoic) - Undivided pre-Cenozoic metasedimentary and metavolcanic rocks of great variety. Mostly slate, quartzite, hornfels, chert, phyllite, mylonite, schist, gneiss, and minor marble.*
Pz	*Marine sedimentary and metasedimentary rocks (Paleozoic) - Undivided Paleozoic metasedimentary rocks. Includes slate, sandstone, shale, chert, conglomerate, limestone, dolomite, marble, phyllite, schist, hornfels, and quartzite.*
SO	*Marine sedimentary and metasedimentary rocks (Silurian-Ordivician) - Sandstone, shale, conglomerate, chert, slate, quartzite, hornfels, marble, dolomite, phyllite; some greenstone.*
um	*Plutonic rocks (Mesozoic) - Ultramafic rocks, mostly serpentine. Minor peridotite, gabbro, and diabase; chiefly Mesozoic.*



Map 7.15: CALVEG Vegetation Type.



Map 7.16: CALVEG Vegetation Type with 100 ft contours.



Map 7.17: CALVEG Vegetation Type of TWC-BVHP.

Table 7.3: CALVEG Vegetation Type Area.

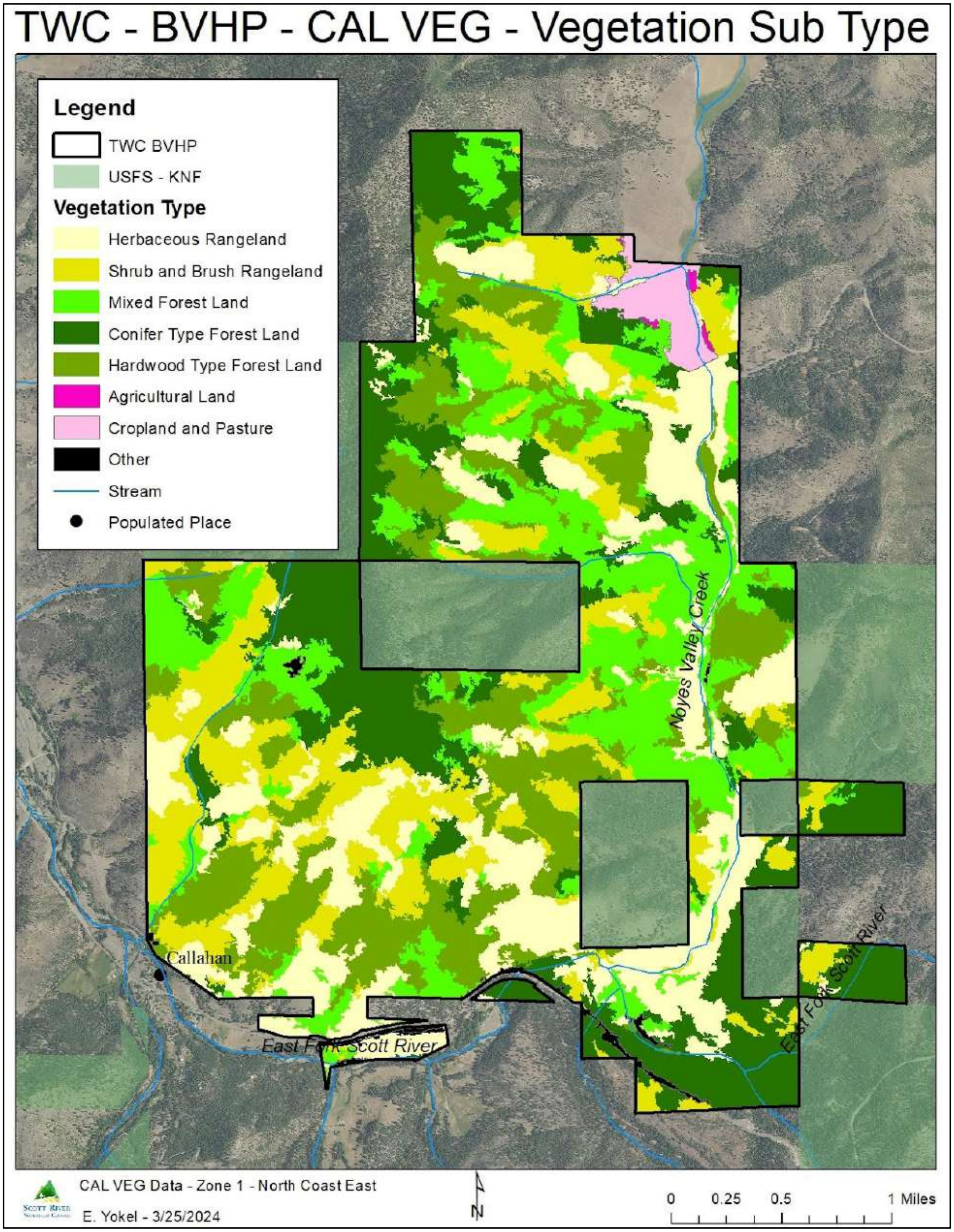
Vegetation Type	Acres	Percent Area
Forestland	3,157	60%
Rangeland	1,994	38%
Agricultural Land	92	2%
Barren land	9	0%
Urban/Built Up Land	21	0%
Total	5,273	

Table 7.4: CALVEG Forestland Vegetation Type – Sub Types.

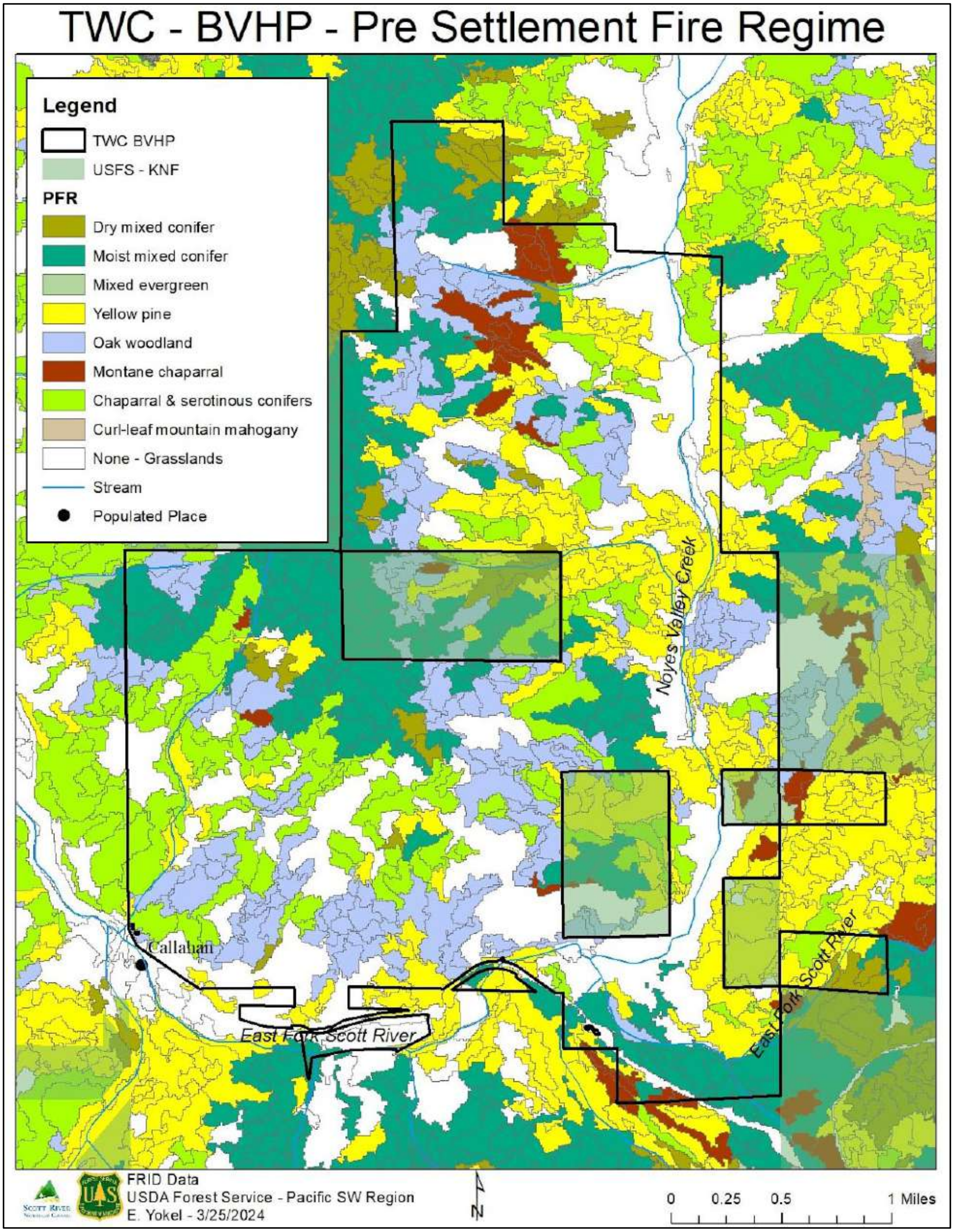
Forestland Vegetation Type	Acres	Percent Area
Mixed Forest Land	1,015	32%
Conifer Type Forest Land	1,118	35%
Hardwood Type Forest Land	1,024	32%
Total	3,157	

Table 7.5: CALVEG Rangeland Vegetation Type – Sub Types.

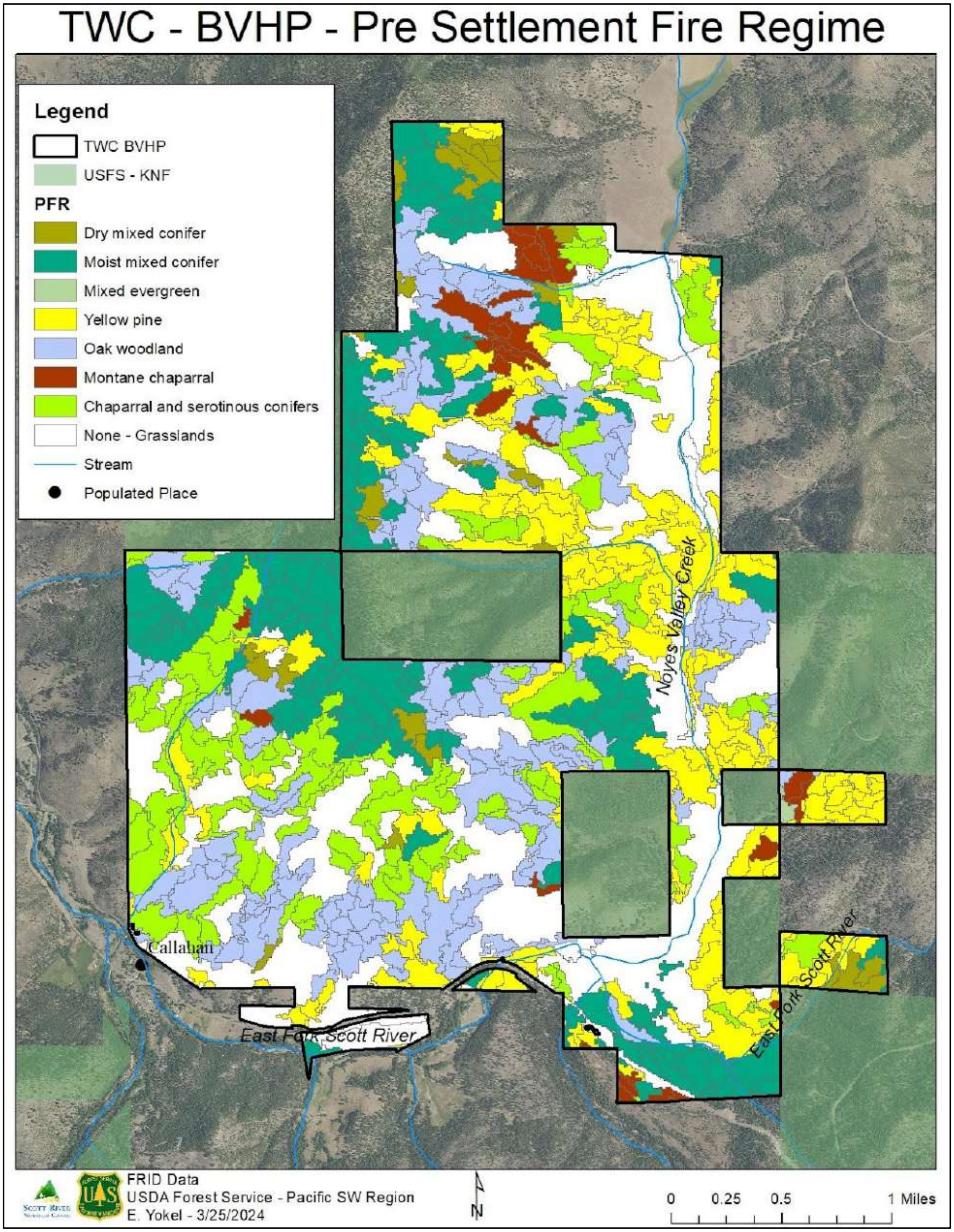
Pastureland Vegetation Type	Acres	Percent Area
Herbaceous Rangeland	1089.8	55%
Shrub and Brush Rangeland	904.55	45%
Total	1,994	



Map 7.18: CALVEG Vegetation Sub Type of TWC-BVHP.



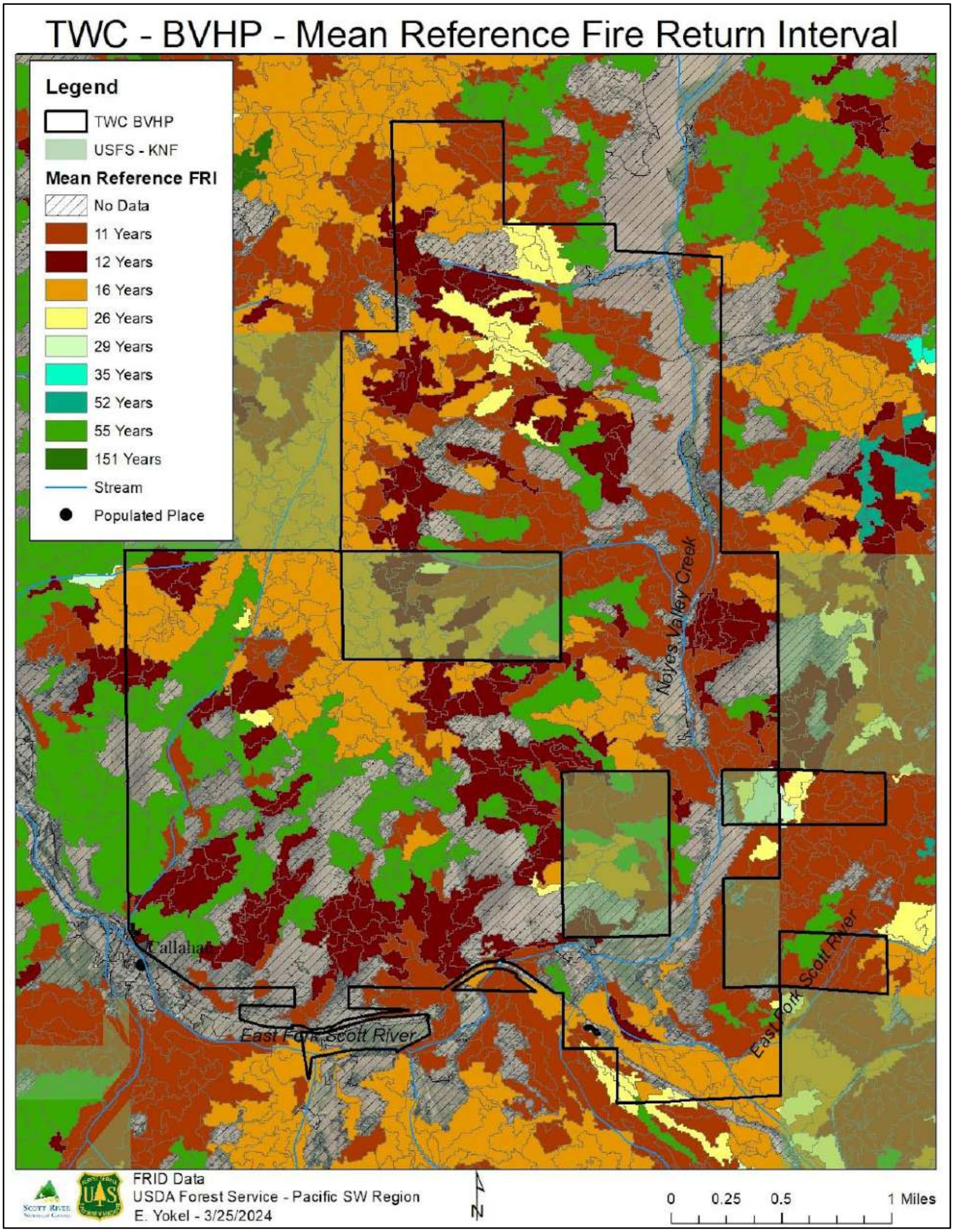
Map 7.19: Pre-settlement Fire Regime from Fire Return Interval Divergence (FRID) dataset.



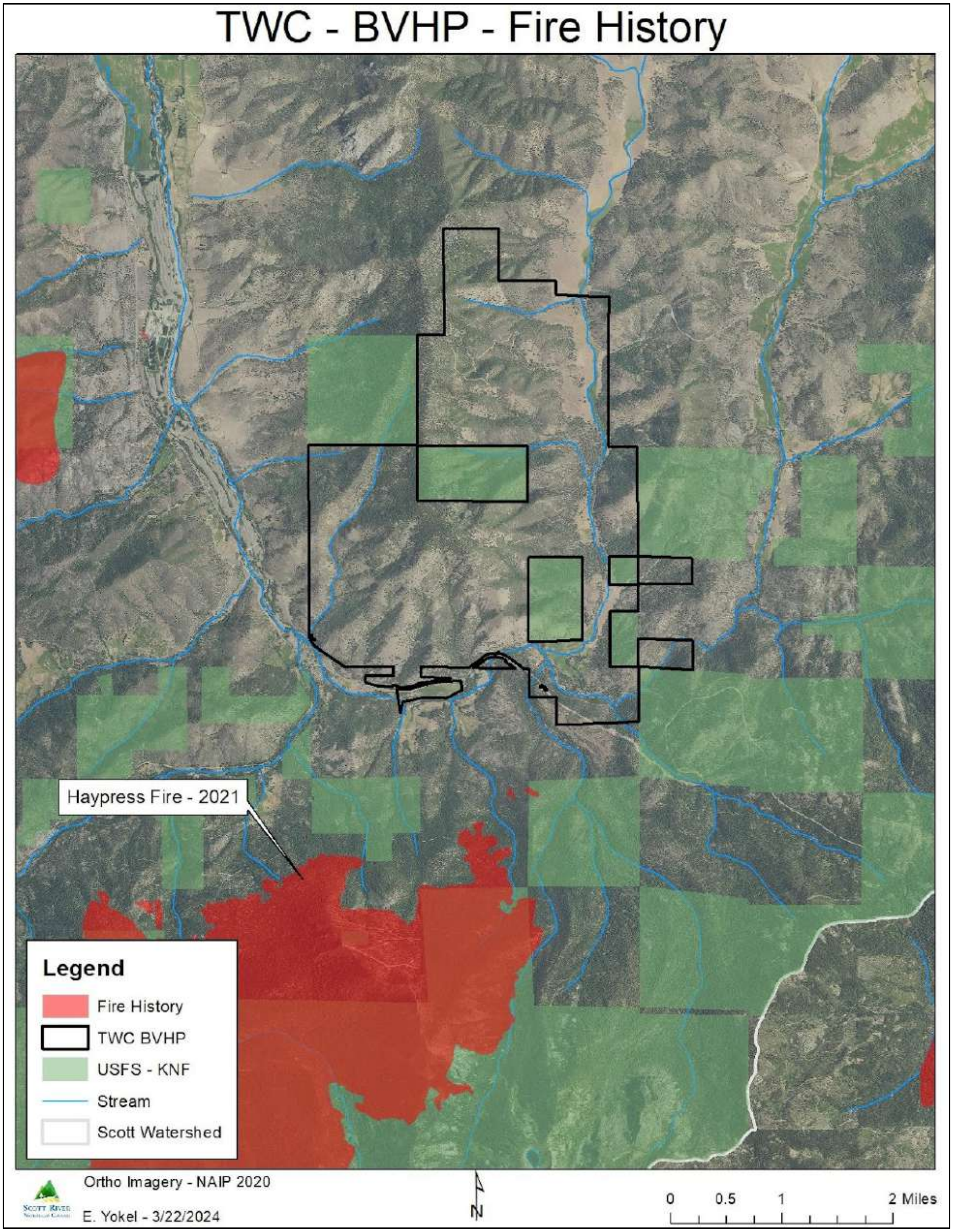
Map 7.20: Pre-Settlement Fire Regime on TWC-BVHP.

Table7.6: Pre-settlement Fire Regime area for TWC-BVHP.

Pre Settlement Fire Regime	Acres	Percent Area
Dry mixed conifer	147	3%
Moist mixed conifer	938	18%
Mixed evergreen	5	0%
Yellow pine	991	19%
Oak woodland	978	19%
Montane chaparral	148	3%
Chaparral and serotinous conifers	766	15%
None - Grassland/ Meadow	1,296	25%
Total	5,269	



Map 7.21: Mean Reference Fire Return Interval from FRID dataset.



Map 7.22: Fire history on BVHP.

7.6 Conclusions

Current proposed drought mortality treatments should be implemented as soon as possible to reduce hazardous fuel loading and to utilize trees while they are still economical to remove. By removing the dead and dying trees using a combination of commercial harvest and the production of chips, this allows for a large quality of the bulk material to be removed, eliminating excess mastication and/or burning methods. There is also the ability to couple instream restoration activities with the need for large wood. Using material from TWC can also aid in the goals of removal of the excesses biomass and put it to work in instream habitat restoration projects, both on TWC and other areas of the Scott River watershed. Post-treatment monitoring should be conducted to limit the spread of invasive species and ensure that erosion control measures are succeeding.

Fortunately, there are forest stands within BVHP, especially at higher elevations, that are not experiencing the levels of mortality that we are seeing in the lower elevations. Although there is less mortality, many of these stands are overstocked and would benefit from thinning. A property-wide forest management plan that utilizes mechanical thinning, non-mechanical thinning and prescribed fire should be developed to guide future operations that aim to create a more biodiverse and fire resilient landscape.

7.7 Bibliography

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Department of Conservation, California Geological Survey. 2013. Geologic Map of California, Version 2.0 (California Geological Survey 150th Anniversary Edition). Charles W. Jennings, with modifications by Carlos Gutierrez, William Bryant, George Saucedo and Chris Wills Sacramento, California.

Hegewisch, K.C. and Abatzoglou, J.T..' Historical Climate Tracker' web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on April 9, 2024.

Appendix 1.1 Methods from CDFW

EXCERPTED FROM THE CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL HABITAT INVENTORY METHODS (Volume III- Page 47) February 2004

The following methods were employed to collect data on the stream width and canopy cover parameters:

Percent Total Canopy - Enter the percentage of the stream area that is influenced by the tree canopy. The canopy is measured using a spherical densiometer at the upstream end of each habitat unit in the center of the wetted channel. (Appendix M).

Percent Hardwood Trees - Estimate the percent of the total canopy consisting of

hardwood, or broadleaf, trees. For watershed where the entire canopy consists of

hardwood trees, use this field to distinguish deciduous trees, or trees that provide partial year shade and leaf-drop.

Percent Coniferous Trees - Estimate the percent of the total canopy consisting of

coniferous, or needle leafed, trees. For watersheds where the entire canopy consists of hardwood trees, use this field to distinguish evergreen trees, or trees that provide year round shade.

Right Bank Composition - Observed from the base of the stream bank to the bankfull discharge level. Enter the number (1 through 4) for the right bank composition type corresponding to the list located on the lower left hand side of the form. Enter one number only. The right bank is the right side of the stream when facing downstream.

Right Bank Dominant Vegetation - Enter the number (5 through 9) for the right bank dominant vegetation type, from bankfull to 20 feet upslope, corresponding to the list located on the lower left hand side of the form. Enter one number only.

Percent Right Bank Vegetated - Estimate the total percentage of the right bank covered with vegetation from bankfull discharge level to 20 feet upslope.

Left Bank Composition - Observed from the lower bank to the bankfull discharge level. Enter the number (1 through 4) for the left bank composition type corresponding to the list located on the lower left hand side of the form. Enter one number only. The left bank is the left side of the stream when facing downstream.

Left Bank Dominant Vegetation - Enter the number (5 through 9) for the left bank dominant composition type, from bankfull to 20 feet upslope, corresponding to the list located on the lower left hand side of the form. Enter one number only.

Percent Left Bank Vegetated - Estimate the total percentage of the left bank covered with vegetation from bankfull discharge level to 20 feet upslope.

Appendix 1.2 Data Sheet

DDDD

Transect ID:		**Lat:**		**Observers:**				
Date:		**Long:**						
Left- Lower Bank Vegetation	**Tree Types**	**Density + Spacing**	**Roots**	**Health**	**Diversity**	**Height**	**Age**	**Lateral Extent**
None/fallow	None	None	Normal	Healty	Mono-stand	Short (0-3)	Immature	Wide belt
Grass	Deciduos	Sparse/clumps	Exposed	Fair/poor	Mixed stand	Medium (3-15)	Mature	Narrow belt
Reeds and sedges	Coniferous	Dense/clumps	Adventitious	Dead	Climax- Vegetation	Tall (15+)	Old	Single row
Shrubs	Mixed	Sparse/continuous	**Notes:**					
Saplings		Dense/continuous						
Trees: species	**Erosion location**	**Present Status**	**Occular Assement**	**Extent of Erosion**	**Severity of Erosion**	**Processes**	**Feature Length:**	
	Outside meander	Intact	Sand/Silt/Clay	None	Insignficant	Parallel flow	**Feature Height:**	
	Inside meander	Eroding dormant	Sand	Local	Moderate	Impinging flow		
	Opposite a bar	Eroding active	Gravel	Reach-scale	Severe	Other (write in		
	US/DS structure	Advancing dormant	Cobbles	System-wide	Catastrophic			
	Other:	Advancing active	Boulder	**Notes:**				
			Bedrock					
Left- Upper Bank Vegetation	**Tree Types**	**Density + Spacing**	**Roots**	**Health**	**Diversity**	**Height**	**Age**	**Lateral Extent**
None/fallow	None	None	Normal	Healty	Mono-stand	Short (0-3)	Immature	Wide belt
Grass	Deciduos	Sparse/clumps	Exposed	Fair/poor	Mixed stand	Medium (3-15)	Mature	Narrow belt
Reeds and sedges	Coniferous	Dense/clumps	Adventitious	Dead	Climax- Vegetation	Tall (15+)	Old	Single row
Shrubs	Mixed	Sparse/continuous	**Notes:**					
Saplings		Dense/continuous						
Trees: species	**Erosion location**	**Present Status**	**Occular Assement**	**Extent of Erosion**	**Severity of Erosion**	**Processes**	**Feature Length:**	
	Outside meander	Intact	Sand/Silt/Clay	None	Insignficant	Parallel flow	**Feature Height:**	
	Inside meander	Eroding dormant	Sand	Local	Moderate	Impinging flow		
	Opposite a bar	Eroding active	Gravel	Reach-scale	Severe	Other (write in		
	US/DS structure	Advancing dormant	Cobbles	System-wide	Catastrophic			
	Other:	Advancing active	Boulder	**Notes:**				
			Bedrock					
Right- Lower Bank Vegetation	**Tree Types**	**Density + Spacing**	**Roots**	**Health**	**Diversity**	**Height**	**Age**	**Lateral Extent**
None/fallow	None	None	Normal	Healty	Mono-stand	Short (0-3)	Immature	Wide belt
Grass	Deciduos	Sparse/clumps	Exposed	Fair/poor	Mixed stand	Medium (3-15)	Mature	Narrow belt
Reeds and sedges	Coniferous	Dense/clumps	Adventitious	Dead	Climax- Vegetation	Tall (15+)	Old	Single row
Shrubs	Mixed	Sparse/continuous	**Notes:**					
Saplings		Dense/continuous						
Trees: species	**Erosion location**	**Present Status**	**Occular Assement**	**Extent of Erosion**	**Severity of Erosion**	**Processes**	**Feature Length:**	
	Outside meander	Intact	Sand/Silt/Clay	None	Insignficant	Parallel flow	**Feature Height:**	
	Inside meander	Eroding dormant	Sand	Local	Moderate	Impinging flow		
	Opposite a bar	Eroding active	Gravel	Reach-scale	Severe	Other (write in		
	US/DS structure	Advancing dormant	Cobbles	System-wide	Catastrophic			
	Other:	Advancing active	Boulder	**Notes:**				
			Bedrock					
Right- Upper Bank Vegetation	**Tree Types**	**Density + Spacing**	**Roots**	**Health**	**Diversity**	**Height**	**Age**	**Lateral Extent**
None/fallow	None	None	Normal	Healty	Mono-stand	Short (0-3)	Immature	Wide belt
Grass	Deciduos	Sparse/clumps	Exposed	Fair/poor	Mixed stand	Medium (3-15)	Mature	Narrow belt
Reeds and sedges	Coniferous	Dense/clumps	Adventitious	Dead	Climax- Vegetation	Tall (15+)	Old	Single row
Shrubs	Mixed	Sparse/continuous	**Notes:**					
Saplings		Dense/continuous						
Trees: species	**Erosion location**	**Present Status**	**Occular Assement**	**Extent of Erosion**	**Severity of Erosion**	**Processes**	**Feature Length:**	
	Outside meander	Intact	Sand/Silt/Clay	None	Insignficant	Parallel flow	**Feature Height:**	
	Inside meander	Eroding dormant	Sand	Local	Moderate	Impinging flow		
	Opposite a bar	Eroding active	Gravel	Reach-scale	Severe	Other (write in		
	US/DS structure	Advancing dormant	Cobbles	System-wide	Catastrophic			
	Other:	Advancing active	Boulder	**Notes:**				
			Bedrock					

Appendix 1.3 Remote Sensing Riparian Analysis – LiDAR derived canopy height, cross sections and profile

LiDAR was first acquired for the TWC – BVHP East Fork Scott River holdings on October 10 – 14, 2010 – a period of relatively low fall flows (approximately 50 cfs at USGS Scott River gage). The 2010 LiDAR products include a bare earth DEM and a highest hits (first return) DSM. LiDAR was acquired for the TWC – BVHP holdings on March 30, 2018, a period of early spring runoff (approximately 465 cfs at USGS Scott River gage).

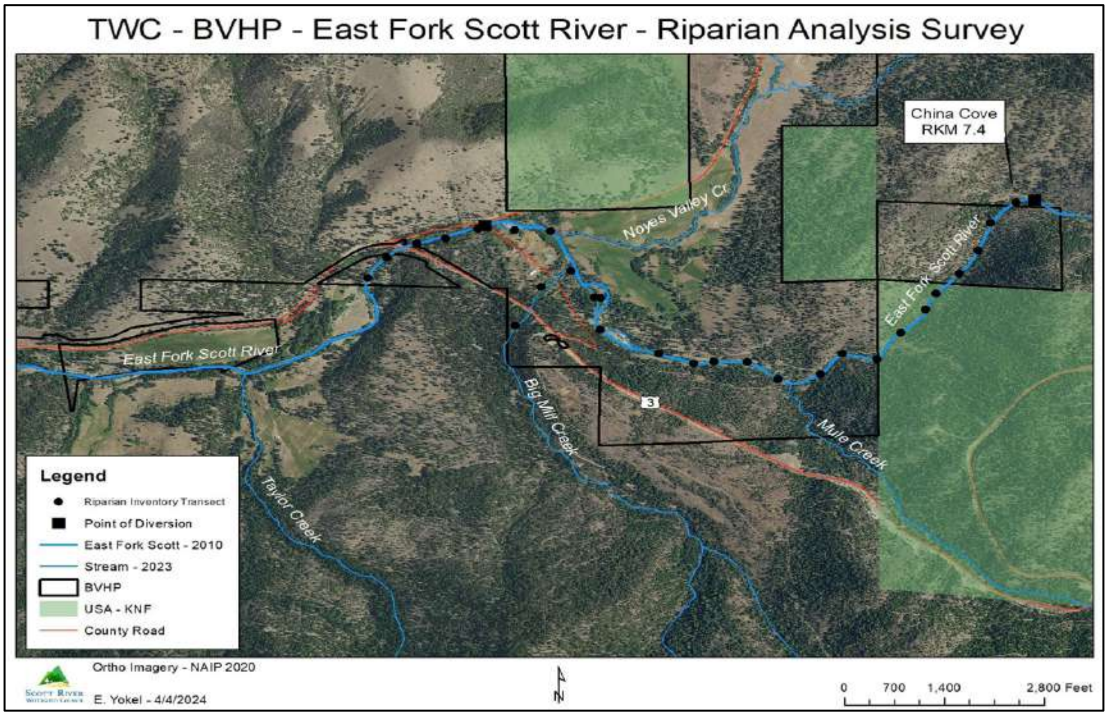
Analysis of the 2010 LiDAR bare earth and highest hit products were utilized to generate longitudinal profiles and cross sections (Map 1), classified canopy height rasters (Maps 2, 4 and 6) and inundation models (Maps 3, 5 and 7). A longitudinal profile of the East Fork Scott River was generated from the 2010 LiDAR bare earth DSM and stream gradient and sinuosity were calculated for stream reaches (Figure 1 and Table 1). Cross sections illustrating the ground elevation from the 2010 and 2018 bare earth DEMs and the canopy elevation from the 2010 highest hits DSM were calculated for the locations of the field survey riparian analysis transects in the East Fork Scott River and Big Mill Creek and for representative locations in Mule Creek and the East Fork Scott River where field surveys were not performed.

The East Fork Scott River in the TWC – BVHP holdings was split into four reaches – China Cove to the confluence of Mule Creek, the confluence of Mule Creek to the confluence of Big Mill Creek, the confluence of Big Mill Creek to the downstream of the Highway 3 Bridge and from the confluence of Taylor Creek to the downstream property boundary. The upstream reach from China Cove to Mule Creek is defined by canyon topography with no floodplain, the highest stream gradient (1.8%) of the project reaches and low to moderate sinuosity (Table 1). Downstream of Mule Creek the East Fork Scott River becomes a lower gradient stream with areas of floodplain and slightly higher sinuosity. The downstream reach is characterized by very limited sinuosity.

The canopy height raster and LiDAR derived stream cross sections were calculated for an area 300 ft from the stream. Canopy height was classified into five classes representing different vegetative types: 0 - 3 ft - bare earth, grasses and small shrubs, 3 - 15 ft - large shrubs to emergent riparian vegetation (e.g. willows), 15 - 55 ft – small and medium trees, 55 - 100 ft and 100 - 157 ft for large trees that are presumed to be conifers.

Large variations of canopy height and vegetation density is observed throughout the East Fork holdings with high densities of mature conifers observed in the upper canyon reach and the reach upstream of the Highway 3 Bridge (Maps 2 and 4) and limited vegetation densities observed in the areas of pasture (Maps 4 and 6).

The analysis of geomorphic change at cross sections derived from the 2010 and 2018 LiDAR products identified two areas of significant channel migration and multiple discrete sites of geomorphic change in the project reach with the largest channel alteration on the East Fork Scott River occurring at the large vertical cut bank downstream of Noyes Valley Creek at RKM 4.2 to 4.3 and at the multi-channel floodplain bar complex upstream of Big Mill Creek at RKM 4.8 to 5 (Figures 20 – 26).



Map 1 - TWC BVHP holdings on the East Fork Scott River and tributaries

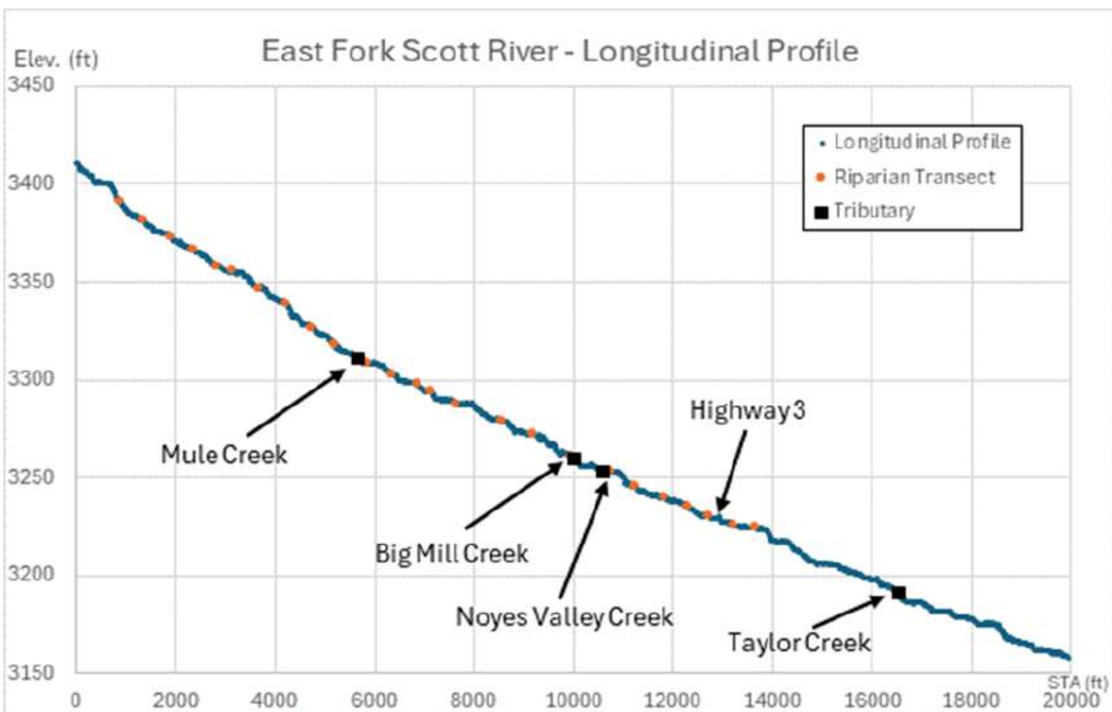
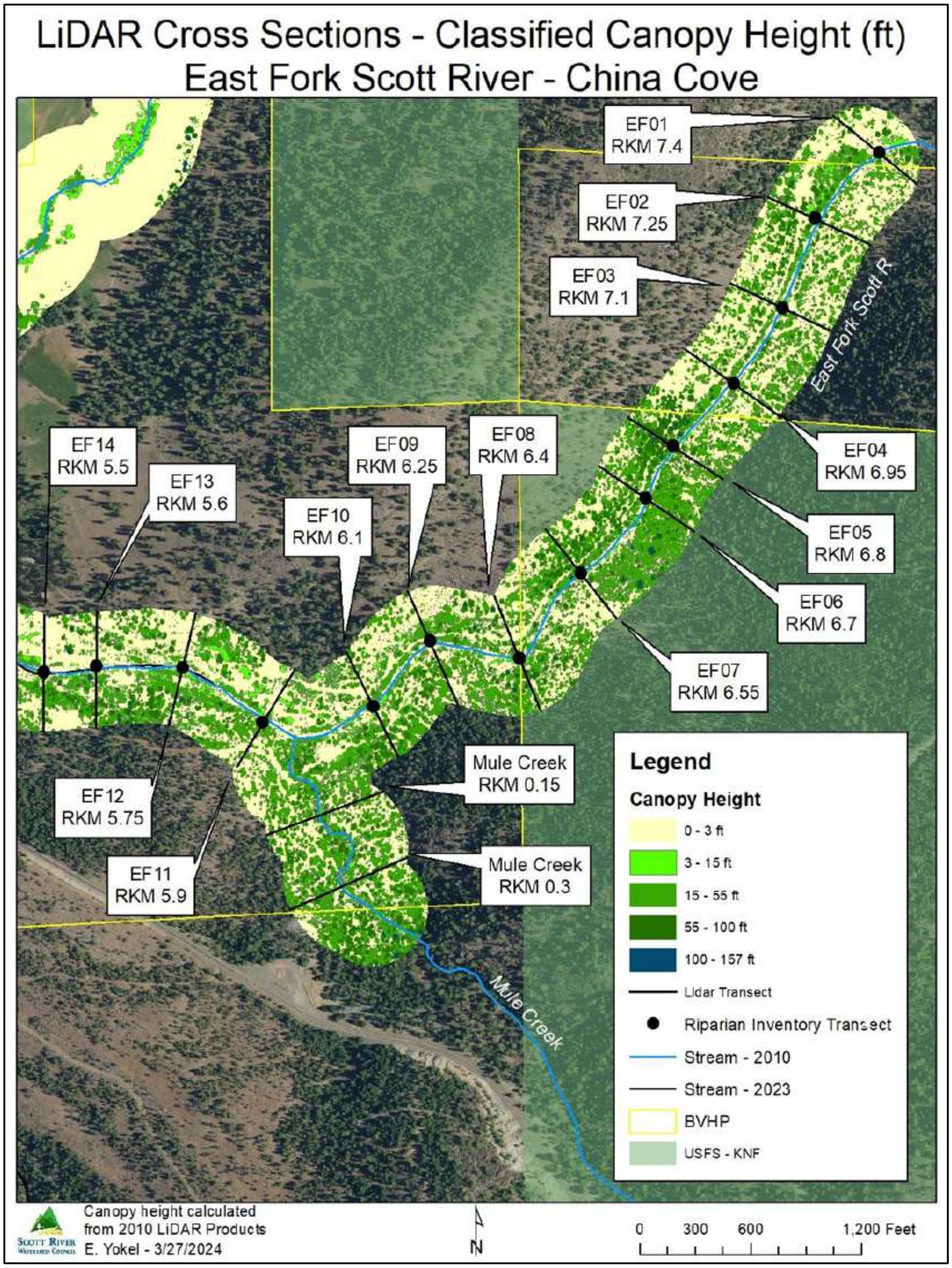


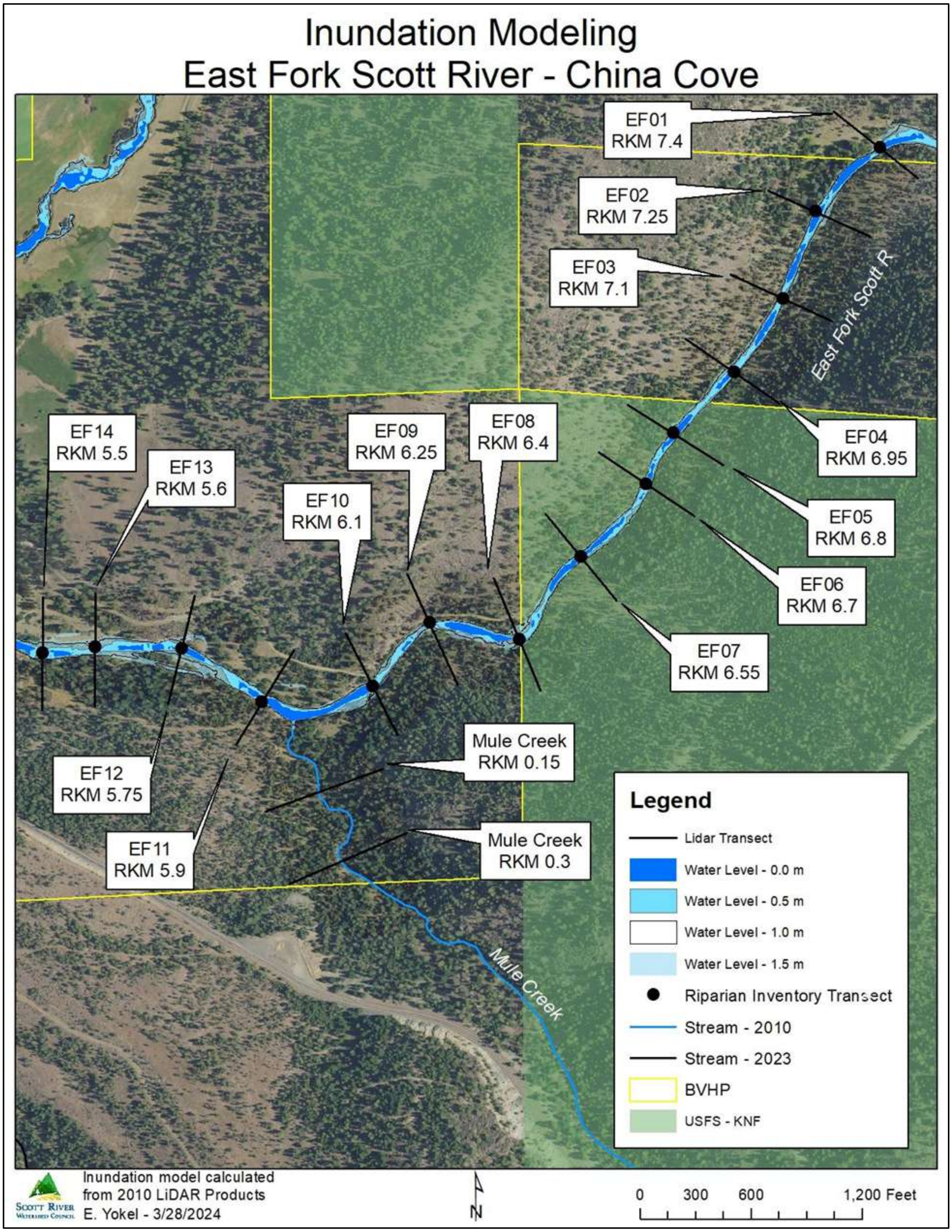
Figure 1: Longitudinal profile of the East Fork Scott River

Table 1: Percent gradient and sinuosity of East Fork Scott River reaches.

Reach	RKM From	RKM To	Percent Gradient	Sinuosity
Upstream China Cove to Mule Creek	7.7	5.95	1.8%	1.16
Mule Creek to Big Mill Creek	5.95	4.6	1.2%	1.21
Big Mill Creek to Downstream Highway 3	4.6	3.5	0.9%	1.27
Taylor Creek to Downstream Property Boundary	2.65	1.8	1.0%	1.02



Map 2: Classified canopy height (ft) and Cross Section Locations



Map 3: Inundation model and Cross Section Locations

East Fork Scott River

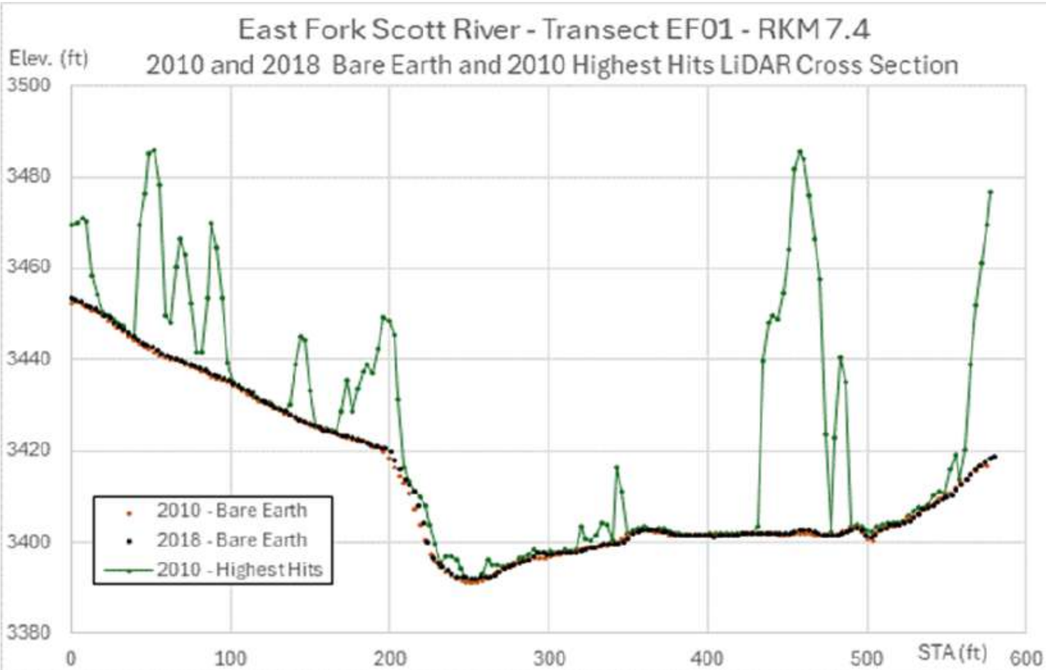


Figure 2: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF01

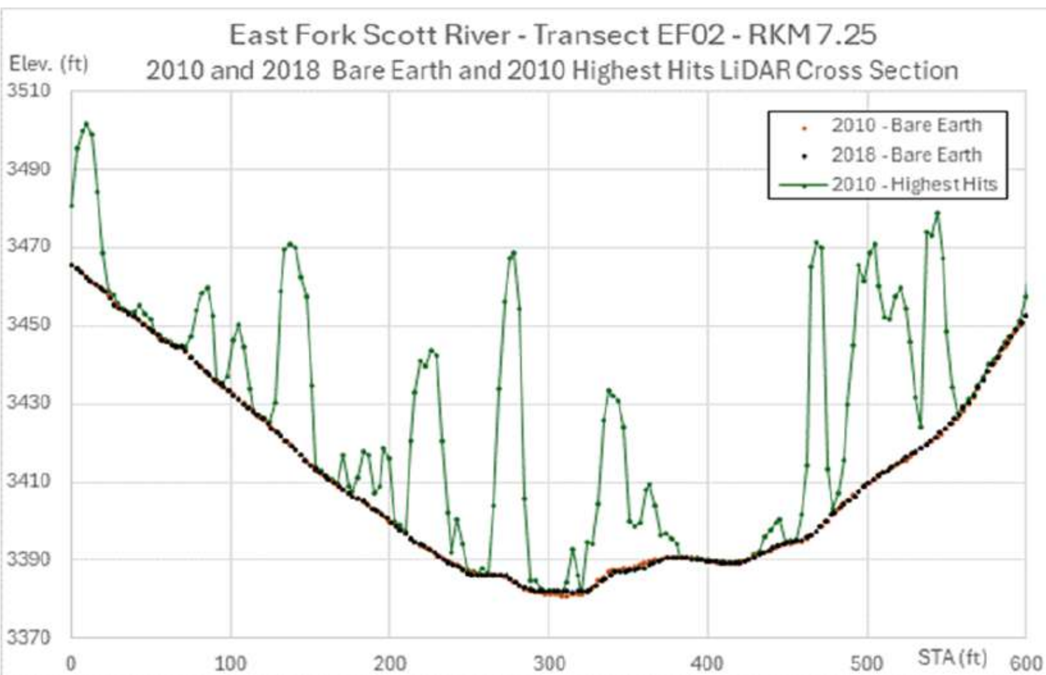


Figure 3: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF02

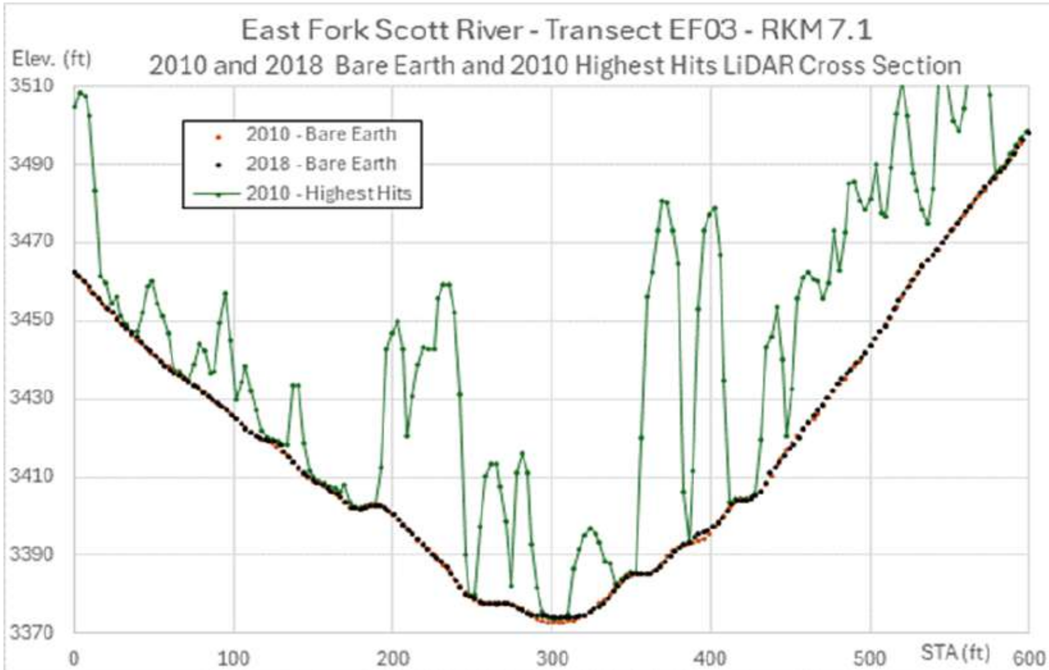


Figure 4: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF03

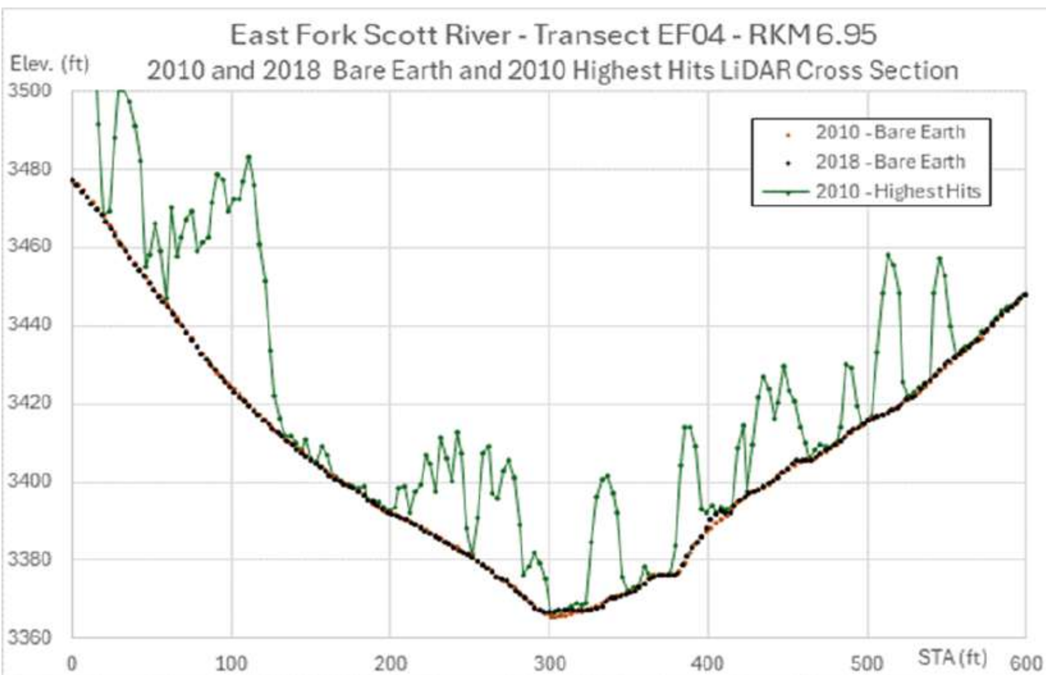


Figure 5: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF04

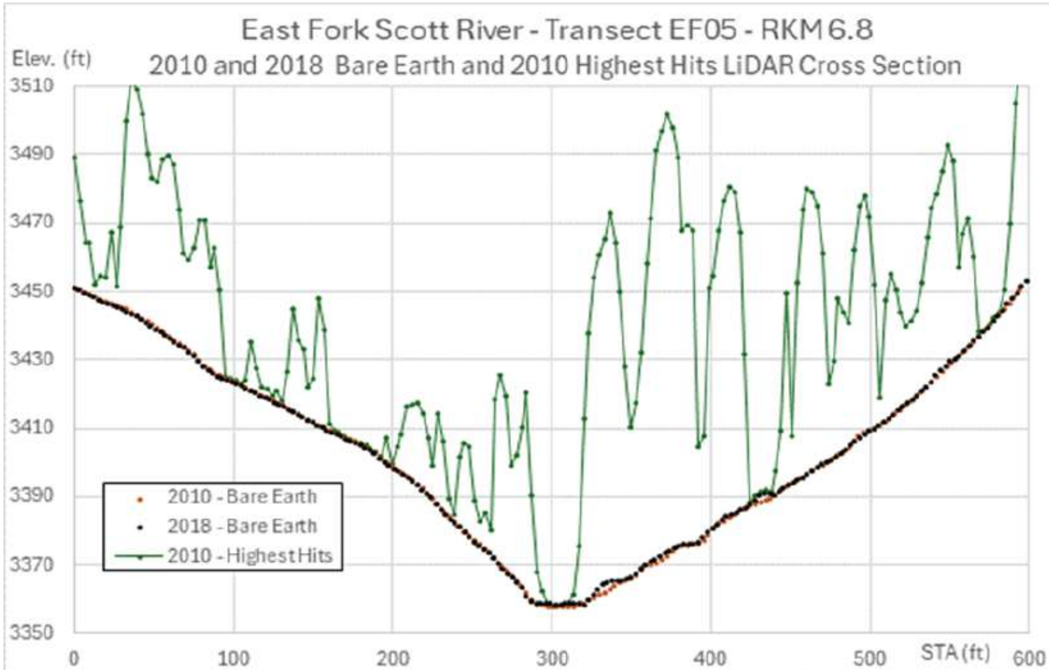


Figure 6: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF05

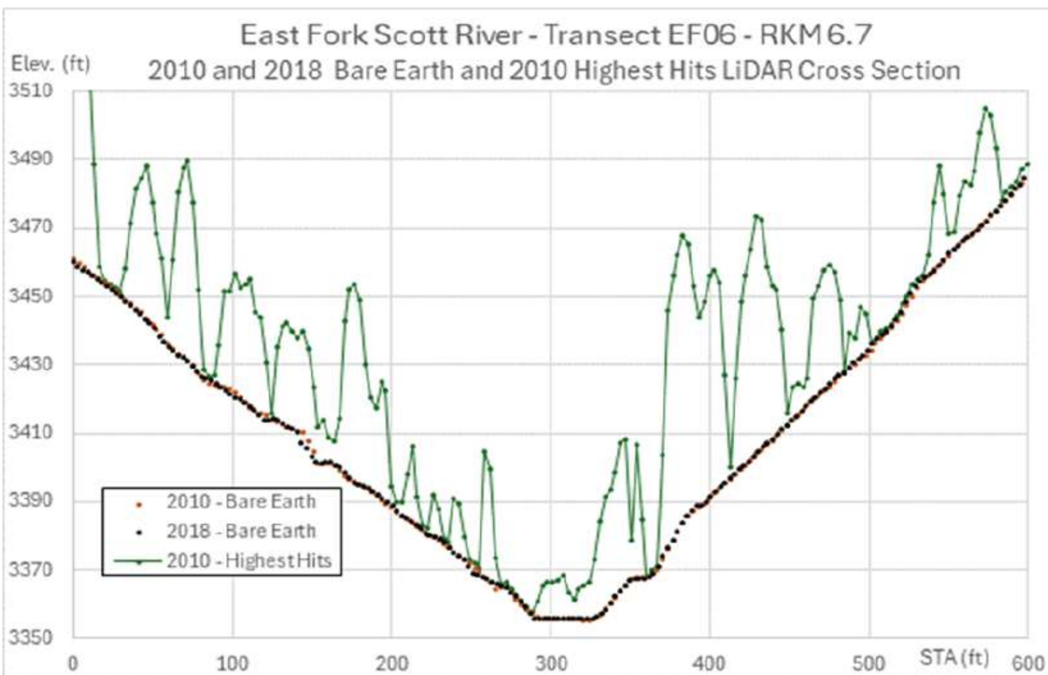


Figure 7: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF06

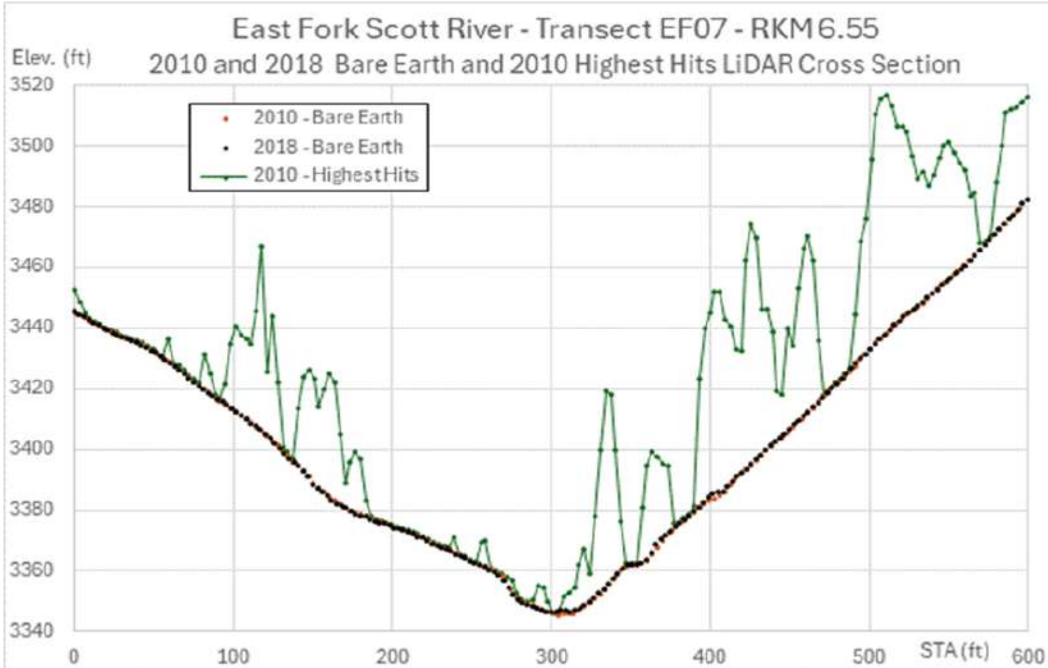


Figure 8: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF07

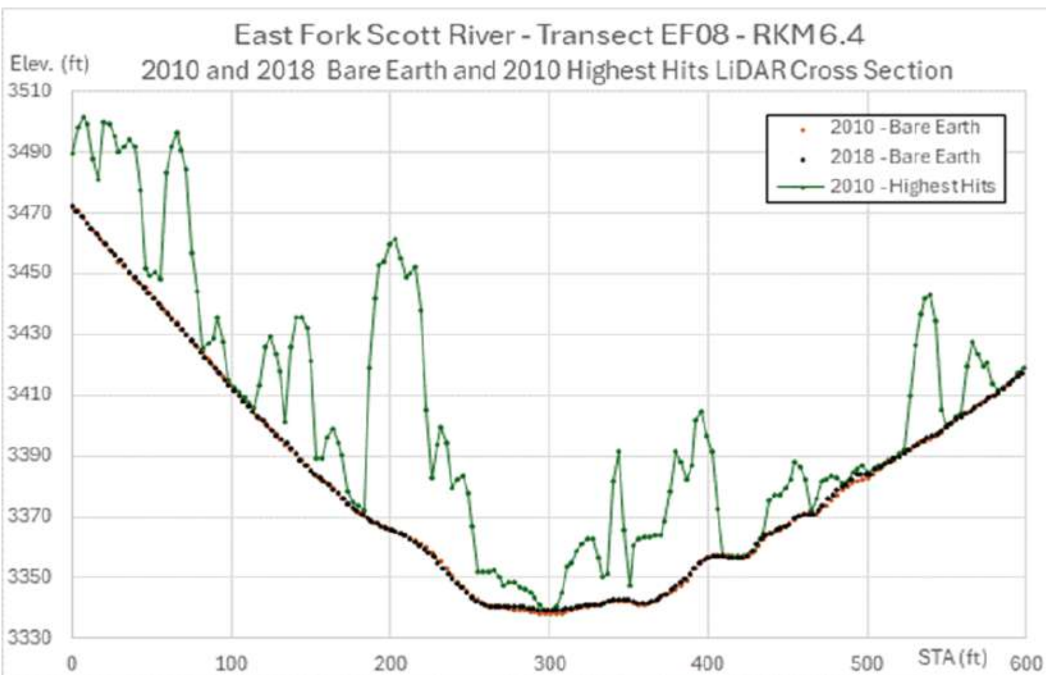


Figure 9: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section -Transect EF08

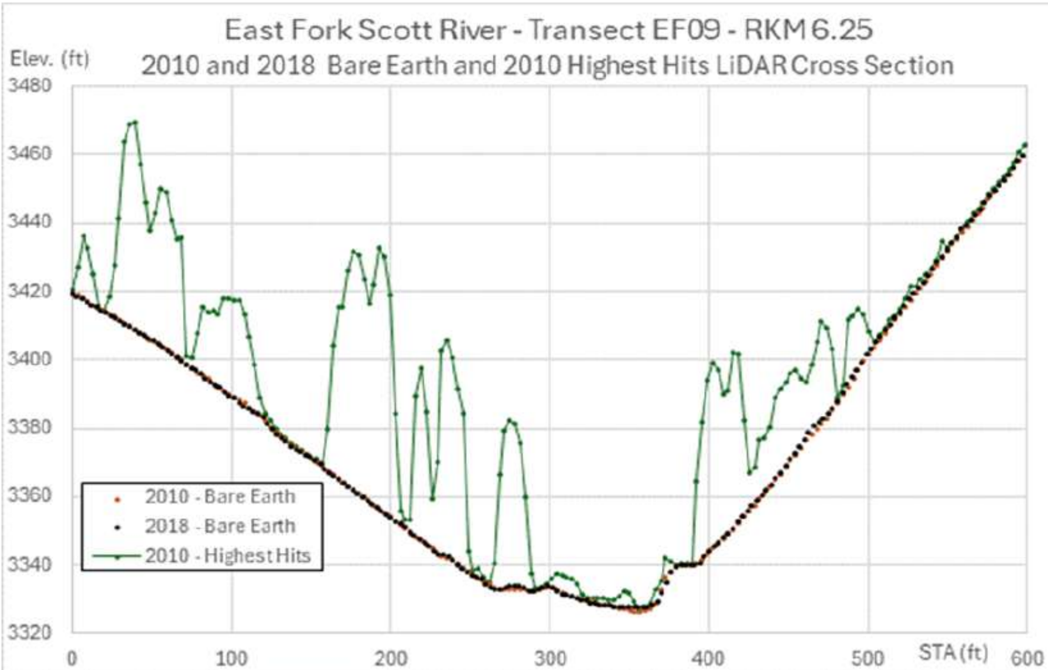


Figure 10: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF09

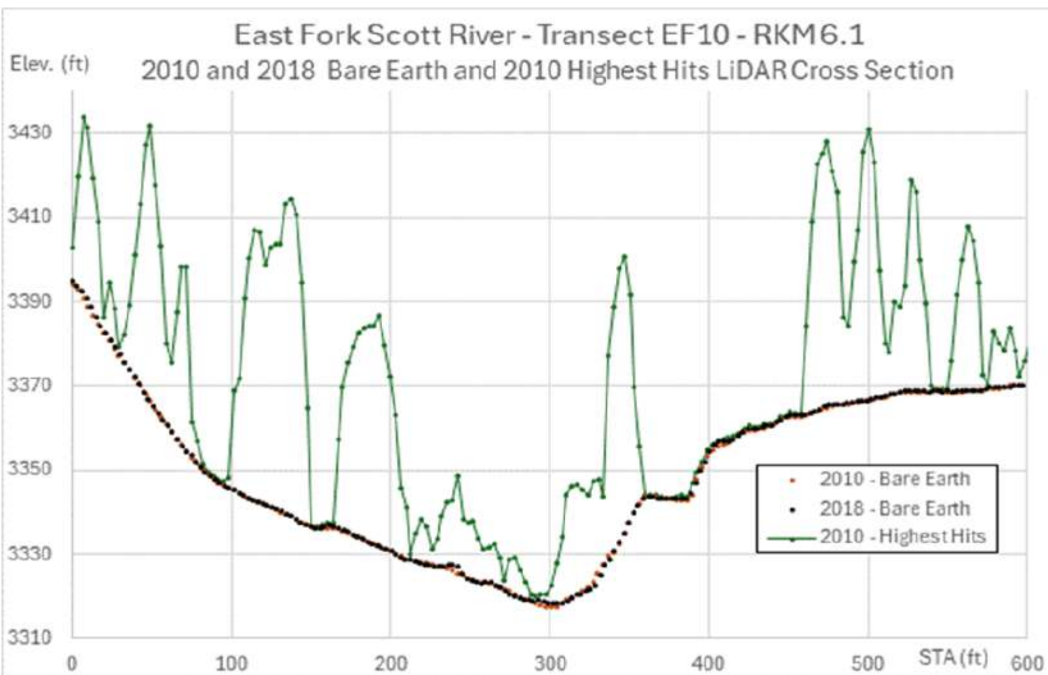


Figure 11: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF10

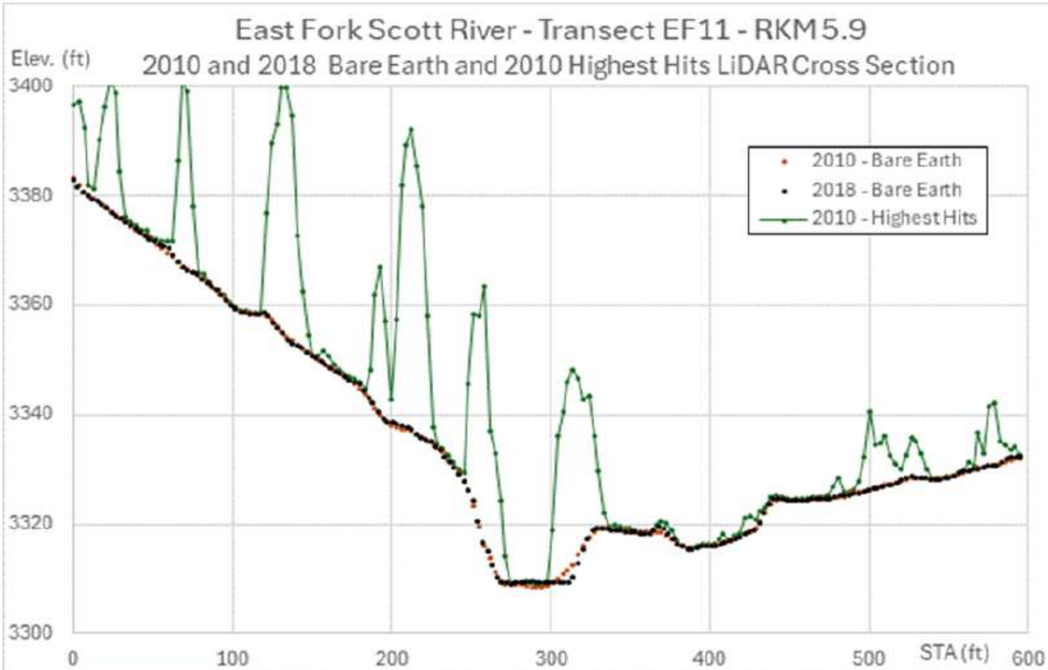


Figure 12: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF11

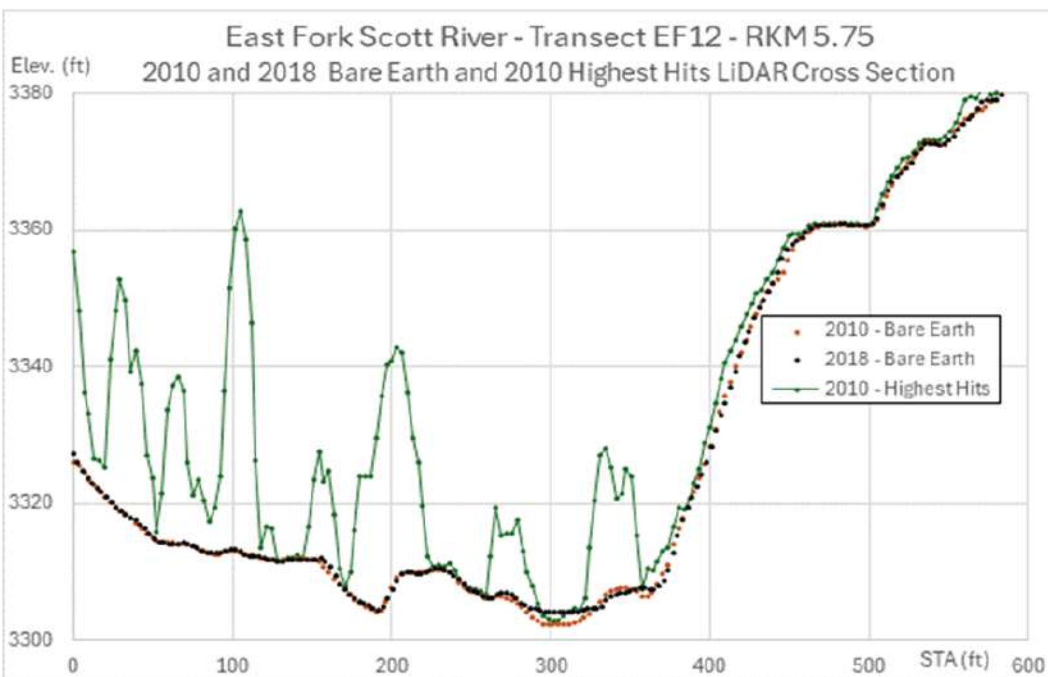


Figure 13: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF12

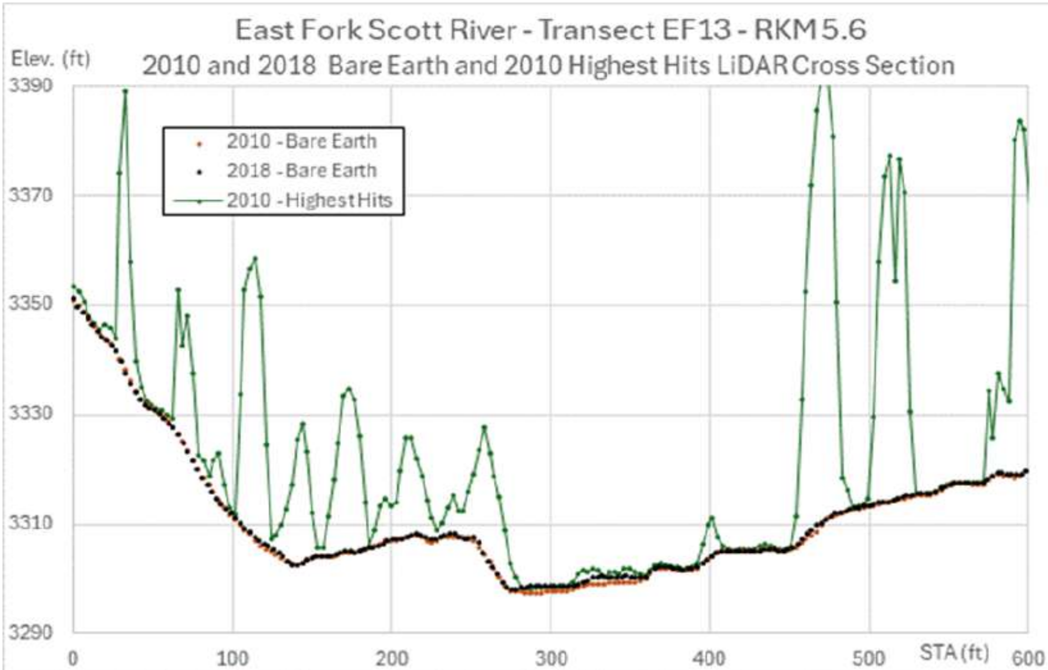


Figure 14: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF13

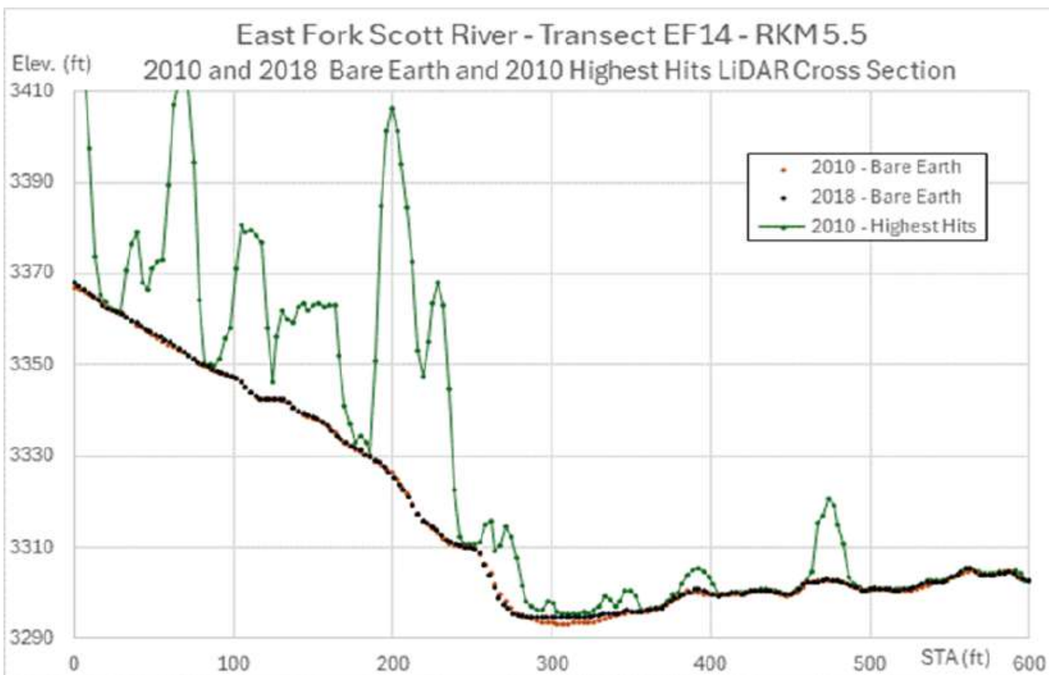


Figure 15: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF14

Mule Creek

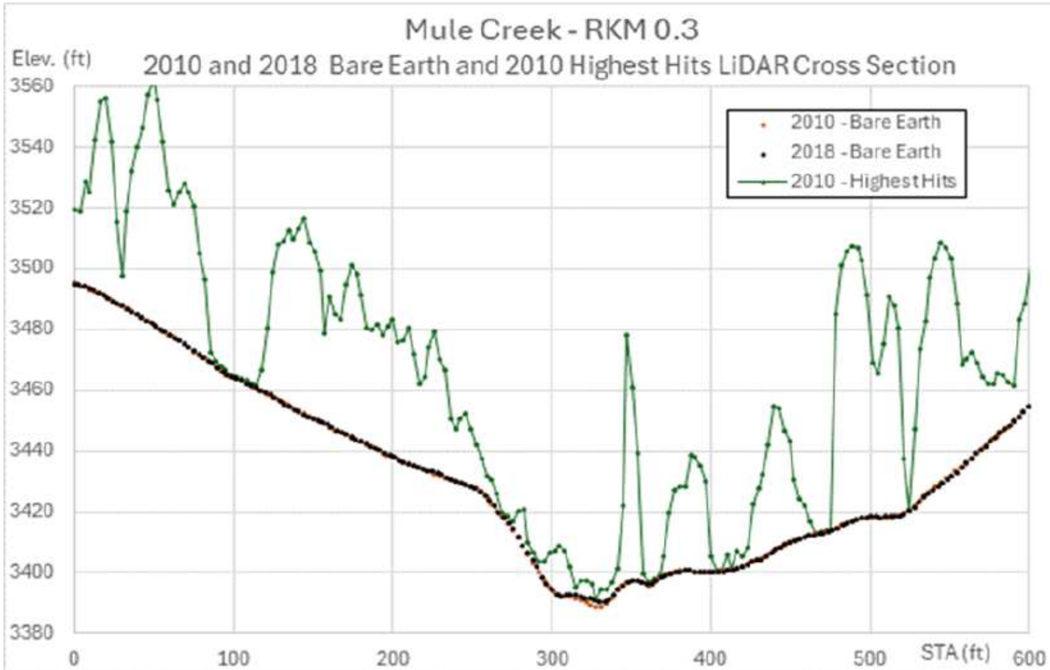


Figure 16: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Mule Cr RKM 0.3

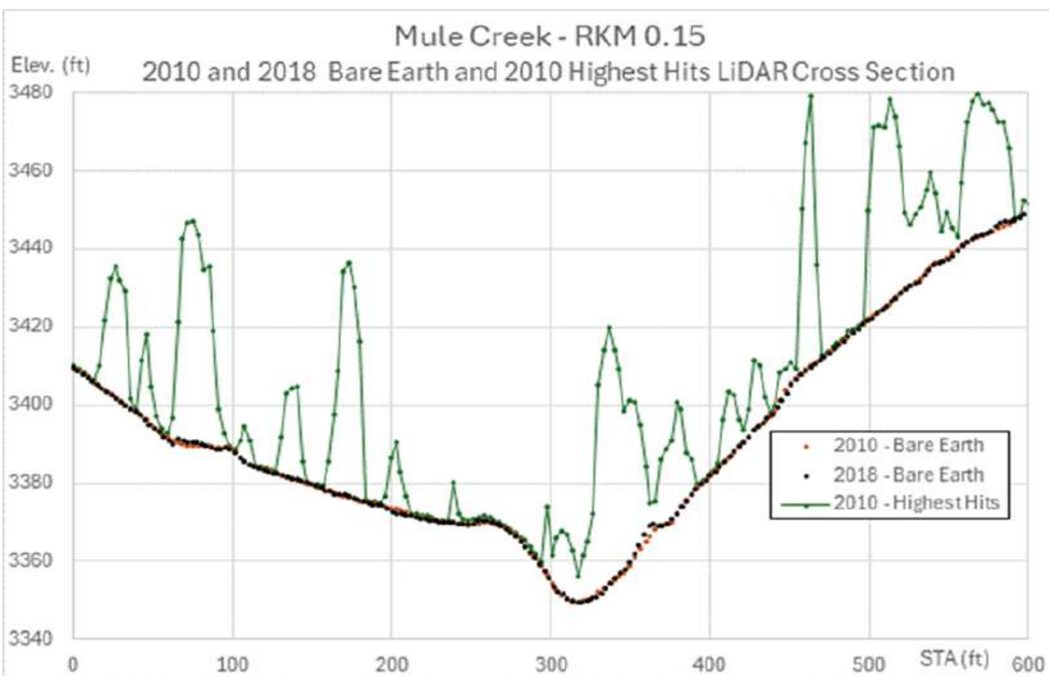
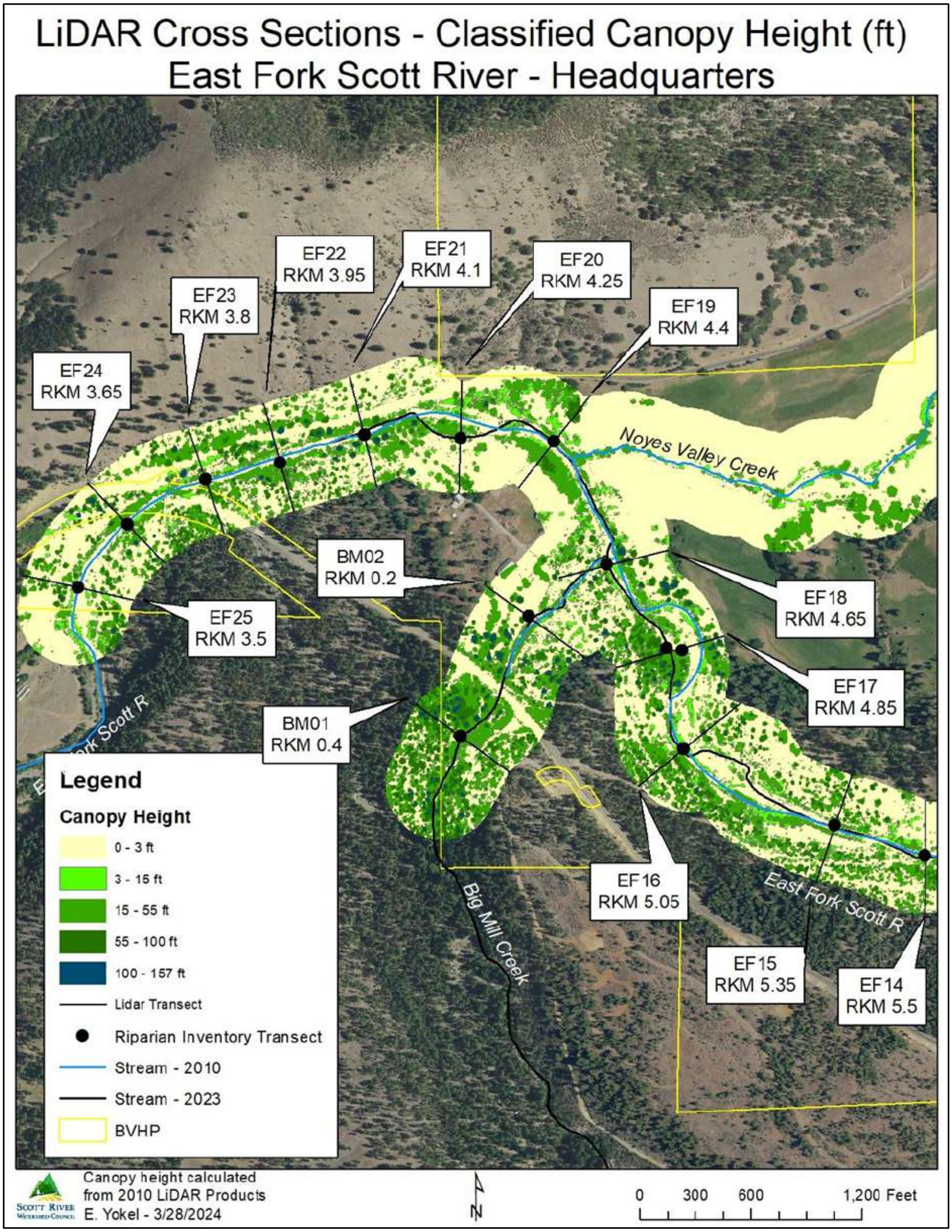
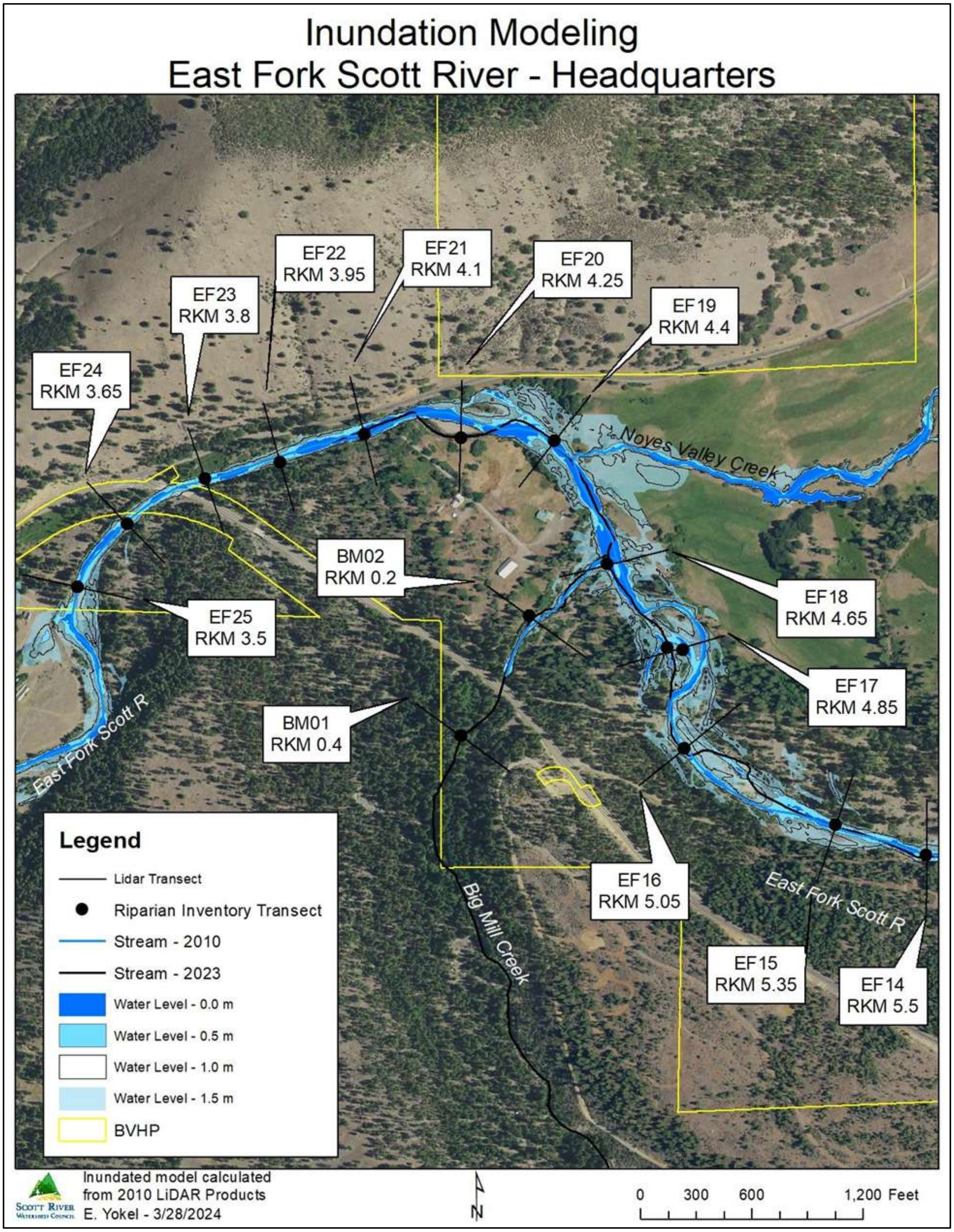


Figure 17: 2010 and 2018 Bare Earth & 2010 Highest Hits LiDAR Cross Section - Mule Cr RKM 0.15



Map 4: Classified canopy height (ft) and Cross Section Locations



Map 5: Inundation model and Cross Section Locations

East Fork Scott River

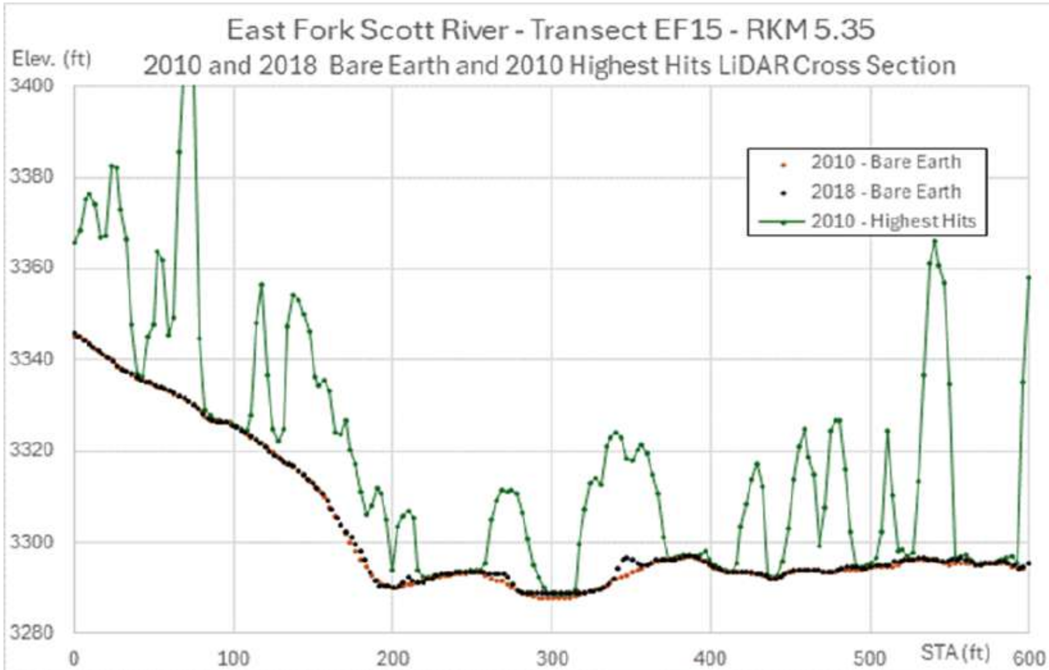


Figure 18: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF15

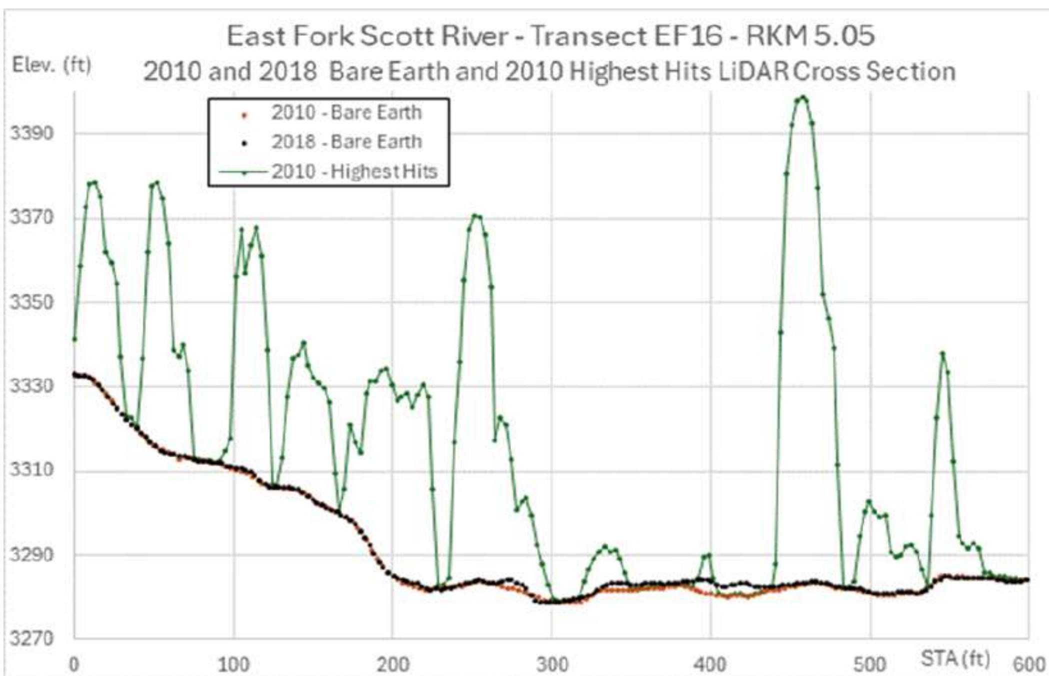


Figure 19: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF16

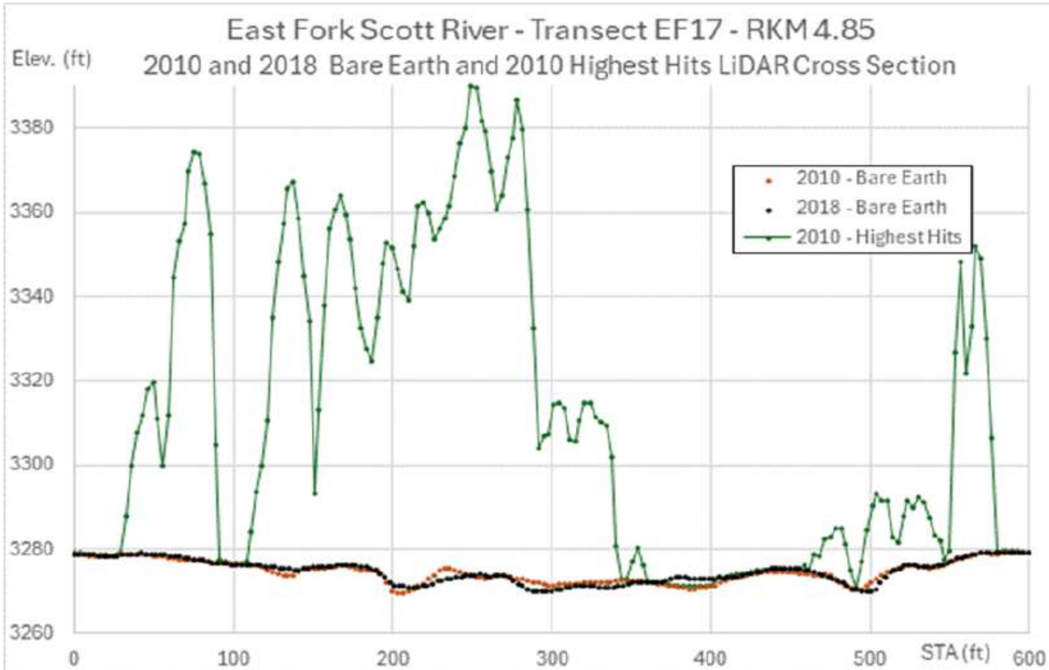


Figure 20: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF17

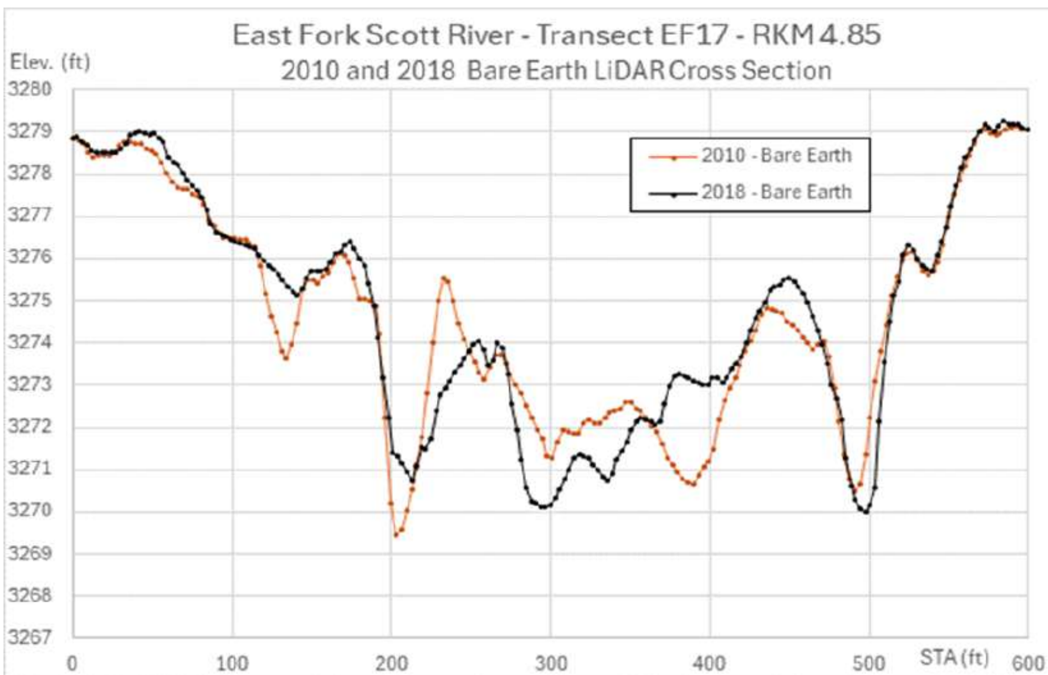


Figure 21: 2010 and 2018 LiDAR Bare Earth Cross Section - Transect EF17

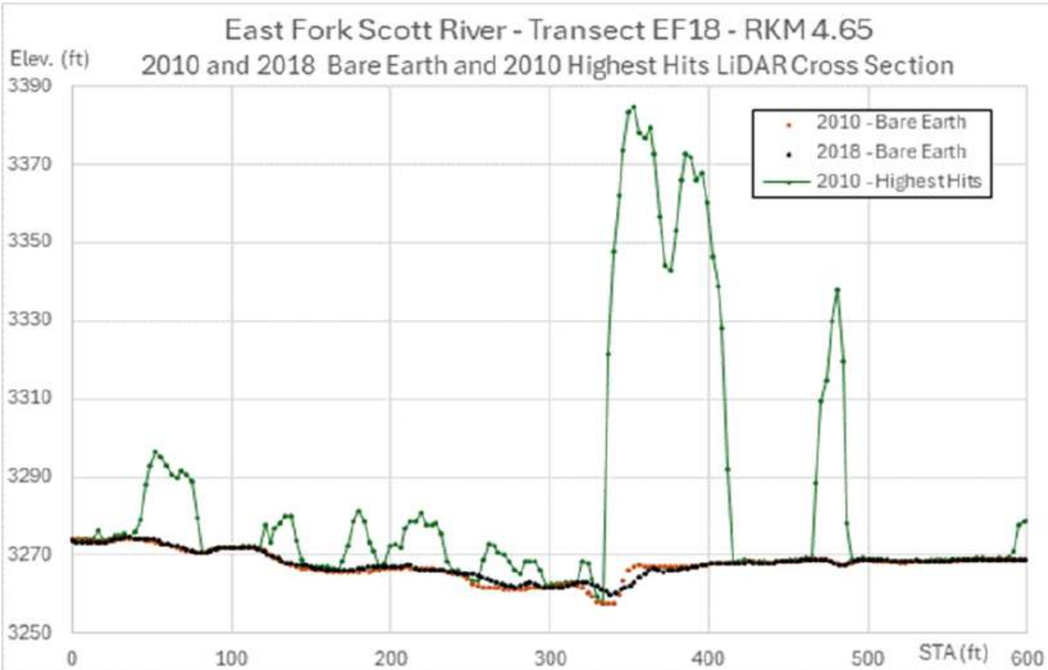


Figure 22: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF18

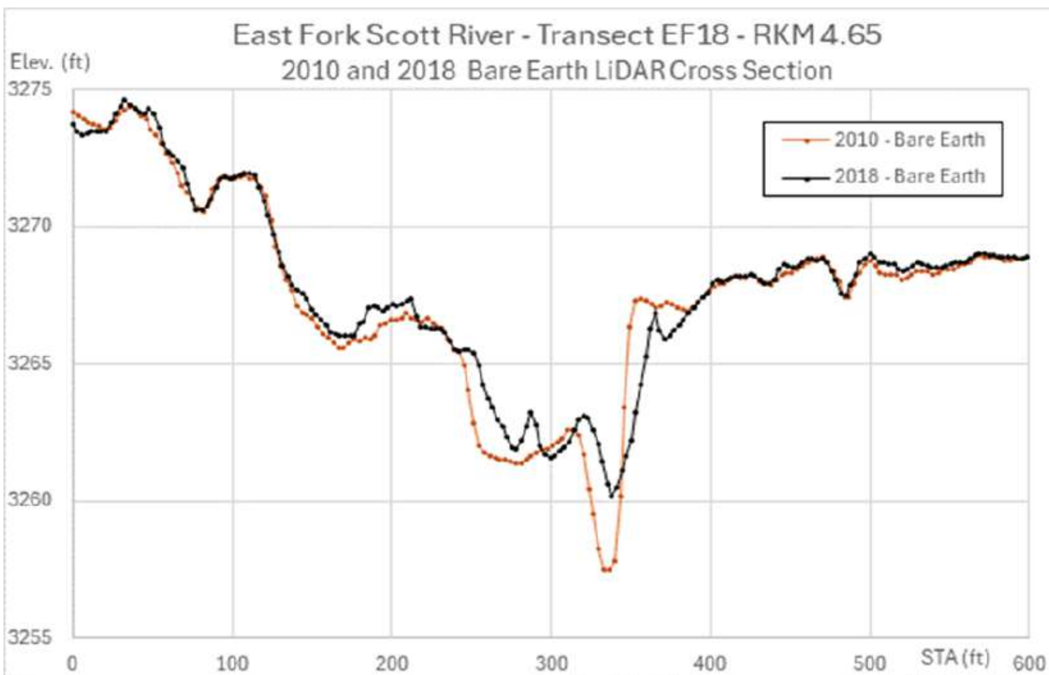


Figure 23: 2010 and 2018 LiDAR Bare Earth Cross Section - Transect EF18

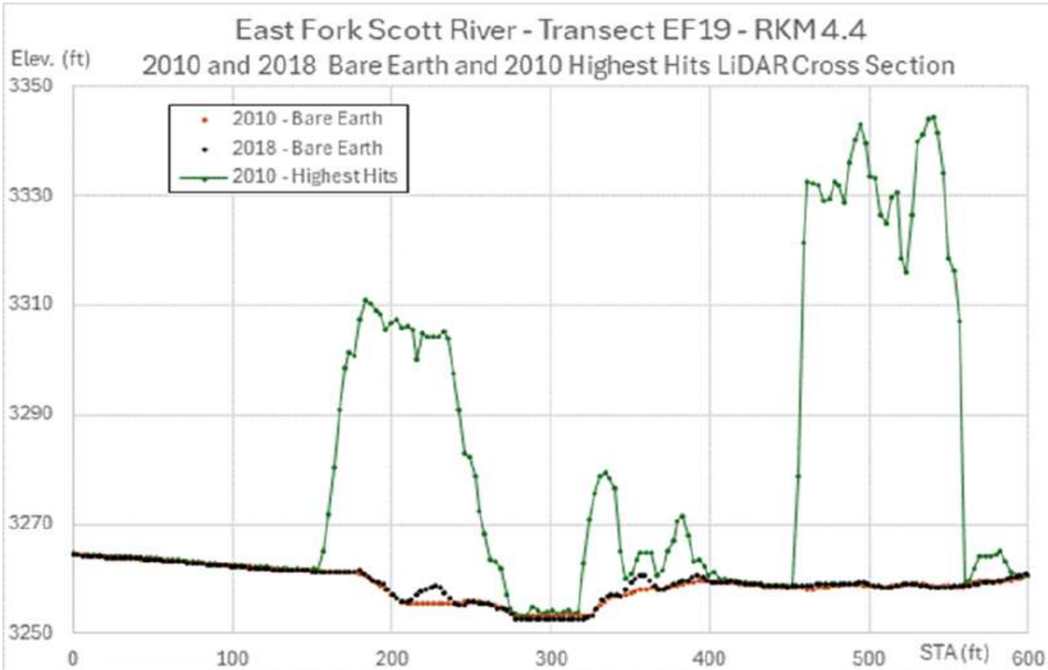


Figure 24: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section -Transect EF19

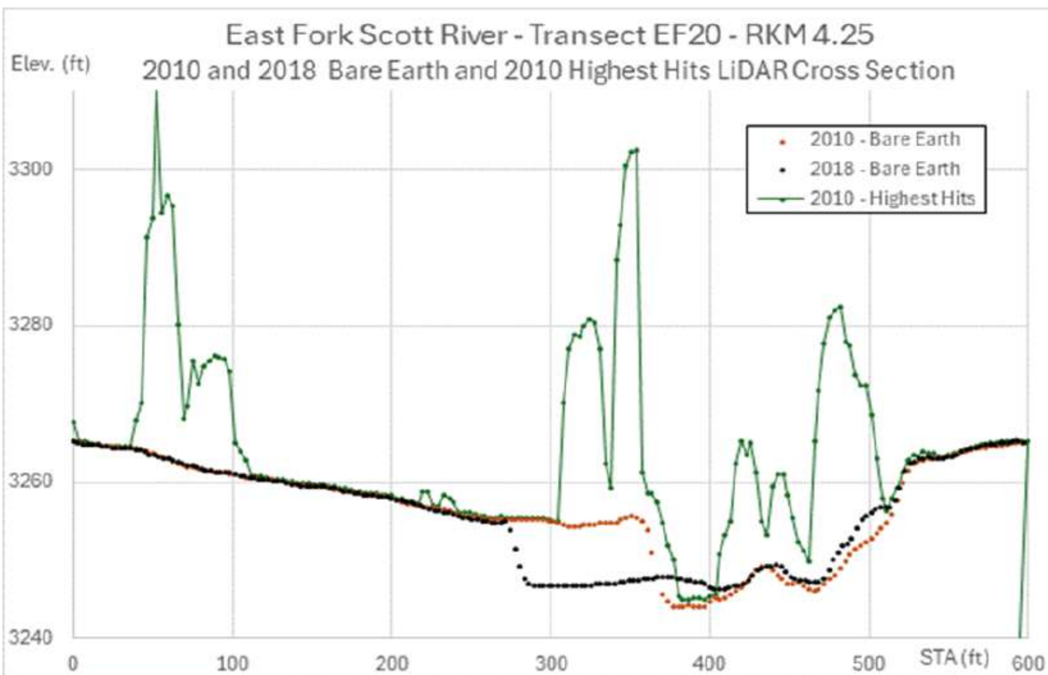


Figure 25: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF20

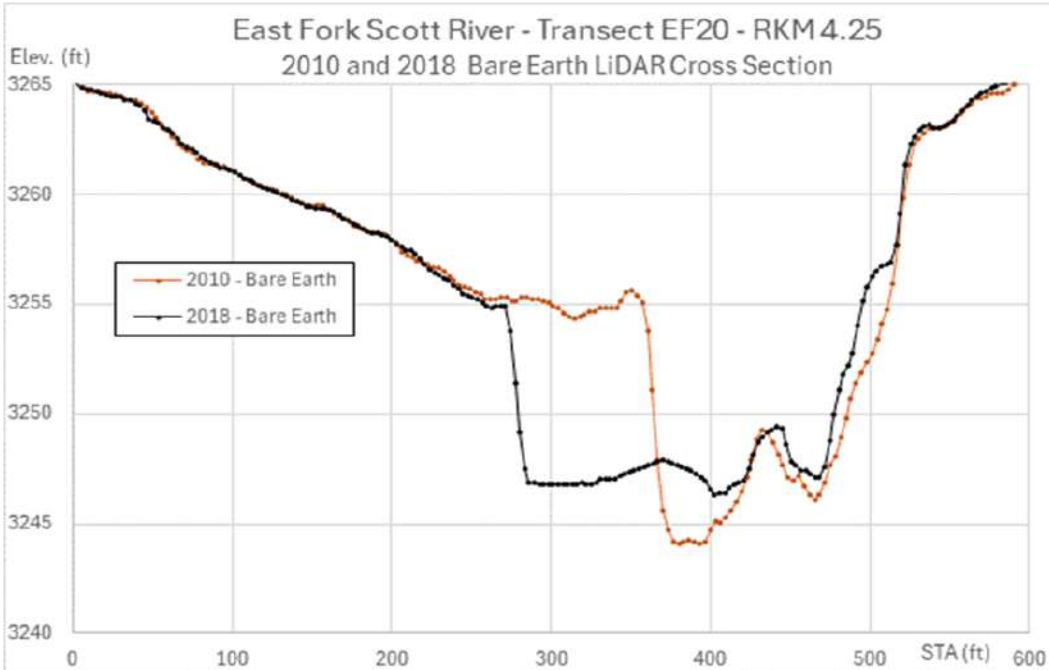


Figure 26: 2010 and 2018 LiDAR Bare Earth Cross Section - Transect EF20

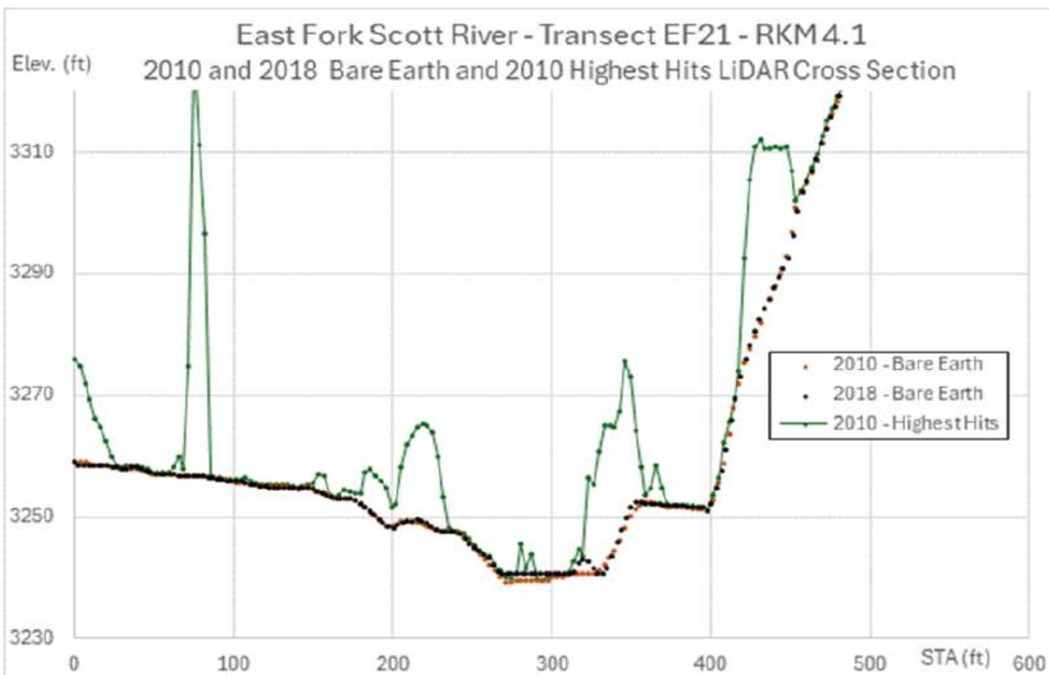


Figure 27: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF21

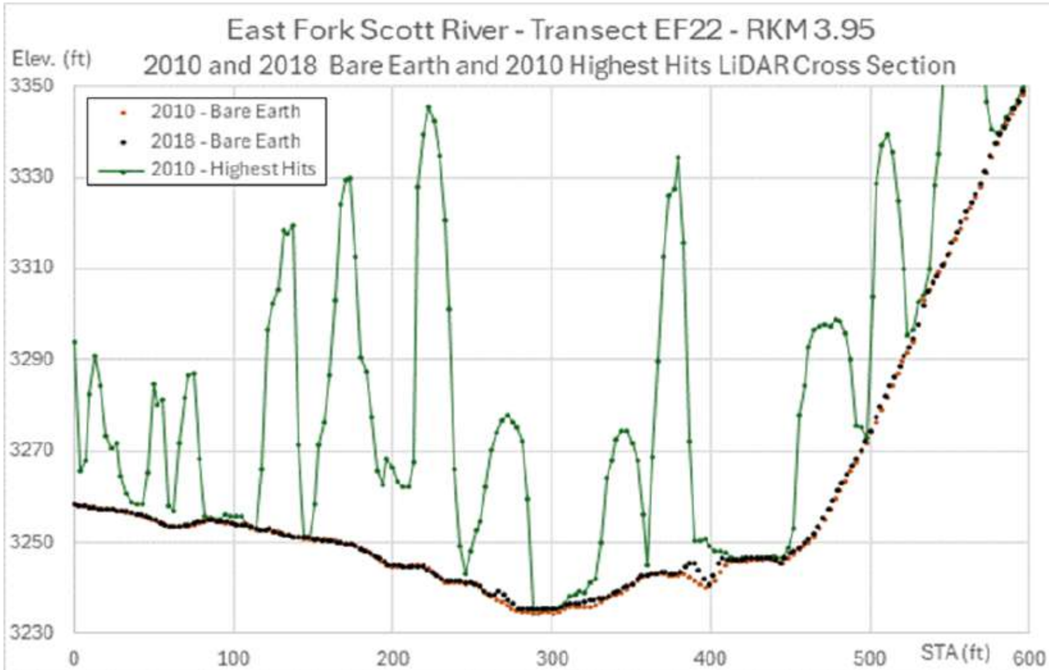


Figure 28: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF22

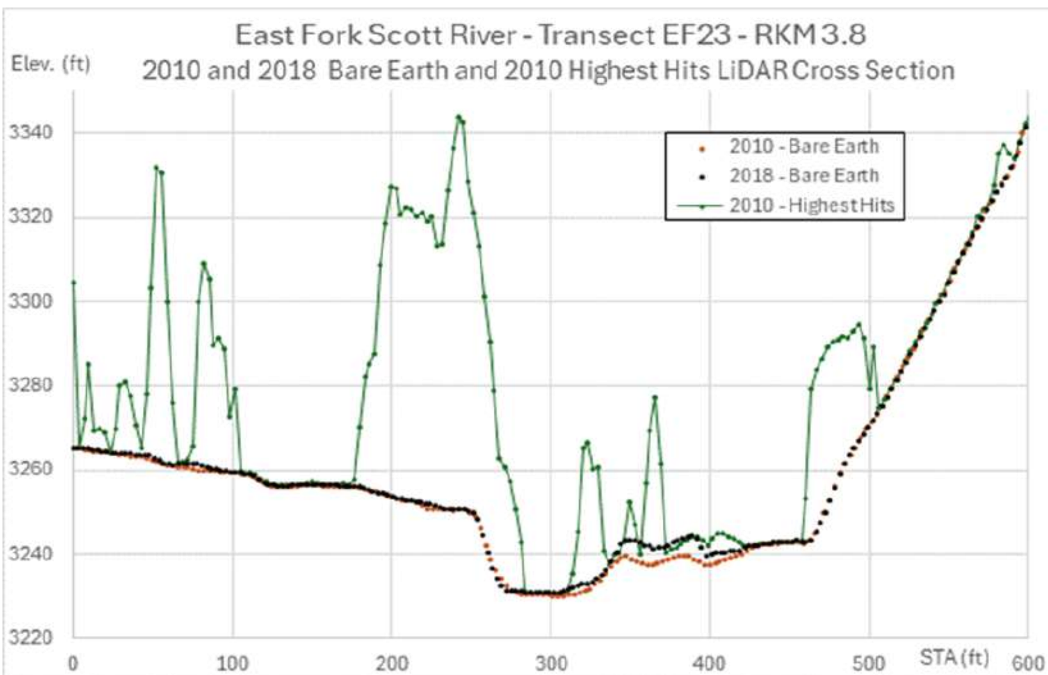


Figure 29: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF23

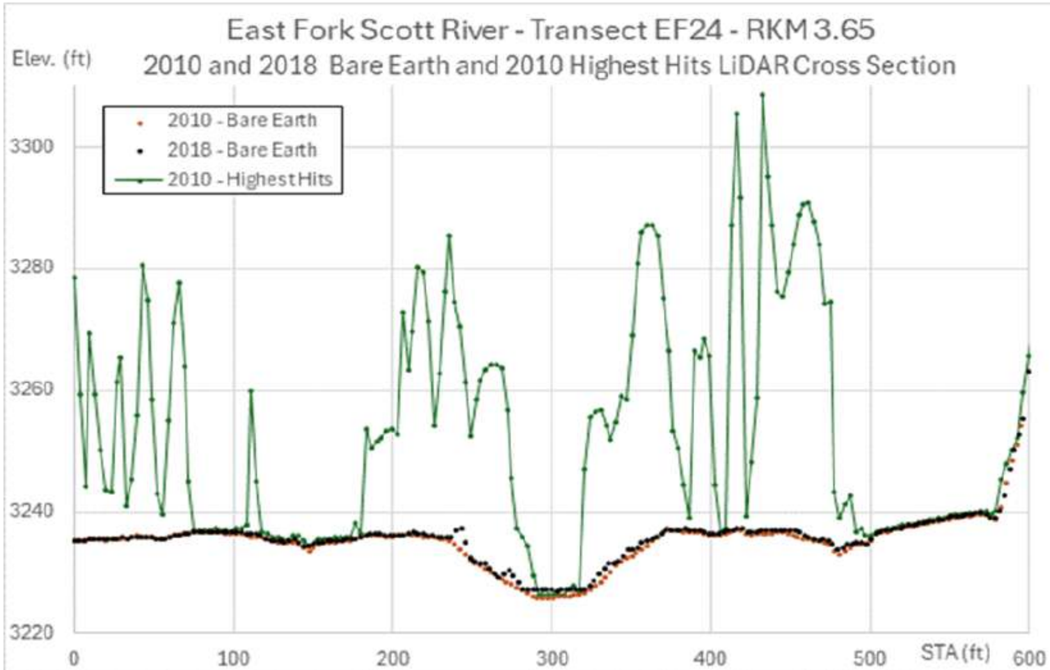


Figure 30: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF24

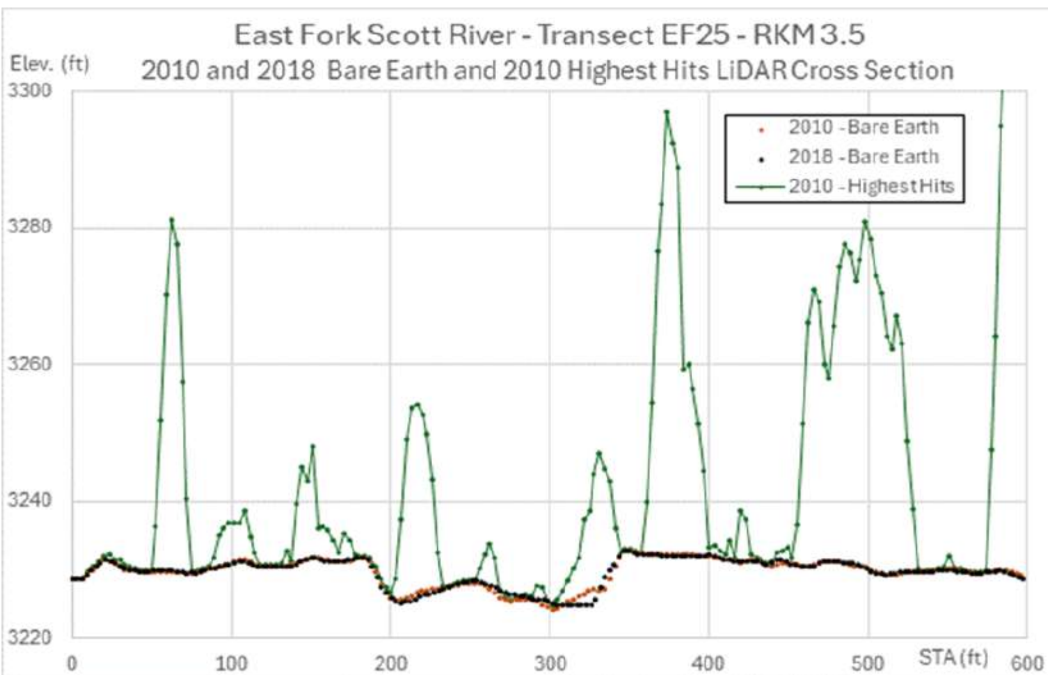


Figure 31: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect EF25

Big Mill Creek

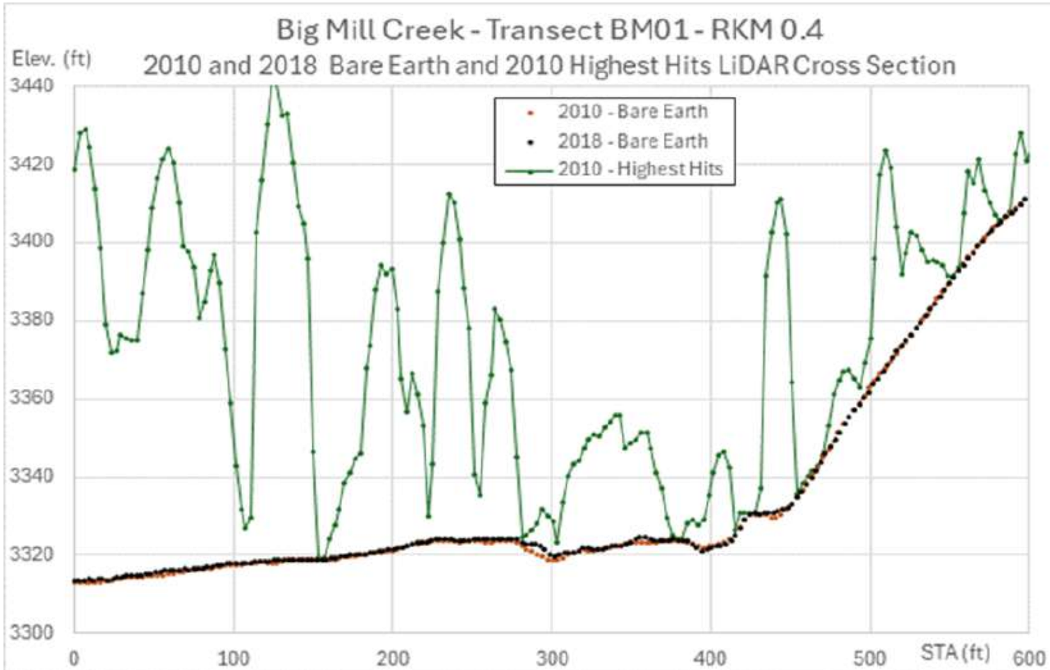


Figure 32: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect BM01

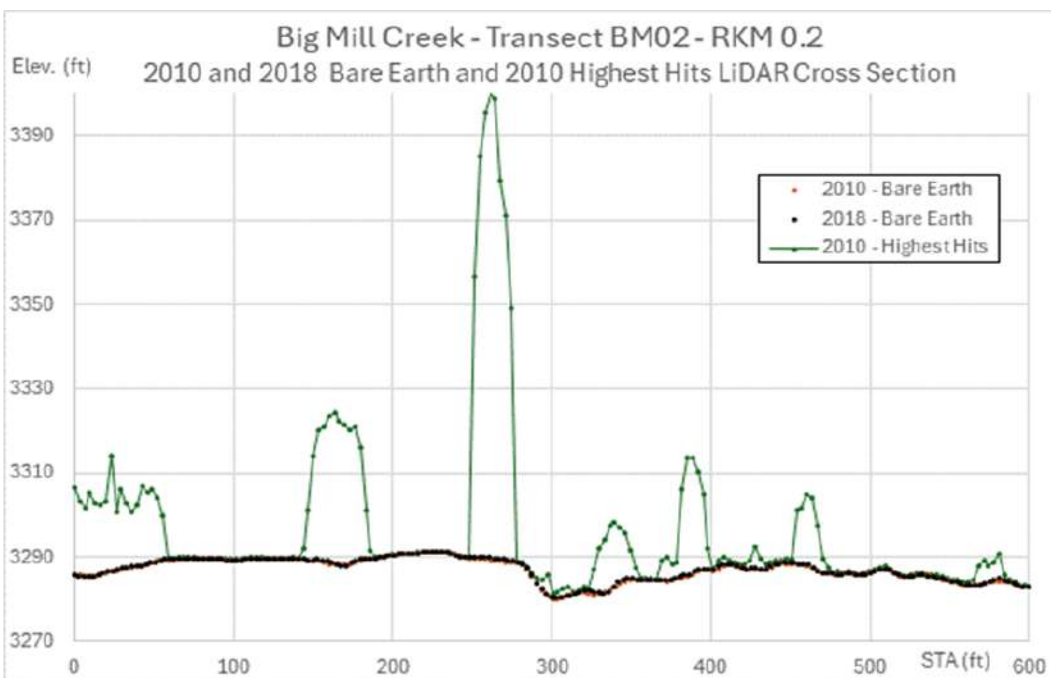
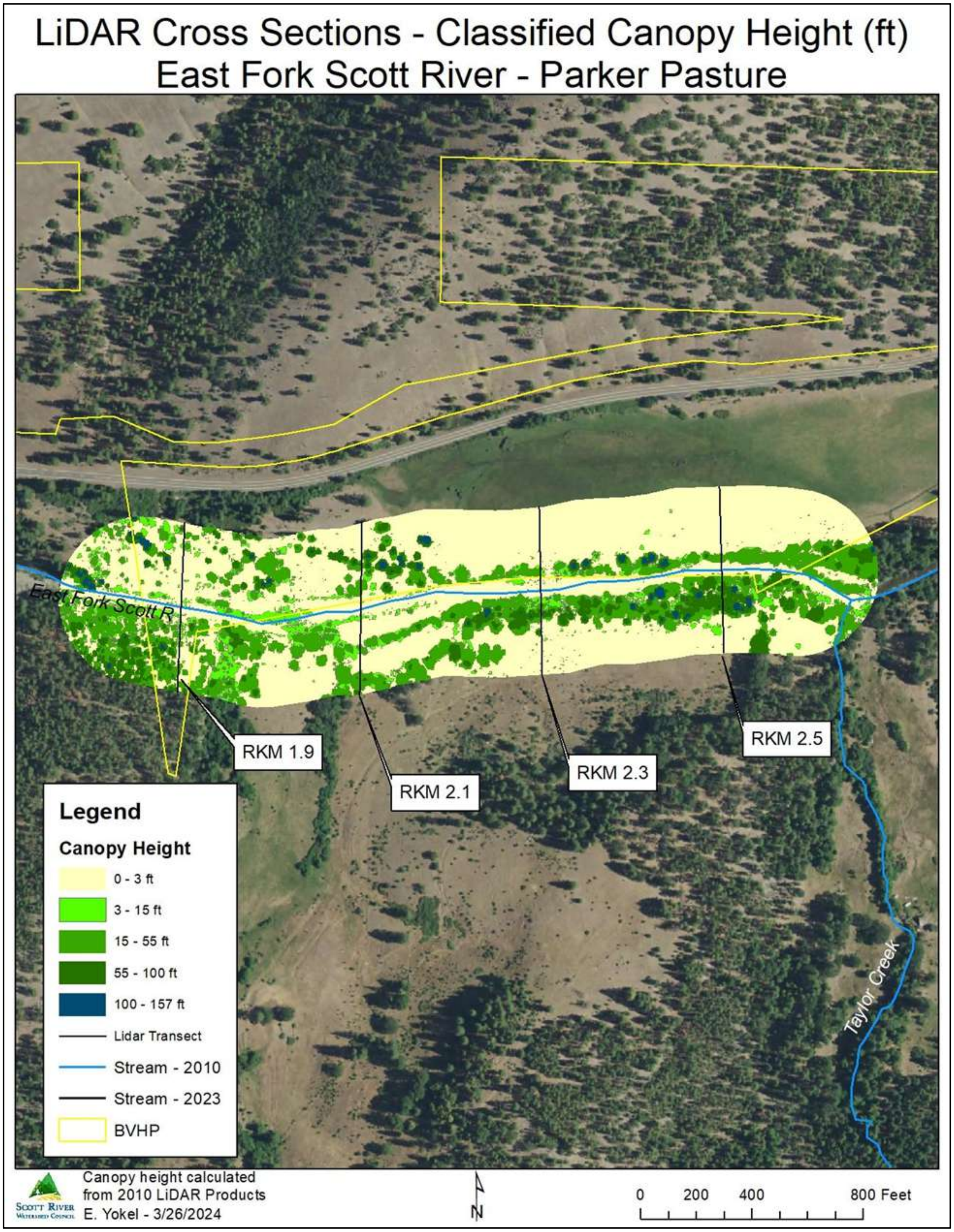
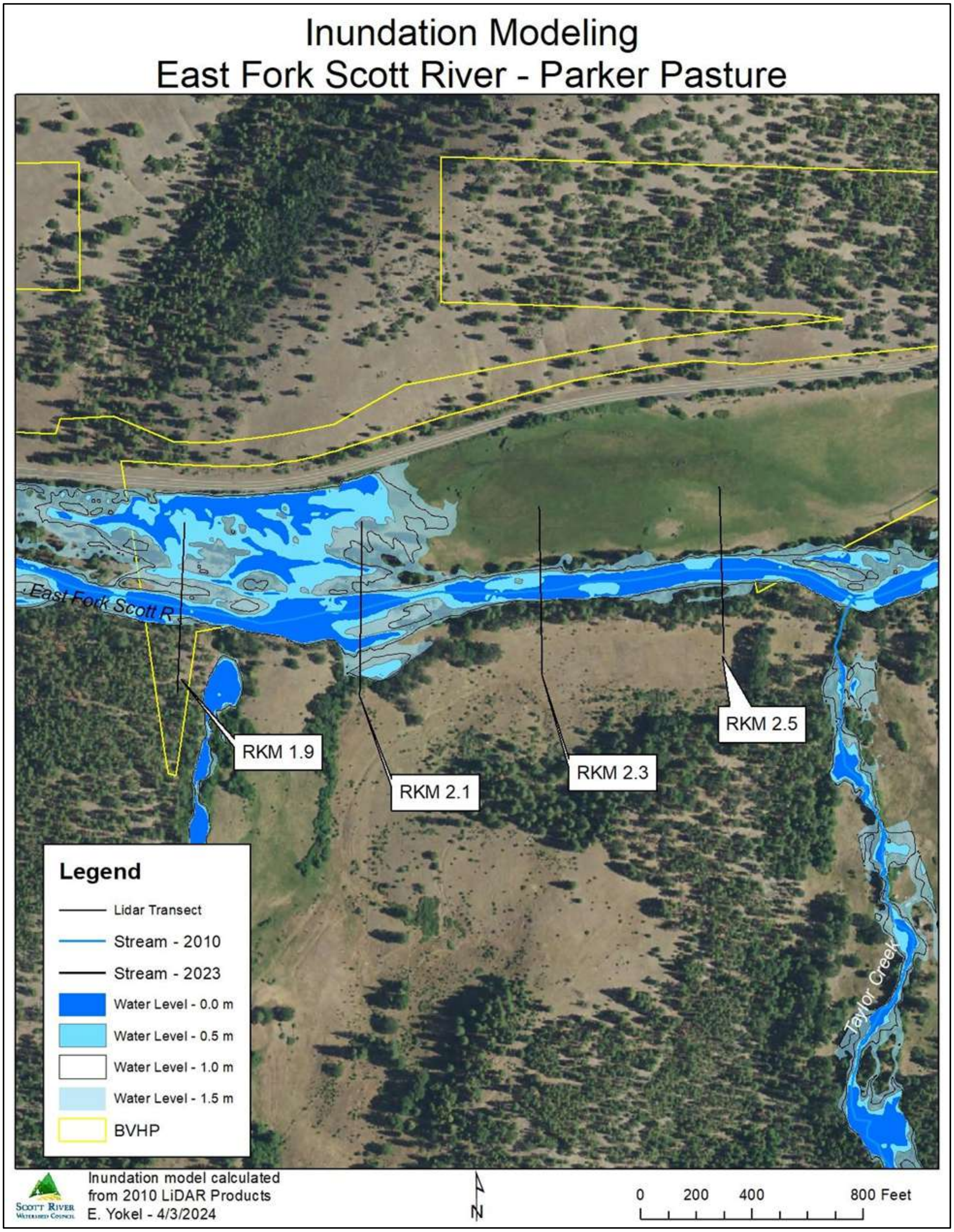


Figure 33: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - Transect BM02



Map 6 – Classified canopy height (ft) and Cross Section Locations



Map 7 – Inundation model and Cross Section Locations

East Fork Scott River – Parker Pasture

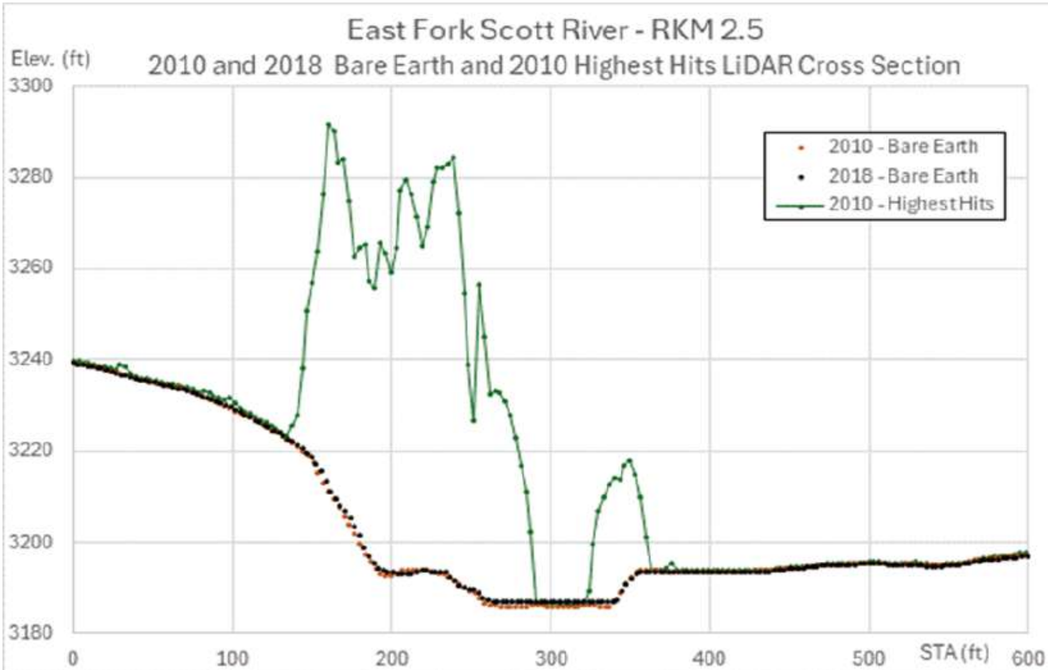


Figure 34: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - RKM 2.5

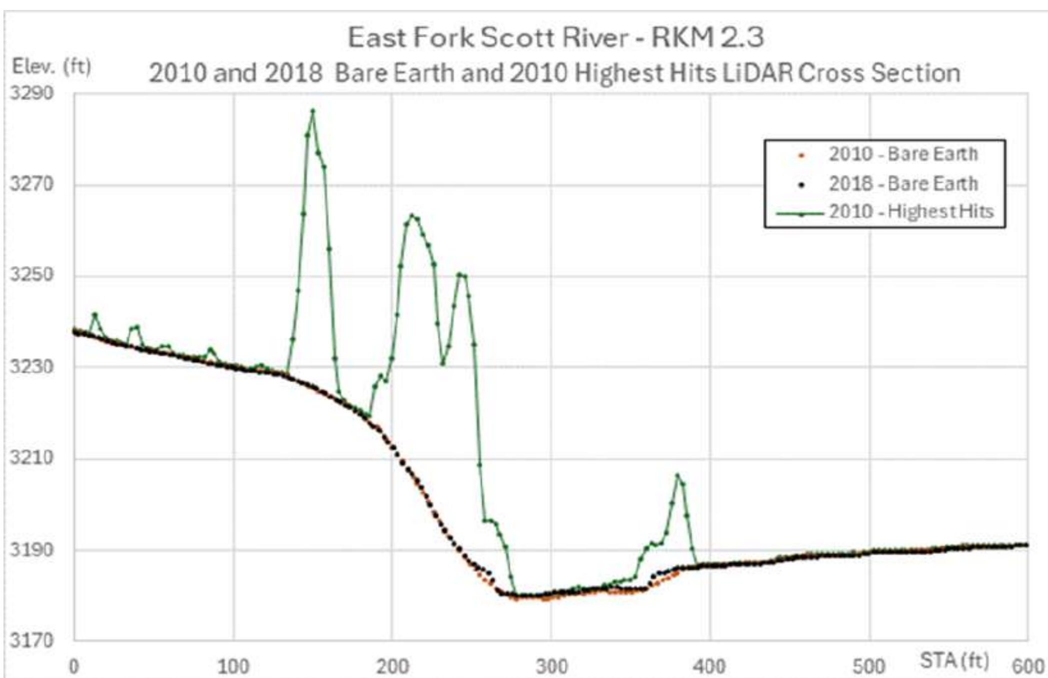


Figure 35: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - RKM 2.3

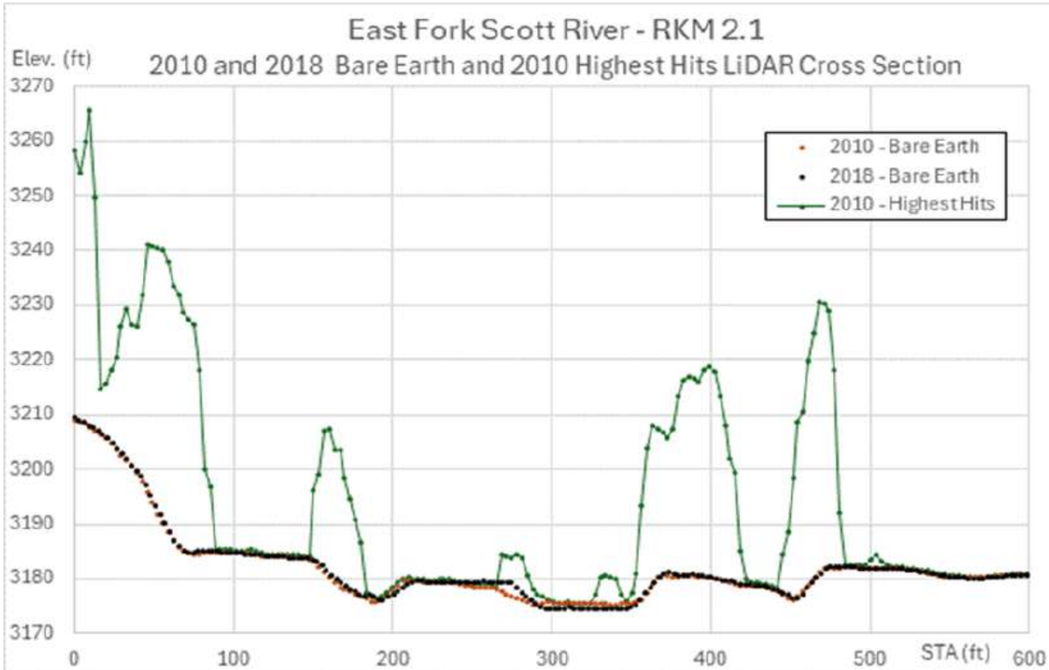


Figure 36: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - RKM 2.1

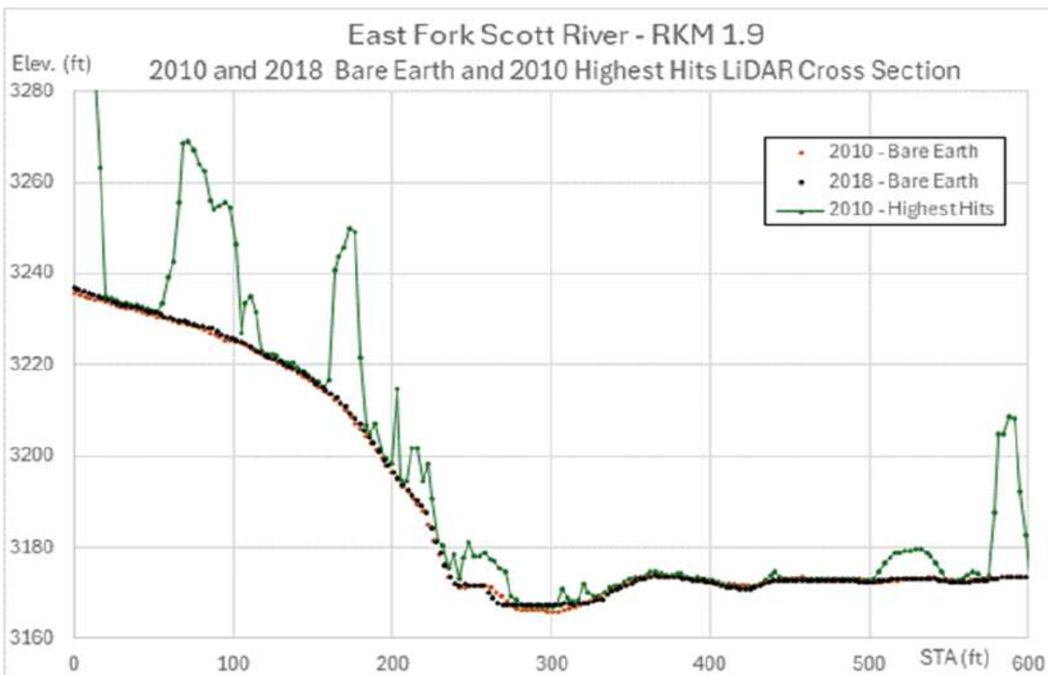


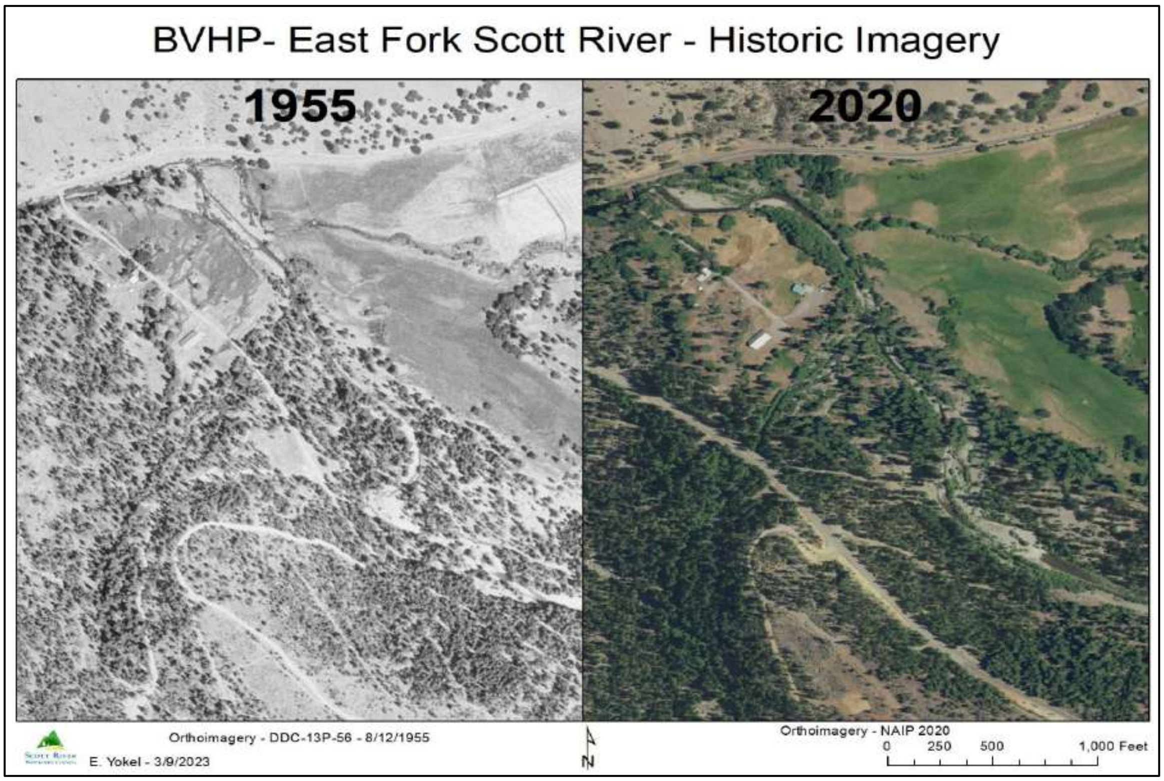
Figure 37: 2010 and 2018 Bare Earth and 2010 Highest Hits LiDAR Cross Section - RKM 1.9

Appendix 1.4 Remote Sensing Riparian Analysis

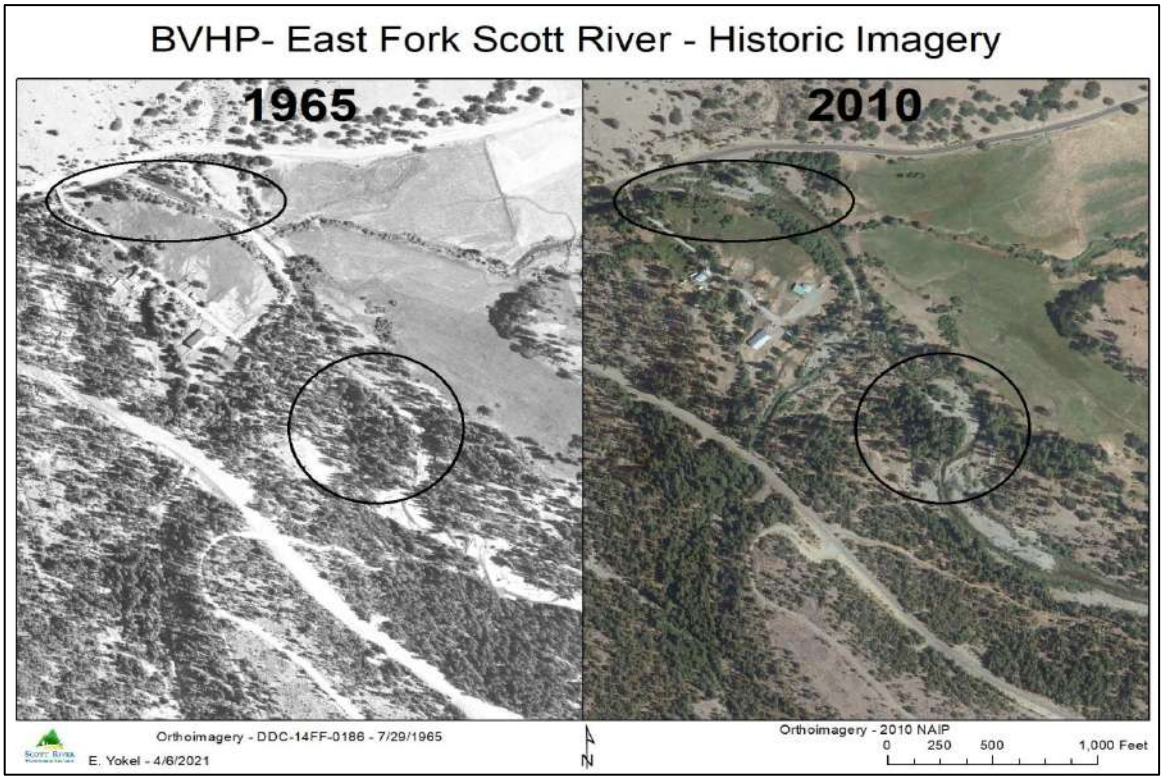
Historic ortho imagery from 1944, 1955 and 1965 were georeferenced for analysis and comparison to contemporary NAIP orthoimagery and from 2010 and 2020 and Unmanned Aerial System orthoimagery acquired by Cascade Stream Solutions in 2023. Comparison of the historic orthoimagery illustrates two areas of the East Fork Scott River in which geomorphic change has occurred over the period of record and the change in vegetation in the study area.

Historic ortho imagery from 1994 to 2023 was utilized to digitize the stream alignment of the East Fork Scott River for the analysis of changes of the stream alignment over the last 30 years.

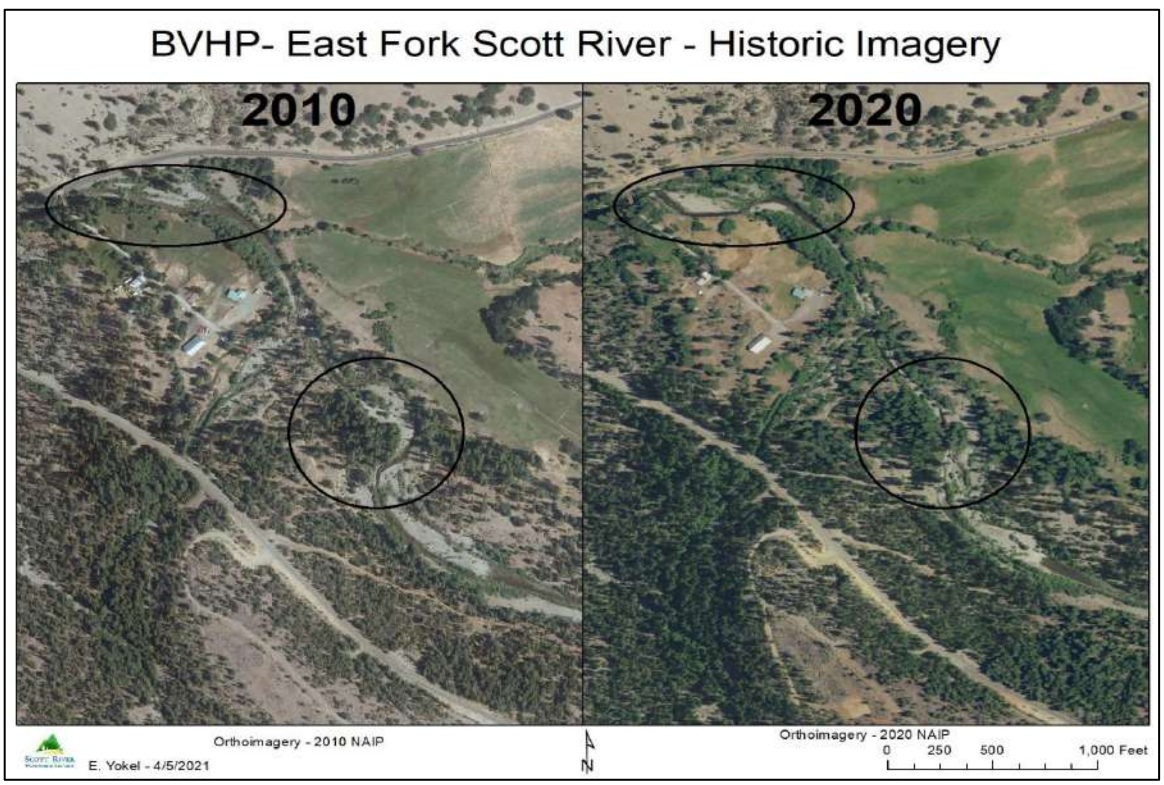
Comparison of 1944 and 2020 orthoimagery with areas of change circled.



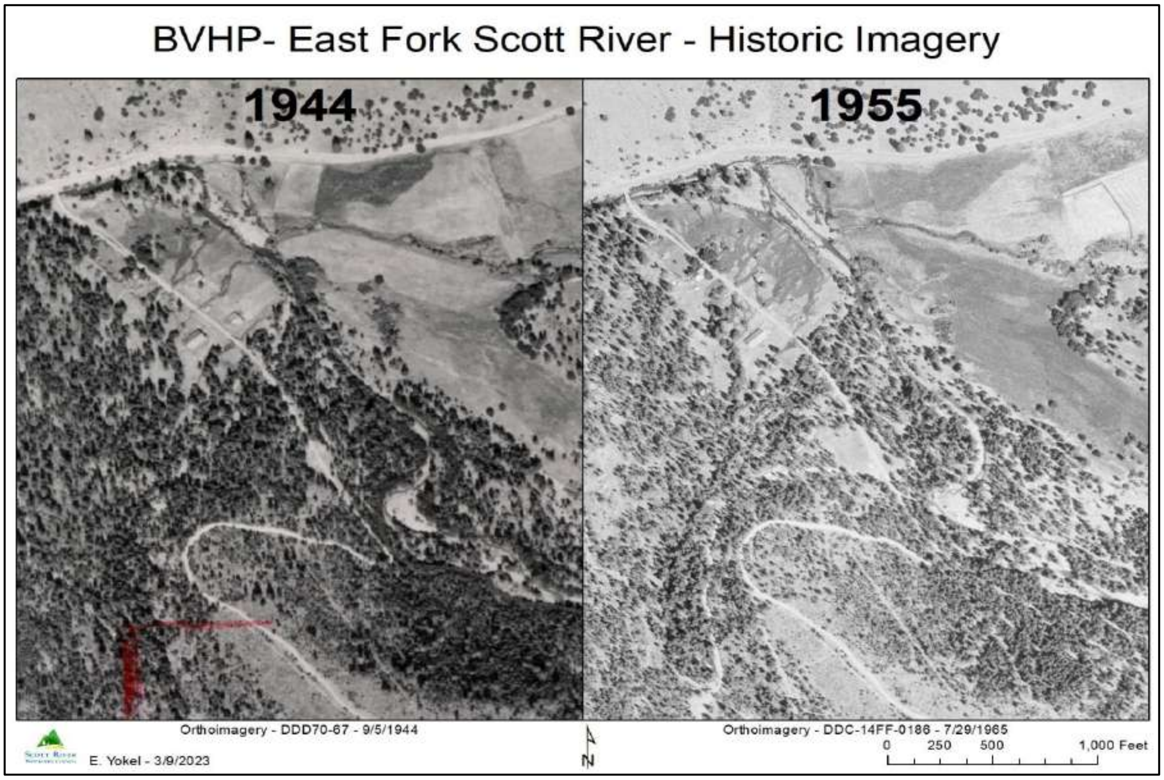
Comparison of 1955 and 2020 orthoimagery



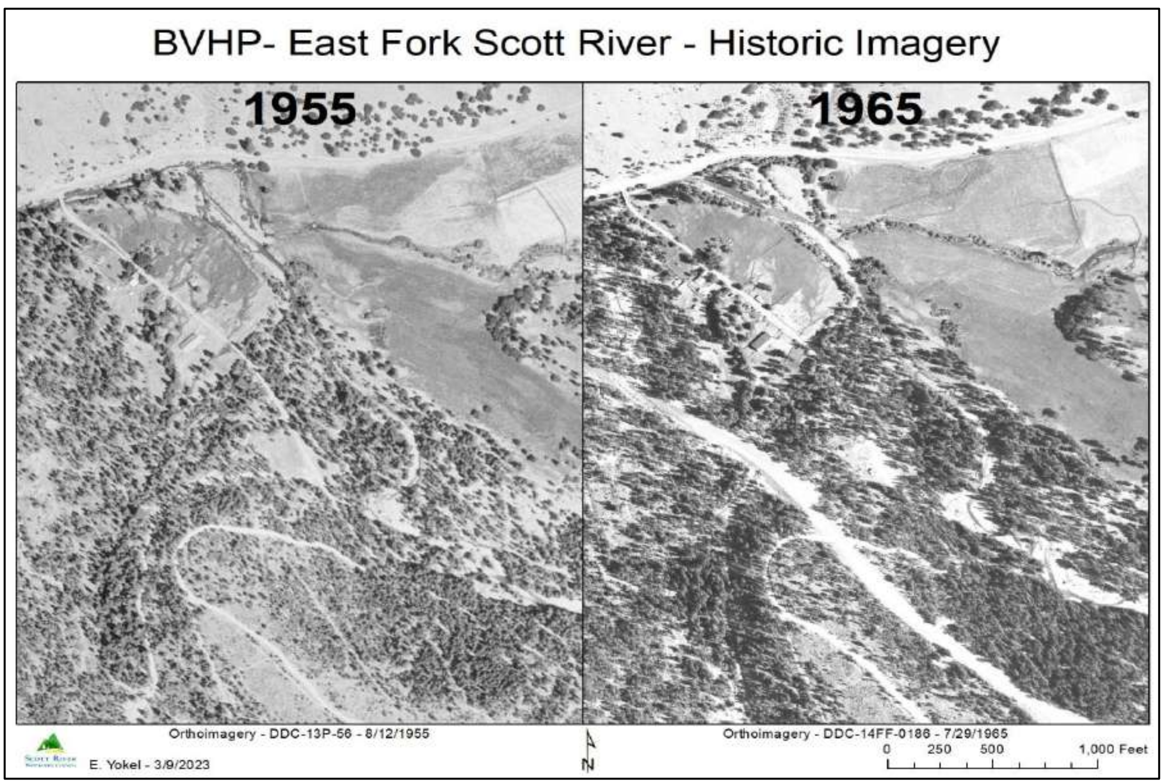
Comparison of 1965 and 2010 orthoimagery with areas of change circled



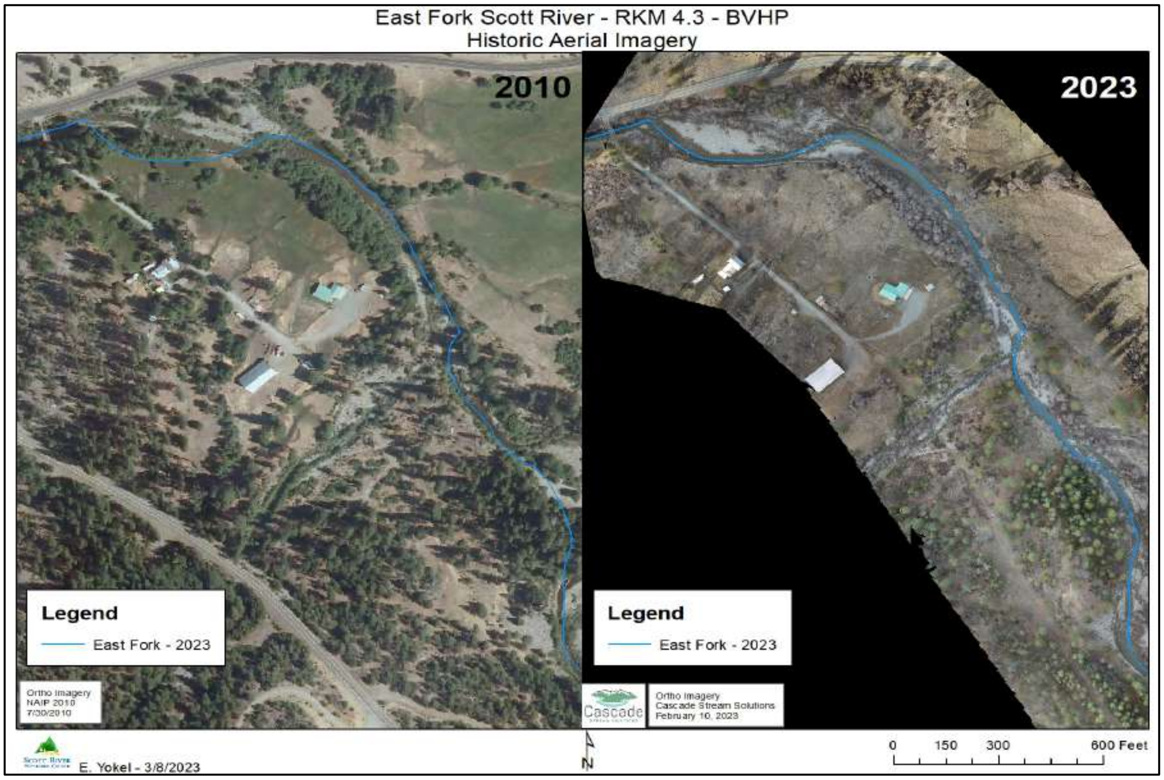
Comparison of 2010 and 2020 NAIP Orthoimagery with areas of significant geomorphic change circled



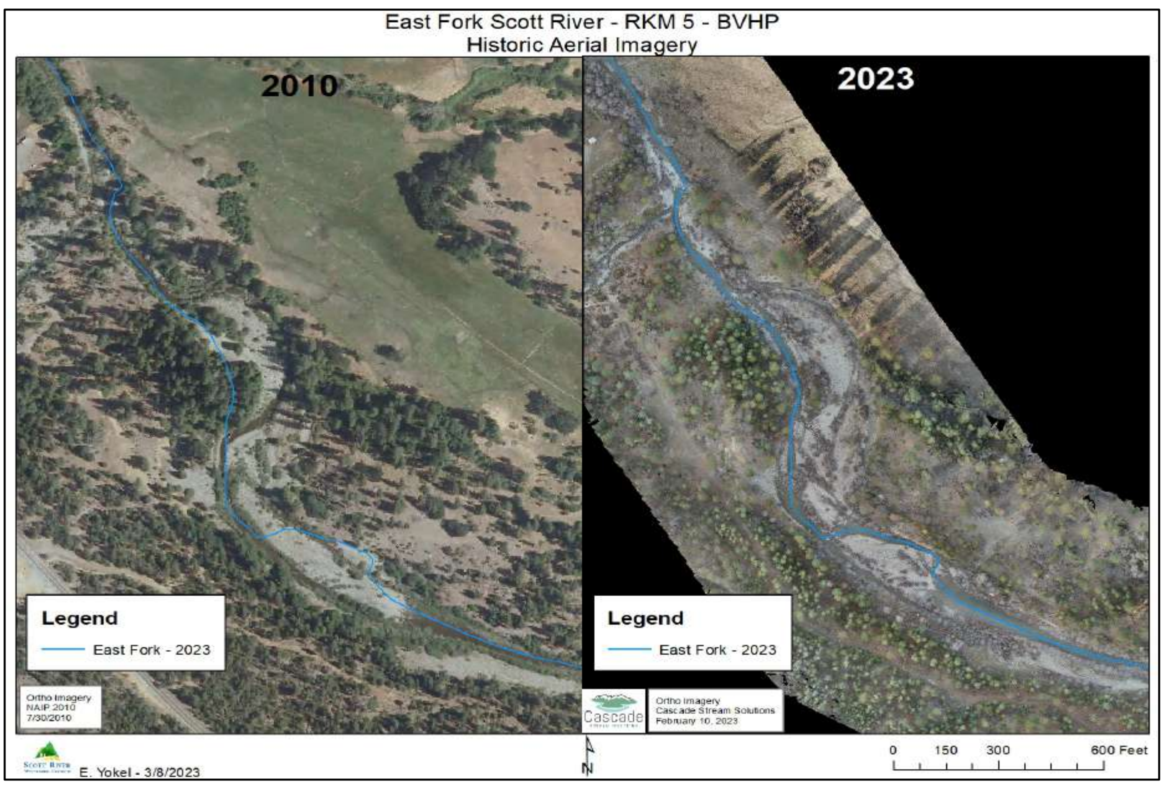
Comparison of 1944 and 1955 orthoimagery



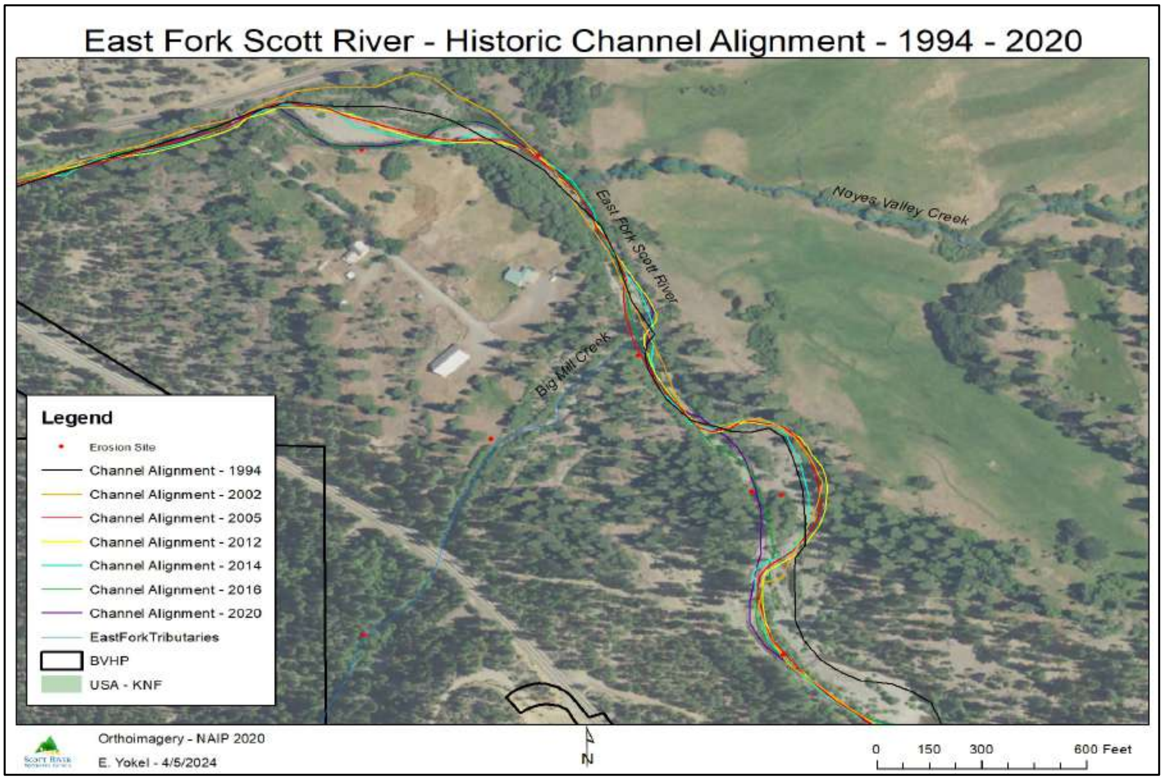
Comparison of 1955 and 1965 orthoimagery



Comparison of 2010 NAIP and 2023 Cascade Stream Solutions Orthoimagery with 2023 East Fork Scott River alignment



Comparison of 2010 NAIP and 2023 Cascade Stream Solutions Orthoimagery with 2023 East Fork Scott River alignment



Historic channel alignment of the East Fork Scott River - 1944 - 2020

Appendix 1.5 Stream Channel and Floodplain Morphology and Relative Elevation and Geomorphic Change Analysis

Cascade Stream Solutions acquired LiDAR of the East Fork Scott River from the Stagecoach Bridge to upstream the confluence of Big Mill Creek (RKM 4.1 - 5.3) in February 2023. Analysis was performed in ArcGIS to compare the elevations in the 2010, 2018 and 2023 LiDAR bare earth DEMs through two reaches in the East Fork Scott River where geomorphic change was detected in the analysis of historic ortho imagery - RKM 4.2 - 4.8 and RKM 4.8 - 5.3.

Two analysis methods were utilized to compare the LiDAR datasets - calculation of the change in elevation between the 2023 and 2010 LiDAR DEMS using Raster Math and creation of cross sections from the 2010, 2018 and 2023 LiDAR DEMs at representative locations.

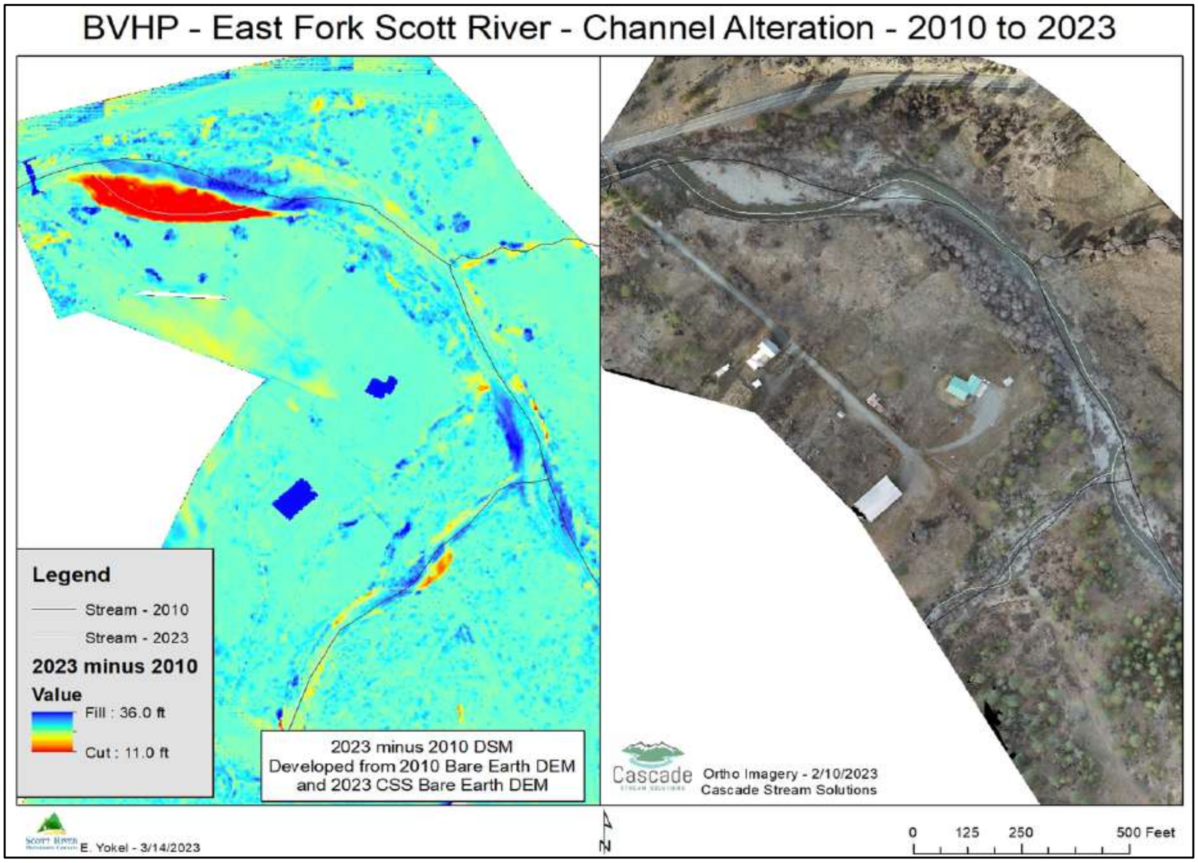
A raster with the value of the difference in elevation between 2010 and 2023 was created by subtracting the 2010 DEM from the 2023 DEM (Map 1). Areas of degradation (decreasing elevations due to erosion) are indicated in the maps with red and areas of aggradation (increasing elevations due to sediment storage) are indicated with blue in the maps.

Cross section locations were identified at approximately 0.1 to 0.05 km intervals through the RKM 4.2 - 4.8 reach at representative locations and elevations for each cross section were sampled from the 2010, 2018 and 2023 LiDAR DEMs (Map 2). Significant changes in elevation due to channel alignment changes, streambank migration and erosional and depositional processes were observed at multiple sites in the last 13 years (Figures 1 - 11)

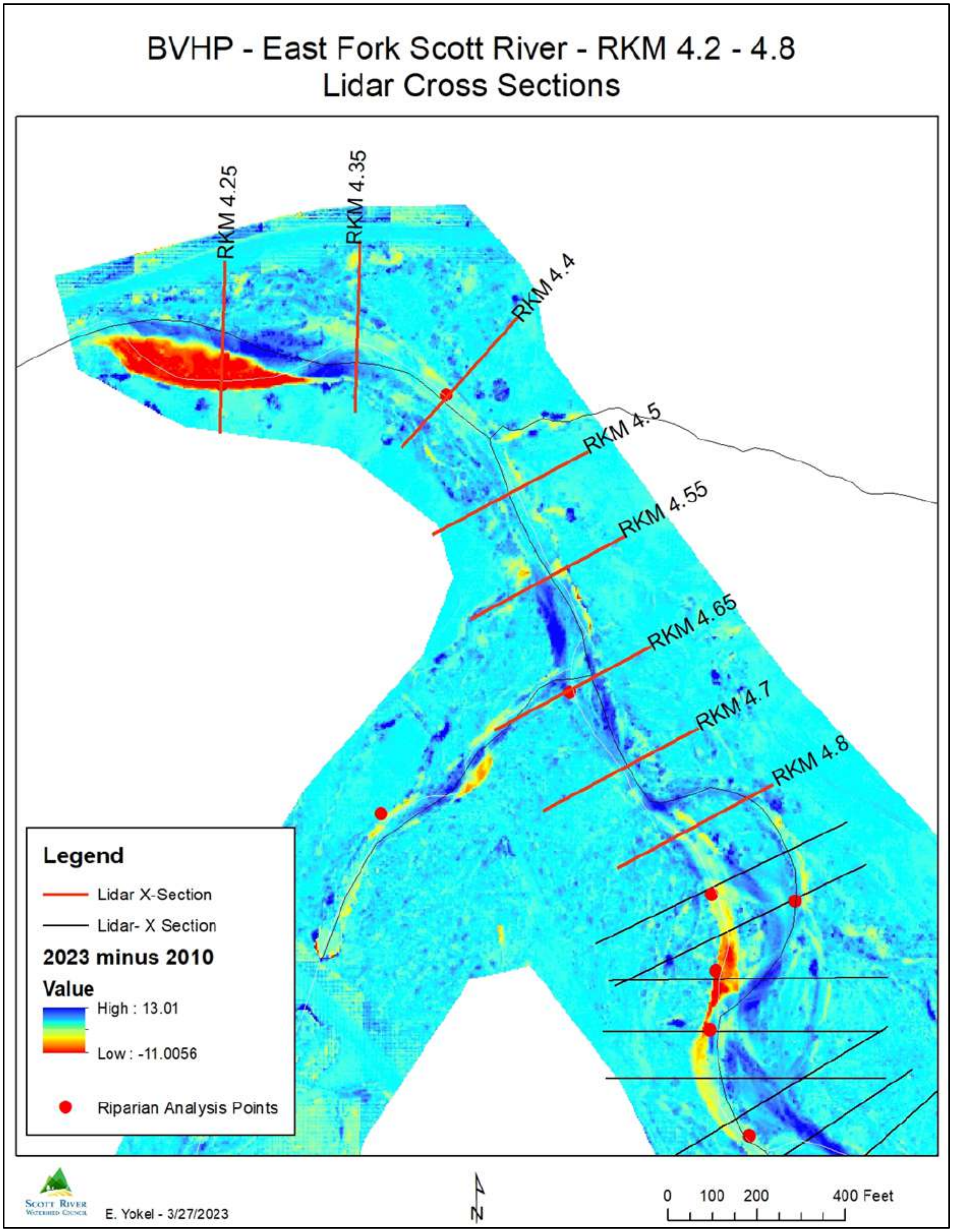
The cross section located downstream of the RKM 4.2 to 4.3 cutbank at the East Fork Scott River RKM 4.15 shows little geomorphic change between 2010 and 2023 (Figure 1). The RKM 4.2 cross section documents approximately 100 ft of lateral migration of the river left cutbank between 2010 and 2018 with little additional movement between 2018 and 2023 (Figure 2). The lateral migration of the cutbank at the RKM 4.25 cross section was approximately 80 ft between 2010 and 2018 with little movement after 2018 (Figure 3). In addition to the lateral bank migration at RKM 4.25, channel aggradation of approximately 2 feet occurred between 2010 and 2018 resulting in a significantly wider channel.

The RKM 4.35 cross section is located upstream of the cutbank where the channel aggraded between 2010 and 2018 with degradation creating the river right side channel (Figure 4). Limited geomorphic change was observed at the RKM 4.4 cross section (Figure 5). The RKM 4.5 cross section illustrates river right bank erosion (Figure 6). The RKM 4.55 cross section is downstream of the confluence with Big Mill Creek where aggradation occurred on river left with degradation on river right (Figure 7). At the RKM 4.55 cross section, the toe of the river right bank migrated approximately 25 ft resulting in the current vertical streambank downstream of Big Mill Creek.

At the RKM 4.6 cross section upstream of the Big Mill Creek confluence four feet of sediment deposition occurred on the river left bar between 2010 and 2018 with lateral streambank migration occurring at river right (Figure 8). Limited geomorphic change was observed at the RKM 4.6 cross section between 2018 and 2023. Three feet of aggradation of the main channel from 2010 to 2023 was observed at the RKM 4.65 cross section (Figure 9). Geomorphic changes were observed at the RKM 4.65 cross section between 2018 and 2023 one of the few locations in which geomorphic change was observed between 2018 and 2023. Minimal change with slight aggradation of the main channel was observed at RKM 4.7 (Figure 10). The RKM 4.8 cross section is at the downstream end of the new main channel on river left and the old primary channel at river right (Figure 11). The river right channel aggraded 2 feet between 2010 and 2023.



Map 1 - Change in elevation between 2010 and 2023 and 2023 ortho imagery



Map 2 - Location of LiDAR cross sections and riparian survey transects - RKM 4.2 - 4.8

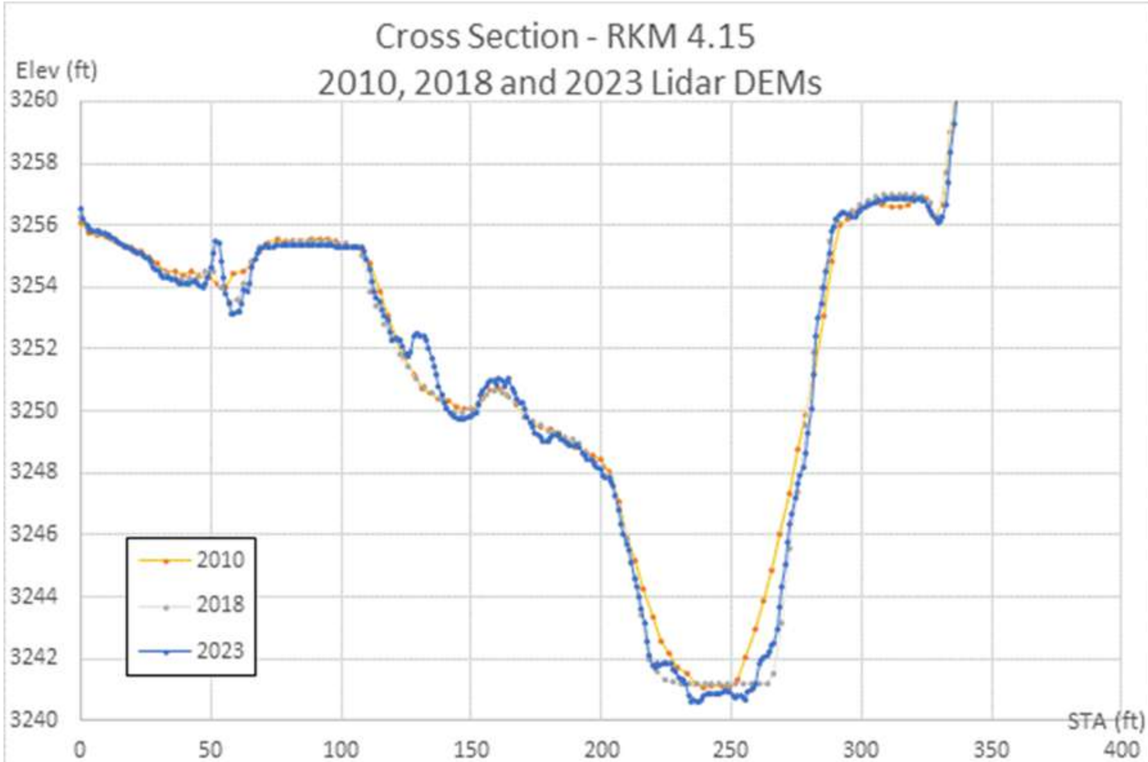


Figure 1 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.15

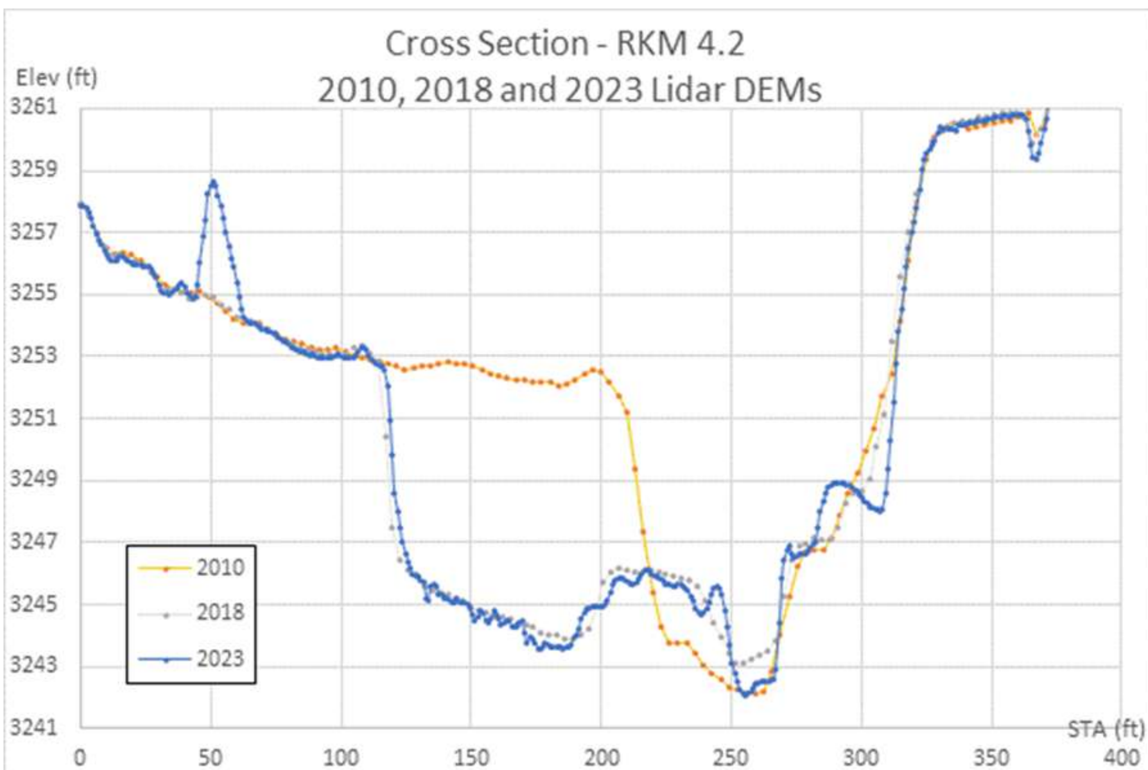


Figure 2 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.2

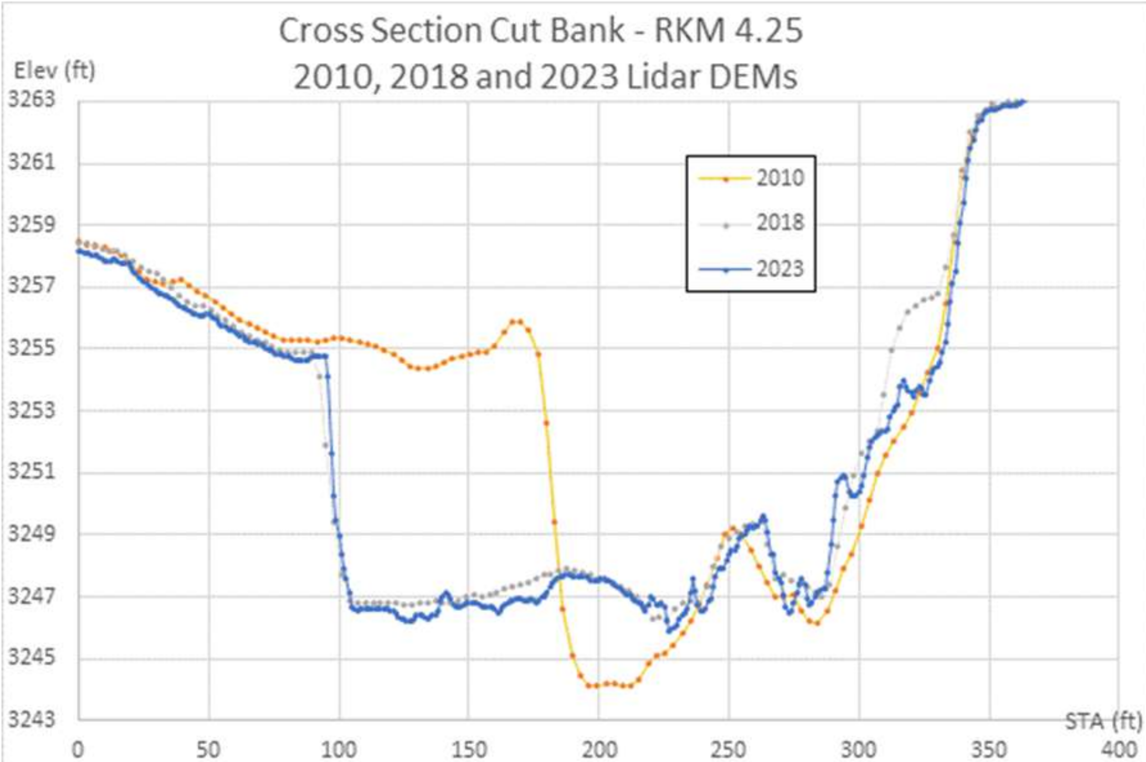


Figure 3 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.25

Cutbank at RKM 4.2 with thin band of willow on river left and river right bar - looking downstream

Cutbank at RKM 4.2 - looking upstream - December 2022

Cutbank at RKM 4.2 - Looking Downstream - Summer 2022

Cutbank at RKM 4.2 - illustrating riparian vegetation at toe of eroding bank

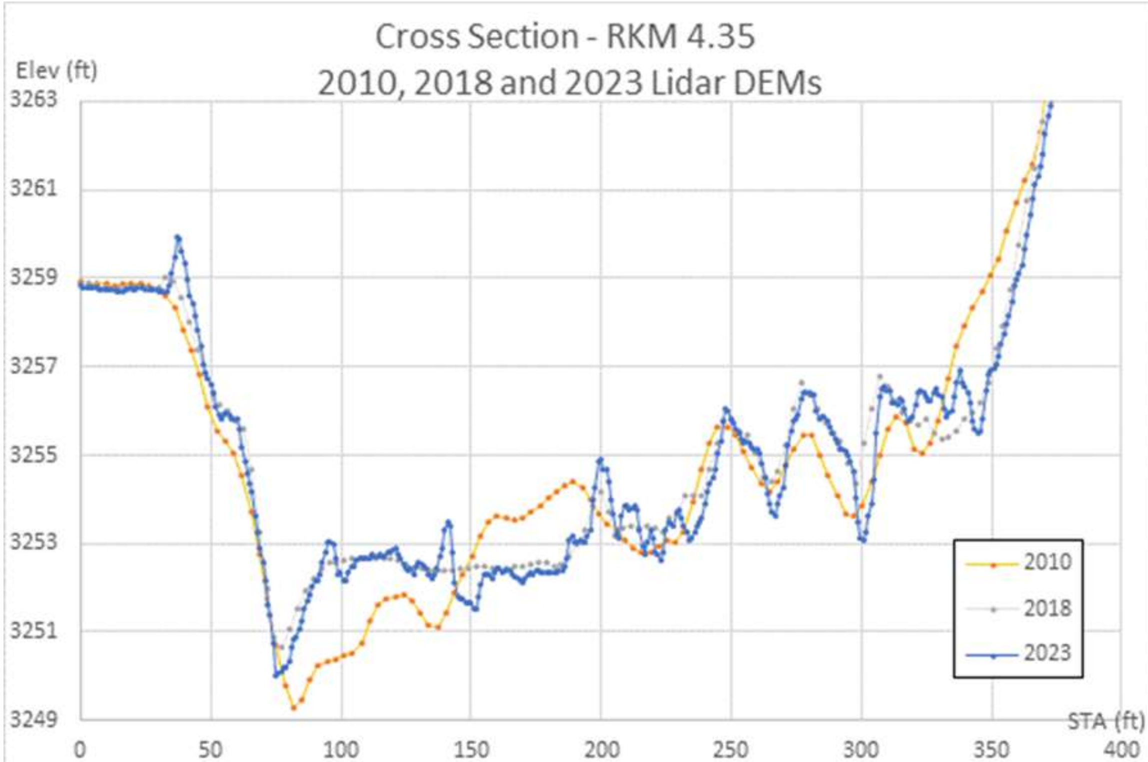


Figure 4 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.35

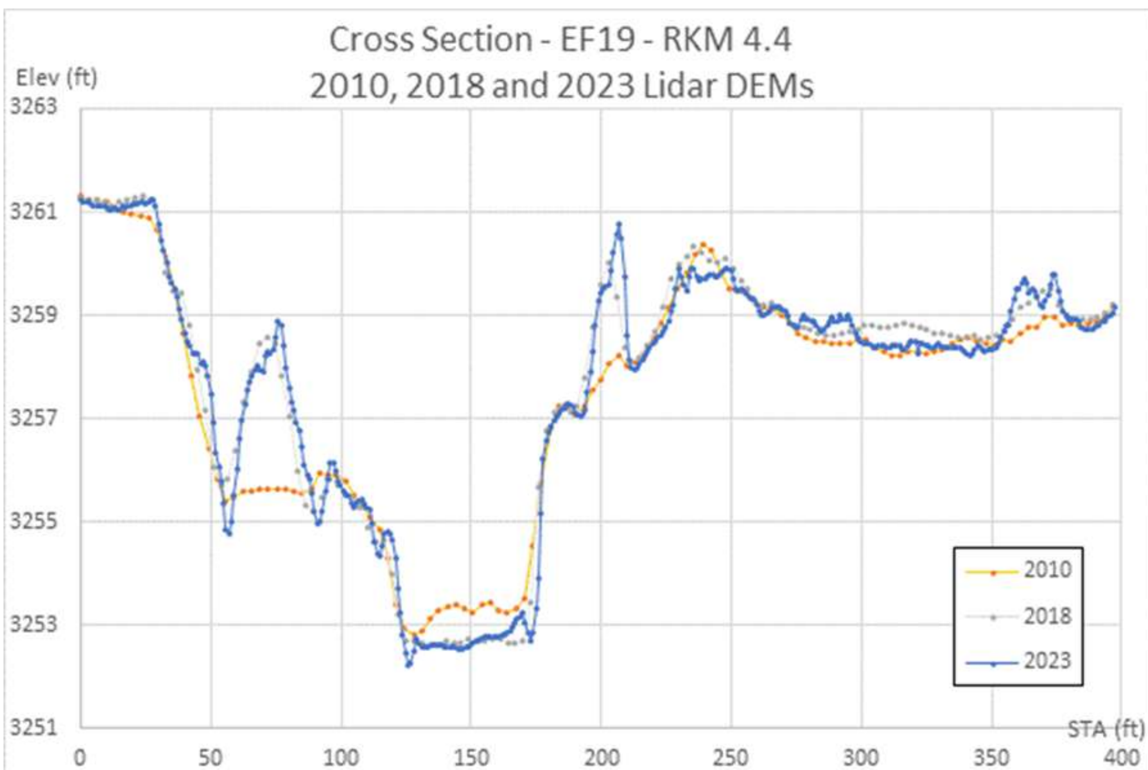


Figure 5 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.4

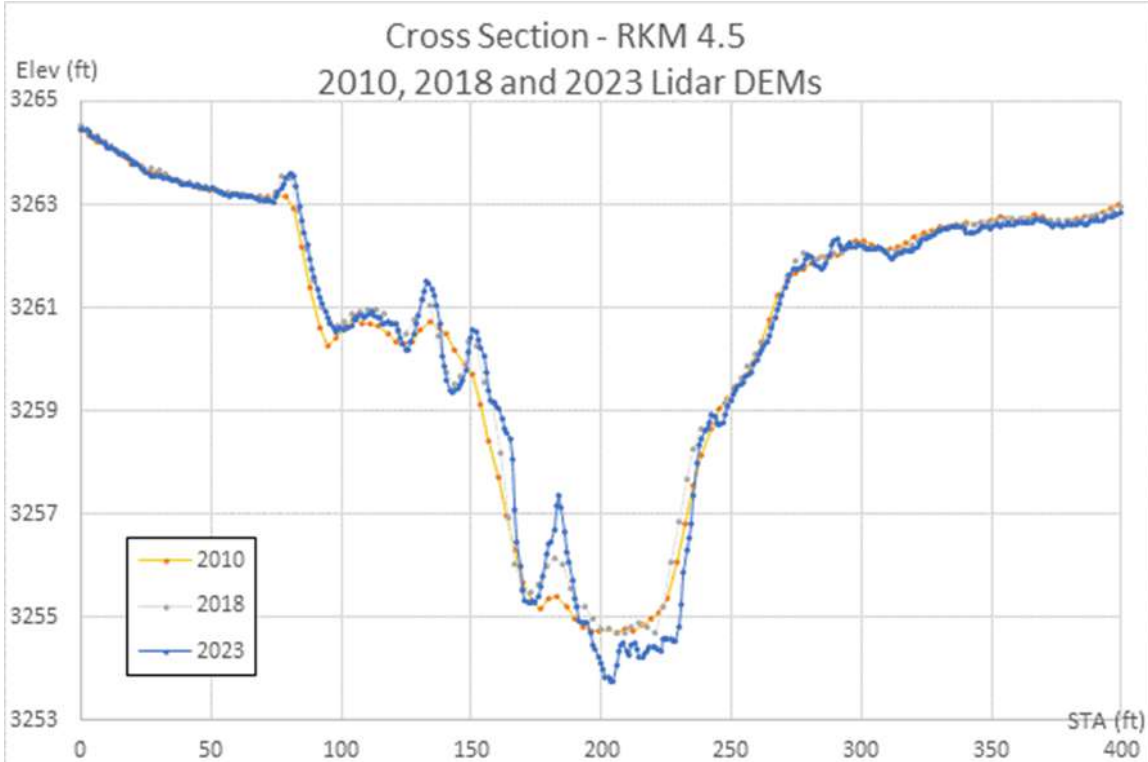


Figure 6 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.5

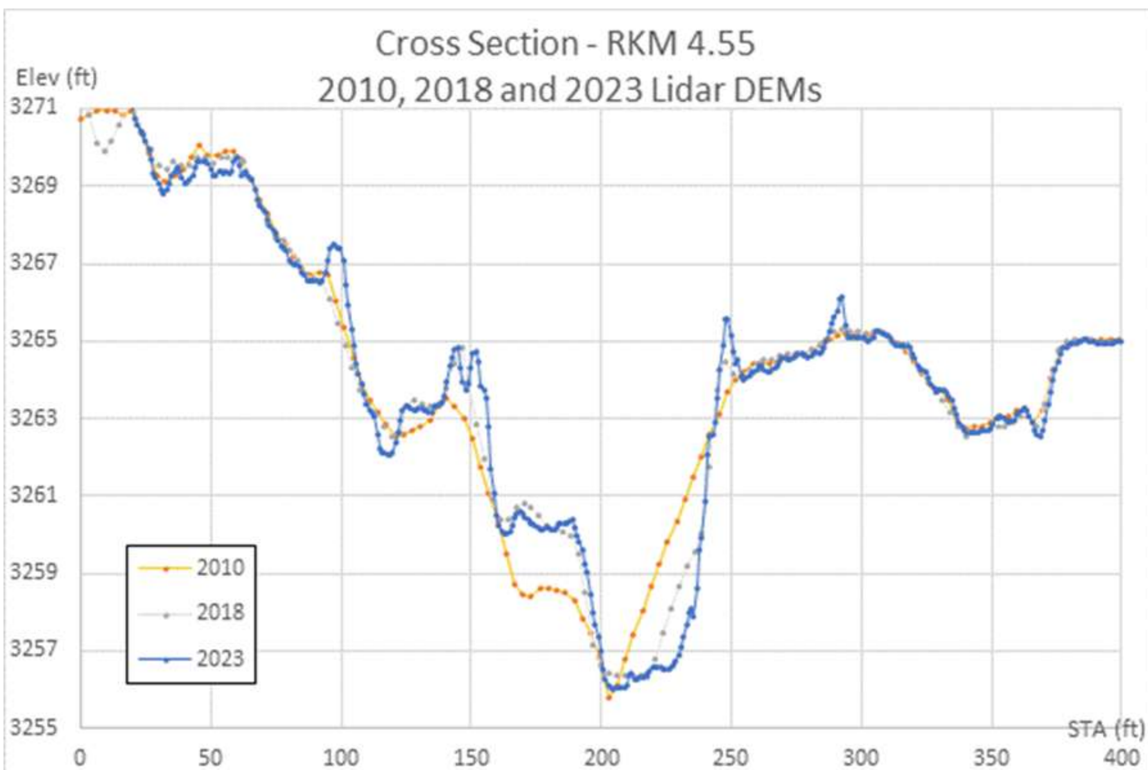


Figure 7 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.55

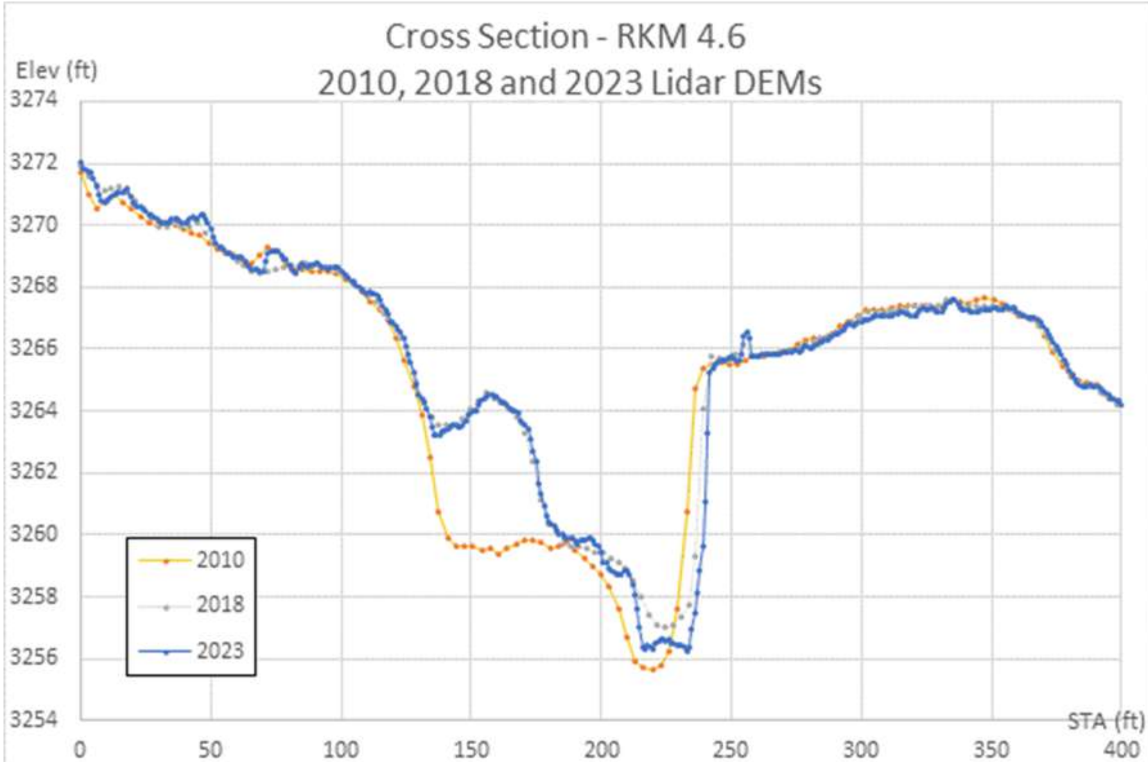


Figure 8 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.6

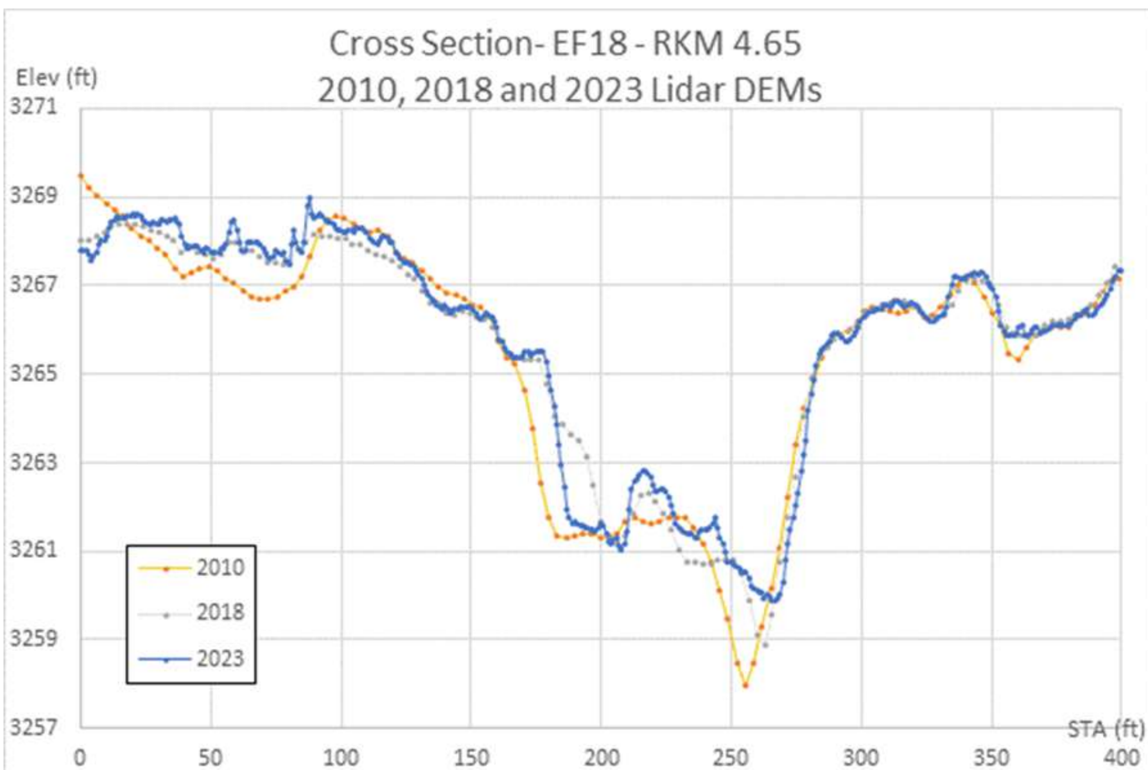


Figure 9 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.65

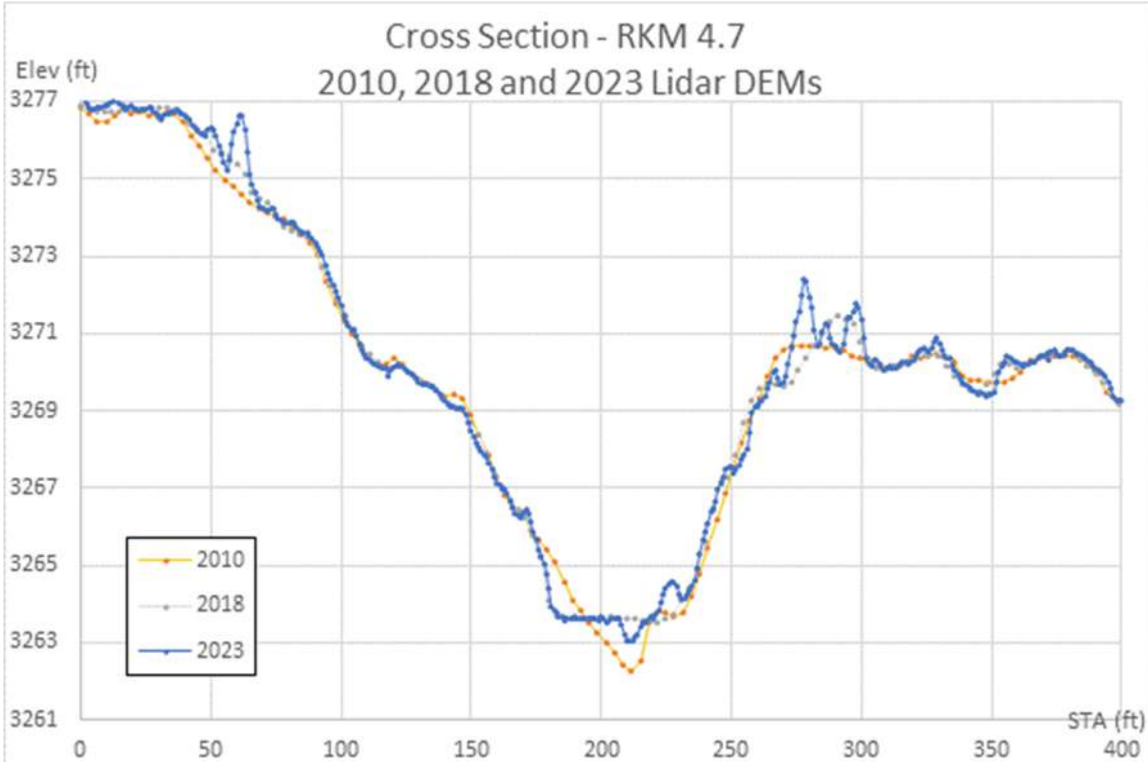


Figure 10 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.7

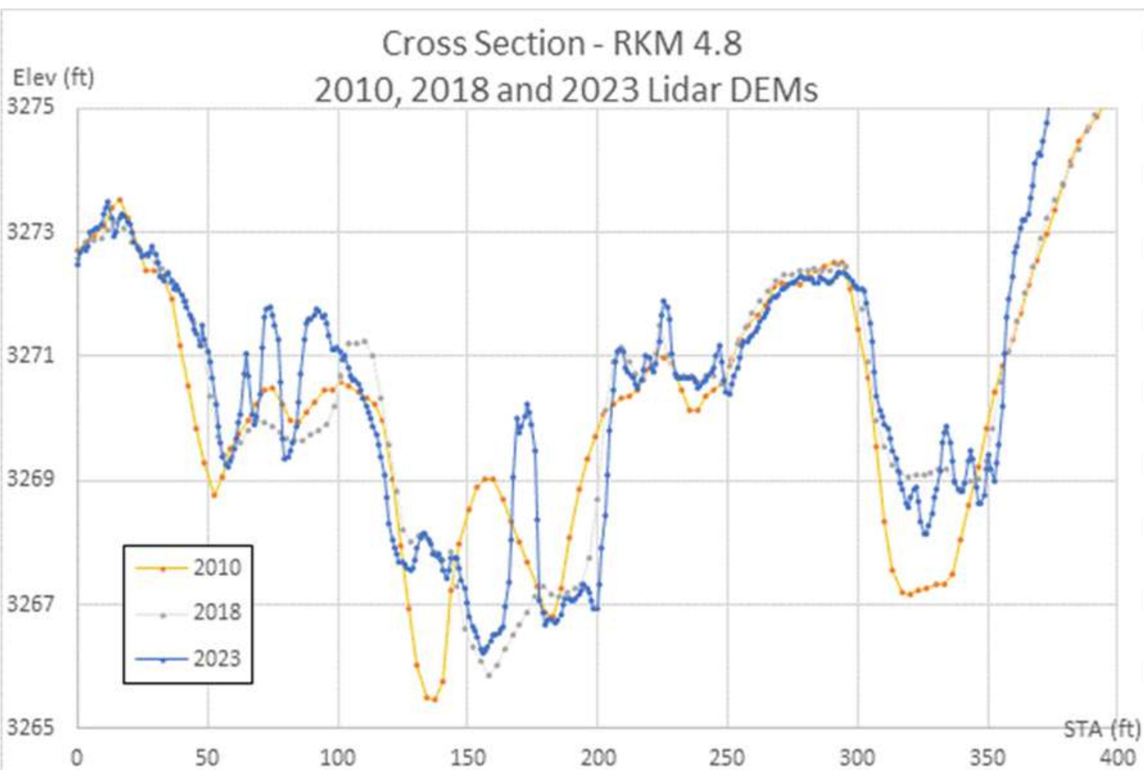


Figure 11 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.8

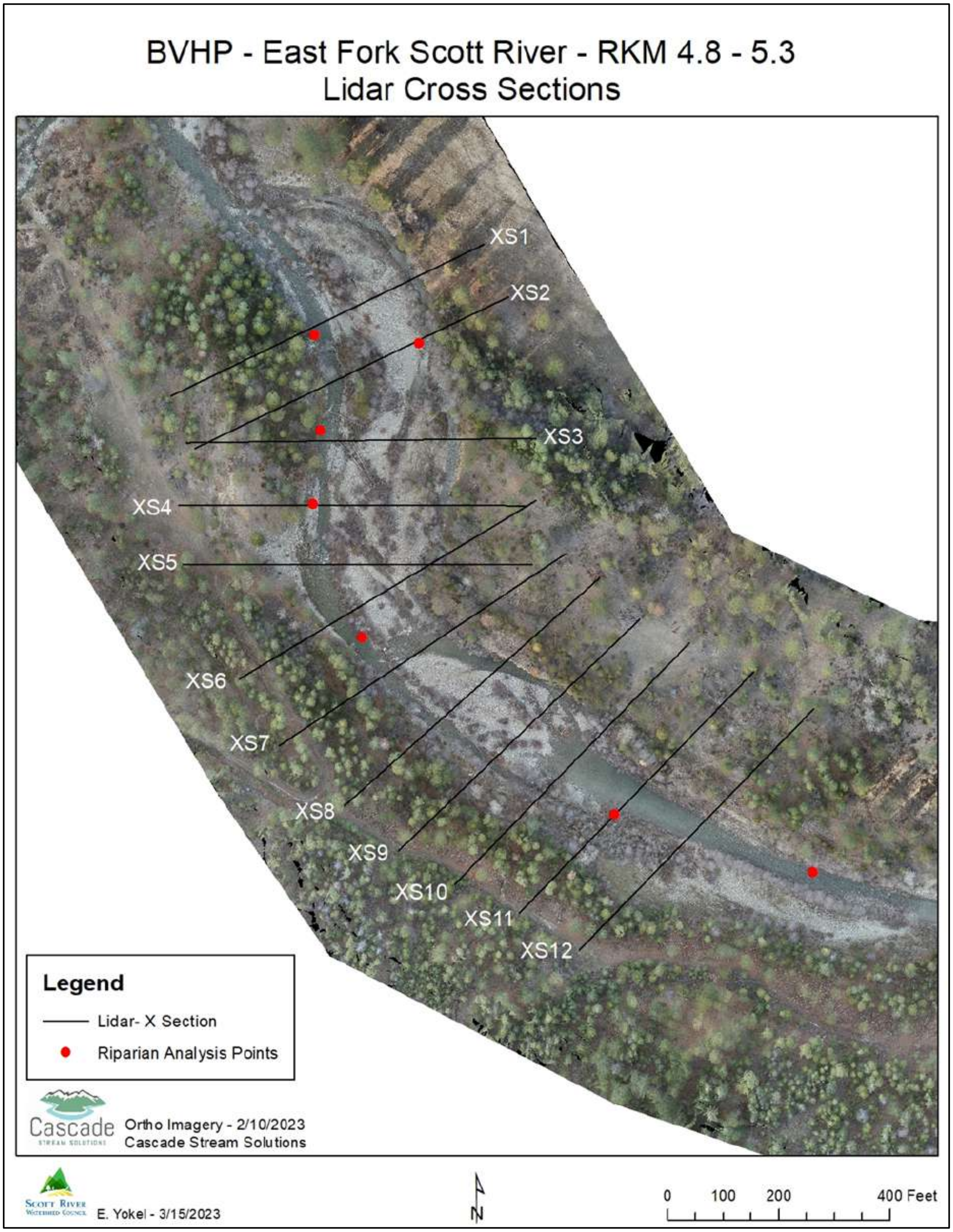
Multiple locations of streambank erosion were documented in the East Fork Scott River from RKM 4.8 to 5.1 during the riparian condition surveys (Map 3) Analysis of the stream channel alignment between 2010 and 2023 illustrates that the primary channel migrated from the river right meander to the less sinuous river left channel eroding an area of dense conifer forest (Map 4). Complex geomorphic change is observed at multiple cross sections in this area.

At the RKM 4.85 cross section the river right and river left channels are at equivalent elevation in 2010 with significant degradation occurring between the two channels between 2010 and 2018 (Figure 12). At the RKM 4.875 cross section the river right channel was two feet lower than the river left channel in 2010 (Figure 13). In 2010, there were four channels with bed elevations between 3,270 and 3,273 ft at RKM 4.875. The river left middle channel degraded approximately four feet between 2010 and 2018 creating a new primary channel with an elevation of 3,269 ft.

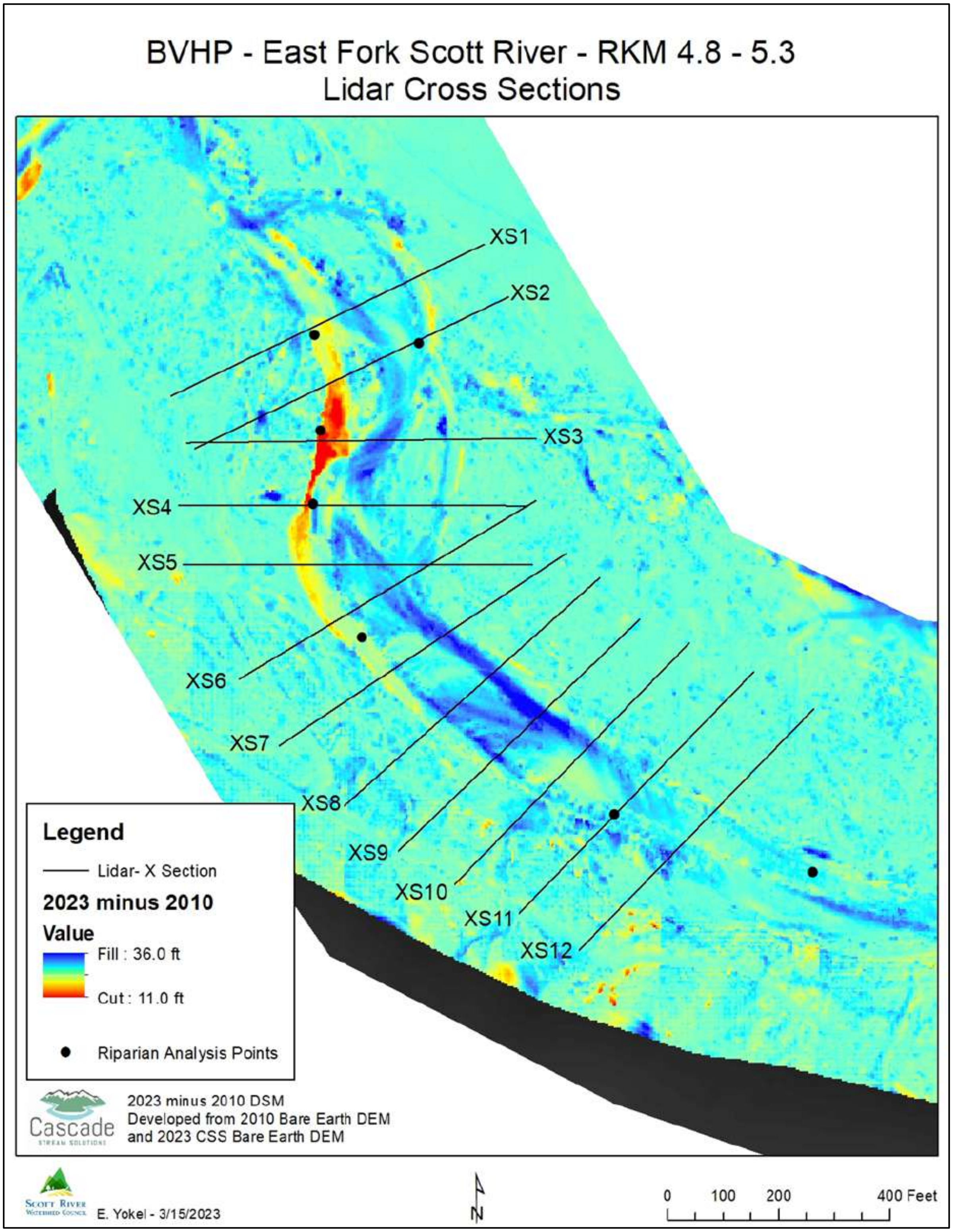
One hundred feet of lateral bank erosion occurred at the river left bank between 2010 and 2018 resulting in a eight foot high vertical streambank and downcutting of the thalweg elevation by 1.5 feet (Figure 14). River left bank erosion was observed at the RKM 4.99 cross section (Figure 15). Fifty feet of lateral bank erosion was observed at the RKM 5.02 cross section with aggradation on the river right floodplain between 2010 and 2023 (Figure 16).

The RKM 5.05 cross section illustrates one foot of degradation of the stream channel and aggradation on the river right bar (Figure 17). Downcutting of almost two feet occurred in the primary channel at the RKM 5.09 cross section with four feet of aggradation at the 2010 middle channel (Figure 18). At the RKM 5.13 cross section, the primary channel elevation was stable with large amounts of aggradation occurring on the river right bar (Figure 19).

Two channels with the same streambed elevation existed at the RKM 5.16 cross section in 2010 with a single channel observed in 2018 due to aggradation of six feet at the 2010 river right channel (Figure 20). Areas of 1.5 to 3 feet of aggradation between 2010 and 2018 occurred on the river right bar at RKM 5.16. Aggradation on the river right bar occurred at the RKM 5.2 and RKM 5.24 cross sections with little change on river left (Figures 21 and 22). Little geomorphic change was observed at the RKM 5.28 transect (Figure 23).



Map 3 - Location of LiDAR cross sections and riparian survey transects - RKM 4.8 - 5.3



Map 4 - Location of LiDAR cross sections and riparian survey transects - RKM 44.8 - 5.3

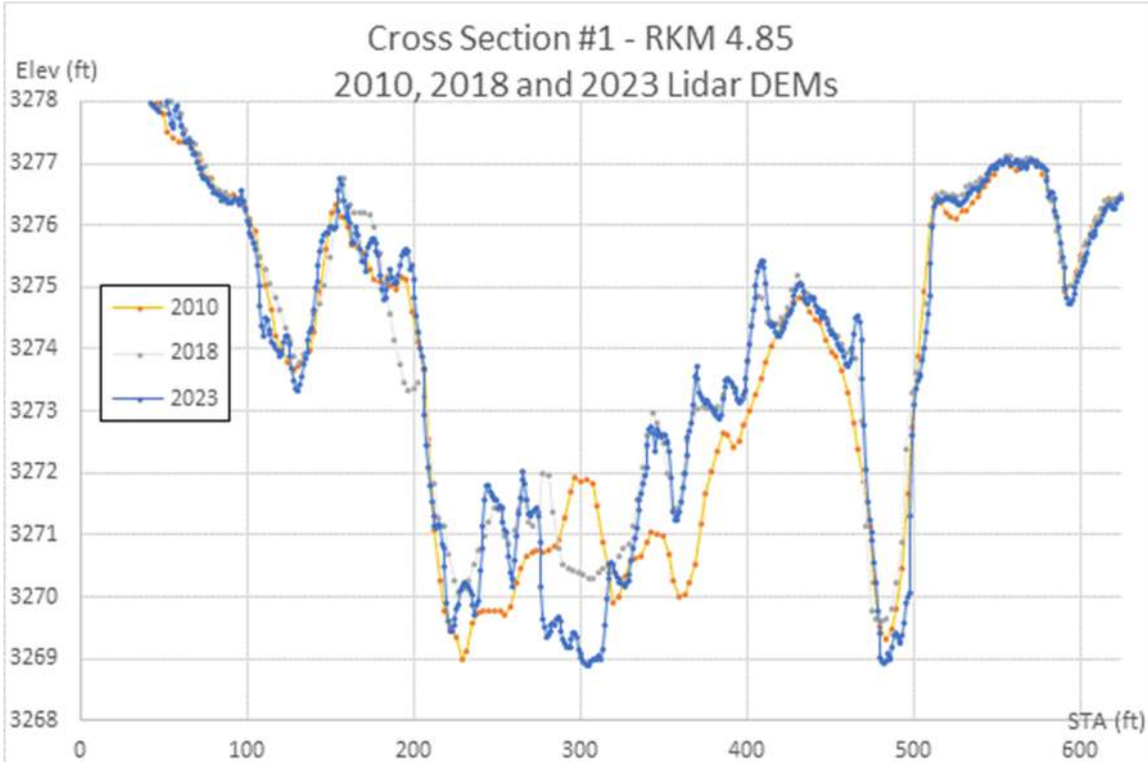


Figure 12 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.85

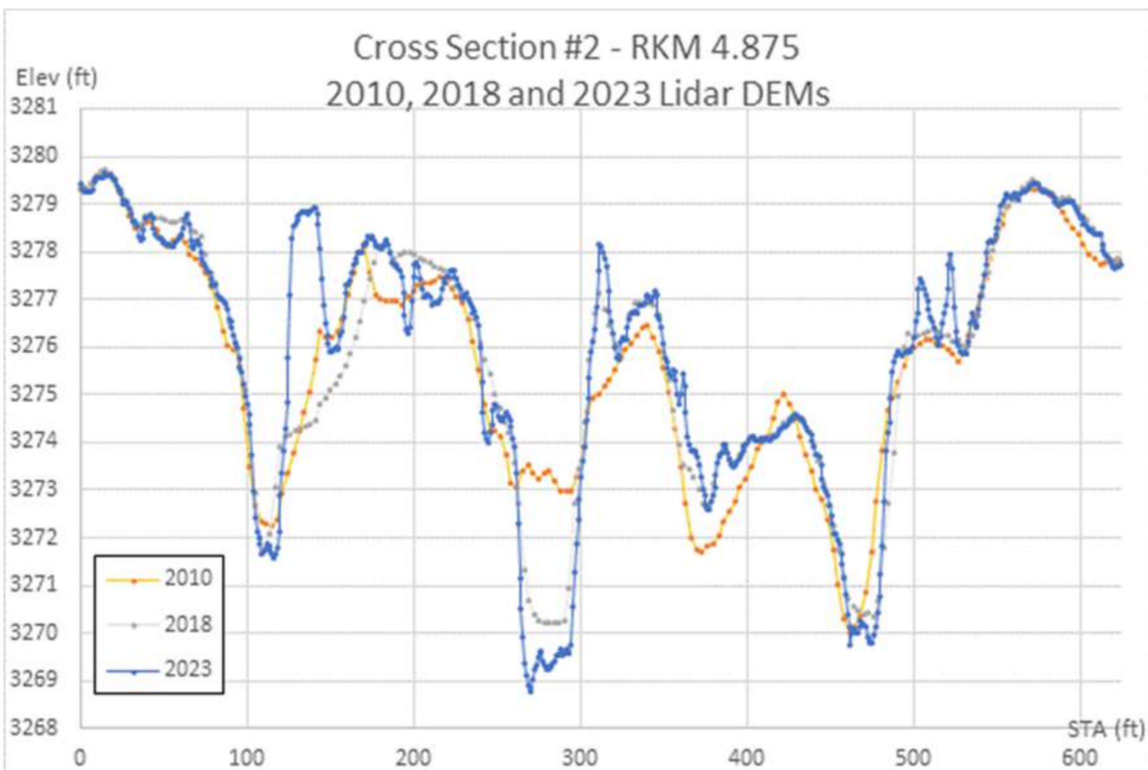


Figure 13 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.875

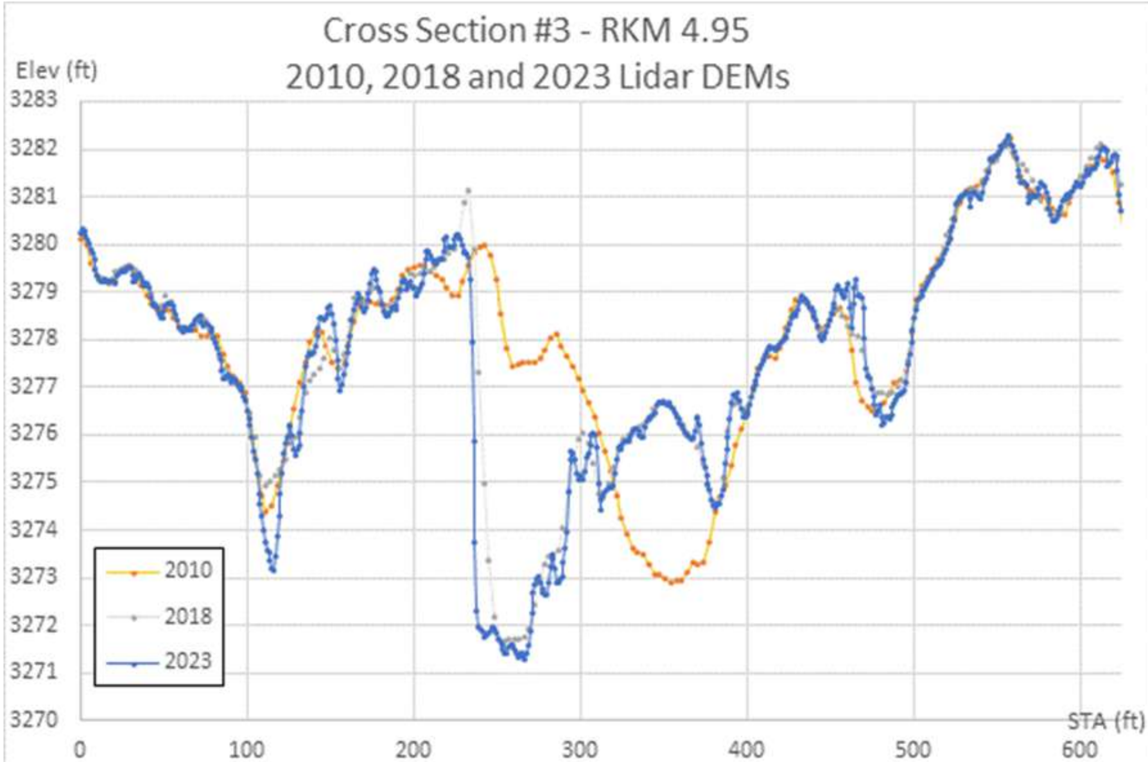


Figure 14 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.95

Upstream end of RKM 5.0 cutbank

Undercut roots of ponderosa pine at RKM 5 cutbank

Upstream end of incised channel at RKM 5 with river left cutbank - looking upstream

Incised channel at RKM 5.0 - 4.9 - looking downstream

Large woody debris at the downstream extent of the incised channel

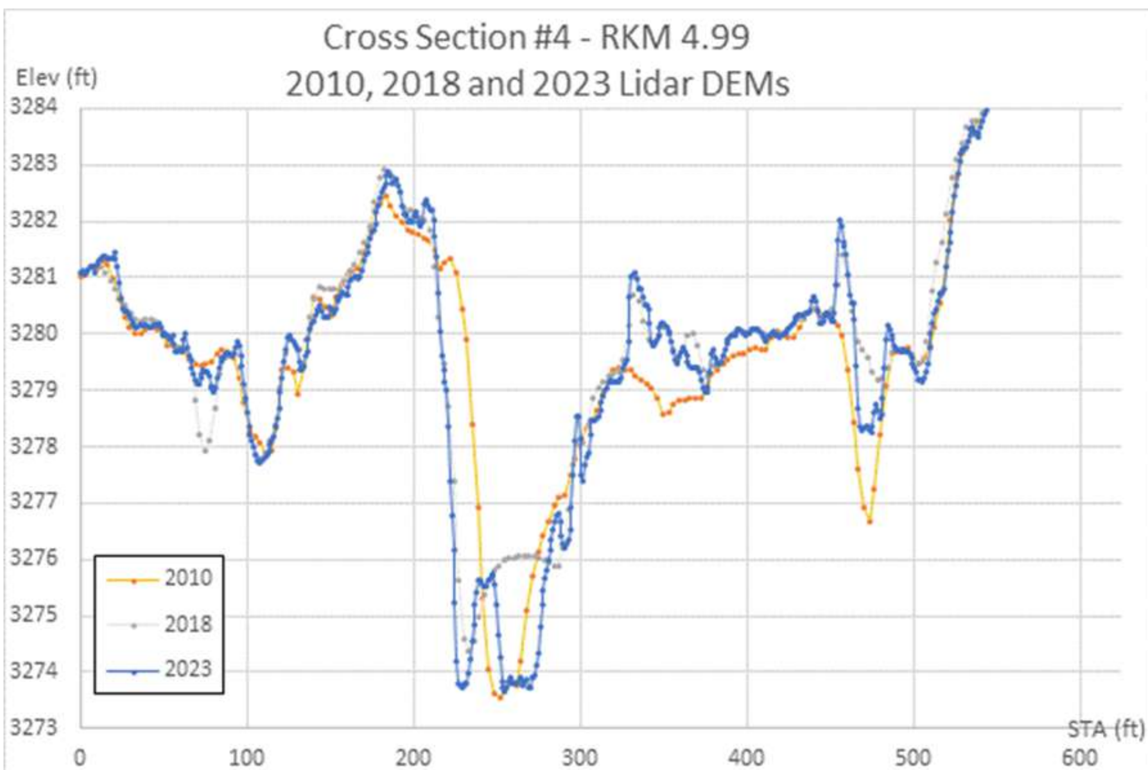


Figure 15 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 4.99

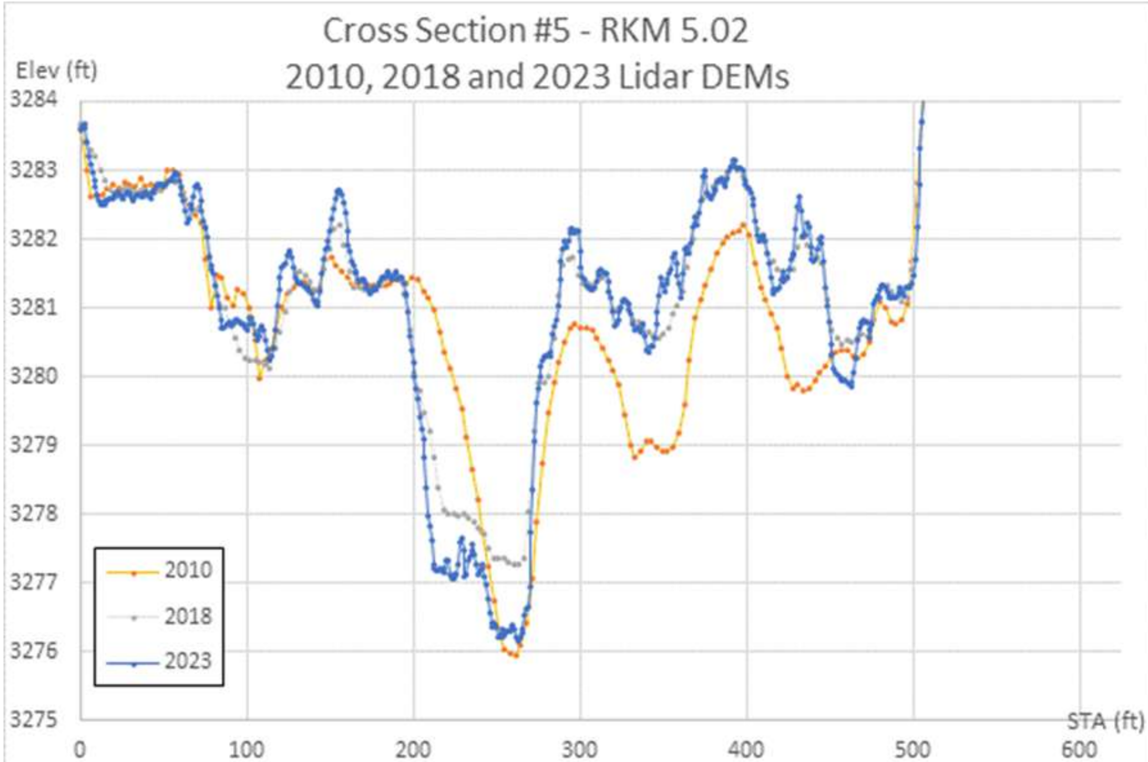


Figure 16 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.02

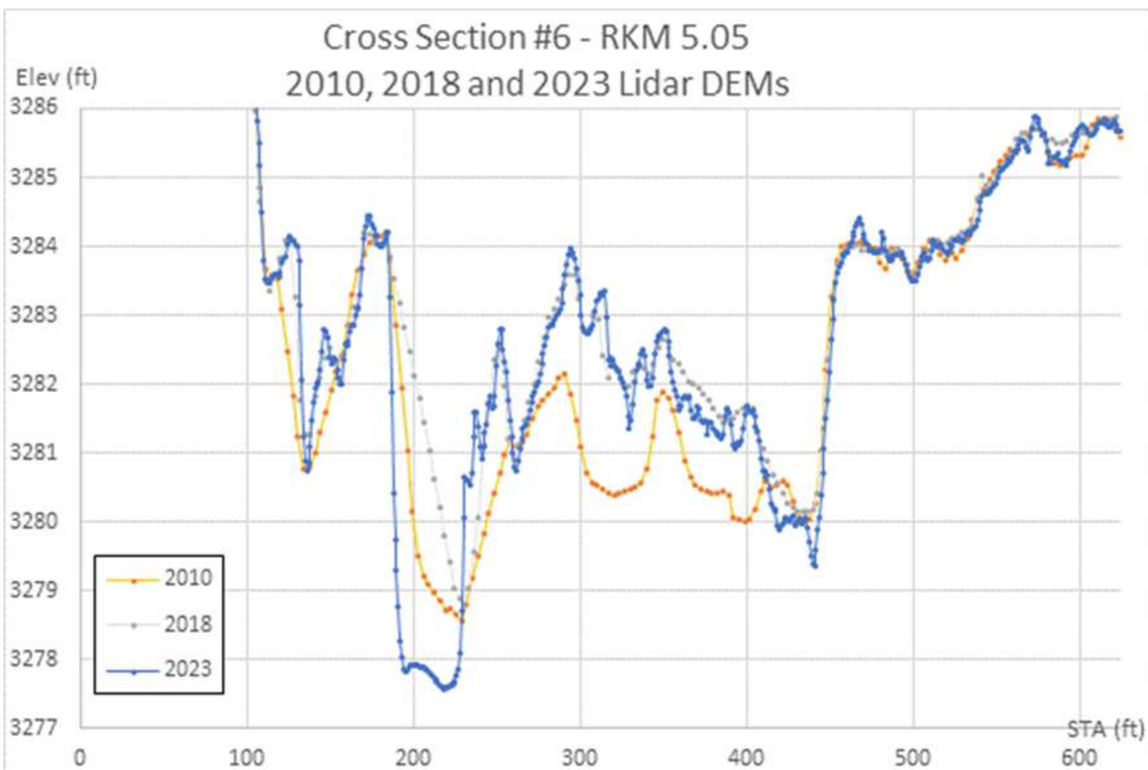


Figure 17 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.05

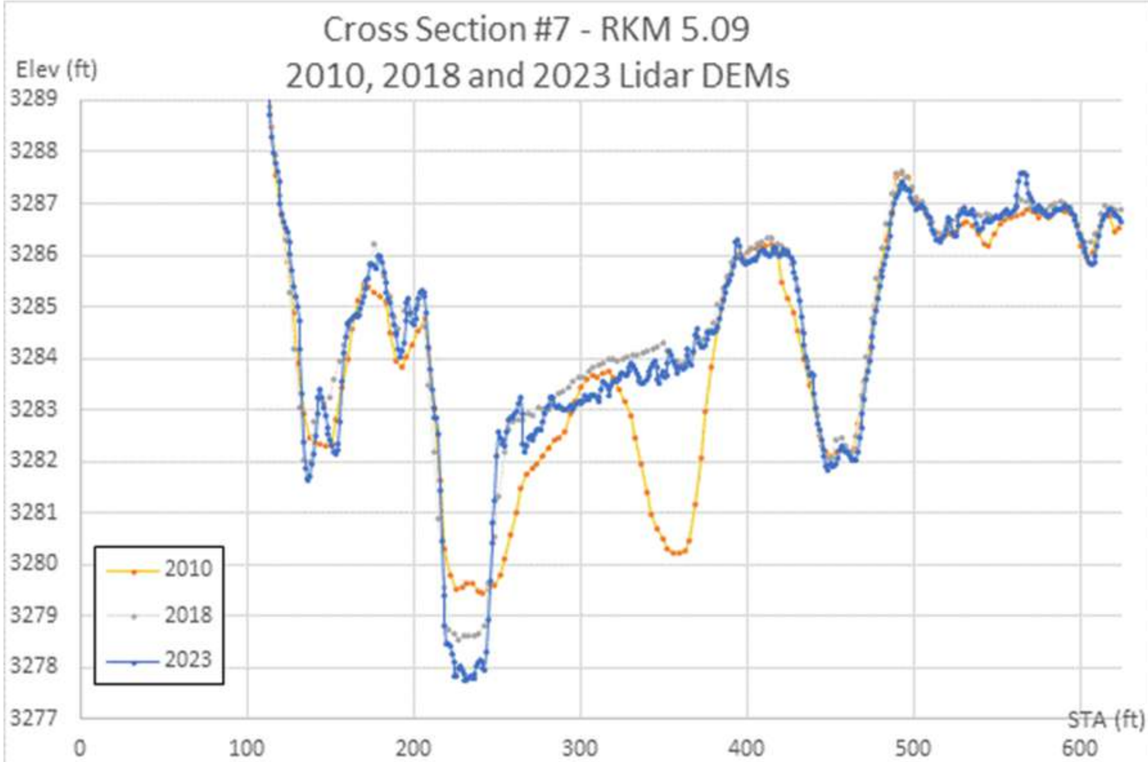


Figure 18 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.09

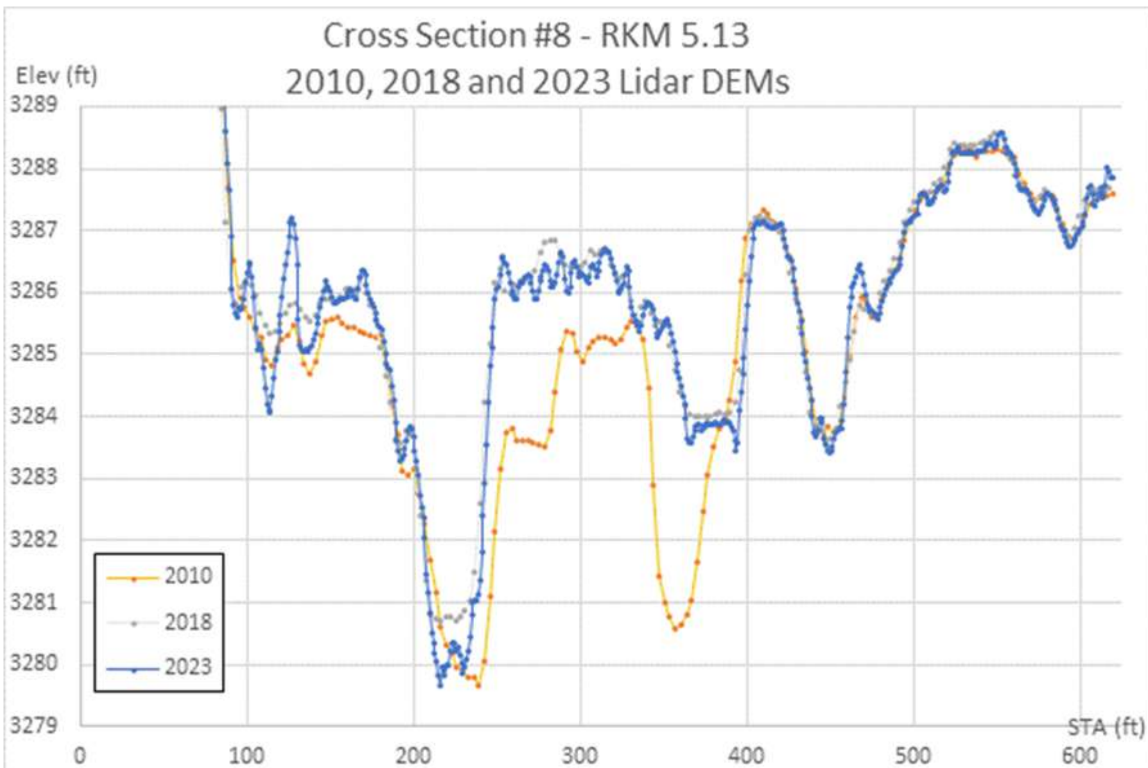


Figure 19 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.13

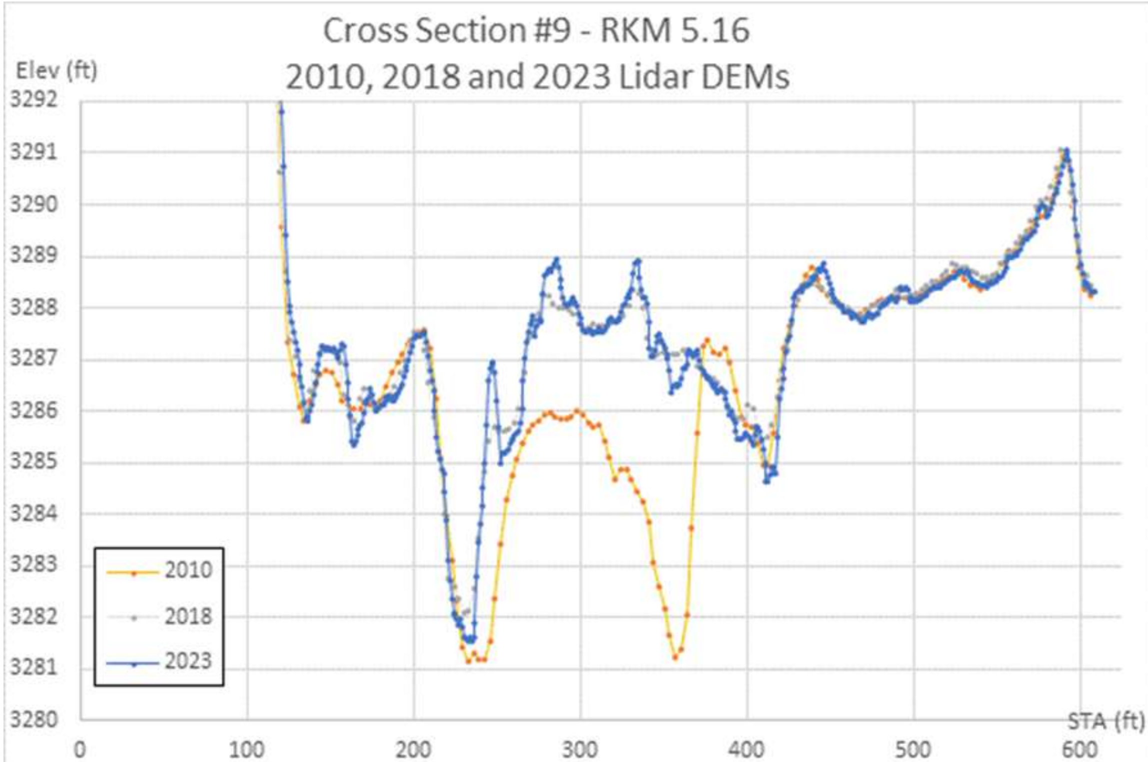


Figure 20 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.16

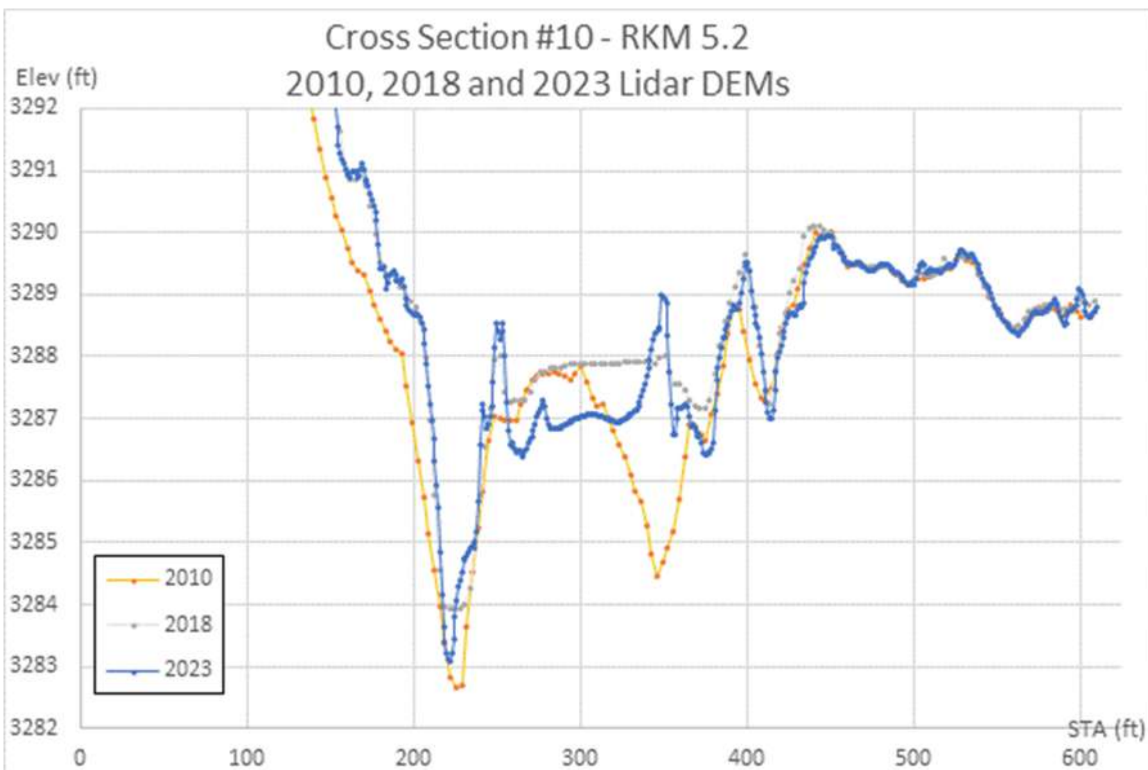


Figure 21 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.2

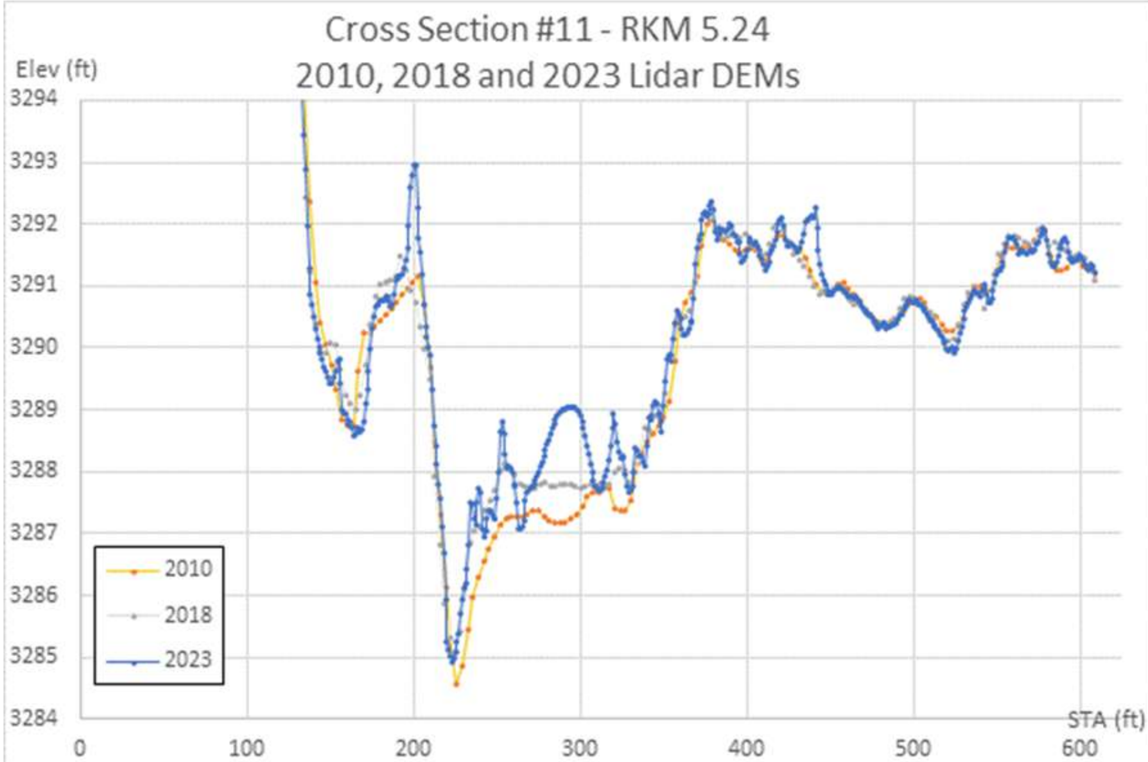


Figure 22- 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.24

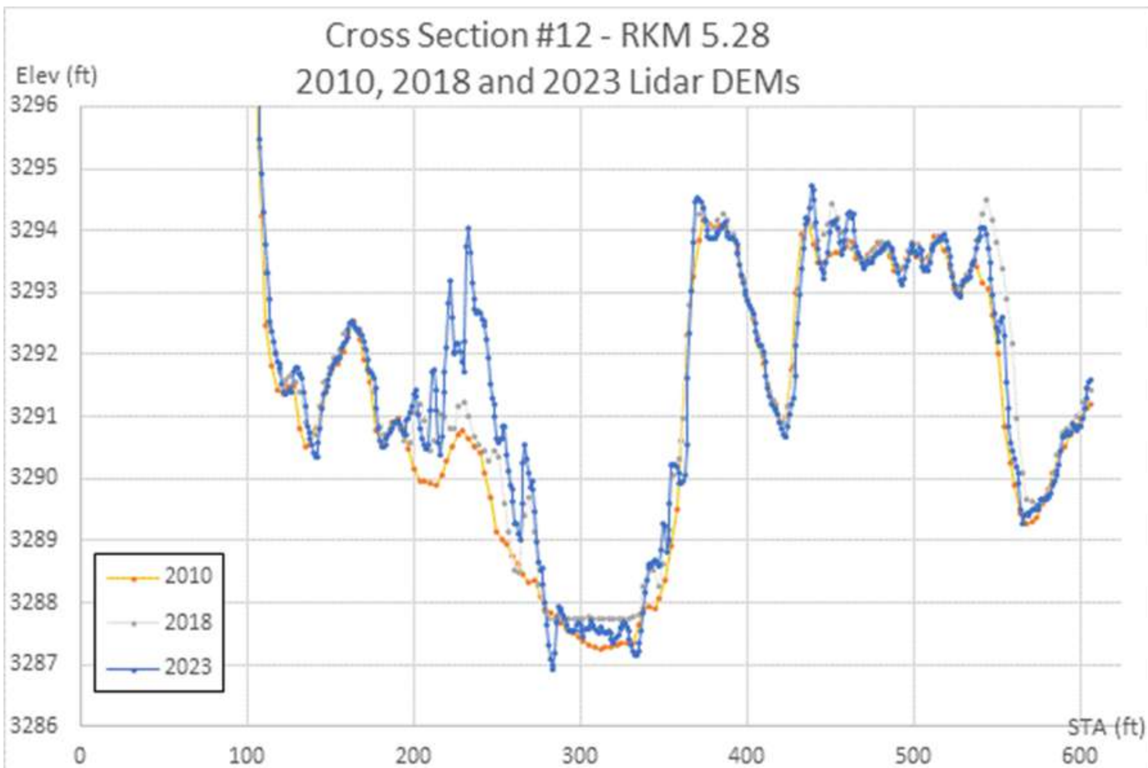
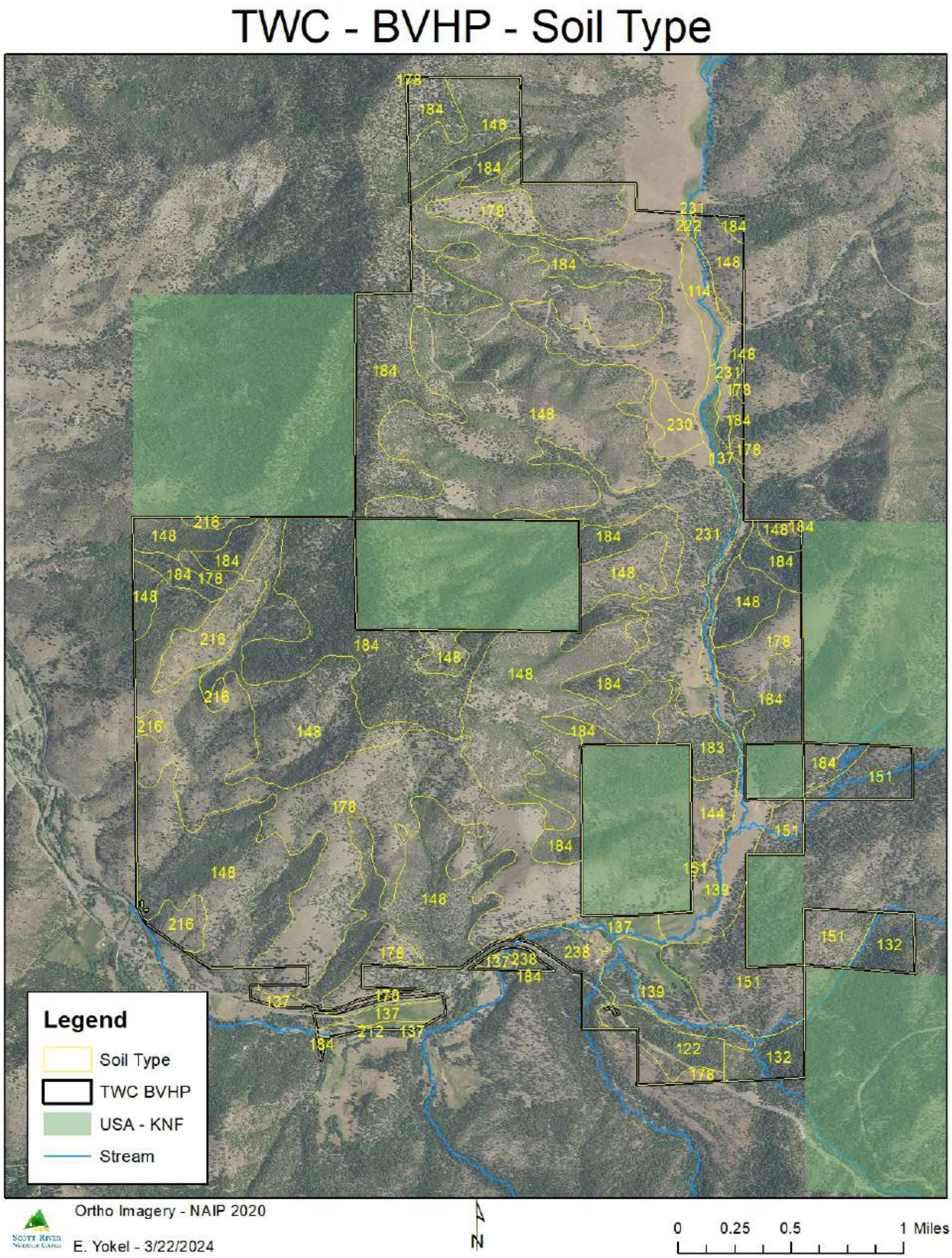


Figure 23 - 2010, 2018 and 2023 LiDAR Cross Section - East Fork Scott River RKM 5.28

Appendix 1.6 Soil Type Map



Soil ID	Soil Type	Acres	Percent Area
114	Bonnet gravelly loam, 2 to 5 percent slopes	36	0.7%
122	Dubakella family, 30 to 70 percent slopes.	53	1.0%
132	Goldridge, gravelly-Clallam, deep-Prather families association, 30 to 90 percent slopes.	81	1.5%
137	Diyou loam, drained	141	2.7%
139	Holland-Aiken families association, 2 to 15 percent slopes.	174	3.3%
144	Holland-Skalan families association, 30 to 70 percent slopes.	40	0.8%
148	Duzel-Jilson-Facey complex, 15 to 50 percent slopes	2,024	38.4%
151	Kang-Beaughton families association, 9 to 90 percent slopes.	241	4.6%
178	Lithic Xerorthents-Rock outcrop complex, 0 to 65 percent slopes*	839	15.9%
184	Marpa-Kinkel-Boomer, cool complex, 15 to 50 percent slopes	981	18.6%
212	Riverwash	11	0.2%
216	Rock outcrop	105	2.0%
222	Settlemeyer loam, 0 to 2 percent slopes	3	0.1%
230	Stoner gravelly sandy loam, 2 to 5 percent slopes	29	0.5%
231	Stoner gravelly sandy loam, 5 to 15 percent slopes	456	8.7%
238	Xerofluvents, nearly level	54	1.0%
	Total	5,269	

Table 1 - TWC – BVHP Soil Types

Appendix 1.7 Riparian Photo Points (2022)

East Fork Riparian Transect #2 - August 24, 2022

Photo 8. East Fork Riparian Transect #2 river right.

Photo 2. East Fork Riparian Transect #2 river left.

Photo 3. East Fork Riparian Transect #2 upstream.

Photo 4. East Fork Riparian Transect #2 downstream.

East Fork Riparian Transect #3 - August 24, 2022

Photo 5. East Fork Riparian Transect #3 river right.

Photo 6. East Fork Riparian Transect #3 river left.

Photo 7. East Fork Riparian Transect #3 upstream.

East Fork Riparian Transect #4 - August 24, 2022

Photo 8. East Fork Riparian Transect #4 river right.

Photo 9. East Fork Riparian Transect #4 river left.

Photo 11. East Fork Riparian Transect #4 upstream.

Photo 12. East Fork Riparian Transect #4 downstream.

East Fork Riparian Transect #5 - August 24, 2022

Photo 13. East Fork Riparian Transect #5 river right.

Photo 14. East Fork Riparian Transect #5 river left.

Photo 15. East Fork Riparian Transect #5 upstream.

Photo 16. East Fork Riparian Transect #5 downstream.

East Fork Riparian Transect #6 - August 24, 2022

Photo 17. East Fork Riparian Transect #6 river right.

Photo 18. East Fork Riparian Transect #6 river left.

Photo 19. East Fork Riparian Transect #6 upstream.

Photo 20. East Fork Riparian Transect #6 downstream.

East Fork Riparian Transect #7 - August 24, 2022

Photo 21. East Fork Riparian Transect #7 river right.

Photo 22. East Fork Riparian Transect #7 river left.

Photo 23. East Fork Riparian Transect #7 upstream.

Photo 94. East Fork Riparian Transect #7 downstream.

East Fork Riparian Transect #8 - August 24, 2022


Photo 25. East Fork Riparian Transect #8 river right.


Photo 26. East Fork Riparian Transect #8 river left.


Photo 27. East Fork Riparian Transect #8 upstream.


Photo 28. East Fork Riparian Transect #8 downstream.

East Fork Riparian Transect #9 - August 24, 2022

Photo 29. East Fork Riparian Transect #9 river right.

Photo 30. East Fork Riparian Transect #9 river left.

Photo 101. East Fork Riparian Transect #9 upstream.

East Fork Riparian Transect #10 - September 1, 2023

Photo 32. East Fork Riparian Transect #10 river right.

Photo 33. East Fork Riparian Transect #10 river left.

Photo 34. East Fork Riparian Transect #10 upstream.

Photo 35. East Fork Riparian Transect #10 downstream.

East Fork Riparian Transect #11 - September 1, 2023

Photo 36. East Fork Riparian Transect #11 river right.

Photo 37. East Fork Riparian Transect #11 upstream.

Photo 38. East Fork Riparian Transect #11 downstream.

East Fork Riparian Transect #12 - September 1, 2023


Photo 39. East Fork Riparian Transect #12 river left.


Photo 40. East Fork Riparian Transect #12 river right.


Photo 41. East Fork Riparian Transect #12 upstream.


Photo 42. East Fork Riparian Transect #12 downstream.

East Fork Riparian Transect #13 - September 1, 2023

Photo 43. East Fork Riparian Transect #13 river right.

Photo 44. East Fork Riparian Transect #13 river left.

Photo 45. East Fork Riparian Transect #13 upstream.

Photo 46. East Fork Riparian Transect #13 downstream.

East Fork Riparian Transect #14 - September 1, 2023

Photo 47. East Fork Riparian Transect #14 river right.

Photo 48. East Fork Riparian Transect #14 river left.

Photo 49. East Fork Riparian Transect #14 upstream.

Photo 50. East Fork Riparian Transect #14 downstream.

East Fork Riparian Transect #15 - September 1, 2023

Photo 50. East Fork Riparian Transect #15 river right.

Photo 51. East Fork Riparian Transect #15 river left.

Photo 52. East Fork Riparian Transect #15 upstream.

Photo 53. East Fork Riparian Transect #15 downstream.

East Fork Riparian Transect #15a - September 1, 2023

Photo 54. East Fork Riparian Transect #15.a river right.

Photo 55. East Fork Riparian Transect #15.a river left.

Photo 56. East Fork Riparian Transect #15.a upstream.

Photo 57. East Fork Riparian Transect #15.a downstream.

East Fork Riparian Transect #17.a - September 1, 2023

Photo 58. East Fork Riparian Transect #17.a river right.

Photo 59. East Fork Riparian Transect #17.a river left.

Photo 60. East Fork Riparian Transect #17.a. downstream.

East Fork Riparian Transect #17.b - September 1, 2023

Photo 61. East Fork Riparian Transect #17.b river right.

Photo 62. East Fork Riparian Transect #17.b river left.

Photo 63. East Fork Riparian Transect #17.b upstream.

Photo 64. East Fork Riparian Transect #17.b downstream.

East Fork Riparian Transect #19 - September 1, 2023

Photo 65. East Fork Riparian Transect #19 river right.

Photo 66. East Fork Riparian Transect #19 river left.

Photo 67. East Fork Riparian Transect #19 upstream.

Photo 68. East Fork Riparian Transect #19 downstream.

East Fork Riparian Transect #20 - September 1, 2023

Photo 69. East Fork Riparian Transect #20 river right.

Photo 70. East Fork Riparian Transect #20 river left.

Photo 71. East Fork Riparian Transect #20 upstream.

Photo 72. East Fork Riparian Transect #20 downstream.

East Fork Riparian Transect #21 - September 13, 2022

Photo 73. East Fork Riparian Transect #21 river right.

Photo 74. East Fork Riparian Transect #21 river left.

Photo 75. East Fork Riparian Transect #21 upstream.

Photo 76. East Fork Riparian Transect #21 downstream.

East Fork Riparian Transect #22 - September 13, 2023

Photo 77. East Fork Riparian Transect #22 river right.

Photo 78. East Fork Riparian Transect #22 river left.

Photo 79. East Fork Riparian Transect #22 upstream.

Photo 80. East Fork Riparian Transect #22 downstream.

East Fork Riparian Transect #23 - September 13, 2023

Photo 81. East Fork Riparian Transect #23 river right.

Photo 82. East Fork Riparian Transect #23 river left.

Photo 83. East Fork Riparian Transect #23 upstream.

Photo 84. East Fork Riparian Transect #23 downstream.

East Fork Riparian Transect #24 - September 13, 2023

Photo 85. East Fork Riparian Transect #24 river right.

Photo 86. East Fork Riparian Transect #24 river left.

Photo 87. East Fork Riparian Transect #24 upstream.

Photo 88. East Fork Riparian Transect #24 downstream.

East Fork Riparian Transect #25 - September 13, 2023

Photo 89. East Fork Riparian Transect #25 river right.

Photo 90. East Fork Riparian Transect #25 river left.

Photo 91. East Fork Riparian Transect #25 upstream.

Photo 92. East Fork Riparian Transect #25 downstream.

Appendix 2.1 Gully Photos

Gully photos illustrate gully features from upslope to discharge point.

Gully Complex 49

Photo 2.1: Gully Complex 49, upslope reach. EFG49g. July 25, 2023.

Photo 2.2: road crossing Gully Complex 49 (natural stream). EFR49. August 5, 2023.

Photo 2.3: Gully Complex 49 (stream) Downstream of road crossing, looking downstream. Note incision. EFR49. August 5, 2023.

Gully Complex 2

Photo 2.4: Outlet of Highway 3 culvert, looking upslope. EFG2a. January 19, 2024.

Photo 2.5: Water during runoff event crossing road, looking upslope. EFR2. January 13, 2023.

Photo 2.6: Erosion of road fill. EFR2. January 13, 2023.

Photo 2.7: Looking upslope towards site of Figure 2.6, on a day without runoff. EFG2c. January 19, 2024.

Photos 2.8 & 2.9: Flow path on road. EFR14; January 20, 2023. EFG2e. January 19, 2024.

Photo 2.10: Flow divided between road and un-engineered inboard ditch. EFG2e. January 19, 2024.

Photo 2.11: Gully 2 crosses road again. EFR13.1. April 13, 2023.

Photo 2.12: Flow path leaving road. EFR13.1. February 10, 2023.

Photo 2.13: Sediment deposited by Gully Complex 2. EFG2f. January 19, 2024.


Photos 2.14 & 2.15: Maximum cross-section of Gully Complex 2 is 89 ft^2. EFG2i. January 19, 2024.

Photo 2.16: Gully Complex 2 discharges into the East Fork Scott River. EFG2j. January 19, 2024.

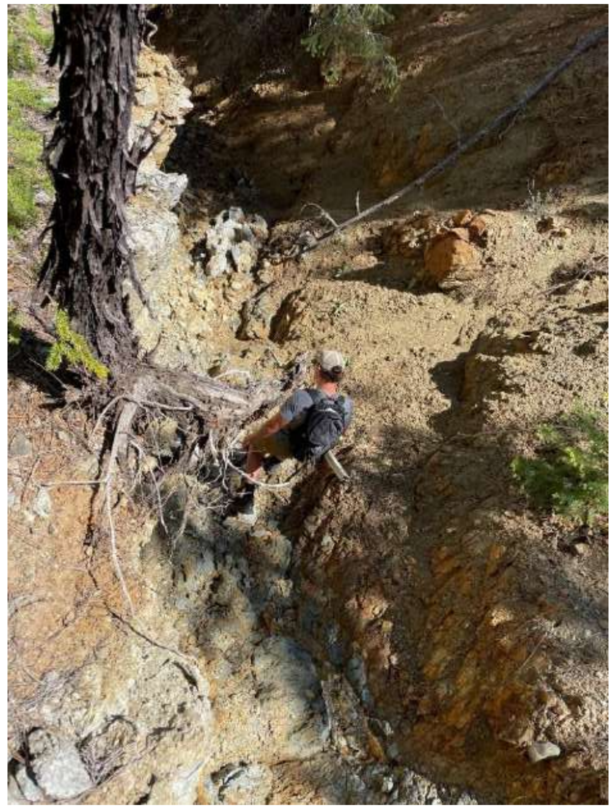
Gully 2.1 (photos below) is a smaller gully that leaves and returns to Gully 2

Photos 2.17 & 2.18: Gully Complex 2 crossing lower road. EFR13. January 20, 2023.

Gully Complex 8



Photos 2.19, 2.20 & 2.21: Gully 8 above Highway 3. EFG8c, EFG8d and EFG8.; May 29, 2023.

Photos 2.22 and 2.23: Left, culvert discharging in Gully 8. EFG8f. Right, Beginning of deep incision. EFG8f. May 29, 2023.

Photo 2.24: Maximum cross-section in Gully Complex 8 is 800 ft^2. EFG8f. May 29, 2023.

Photos 2.25 and 2.26: Left, maximum cross-section. EFG8f. Right, below bifurcation. EFG8h. May 29, 2023.

Photos 2.27 and 2.28: Segments below bifurcation. EFG9b and EFG8g. May 29, 2023.

Photo 2.29: EFG 8.2 discharges into the East Fork Scott River. EFG8j. May 29, 2023.

Photo 2.30: Looking upslope from the confluence of EFG 8.2 and the East Fork Scott River. EFG8j. April 5, 2024.

Photo 2.31: EFG 8.3 discharges into the East Fork Scott River. EFG9. April 5, 2024.

Photo 2.32: Deep incision where EFG 8.3 discharges into the East Fork Scott River. EFG9. April 5, 2024.

Photo 2.33: EFG 8.4 discharges into the East Fork Scott River. EFG10e. April 5, 2024.

Photo 2.34: Incision where EFG 8.4 discharges into the East Fork Scott River. EFG10e. April 5, 2024.

Gully Complex 12

Photo 2.35: Culvert discharges at the top of Gully Complex 12. January 18, 2024.

Photo 2.36: Discharge from outboard ditch erodes fill at the top of Gully Complex 12. January 18, 2024.

Photos 2.37 & 2.38: Typical features in Gully Complex 12. EFG12

Photos 2.39 & 2.40: Greatest cross-section of Gully Complex 12 is 32 ft^2; looking up and down the gully at that point.

Photos 2.41 and 2.42: Typical features in Gully Complex 12. EFG 12d and EFG12g. May 23, 2023.

Photo 2.43: The two branches of Gully Complex 12 flow into Mule Creek at the same point. EFG12e. April 5, 2024.

Photo 2.44: The two branches of Gully Complex 12 flow into Mule Creek at the same point. EFG12e. April 5, 2024.

Gully Complex 5

Photo 2.45: Below Highway 3 outboard ditch. EFG6.5.2c. June 2, 2023.

Photo 2.46: Immediately above road crossing. EFR6. May 23, 2023.

Photo 2.47: Gully Complex 5 road crossing. EFR6. May 23, 2023.

Photo 2.48: Gully Complex 5 road crossing. EFR6. May 23, 2023.

Photo 2.49: EFGC 5 discharges into the East Fork Scott River. April 5, 2023

Gully 24

Photo 2.50: This inboard ditch on Highway 3 is the source for EFG 24. EFG24a. April 5, 2024.

Photo 2.51: Beginning of EFG 24. Inboard ditch flows past culvert. EFG24a. April 5, 2024.

Photo 2.52: EFG 24 downstream of bypassed culvert. April 5, 2024.

Photo 2.53: EFG 24 crosses the private road. April 5, 2024.

Photo 2.54: EFG 24 below road. EFG24b. April 5, 2024. *Photo 2.55: EFG 24 discharges into Big Mill Creek. EFG24e. April 5, 2024.*

Gully Complex 6

Photo 2.56: Beginning of Gully 6. EFG6.1a. May 29, 2023.

Figure 2.57: Looking downslope from beginning of gully. EFG6.1a. May 29, 2023.

Photo 2.58: Significant layer of duff. EFG6g. May 29, 2023. *Photo 2.60: Duff and vegetation in gully. EFG6e. May 29, 2023.*

Appendix 6.1 Noyes Valley Creek Stream Conditions Analysis

Map 1. Lower Noyes Valley Creek.

The 2010 and 2018 LiDAR bare earth DEMs were used to analyze the condition and geomorphic change of Lower Noyes Valley Creek (Masterson Road low water crossing to confluence with the East Fork Scott River) (Map 1). A longitudinal profile of Noyes Valley Creek was developed from the two LiDAR products (Figure 1). It should be noted that the 2010 and 2018 LiDAR were acquired during significantly different flow regimes with the 2010 LiDAR acquired in late October during a period of low fall flow and the 2018 product acquired in March during a period of higher winter runoff flows. Due to this difference in flow regimes and inability of LiDAR to penetrate water the higher elevations observed in the 2018 DEM in the stream channel are likely attributed to the higher surface water elevation at time of acquisition and not geomorphic change.

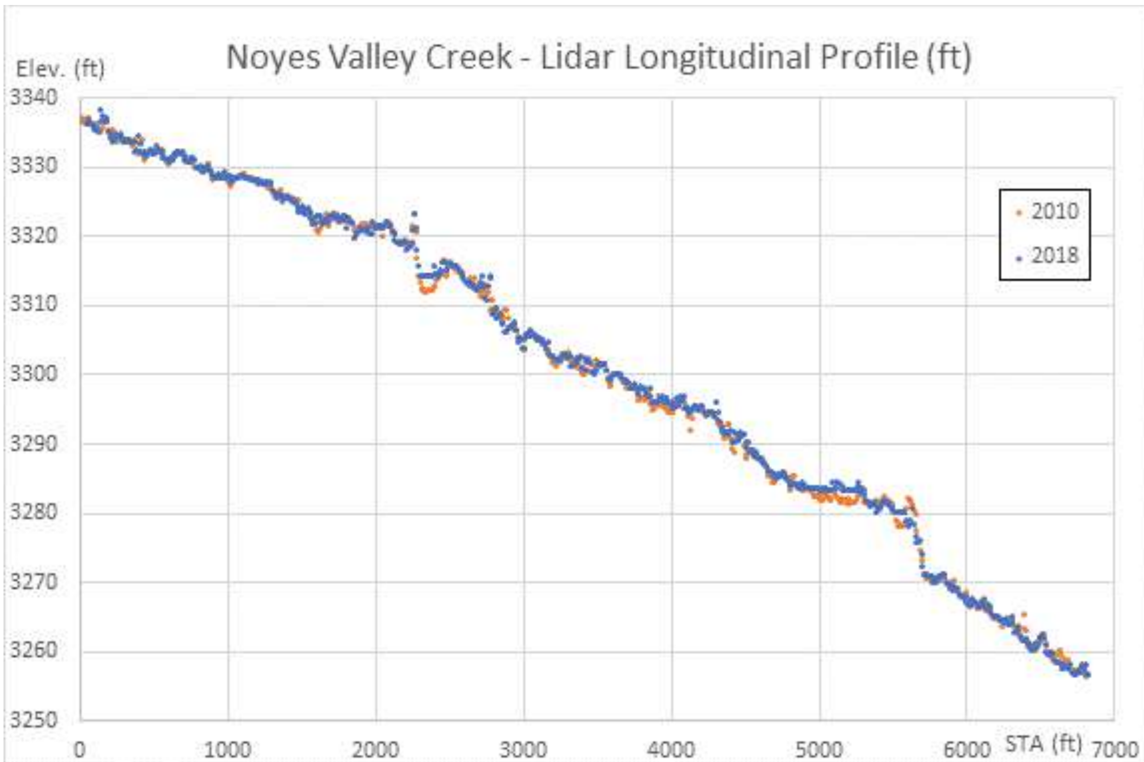


Figure 1. Noyes Valley Creek - Longitudinal Profiles derived from 2010 and 2018 LiDAR DEM.

Two areas of Noyes Valley Creek with potential geomorphic change were identified in the longitudinal profiles developed from the 2010 and 2018 LiDAR DEMs. The upstream site (Site #2) was identified at Station 2,900 where indications of degradation (up to 2 feet) were detected between the 2010 and 2018 LiDAR products indicative of potential erosion and downcutting of the channel (Figure 2). The downstream site (Site #1) was identified at Station 5,600 directly downstream from a man-made channel spanning berm on Noyes Valley at which degradation was detected between 2010 and 2018 (Figure 3).

Rasters illustrating the change in elevation between the 2010 and 2018 LiDAR bare earth DEMs were generated using Raster Math in ArcGIS. The 2010 DEM was subtracted from the 2018 DEM generating a raster with values of the elevation difference with positive values indicating increased elevations in 2018 compared to 2010 and negative values indicating decreased elevation (Map 2). Due to the different flow regimes at the time of acquisition it is impossible to determine if areas of increased elevation are due to aggradation or the different water surface elevations. Area of decreased elevation between 2010 and 2018 can be attributed to degradation caused by erosion of the streambed and banks.

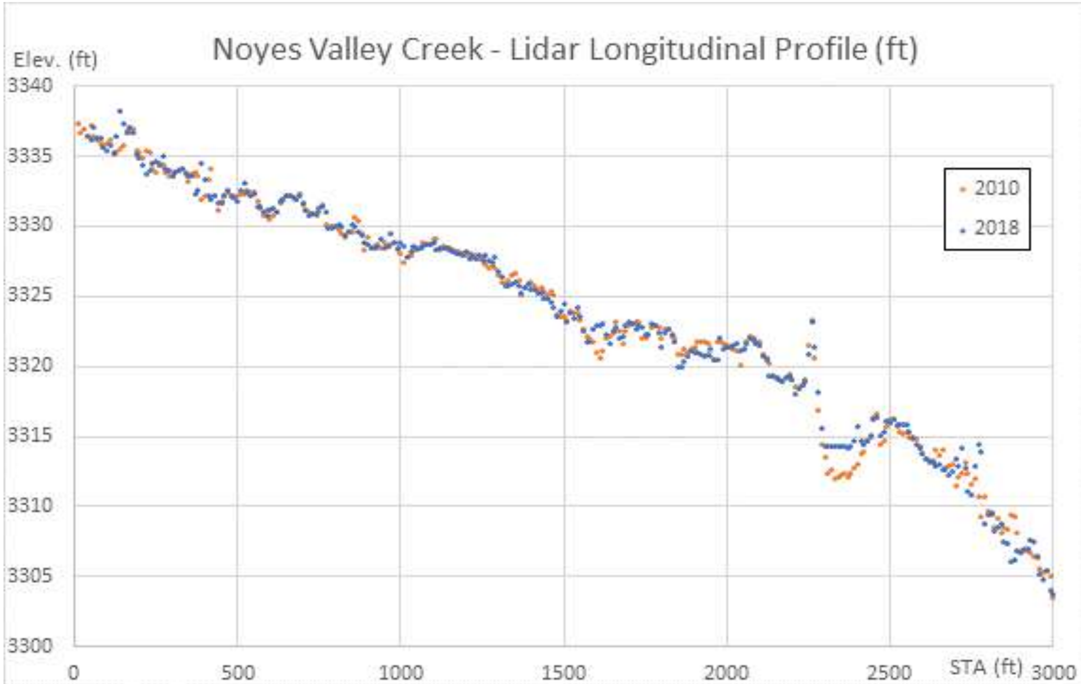


Figure 2. Noyes Valley Creek - Longitudinal Profiles derived from 2010 and 2018 Lidar DEM.

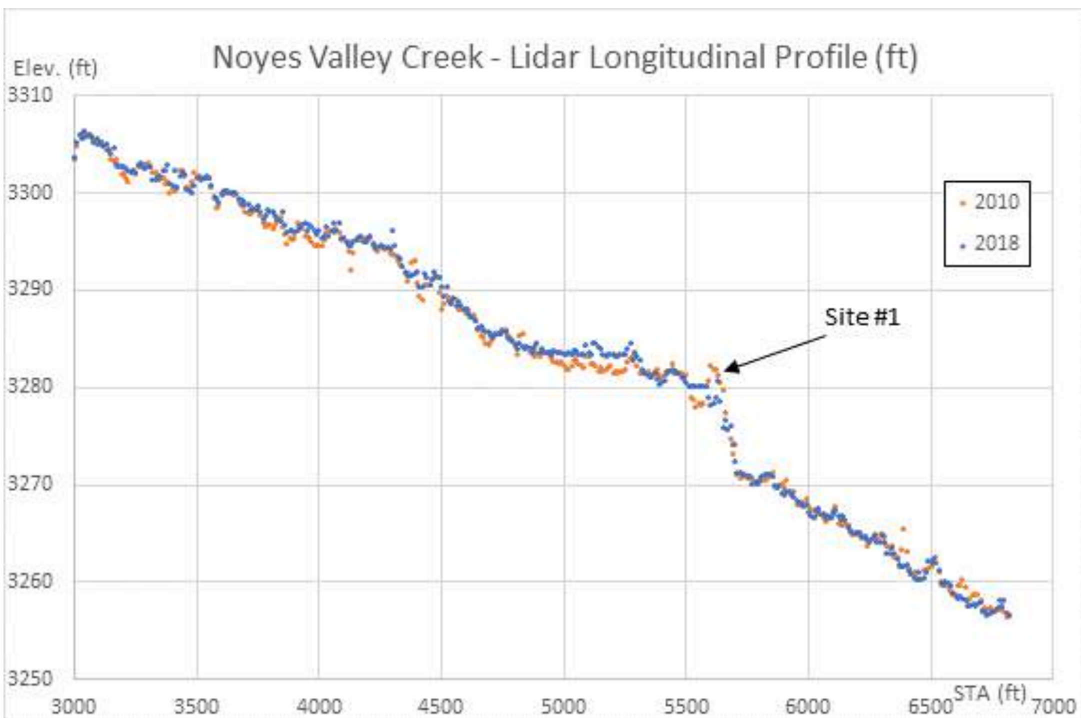
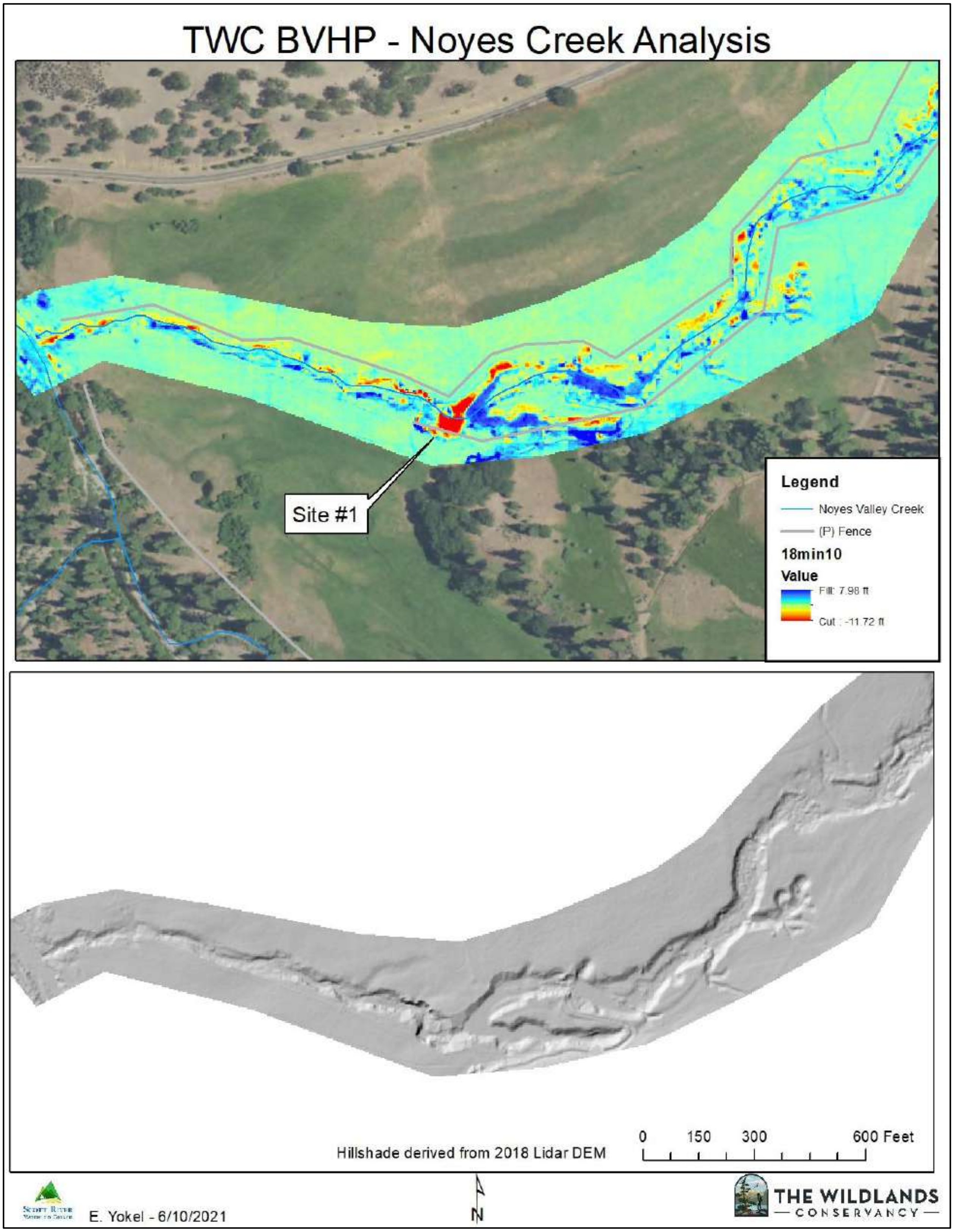


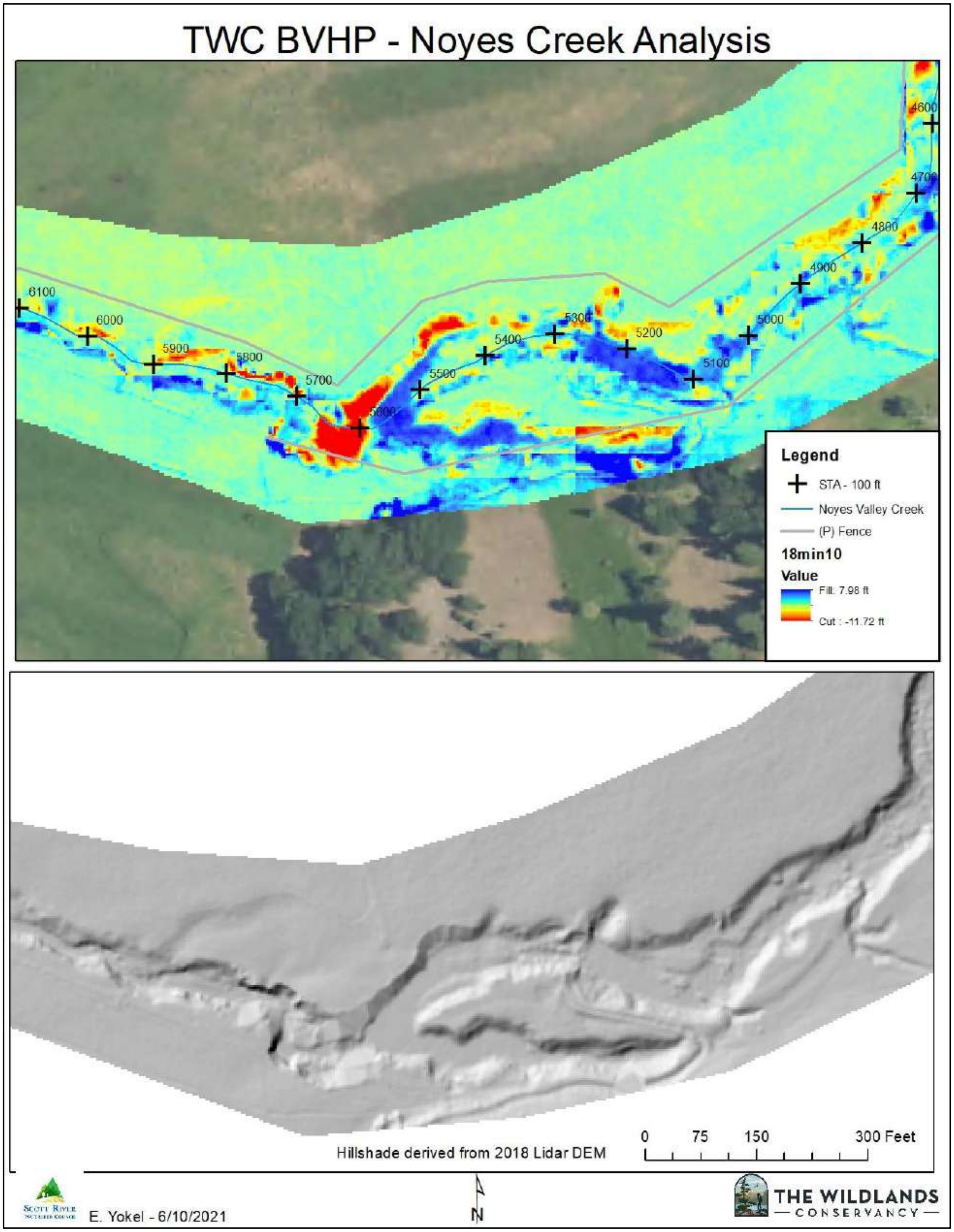
Figure 3. Noyes Valley Creek - Longitudinal Profiles derived from 2010 and 2018 Lidar DEM.

Multiple locations of lower elevations (cut) in 2018 compared to 2010 are identified in the stream banks and streambed of Noyes Valley Creek (Maps 2 - 4). More than a dozen sites of streambank degradation can be observed on Noyes Valley Creek upstream and downstream of Site #1 (Map 3). A large area directly downstream of the man-made berm degraded between 2010 and 2018. The hillshade model derived from the 2018 LiDAR DEM of Site #1 illustrates the area impounded above the berm and areas with steep streambanks.

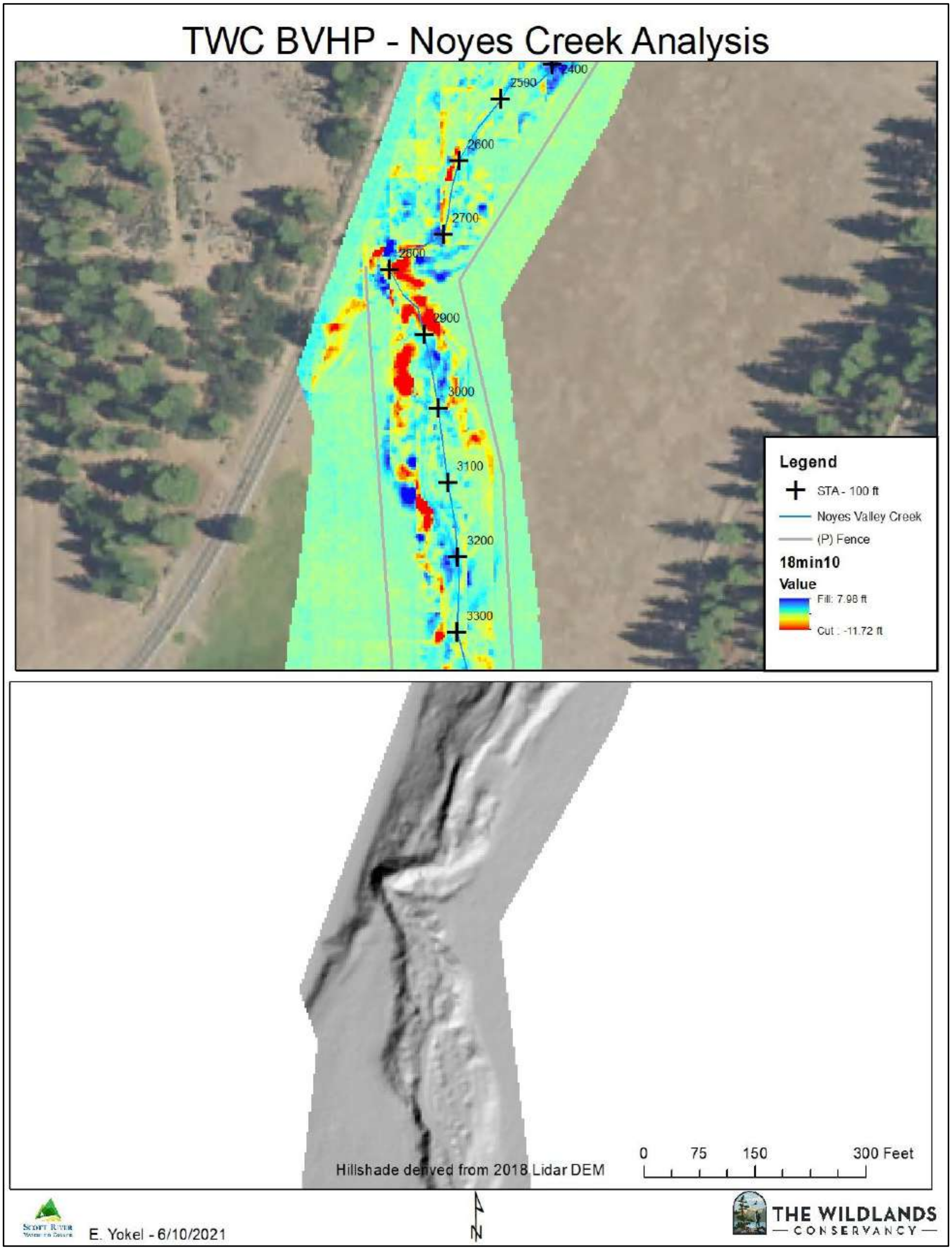
Site #2 is located at a sharp meander on Noyes Valley Creek that is adjacent to the county road (Map 4). Areas of degradation are observed at the meander, upstream and downstream of the meander and along the toe of the road prism downstream of the meander. The channel is constricted upstream and through the meander becoming significantly wider downstream of the meander indicative of a sediment transport reach transforming to an area of deposition. Channel and streambank degradation is observed at the inside and outside of the sharp meander with the outside degradation less area than the degradation at the inside of the meander. The hillshade model of Site #2 indicates areas with steep or potentially vertical banks that could be areas of lateral bank erosion.



Map 2. Change in Elevation from 2010 to 2018 Lidar DEMs and 2018 Lidar Hillshade Model.



Map 3. Change in Elevation from 2010 to 2018 Lidar DEMs and 2018 Lidar Hillshade Model - Site #1.



Map 4. Change in Elevation from 2010 to 2018 Lidar DEMs and 2018 Lidar Hillshade Model - Site #2.