July 2023
Colony Creek and Harrison Creek Assessment and Modeling

Summary and Recommendations Report

Prepared for Skagit Conservation District

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Prepared for
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ABBREVIATIONS

cfs	cubic feet per second
NAVD88	North American Vertical Datum of 1988
NHC	Northwest Hydraulic Consultants
SRT	self-regulating tide gate
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WSE	water surface elevation

1 Introduction

Colony Creek flows from its headwaters on the southern slopes of the Chuckanut Mountains northeast of Bow, Washington, in Skagit County. The creek is composed of two branches that generally flow southwest along a steep hillside before converging and entering the flat Samish River floodplain. As Colony Creek exits the hillside and enters the floodplain, the creek becomes channelized and continues flowing to the northwest, joining with Harrison Creek downstream. The combined flows of Colony Creek and Harrison Creek continue to the northwest, flowing through the town of Blanchard, Washington. Whitehall Creek, another creek flowing from the steep hillslopes to the east, converges with Colony Creek before it enters Puget Sound.

Historic channel modifications along Colony Creek have limited natural channel processes. In recent history, the creek's modified alignment and close proximity to residences and infrastructure have resulted in sedimentation issues, habitat degradation, and flooding along adjacent residential areas as well as on county and private roads. Skagit Conservation District, in coordination with local landowners, is seeking solutions to improve riparian habitat condition while addressing three main concerns in the Colony Creek and Harrison Creek project area: sedimentation, flooding, and habitat degradation.

The purpose of this Summary and Recommendations Report is to draft and evaluate a set of possible project alternatives for the Colony Creek and Harrison Creek project area that aim to address the three main concerns at this site. Each conceptual alternative will be evaluated based on a set of criteria outlined in Section 3.1. Based on the evaluation of each conceptual alternative and hydraulic modeling results, recommendations will be made for future work in the project area.

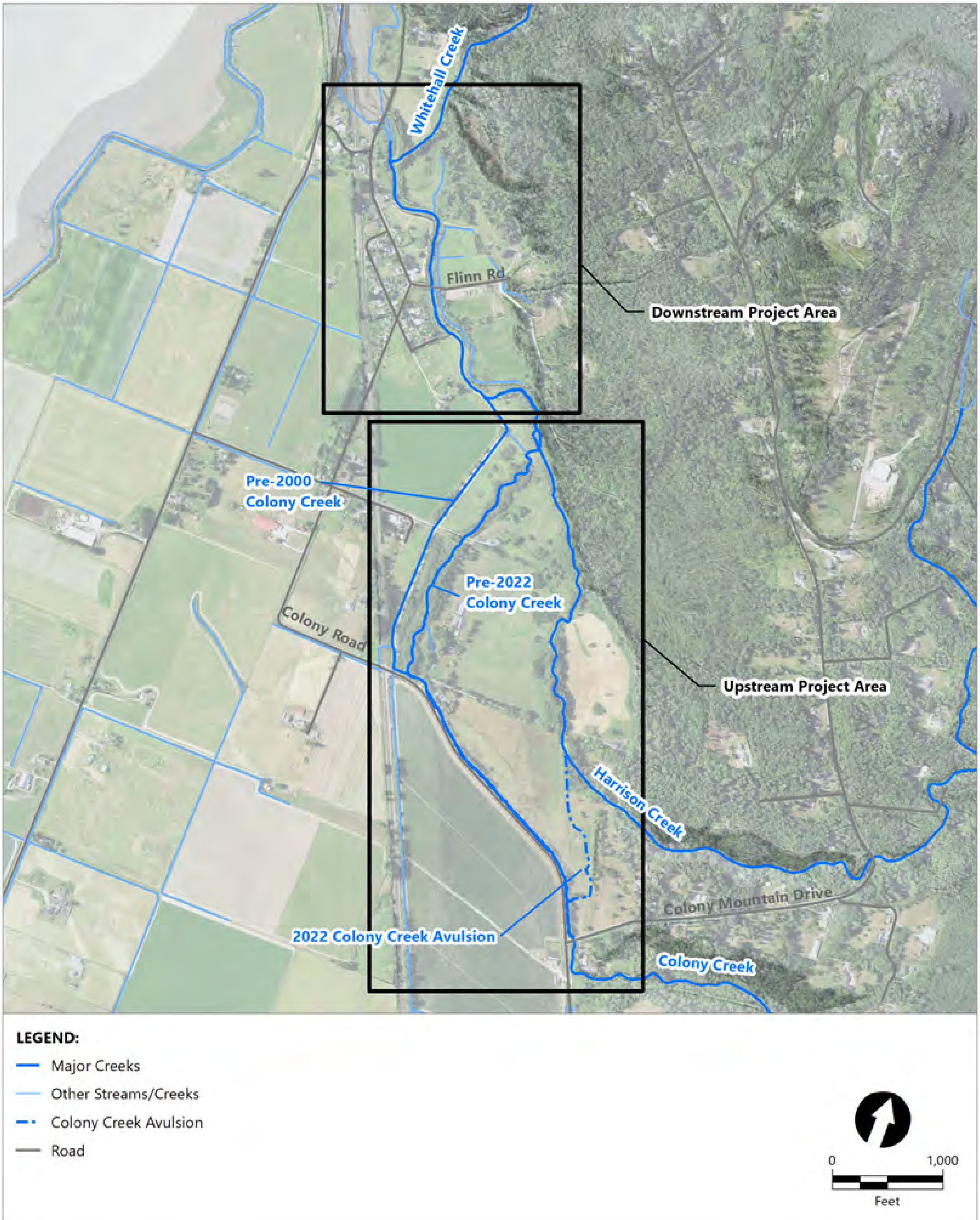
1.1 History of Other Work Done

Several projects have occurred along Colony and Harrison creeks in the last few decades. In 1999, the Harrison Creek Restoration Project was completed; this project re-meandered an approximately 3,400-foot-long stretch of Harrison Creek and reconnected two off-channel rearing ponds. The project also included installation of large wood, spawning gravels, and native trees and shrubs (SFEG 2022). A year later, the Colony Creek Restoration Project was undertaken, which re-meandered a 2,560-foot-long reach of Colony Creek, reconnected an off-channel rearing pond, and included installation of large wood, spawning gravels, and native trees and shrubs (Figure 1-1; SFEG 2022).

In addition to reopening 1 river mile and 4.75 acres of estuary for fish use, the 2006 McElroy Slough Estuary Restoration Project also improved access to Colony Creek, Harrison Creek, and Whitehall Creek; this project included culvert replacements and installation of tide gates (SRP 2022). One year later, in 2007, Northwest Hydraulic Consultants, Inc. (NHC) did an assessment of Colony Creek. Their investigation focused on flooding and sedimentation along Colony Creek. During this study, NHC surveyed the Colony Creek channel, spoke with landowners about flood history and maintenance, and ultimately drafted a set of alternatives intended to address flooding and sedimentation concerns along a 3,200-foot-long reach of the creek along Colony Road (NHC 2007). Findings from NHC's study will be discussed further in Section 2.1.

More recent projects in the area included a 2011 bridge replacement upstream of the project area, where a Colony Creek culvert was replaced with a bridge structure (SRP 2022), and a 2012 bridge replacement at the Colony Mountain Road crossing where two culverts that had infilled with gravels and debris were removed and replaced with a bridge structure (Granite 2012). The most recent work completed in the area was a 2014 Colony Creek Re-Plant Project. This project involved removal of invasive species and planting of native species, as well as thinning of alders and re-planting cedar and spruce trees; the project also involved adding tubes, wires, and stakes around new plantings to protect them from beavers (SRP 2022).

Figure 1-1
Project Area Locations



Note: Aerial imagery from United States Department of Agriculture (USDA 2019). Hillshade from North Puget Sound LiDAR (QSI 2017).

1.2 Specific Problems Identified

Based on past work, a 2022 site assessment, and input from local landowners, six specific areas of concern have been identified: tide gate functionality, ineffective levees and drainage, development in the upper watersheds, sediment deposition, reed canary grass, and flooding/fish stranding. The objectives originally set forth for this assessment already encompassed finding solutions to these issues, but the final objectives as stated in Section 1.3 have been molded to more completely encompass these issues that are most pressing to the community.

1.2.1 Tide Gate Functionality

Tide gate functionality is known to be an issue for local landowners, especially those living downstream of Flinn Road. The main tide gates for Colony Creek/McElroy Slough are located at the Blanchard Road crossing just downstream of Whitehall Creek. The current tide gates were constructed to replace the previous tide gate system in 2006 (MWG 1999). That project reconstructed the tide gate system to include three top hinge flap gates and one self-regulating tide gate (SRT) on a concrete box culvert with four barrels. The SRT was designed to remain open until the tide elevation downstream of the gate reached 5.0 feet North American Vertical Datum of 1988 (NAVD88). Landowners have noted that the SRT has had maintenance issues in the past, and because of the elevation of surrounding landowner houses, any problems with the SRT represent an emergency. Landowners also report that the top hinge flap gates do not open more than 6 inches, which could potentially decrease the capacity of the top hinge gates to release water as the tides go down. This would become a problem when a large storm event occurs just after a high tide event, when the rate at which the tide gate releases water is critical to preventing flooding within the Blanchard community.

While the main tide gate at Blanchard Road represents the most discussed issue to the Blanchard community, there are also multiple smaller flap gates throughout the Blanchard area levees that allow surface water runoff drainage into the Colony Creek/McElroy Slough. Many landowners report problems with these gates including both sizing and lack of effectiveness due to maintenance issues. These problems have exacerbated flooding and reduced levee effectiveness throughout the project area. Particular problems were noted by the left and right bank landowners just upstream of the main Blanchard Road tide gate, as well as the culvert for drainage of the Blueberry fields south of Colony Road.

1.2.2 Ineffective Levees and Drainage

Ineffective levees and drainage are also major concerns for landowners, particularly those living in the downstream project area. From the pre-2022 Colony Creek and Harrison Creek confluence downstream to the mouth of Colony Creek, levees are in place on either one side or both sides of Colony Creek. In the reach downstream of Flinn Road, levees placed along Colony Creek provide the creek with limited floodplain area, and many of the levees that are in place are in disrepair. The current condition of the levees makes them ineffective at reducing flooding on adjacent properties. Similarly, existing levees along Whitehall Creek have not been maintained and are also ineffective at reducing flooding.

Furthermore, landowners report that stormwater runoff throughout the Blanchard community often causes flooding that is separate from flows within Colony Creek, causing some inundation from stormwater alone. The low elevation and low relief of the Blanchard community make managing stormwater runoff a difficult challenge that is exacerbated by tide gate functionality and maintenance issues.

1.2.3 Development in Upper Watersheds

Development in the upper watersheds along the hillside just east of Colony Creek is also an issue for local landowners. Development and construction activities in the upper watersheds along this hillside has increased surface flows and runoff, thus causing additional flooding and drainage issues for landowners at the base of the hillside. Because some properties along the base of the hillside already experience flooding from Colony, Harrison, and/or Whitehall creeks, the additional runoff has worsened already existing flooding and drainage issues.

1.2.4 Sediment Deposition

Sediment deposition is also a key concern, particularly in Colony Creek through the upstream project area. In its pre-2022 alignment, Colony Creek was confined to a ditched channel along Colony Road that experienced excess deposition, in part due to the abrupt change in channel gradient as Colony Creek exits the steep hillside and enters flatter terrain, but also due to the unnatural alignment and ditched nature of the channel that limited natural depositional processes. Sedimentation issues within the Colony Creek ditch also worsened after extreme flood events, and increased infilling of the channel made flooding along Colony Road and adjacent properties more severe.

1.2.5 Reed Canary Grass

Reed canary grass, an invasive grass, is prevalent throughout the project area. Reed canary grass outcompetes other native riparian species that might typically inhabit Colony Creek’s and Harrison Creek’s riparian areas, thus reducing plant diversity in the project area. In addition to preventing other riparian species from becoming established along the creeks, reed canary grass also does not provide shade or cover to the creeks, which is a key ecological benefit of native riparian shrubs and trees. Native riparian vegetation can provide both shade and cover to stream channels, allowing water temperatures to stay cooler during summer months and providing salmonids protection from predation. When reed canary grass becomes established along a riparian corridor, it can also alter hydrology; once reed canary grass becomes established, it can constrict waterways, but if its presence is widespread and channel gradients are low, as is the case throughout much of the project area, it can also spread out a channel's flow over a large area, which makes navigating a stream channel difficult for salmonids.

1.2.6 Road Flooding and Fish Stranding

Lastly, both flooding and fish stranding are major concerns within the project area. Before the 2022 avulsion when Colony Creek flowed through the ditch along Colony Road, flooding over Colony Road occurred frequently during some precipitation events. Roadway flooding not only created a safety hazard for drivers during flood events, but it also led to fish stranding when the floodwaters receded. Though Colony Creek is no longer flowing through the ditch alignment, both road flooding and fish stranding should still be considered when identifying conceptual designs.

1.2.7 Fish Stranding

Numerous landowners have observed fish stranding in agricultural lands adjacent to Colony Creek and Harrison Creek due to flooding. While some landowners observed fish becoming stranded in agricultural fields due to roadway flooding and lack of fish screens, others have observed fish stranding in other areas unrelated to roadway flooding (e.g., the Wrucha property). Where Colony and Harrison Creeks merge the flow is either confined to a single channel or lacks channel definition all together, and because of this during flood events, fish can become stranded in fields adjacent to the main channel, and when waters recede, they are unable to find their way back to the main channel; the channelized morphology, lack of side channels, and degraded nature of the floodplain/riparian areas increases the risk of fish stranding in the project area.

1.3 Site Objectives

The site objectives for the Colony Creek and Harrison Creek project area are to address flooding, sedimentation, and riparian and instream habitat degradation concerns in the lower reaches of the creeks. To do this, conceptual plans were drafted based on input from local landowners, past site assessments, a 2022 geomorphic site assessment, and hydraulic modeling. The main site objectives include the following:

1. Restore natural sediment transport processes.
2. Reduce flooding of valuable agricultural land and residential areas.
3. Restore native vegetation in riparian areas.
4. Improve instream and off-channel/riparian wetland habitat.

2 Geomorphic Setting and Historic Conditions

This section describes the historic and existing channel alignment and geomorphic conditions in Colony Creek. To fully understand the changes Colony Creek has undergone, it is also important to understand the sediment deposition and transport processes in the channel and how these processes have changed over time. Understanding the current channel morphology and sediment transport processes along Colony Creek will also be important for development of conceptual alternatives and sediment management strategies.

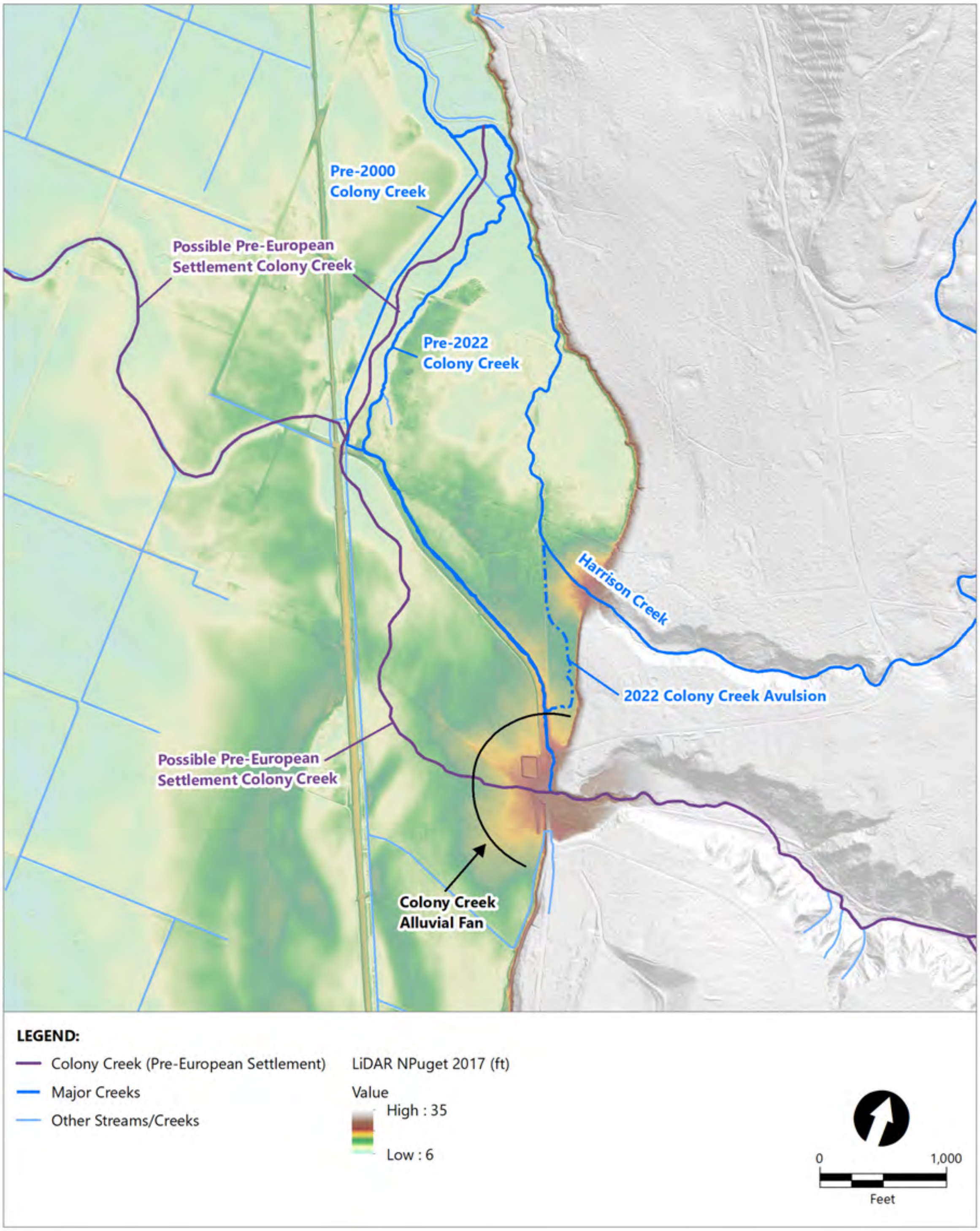
2.1 Historic Conditions and Geomorphic Setting

2.1.1 Historic Channel Alignment

Historical survey maps from the Bureau of Land Management's General Land Office records show limited information about Colony Creek's alignment during the late 1800s aside from a general direction of unnamed stream flow to the west. Despite the limited information regarding Colony Creek's alignment prior to European settlement, probable channel alignments can be estimated based on local topography and relic channel features (Figure 2-1). Figure 2-1 shows two probable pathways for Colony Creek prior to European settlement. As it exited the steep hillside to the east, Colony Creek likely flowed to the west, depositing sediment at the base of the hillside, which over time, formed the alluvial fan that can be seen in Figure 2-1. Montgomery Water Group, Inc. noted that Colony Creek was likely rerouted from its historic alignment, which may have flowed to the southwest from the base of the hillside, with the construction of Colony Road and the Burlington North Railroad (MWG 1999). Before it was realigned and confined to a single channel, Colony Creek likely migrated across its own alluvium as it flowed to the southwest and may have developed a braided morphology depending on sediment load.

After flowing southwest through its alluvial fan, Colony Creek likely flowed northwest through what appears to be a low elevation historic river corridor. Figure 2-1 shows two plausible flowpaths for Colony Creek's downstream reach; one potential flow path shows Colony Creek continuing northwest through the low elevation historic river corridor, while the other shows Colony Creek flowing westward through what appears to be a narrow, low elevation relic channel. The latter possibility suggests that Colony Creek may not have joined with Harrison Creek, but rather continued westward until reaching Puget Sound. The former possibility suggests that Colony Creek may have flowed through a similar alignment to the pre-2022 Colony Creek channel (location of the 2000 restoration project) before joining with Harrison Creek and flowing into Puget Sound.

Figure 2-1
Colony Creek Historic and Current Channel Alignments



Note: Relative Elevation Model was created from North Puget Sound LiDAR (QSI 2017). Colony Creek Pre-European Settlement channel alignments were estimated based on low elevation pathways from the Relative Elevation Model and are not based on historical observations or data.

2.1.2 Modern Channel Alignment and Channel Conditions

The Colony Creek estuary area is the ancestral homelands of the Coast Salish peoples of the Pacific Northwest. In the late 1800s and early 1900s, European settlement began in the area; a socialist community called the *Equality Colony* inhabited an area just southeast of Blanchard near present-day Colony Road (Skagit River Journal 2020). Additionally, local logging and milling activity began in the area, and increased development followed eventually forming the Blanchard area community that exists today.

In modern history, Colony Creek has flowed from the steep southern slopes of the Chuckanut Mountains and entered the flat Samish River floodplain before making a sharp 90-degree turn to the northwest, flowing through a culvert on Colony Mountain Road and entering a ditched alignment. Colony Creek continued in a straight ditched alignment along the east side of Colony Road for approximately 0.58 mile downstream of the Colony Mountain Road culvert. As it flowed through the ditched alignment, Colony Creek also passed through two driveway bridges. Just before the northwest to southeast railroad, Colony Creek was routed through a ditched alignment to the north and continued in a straightened channel through private property until it reached the confluence with Harrison Creek; a restoration project re-meandered this reach in 2000 (Section 1.1), routing Colony Creek just to the east in a meandering planform rather than a straight ditch alignment. After Colony and Harrison creeks merged downstream of the restored reach, the combined flow continued northwest in a somewhat meandering planform through the town of Blanchard before reaching Puget Sound.

2.1.3 Modern Sediment Transport and Deposition

In its modern alignment, sediment transport and depositional processes in Colony Creek have been driven largely by channel alignment and conditions in the upper watershed. As Colony Creek exits the steep slopes of the Chuckanut Mountains and enters the Samish River floodplain, slopes flatten rapidly, which has caused the development of an alluvial fan at the base of the hillside. Under natural conditions, when a creek abruptly shifts from a confined, high gradient channel to an unconfined, low-gradient channel, this causes flow divergence and low flow velocities, thus prompting deposition and alluvial fan formation; a natural channel often shifts positions through its alluvial fan or develops a braided morphology due to the high sediment load. Because Colony Creek has been confined to a ditched alignment once it exits the steep hillside, the sediment that would normally be deposited in the fan is forced to deposit in a single channel. Additionally, due to the low channel gradient along most of the creek, Colony Creek typically lacks the ability to transport significant amounts of sediment to its downstream reaches. This has caused sedimentation issues, and subsequent flooding concerns, in the upper reaches of the creek, particularly along the ditched alignment along Colony Road.

In 2007, NHC drafted a report that investigated flooding and sediment management along Colony Creek. NHC outlined the existing conditions they observed during their site visits and focused on the issue of increased sedimentation within the channel and within culverts that had worsened flooding in the vicinity of the creek (NHC 2007). NHC's 2007 report outlined some broad observations about existing conditions at the site, noting that there was a shift from clean gravels (approximately 1,000 feet downstream of the Colony Mountain Road culverts) to mucky silt in the vicinity of the downstream driveway bridges where the channel gradient flattens. They also noted the presence of spoil piles along the right bank that they associated with past channel clearing activities; however, they noted that channel clearing activities had not occurred recently, as evidenced by the Colony Mountain Road culverts being almost completely filled with sediment during NHC's site visit. During a December 2006 site visit, NHC also collected survey data (streambed thalweg and water surface profiles) from 600 feet upstream of Colony Mountain Road to 3,000 feet downstream; the survey data showed Colony Creek's transition from a moderate gradient upstream to a nearly flat gradient downstream.

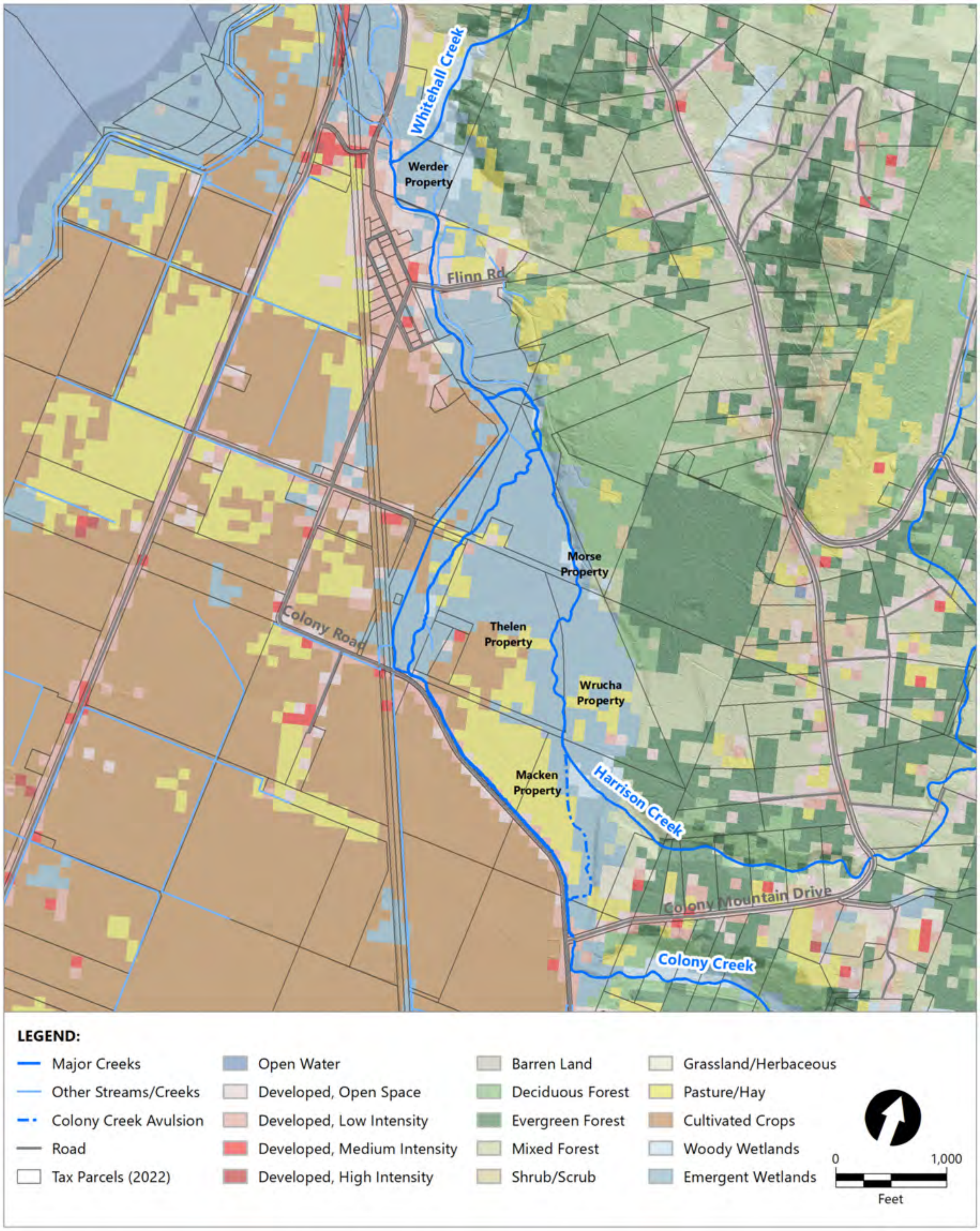
In the 2007 report, NHC also outlined Colony Creek's flood history, noting that banks are overtopped several times each year. Aside from the normal flooding that occurs along Colony Creek, NHC also noted more extreme floods that occurred in February 2002 and November 2004; both floods occurred due to beaver dam failures near the headwaters of the West Branch of Colony Creek. Beaver dams impound two lakes in the upper Colony Creek watershed, and the beaver dam failures prompted large releases of water and sediment from the lakes. The February 2002 flood was caused by a failure in the upper beaver dam, and NHC estimated that discharges could have reached 2,000 to 2,500 cubic feet per second (cfs), which is five times greater than the 100-year discharge on Colony Creek. The November 2004 flood was caused by a failure in the lower beaver dam, and NHC estimated that discharges could have reached 500 to 600 cfs. Both floods caused significant deposition in the 3,200-foot-long reach along Colony Road and exposed, and in some cases destabilized, upstream slopes, which NHC observed during a 2007 site visit; NHC noted that the unstable slopes they observed in the upstream reaches of the West Branch of Colony Creek would likely contribute sediment to the channel for years until vegetation becomes established and the slopes stabilize.

To better understand sediment transport and depositional processes in Colony Creek, particularly along flood-prone reaches adjacent to Colony Road, NHC discussed flooding and channel clearing activities with landowner Beverly Macken, who owns property along Colony Creek. Macken noted that the 3,200-foot-long reach of Colony Creek had been cleaned in the late 1950 or 1960s and again in the early 1980s, and that Colony Creek was 4 to 5 feet deep after the clearing activities. Macken also noted that from the 1980s to 2002, before the beaver dam outburst flood, approximately 2 feet of sediment had been deposited within the Colony Mountain Road culverts. With this information from Macken, NHC was able to (roughly) estimate the rates of deposition in

Colony Creek, and their calculations resulted in a deposition rate of 120 cubic yards per year over the last 50 years.

Overall, under modern conditions, sediment delivery to the downstream reaches of Colony Creek has been driven by both typical streambed degradation and bank instability, and infrequent but extreme flood events (beaver dam failures). Increased deposition in the ditched Colony Creek channel, however, was driven by both the abrupt, but natural change in channel gradient, and the (unnatural) confinement of the creek to a single, ditched channel as it exits the steep hillside. Under natural conditions, the creek would likely be regularly avulsing and depositing sediment across its alluvial fan to the southwest, but instead, the channelization and rerouting of the creek has limited deposition to the low-gradient ditched channel, ultimately causing infilling of the channel and subsequent flooding issues.

Figure 2-2
Landcover Map



Note: Hillshade from North Puget Sound LiDAR (QSI 2017). Landcover from U.S. Geological Survey (USGS) National Land Cover Database (USGS 2019).

2.2 Present Conditions and Geomorphic Setting

2.2.1 Existing Channel Alignment and Channel Conditions

A site visit was conducted by Anchor QEA staff on December 6, 2022, to assess the existing conditions in Colony Creek. Anchor QEA staff were also joined by a landowner and a staff member from Skagit County Conservation District for a portion of the site visit. Anchor QEA staff observed existing conditions in Colony Creek from Colony Mountain Road to the former Colony Creek and Harrison Creek confluence. Though the existing Colony Creek channel joins with Harrison Creek much farther upstream than it had prior to 2022, staff still observed conditions in both Colony Creek's previous alignment and Colony Creek's older, ditched alignment.

Photo 2-1
Colony Creek Avulsion Area

At the upstream end of the observed reach (along the Macken property), Colony Creek remains in its previous alignment along Colony Road for approximately 340 feet downstream of Colony Mountain Road before avulsing through the Macken property (Figure 2-2; Photo 2-1). The former creek alignment along Colony Road shows significant fine sediment deposition within the channel. The existing Colony Creek channel cuts through the right bank and flows east. Through the avulsion area, there is no single defined channel; the avulsion area has a more braided morphology, and clean gravels were observed though this area. The avulsion path flows eastward for approximately 200 feet before flowing to the north along the hillside (right bank). In general, as Colony Creek flows north through the Macken property, the channel lacks any definition and is entirely dominated by reed canary grass (Photo 2-2). Colony Creek flow then enters a large 2- to 3-foot-deep pond (Photo 2-3). Though the outflow is undefined, downstream of the pond, Colony Creek flow continues north, flowing on both sides of a private road on the Macken property. Colony Creek's flow eventually joins Harrison Creek upstream where Harrison Creek flows beneath a private driveway to the Wrucha property.

Photo 2-2
Undefined Flow of Colony Creek and Widespread Reed Canary Grass

Photo 2-3
Colony Creek Ponding on Macken Property

The combined flows of Colony and Harrison Creek flow through the 5-foot-diameter driveway culvert, which has approximately 2 feet of sediment in it (Photo 2-4). Just downstream of the culvert, the creeks are somewhat channelized and more defined than upstream. In this reach, there are downed alders, and, in some areas, gravel (1- to 2-inch) deposition has occurred around the large wood. Wooden posts were also observed in the channel, suggesting some restoration work has occurred in Harrison Creek in the past. Downstream of the wooden structures, though the channel is still defined, the floodplain becomes more inundated; a patch of conifers along the left bank floodplain were in a few inches of ponded water. Just downstream, the channel widens and deepens, and the floodplain area continues to be dominated by reed canary grass. The channel continues through the Wrucha property, but the group was not able to access the property.

Photo 2-4
Wrucha Private Road Culvert and Combined Colony/Harrison Creek Flow Just Downstream


Downstream, Colony Creek and Harrison Creek flow through the Morse property. At the upstream end of the property, the channel is extremely wide/ponded and there is evidence of a cleared beaver dam on the floodplain. Just downstream, the channel becomes less ponded and more defined, and Anchor QEA staff measured bankfull widths of approximately 12 feet and channel depths of approximately 3 feet. The channel is relatively straight and lacks complexity in this reach, and the bed material is dominated by silt and sands. Through the defined reach, the left bank floodplain is relatively flat and dry, and the right bank is moderately sloping as the channel flows along the hillside. The hillside along the right bank is undergoing clearing and development, which could impact sediment delivery and peak flows in the future. Just downstream, there is a large channel-spanning log that has slowed flow velocities upstream and downstream.

Approximately 245 feet downstream of the channel-spanning log, the channel begins to lose definition and the left bank is low and wet (Photo 2-5). These conditions continue downstream, and the floodplain area is dominated by reed canary grass. Approximately 600 feet downstream of where the channel loses definition, a beaver dam was observed within the channel. There is ponding and channel widening upstream of the dam, and immediately downstream, the channel has a bankfull width of 12 to 13 feet. Immediately downstream of the beaver dam, perched channel-spanning wood was observed; though water was readily moving under the wood and channel widening was not observed upstream, the channel-spanning wood appeared to be capturing mobile debris. Downstream of the channel-spanning wood, the channel and floodplain are dominated by reed canary grass and the channel loses definition again. Approximately 200 feet downstream of the channel-spanning wood is the confluence of the current Colony Creek and Harrison Creek and the former Colony Creek alignment, which still has water in it.

Photo 2-5
Colony/Harrison Creek Channel and Floodplain Dominated by Reed Canary Grass

Anchor QEA staff also walked back upstream along the former Colony Creek alignment, which was previously the site of the 2000 Colony Creek Restoration Project that re-meandered a stretch of the creek. Evidence of more recent (2014) restoration activities were observed in this alignment, including dense riparian willows and large wood and boulder features. In general, the channel in this alignment is wider and shallower than the existing Colony Creek. A beaver dam was observed in this alignment; however, it appears that the dam had been breached. Based on site observations, it appears that there is at least one cut connecting the ditched alignment and former Colony Creek alignment; additionally, George Thelen noted that flow from former Colony Creek inundates the area between the two alignments, often reaching the ditched alignment. Lastly, George also noted that there was fill material place on the left bank where the former Colony Creek alignment separates from the ditched alignment, preventing flow from upstream from going into the ditched reach.

2.2.2 Existing Sediment Transport and Deposition

The sediment transport regime is ultimately driven by the ongoing process in the upper watershed that delivers sediment from the mountains to the estuary and lowland areas. For the most part, these drivers are likely the same today as in historical conditions and include normal degradation, upstream bank instability, and infrequent beaver dam floods. However, due to the infrequent and episodic or "threshold event" nature of some of these drivers (i.e., beaver dam breaks and slope failure) it is difficult to estimate a specific rate per year for the expected sediment delivery from upstream. In addition to the historical contributing factors of sediment delivery, Colony Creek may now also be susceptible to additional sediment delivery from the steep right bank hillslopes. As previously noted, the hillside along the right bank is experiencing clearing and development, which has the potential to increase sediment delivery to the channel.

In historic conditions the episodic nature of sediment delivery was likely mitigated by wide active floodplains and estuary areas that were resilient to change and sudden influxes of sediment through shifting channel alignments and large off-channel areas. These side channels and floodplain areas could store sediment during high influx years and release that sediment during years when less sediment was transported from the upper watershed. However, in the recent context, Colony Creek has been channelized to a low slope ditch with no floodplain or side channel areas for a significant length. This condition had caused continuous sediment buildup, which would further decrease the slope in the channel, making sediment deposition more common, and eventually result in the frequent flooding of Colony Road and the surrounding areas.

Since the 2022 avulsion and subsequent shift in the location of the active Colony Creek channel, in-channel deposition and channel infilling within the Colony Creek ditch along Colony Road will likely only be a concern from the base of the hillside downstream to the 2022 avulsion location, located approximately 340 feet downstream of the Colony Mountain Road crossing. If flows in Colony Creek are sufficient to transport sediment downstream of the avulsion, deposition will likely continue in the undefined, multichannel reach through the Macken property, which is an area that could provide the sediment storage and floodplain area seen in historical conditions. Under existing conditions, this reach has a braided morphology and is dominated by gravels but then transitions to a completely undefined channel/wetted area with extensive reed canary grass. As a result of the avulsion, sedimentation upstream of the avulsion is likely restricted to in-channel deposition, while deposition downstream of the avulsion is less restricted and likely occurs across Colony Creek's new floodplain through the Macken property.

It should be noted that in Colony Creek's current alignment, reed canary grass, an invasive species, is the dominant vegetation; this has important implications for biology, hydrology, channel morphology, and sedimentation. In addition to reducing habitat diversity, reed canary grass can spread rapidly through wetted areas and slow flow velocities, which ultimately promotes sedimentation of fine material. Areas where water depths are already shallow and velocities are low can be particularly susceptible to increased sedimentation, shallowing, and in some cases, a wetted area can dry up entirely.

At the downstream end of Colony Creek, Whitehall Creek currently provides a significant coarse (medium gravel) sediment input immediately before the tide gates to the estuary. Whitehall Creek has been severely channelized and leveed, resulting in a straight channel with no storage area for flood flows or sediment. Because of this, the influx of coarse material from Whitehall Creek to the lower reaches of Colony Creek is likely significantly higher than in the historical conditions. During site visits by the Anchor QEA team, large gravel deposits at the outlet of Whitehall Creek were noted which show clear evidence of this condition.

Overall, under existing conditions, sediment delivery to Colony Creek is still driven by upstream erosion and bank instability, and infrequent but extreme flood events (beaver dam failures); however, in the 2022 alignment, clearing and development of the right bank hillside is another driver of sedimentation to Colony Creek. In the existing alignment, sediment transport and deposition processes have changed. Though the channel is still confined and channelized as it exits the hillside, the channel is now unconfined through the Macken property downstream of the 2022 avulsion. Though this shift means that increased in-channel deposition along Colony Road is no longer a major concern, there are now additional factors affecting sedimentation in Colony Creek, like land clearing and development, extensive reed canary grass throughout the Colony Creek floodplain, and lack of channel definition. While sediment delivery from the upstream will not be changed through restoration activities downstream, restoration activities within the upstream and downstream project areas can address sedimentation concerns by increasing the area where sediment can be deposited and stored within the Colony Creek floodplain.

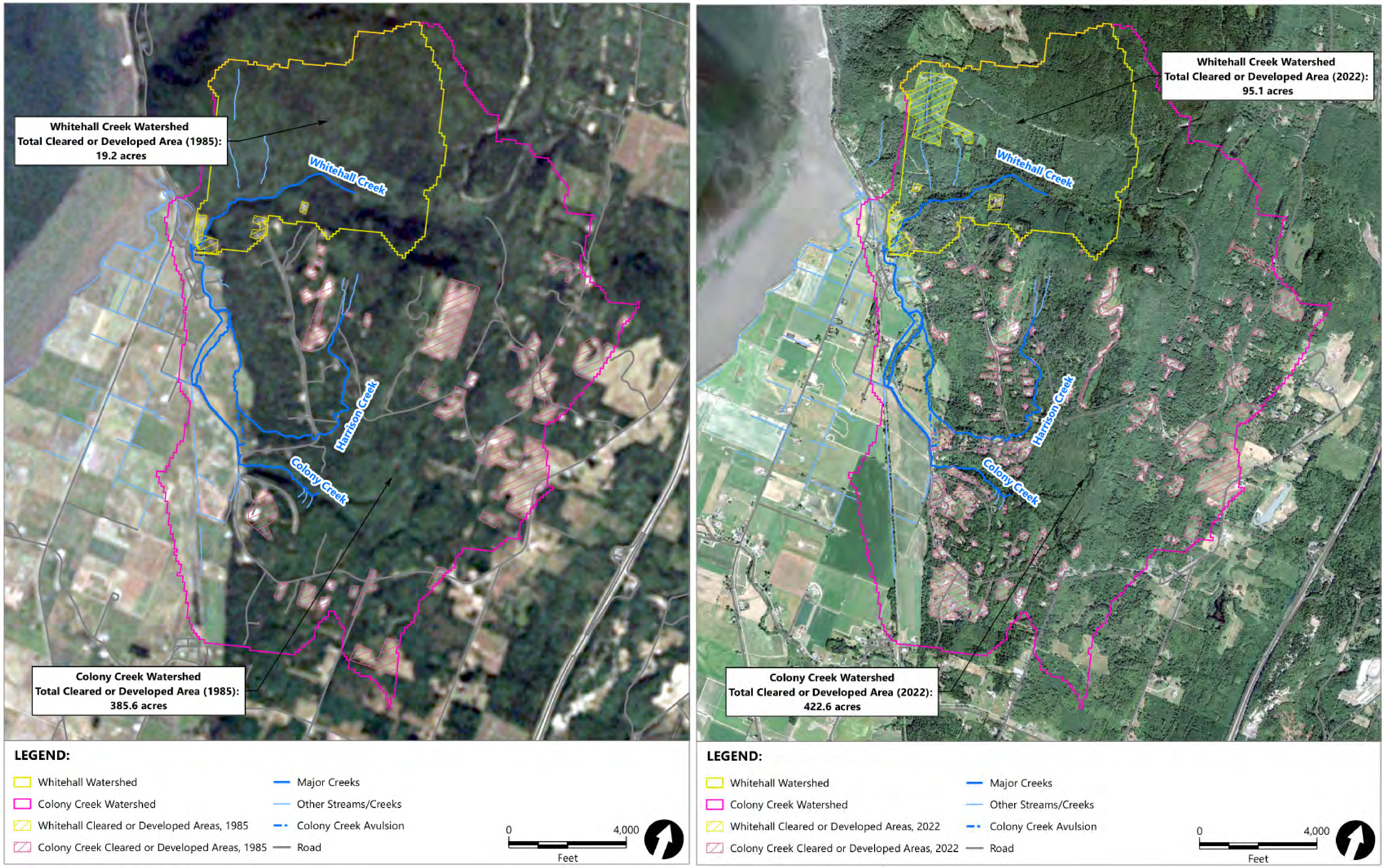
2.2.3 Watershed Conditions

Landcover on the hillslopes to the east of the project area in the Colony Creek, Harrison Creek, and Whitehall Creek watersheds has generally been dominated by deciduous, evergreen, and mixed forest, with minor areas of developed land and pasture/hay (Figure 2-2). The abundant forest cover likely promotes infiltration during precipitation, while the most significant surface runoff is likely limited to the sparse areas that have undergone development.

Multiple landowners have noted that the upper watersheds are currently experiencing increased land development and construction activities. Communications with landowners suggest that this is leading to increased surface water runoff and drainage issues as the base of the hillslope, an area that already experiences flooding and drainage issues.

To quantify the changes in development that have occurred over the last few decades within the Whitehall Creek and Colony Creek watersheds, cleared and developed areas were digitized based on 1985 and 2022 aerial imagery (Google Earth 2023). Figure 2-3 shows how development in the watersheds has changed from 1985 to 2022. In 1985, the Whitehall Creek watershed included approximately 19.2 acres of cleared or developed land compared to the 95.1 acres of cleared or developed land observed in the 2022 imagery (Figure 2-3). In 1985, the Colony Creek watershed included approximately 385.6 acres of cleared or developed land compared to the 422.6 acres of cleared or developed land observed in the 2022 imagery (Figure 2-3). These results suggest that though the Colony Creek watershed is significantly larger than the Whitehall Creek watershed, the Whitehall Creek watershed has experienced more land clearing and development activity over the last few decades. Increased development in this small watershed could have significant hydrologic implications that could impact timing of flows, as well as flooding and drainage in the downstream project area.

Figure 2-3
Change in Land Development in the Whitehall Creek and Colony Creek Watersheds from 1985 to 2022



Note: Aerial imagery acquired from Google Earth (2023).

3 Potential Project Elements and Conceptual Alternatives

Based on past work, site assessments, and discussions with project stakeholders, a set of potential design elements and actions were developed to address the issues identified and meet the project objectives. These project elements were combined into four potential alternatives for evaluation. The level of effort and design elements vary between alternatives, and evaluation of the alternatives is based on the criteria described in Table 3-1. The alternatives in this section do not represent all of the potential configurations of design elements, and the actual actions will likely be different that any of these alternatives as individual projects are implemented. However, these alternatives are meant to provide a useful tool for guiding future restoration actions in the Colony Creek area. In addition to describing the criteria that will be used to evaluate the four proposed alternatives, the following section includes descriptions of all design elements proposed in the alternatives, as well as detailed descriptions of each proposed alternative.

3.1 Evaluation Criteria

All four of the potential alternatives will be evaluated based on the criteria shown in Table 3-1. Changes in flood storage and reductions in potential flood damages are evaluated using hydraulic modeling results, while criteria related to riparian area, instream habitat, and floodplain sediment storage are evaluated based on proposed terrain analyses. Level of effort is estimated based on landowners' willingness to participate in potential projects.

Table 3-1
Alternatives Evaluation Criteria

Evaluation Criteria	How will criteria be evaluated?
Changes in Flood Storage Upstream of Tide Gate	Flood storage upstream of the tide gate will be quantified with the hydraulic model by comparing water surface elevation values at various monitoring points.
Reduces Potential Flood Damages to Private Property	Reduction in potential flood damages will be a qualitative visual assessment based on a comparison of modeled existing and proposed conditions inundation extents at various flows.
Increases in Riparian Area	The area of proposed riparian habitat will be quantified for each alternative. Proposed riparian areas also provide space where large wood can be placed.
Increases in In- and Off-Channel Habitat	The increase in cumulative channel length compared to existing conditions will be quantified for each alternative.
Increases Ability to Store Sediment in Floodplain	The total net cut-fill volume will be quantified for each alternative to show the total volume change for each alternative compared to existing conditions.
Addresses Potential Tide Gate Issues	Yes/No
Level of Effort	Level of effort will be rated on landowners' willingness to participate and potential for funding

3.2 Design Elements

Multiple design elements were identified that could be implemented to address issues and meet the project objectives for Colony Creek. Many of the design elements work to address multiple issues and many work better when combined with one or several other design elements. For that reason, these design elements were not evaluated individually for effectiveness, but were rather combined into four potential alternatives that represent a range of potential actions. The following subsections outline and describe these key project elements and their objectives. Section 3.3 describes the four potential alternatives, which are a combination of different degrees and methods of implementation of these project elements.

3.2.1 Tide Gate Modifications

The main tide gates for Colony Creek/McElroy Slough were identified as an issue by landowners during public outreach meetings (Section 1.2). Because the tide gates are at the downstream end of the system, they are perceived to play a key role in potential for flooding in the Blanchard community. For this assessment the evaluation of the tide gate efficiency has been kept separate from the overall analysis of alternatives so that changes to the tide gate would not affect conclusions about other project elements. Section 4.3.1 details the evaluation of the main tide gates and discusses the results of that evaluation.

For the other, smaller tide gates throughout the Colony Creek system, the issues mostly revolve around maintenance and proper functioning. This evaluation does not include a detailed evaluation of all these smaller tide gates, and the modeling and evaluations presented here assume all tide gates are functioning properly. A detailed evaluation of the stormwater drainage and these smaller tide gates as well as a regular maintenance program is one of the recommended actions in Section 6.

3.2.2 Channel Alignment Modifications

Channel alignment modifications are intended to reroute main channel flow to a more geomorphically stable location. This typically involves realigning a channel into a location closer to its natural, historic alignment where natural processes can occur, like alluvial fan deposition. Realignment can also be used to alter a channel's longitudinal profile, which can alter the vertical stability of a channel and change timing of flows. Lastly, channel alignment modifications have the potential to increase floodplain connection by routing the channel through an area with more available floodplain area.

3.2.3 Setback Levees and Sediment Berms

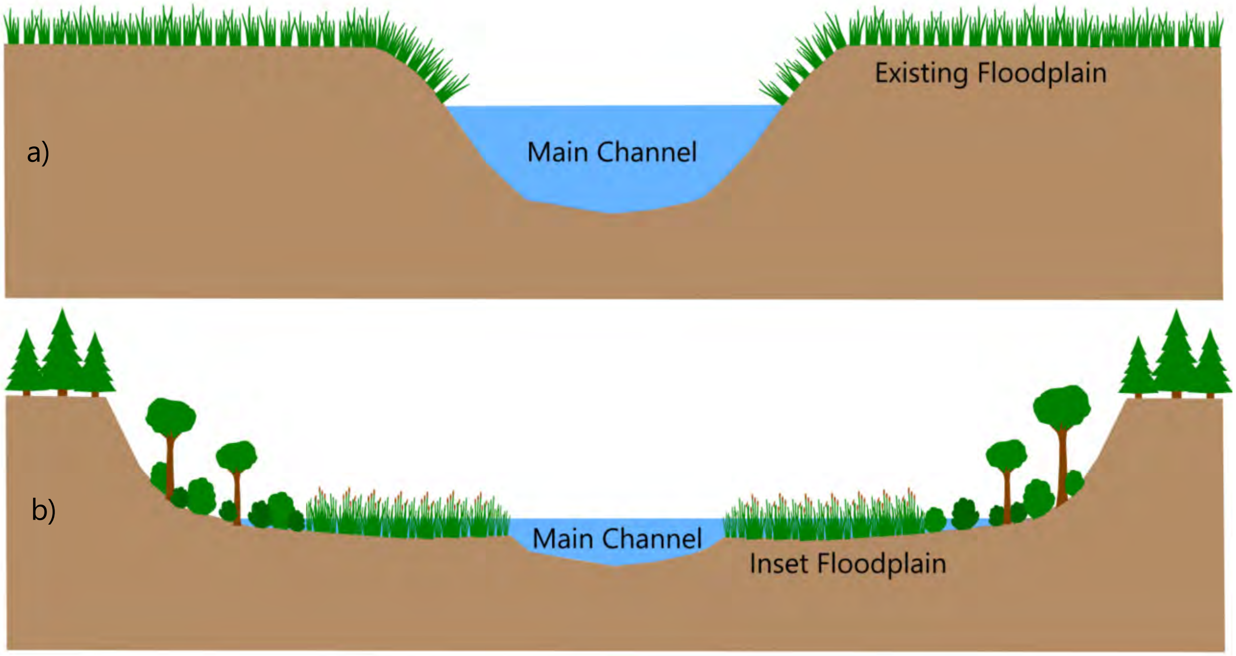
Setback levees and sediment berms are intended to help meet all three project objectives. By providing a high elevation barrier between active floodplain areas and adjacent private property/agricultural land, the proposed levees/berms have the potential to reduce flooding on property adjacent to these features. The elevation of proposed levee/berm features is dependent on local elevations in a particular project area, but in general, elevations are set to be higher than the existing modeled water surface elevation (WSE) at the 2-year flow event to reduce the likelihood of the levees being overtopped.

Proposed setback levees/berms are also intended to increase floodplain area. The location of proposed levees throughout the project area is set back from the active channel flow to provide adequate floodplain area; this creates a floodplain corridor that allows the channel to migrate, overtop its banks, and deposit sediment in its floodplain, thus restoring natural channel processes. Along with this, defining a set floodplain corridor between levees/berms and allowing for natural channel processes to occur in this corridor also has the potential to increase riparian and instream habitat.

3.2.4 Inset Floodplain

Inset floodplains are also intended to help meet all three project objectives. The purpose of an inset floodplain is to remove existing sediment from the floodplain, thus creating an inset, or recessed, floodplain that increases the potential storage area for sediment and water during high flow events. In addition to increasing sediment storage and flood storage capacity, the inset floodplain also spreads flows out across the wide inset floodplain, thus improving floodplain connectivity, which can increase both riparian habitat and side channel habitat (Figure 3-1). Lastly, but increasing both the sediment and flood storage capacity of the floodplain, an inset floodplain can reduce flood impacts along adjacent properties.

Figure 3-1
Existing and Inset Floodplain Cross Section Example



Note: a) Example cross section under existing conditions with reed canary grass encroachment limiting the extent of the main channel and outcompeting native vegetation. B) Example cross section showing a wide inset floodplain with high hydrologic connectivity and native aquatic, riparian, and upland vegetation.

3.2.5 Pilot Channel Cuts

All proposed alternatives include some form of channel cut and/or multiple flowpaths. The goal with side channel cuts is to provide additional flow paths for a channel to take to increase in-channel habitat for salmonids and increase overall channel complexity. In addition to habitat benefits of channel cuts, adding multiple flow paths to a channel increases the area where sediment can be deposited. In areas where flood and sediment storage capacity are limited, multiple flowpaths can offer more locations for sediment to be deposited and stored. Lastly, because rivers and streams are dynamic, it is expected that they will evolve and migrate over time. Cutting alternate flowpaths for a channel to migrate to adds resiliency to a stream network, making unexpected avulsions, like the 2022 Colony Creek avulsion, less likely.

3.2.6 Improve Function of Crossing Structures, Flap Gates, and Fish Screens

All alternatives include installation of a flap gate or fish screen. Because fish stranding is an issue within the project area, installation of flap gates or fish screens is proposed for all alternatives. When road crossing structures like culverts do not have flap gates or fish screens, fish traveling upstream can access areas that lack suitable habitat, like drainage ditches. Additionally, during flood events, fish may be able to access certain areas when water levels are high but may become stranded when water levels recede. The blueberry field in the upstream project area is one area where fish are known to become stranded. Placement of flap gates or fish screens can prevent fish from swimming upstream into undesirable locations, or locations where they may become stranded.

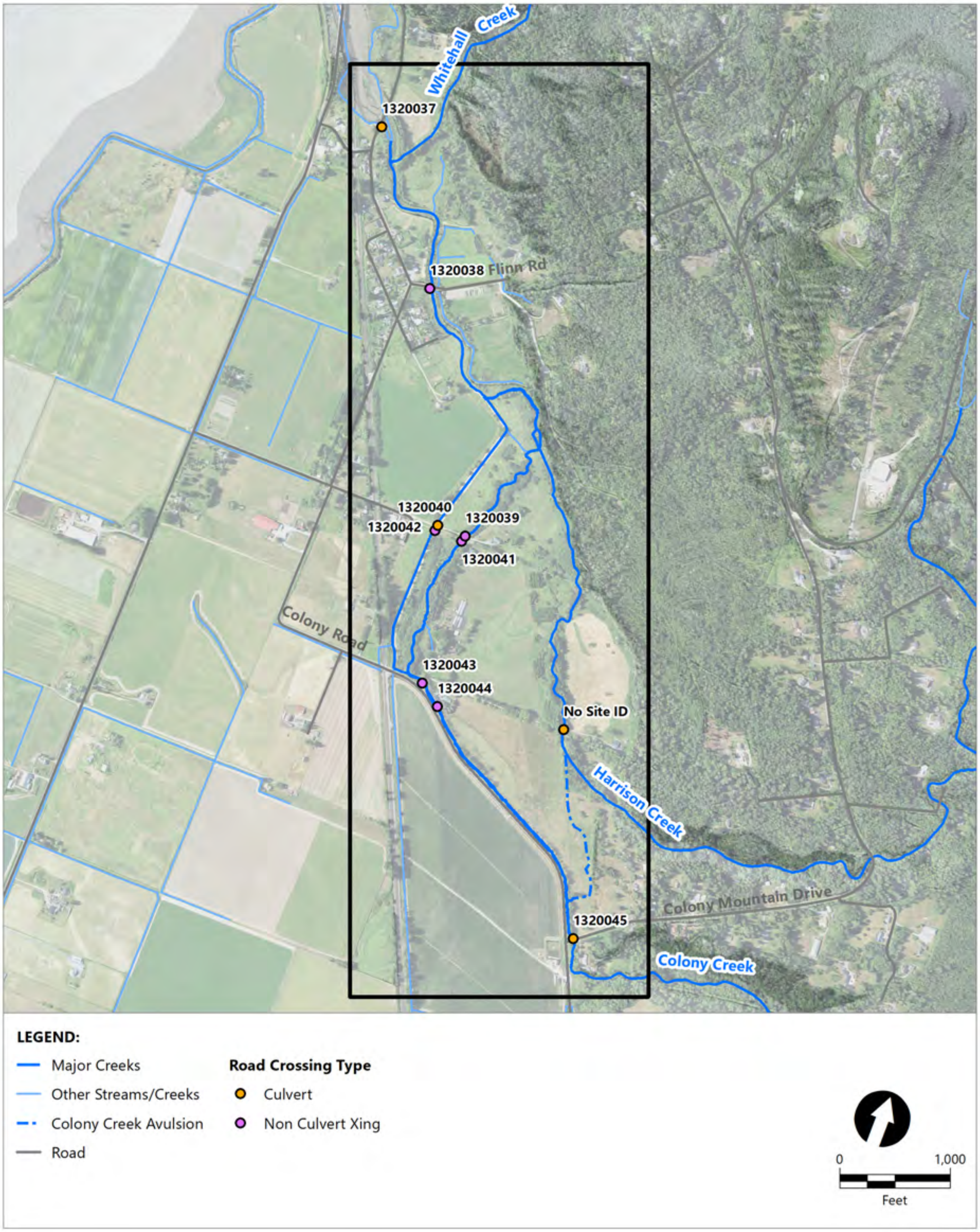
Another design element included in all alternatives is crossing structure improvements. Due to sedimentation, low channel gradients, and in some cases, channel avulsions, some crossing structures within the project area are not designed to efficiently convey sediment load and stream flow from Colony Creek and Harrison Creek (Table 3-2; Figure 3-2). In addition to improving conveyance of flow and sediment, installing or improving crossing structures can also help reduce potential flooding upstream of structures that may occur when a structure infills with sediment or structures are not designed to convey sufficient flow during less frequent high flow events.

Table 3-2
Existing Crossing Structures

Road Crossing	Structure Type	Condition/Issues
Colony Mountain Road (Site ID 1320045)	Concrete box culvert	Sediment Infilling
Private Driveway (Site ID 1320044)	Bridge	100% passable
Private Driveway (Site ID 1320043)	Bridge	100% passable
Private Driveway (Site ID 1320042)	Bridge	100% passable
Private Road (Site ID 1320041)	Bridge	100% passable
Private Driveway (Site ID 1320040)	Culvert	N/A
Private Road (Site ID 1320039)	Bridge	100% passable
Private Road (No Site ID) – Wrucha Property)	Corrugated steel culvert	Sediment infilling, undersized for combined Colony Creek and Harrison Creek flow
Flinn Road (Site ID 1320038)	Bridge	100% passable
Blanchard Road (Site ID 1320037)	Culvert/tide gate	Potentially inefficient tide gate

Note:
Road crossings with a site ID have been assessed by Washington Department of Fish and Wildlife (WDFW). Road crossing information from WDFW Fish Passage Inventory (WDFW 2023).

Figure 3-2
Existing Crossing Structures in Project Area



Note: Road crossings with a site ID have been assessed by WDFW. Road crossing information from WDFW Fish Passage Inventory (WDFW 2023).

3.2.7 Remove Reed Canary Grass and Restore Native Riparian Vegetation

As discussed in Section 1.2, reed canary grass is widespread in the project area. Removal of this invasive species, paired with riparian plantings, will allow for more natural riparian and estuary conditions to form in the upstream and downstream reaches. In addition to allowing native riparian vegetation to become established in the floodplain area, removal of reed canary grass will also allow natural channel processes to be restored; under existing conditions, reed canary grass limits natural channel processes and has caused the channel to become entrenched in some reaches and has caused the channel to lose all definition in others.

Removal of reed canary grass and planting native riparian species not only improves riparian habitat conditions, but also in-channel conditions for salmonids; riparian vegetation can provide shade to streams that keeps water temperatures lower and more suitable for salmonids in warmer months, as well as protection from predation. Over time, riparian trees can also provide large wood input to the channel, further benefiting in-channel habitat conditions.

3.2.8 Add Large Woody Material

All alternatives also include placement of large wood within the channels and floodplain. Large woody material can create in-channel habitat and refugia for salmonids and can also encourage formation of deep-water pools. Placement of large woody material in the floodplain can also encourage the maintenance or formation of side channels, thus improving channel complexity. In addition to habitat benefits, large wood can also be used as bank protection. In areas that are experiencing rapid erosion or bank scour, placement of large wood can slow this scour and protect highly erodible or unstable banks.

3.3 Conceptual Alternative Configurations of Potential Project Elements

Though many of the proposed alternatives include similar design elements, there are notable differences between each of the alternatives. It is important to note that these alternatives do not represent all the possibilities for actions at this site. However, these alternatives were created to provide a range of possible configurations for the project elements described in Section 3.2. The one exception is the potential modifications to the tide gate at Blanchard Road. Because the tide gates represent such a critical piece of the Colony Creek system, proposed modifications were evaluated separately from other alternatives. Any modifications to the tide gates with existing conditions should have similar effects with any of the other potential alternatives. The following subsections include detailed descriptions of all four project alternatives and the separate tide gate evaluations and highlight important project elements in the upstream and downstream project areas. Larger scale images of the concept maps can be found in Appendix C.

3.3.1 Alternative 1

Conceptual Alternative 1 is intended to evaluate a scenario where there is a major Colony Creek realignment that shifts the creek to a more natural location where it is connected to its historical alluvial fan.

Upstream Project Area

Alternative 1 includes a realignment of Colony Creek's upstream reach (Figure 3-3). This realignment allows Colony Creek to continue flowing to the west as it exits the steep hillside rather than being routed into a 90-degree bend just upstream of the existing Colony Mountain Road crossing. This alternative includes a proposed crossing structure on Colony Road to convey flow across the road and into an existing blueberry field; this alignment is likely closer to the historic Colony Creek alignment as is evidenced by the historical Colony Creek alluvial fan that is visible in digital elevation models.

Through the blueberry field, a wide riparian floodplain bounded by setback berms is proposed, which will allow for natural overbank deposition and floodplain connectivity while reducing flooding of adjacent agricultural lands (Figure 3-3); a small culvert is proposed at the downstream end of the left bank setback berm to allow flow from the blueberry field ditch to continue downstream. Large wood and riparian plantings are also proposed throughout the floodplain area. It should be noted that for all four alternatives, floodplain areas where riparian plantings are proposed will also be treated to remove reed canary grass, an invasive plant that is prevalent throughout the project area. Through the wide floodplain area, a meandering channel planform is proposed that will ultimately tie-in to a previously restored reach of Colony Creek downstream of a second proposed Colony Road crossing structure; a fish screen or flap gate is also proposed near this proposed crossing to prevent fish from traveling upstream in the old Colony Creek ditch and becoming stranded. Riparian plantings and channel cuts are proposed between the previously restored reach and the old Colony Creek ditch to create off-channel habitat. To reduce potential roadway flooding, Alternative 1 also includes raising the elevation of South Blanchard Road.

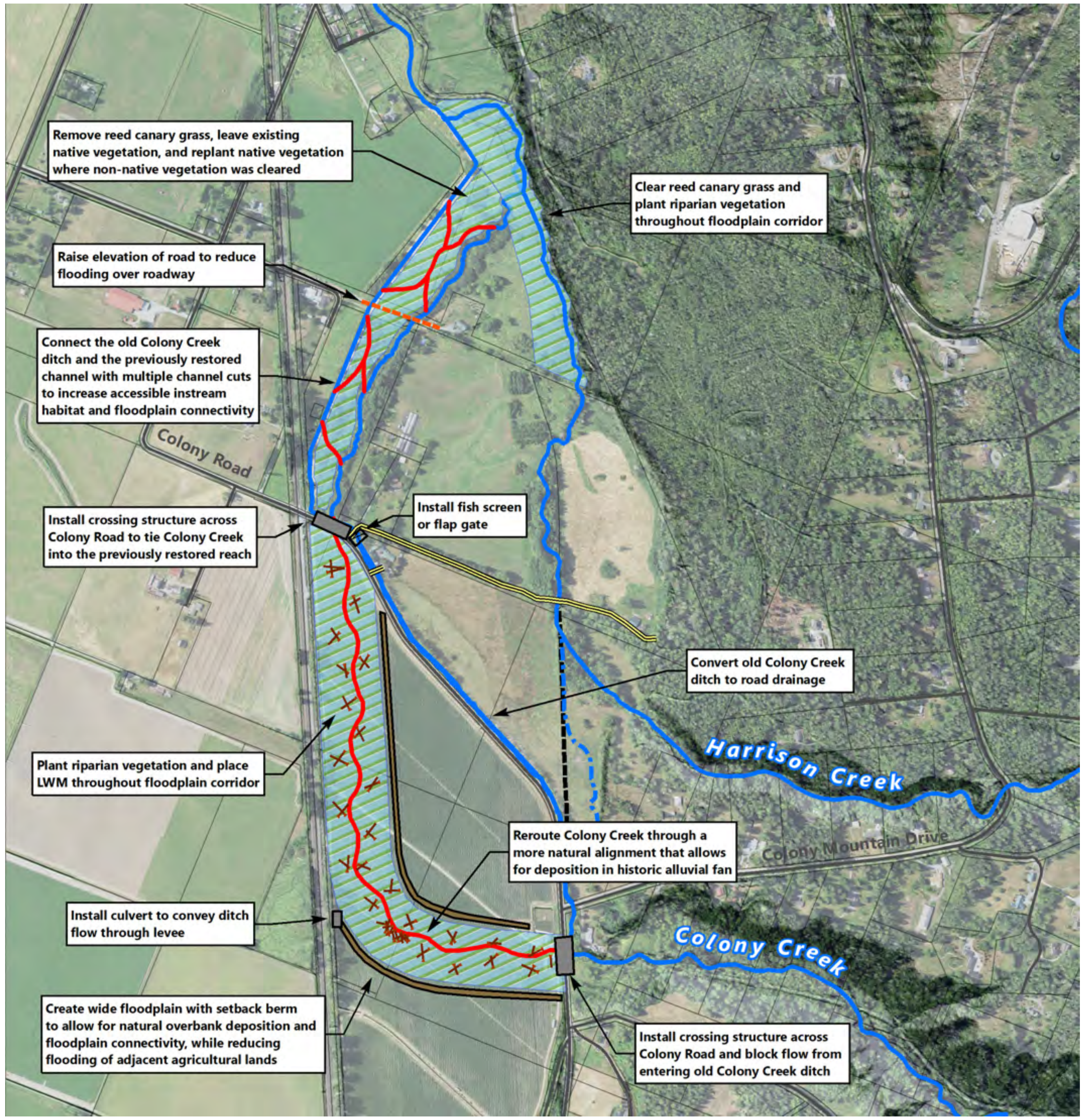
Downstream Project Area

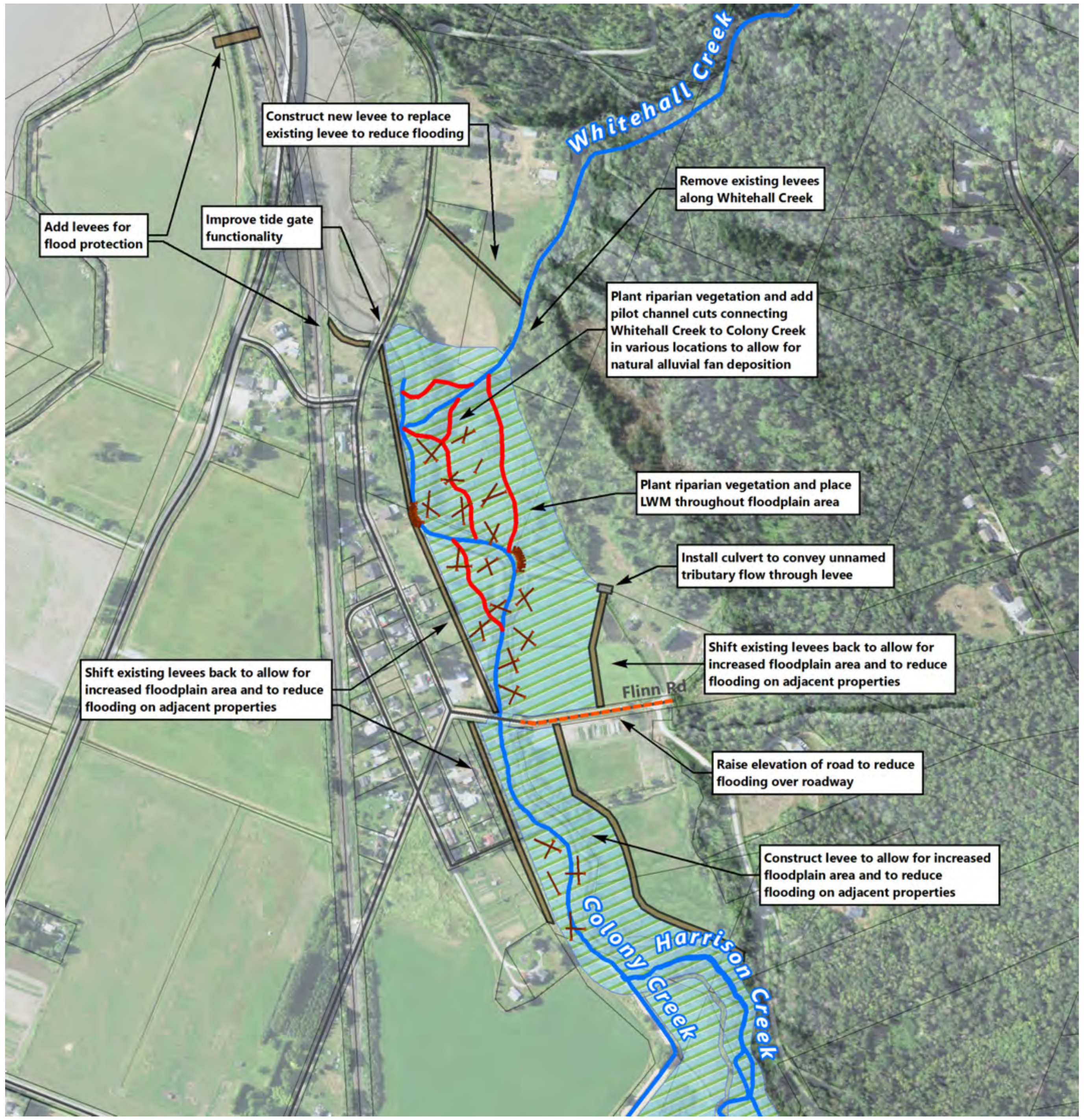
In the downstream project area, a new setback levee is proposed along the left bank of Colony Creek from the Colony Creek and Harrison Creek confluence to Flinn Road, and riparian plantings and large wood is proposed within the floodplain area (Figure 3-3). The existing left bank levee alongside Colony Creek will be removed and replaced with the proposed setback levee that allows for increased floodplain area while also reducing flood risk to adjacent properties. To reduce potential roadway flooding, Alternative 1 also includes raising the elevation of Flinn Road.

In the downstream reach from Flinn Road to Blanchard Road, removal of the existing levee and replacement with a new setback levee is proposed along the left bank. The location of the proposed setback levee allows for reduced flood risk for the left bank properties, while also increasing riparian area around the large left bank point bar (center of map, Figure 3-3). A short setback levee is proposed downstream of Flinn Road on the right bank; the existing right bank levee would be removed, and the proposed levee would be set back to allow for increased available floodplain area. Installation of a small, one-way culvert is proposed along this right bank levee for all alternatives to convey flow from a small unnamed tributary coming off the eastern hillside.

In Alternative 1, only one setback levee is proposed along the right bank, west of Whitehall Creek. This levee is set back from the Colony Creek and Whitehall Creek confluence to allow for natural alluvial fan deposition at the Whitehall Creek mouth and to increase riparian areas and floodplain connectivity near the confluence of Whitehall and Colony Creek while still providing some flood protection to the landowner. In addition to the riparian plantings proposed through the wide floodplain area between Flinn Road and Blanchard Road, large wood and side channel cuts are also proposed to provide instream habitat. Lastly, Alternative 1 includes tide gate improvements to the existing Blanchard Road tide gate, as well as two small levees at the downstream end of the project area for flood protection. However, the tide gates were evaluated separately and the levees downstream of the tide gates were not included in the modeling and evaluation.

Figure 3-3
Alternative 1





3.3.2 Alternative 2

Conceptual Alternative 2 is intended to evaluate a scenario where Colony Creek remains in its existing alignment, but wide setback levees and side channels are proposed to encourage natural channel and floodplain processes.

Upstream Project Area

Alternative 2 includes maintaining the existing Colony Creek alignment upstream of Colony Mountain Road and upgrading the road crossing structure to improve flow and sediment conveyance (Figure 3-4). This alternative also involves rerouting Colony Creek downstream of the road crossing, so it ties into the existing Colony Creek avulsion location. Through the property between Colony Mountain Road and the private driveway, a multithread channel with large wood is proposed in addition to riparian plantings. The riparian treatment area will extend from the base of the eastern hillside to the proposed setback levee along the left bank of the proposed Colony Creek channel. An existing access road that is now in the proposed alignment path will be removed, and a new access road is proposed along the proposed setback levee.

At the private driveway crossing, the existing crossing structure will be upgraded with a structure fit to convey the combined flows of Colony and Harrison creeks, and the elevation of the private driveway to the east of the structure will be raised to reduce the risk of flooding over the roadway. Downstream of the road crossing, setback levees are proposed on either side of the Colony Creek channel and will be set back to allow for a wide floodplain area, which will be planted with riparian vegetation; the setback levees also allow for reduced flood risk along adjacent properties. Side channel cuts and large wood are also proposed through this wide floodplain area, as is a new boardwalk that will allow for property access through the riparian area.

On the western portion of the upstream project area, restoration actions are also proposed. Like Alternative 1, Alternative 2 also includes riparian plantings and channel cuts between the previously restored reach and the old Colony Creek ditch to create off-channel habitat. This alternative also includes raising the elevation of South Blanchard Road to reduce roadway flooding and includes the installation of a fish screen or flap gate at the upstream end of the previously restored reach to limit risk of fish stranding in the blueberry field.

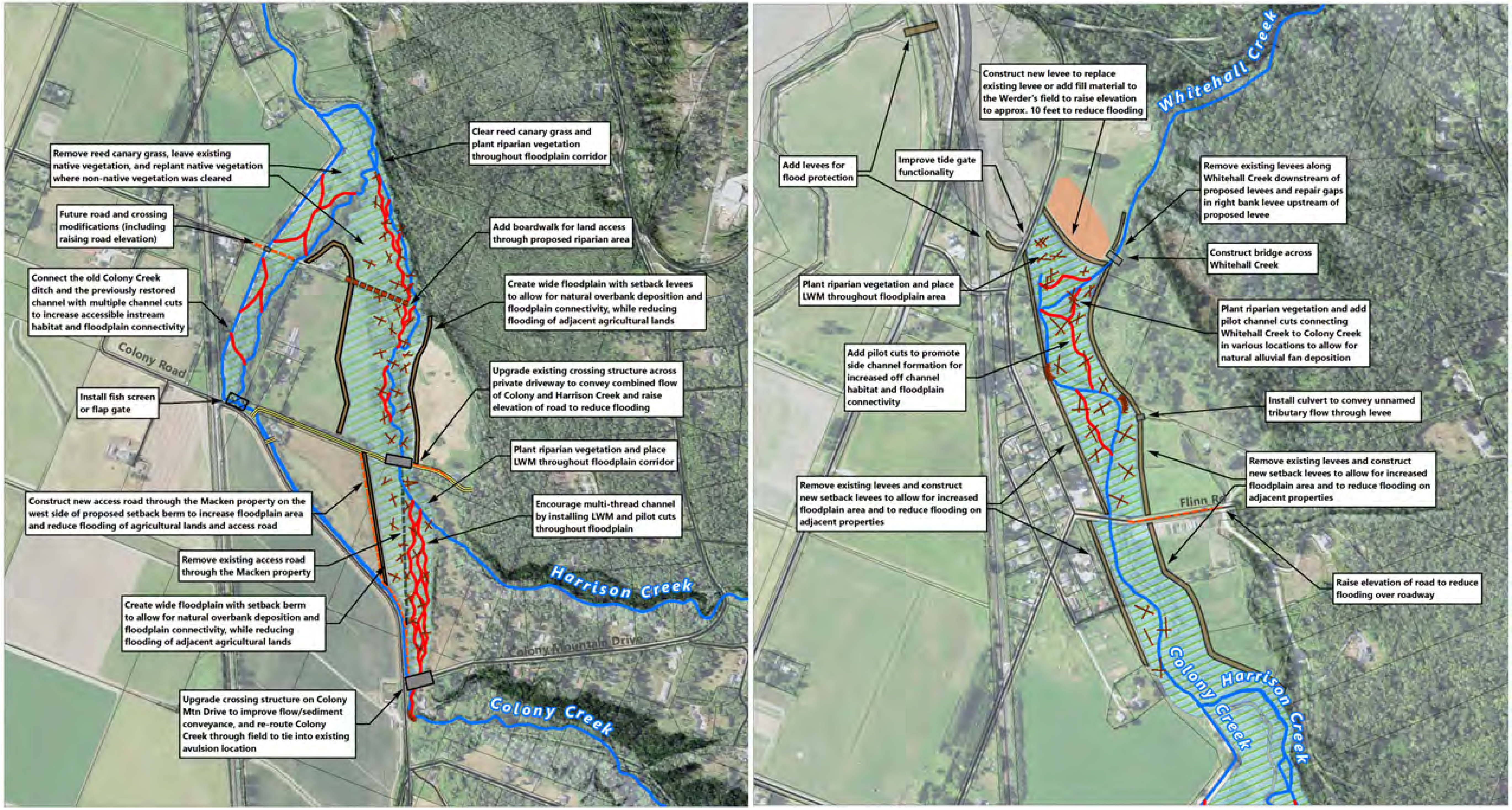
Downstream Project Area

In the downstream project area, new setback levees are proposed on both sides of Colony Creek from the Colony Creek and Harrison Creek confluence to Flinn Road, and riparian plantings and large wood is proposed within the floodplain area (Figure 3-4). Existing levees alongside Colony Creek will be removed and replaced with the proposed setback levees that allow for increased floodplain area while also reducing flood risk to adjacent properties. To reduce potential roadway flooding, Alternative 2 also includes raising the elevation of Flinn Road.

In the downstream reach from Flinn Road to Blanchard Road, removal of the existing levee and replacement with a new setback levee is proposed along the left bank. The location of the proposed setback levee allows for reduced flood risk for the left bank properties, while also increasing riparian area around the large left bank point bar (center of map, Figure 3-4). A setback levee is also proposed downstream of Flinn Road along the right bank; the existing right bank levee would be removed, and the proposed levee would be set back to allow for increased available floodplain area and would extend from Flinn Road to the proposed Whitehall Creek bridge. Though this right bank levee allows for a larger floodplain area compared to existing conditions, the available floodplain area is smaller than the floodplain proposed in this reach for Alternative 1.

Along Whitehall Creek, a setback levee is proposed that extends from the right bank of Whitehall, near the proposed bridge structure, northwest to Blanchard Road. This levee is intended to reduce flooding on the property along the right bank of Whitehall Creek while also providing more floodplain area at the Colony Creek and Whitehall Creek confluence to promote natural alluvial fan deposition at the Whitehall Creek mouth and increase riparian areas and floodplain connectivity near the confluence. Alternative 2 also includes repairs to the existing right bank Whitehall Creek levee; under the existing conditions, this levee has been breached in multiple places. Repairs to this levee would reduce flood risk along the adjacent property. In addition to the riparian plantings proposed through the floodplain area between Flinn Road and Blanchard Road, large wood and side channel cuts are also proposed to provide additional instream habitat. Lastly, Alternative 2 includes tide gate improvements to the existing Blanchard Road tide gate, as well as two small levees at the downstream end of the project area for flood protection. However, the tide gates were evaluated separately and the levees downstream of the tide gates were not included in the modeling and evaluation.

Figure 3-4
Alternative 2



3.3.3 Alternative 3

Conceptual Alternative 3 is intended to evaluate a scenario where Colony Creek is realigned through the Macken field within a wide inset floodplain and does not merge with Harrison Creek until the creek approaches the downstream project area.

Upstream Project Area

Alternative 3 includes maintaining the existing Colony Creek alignment upstream of Colony Mountain Road and upgrading the road crossing structure to improve flow and sediment conveyance (Figure 3-5). This alternative also involves rerouting Colony Creek downstream of the road crossing, so it ties into the existing Colony Creek avulsion location. Through the property between Colony Mountain Road and the private driveway, a multithread channel and inset floodplain is proposed; the inset floodplain involves excavating a wide floodplain area to allow for increased water and sediment storage. Large wood and riparian plantings are proposed throughout this inset floodplain (Figure 3-5). An existing access road that is now in the proposed alignment path will be removed, and a new access road is proposed along a setback levee that is proposed along the left bank of the inset floodplain.

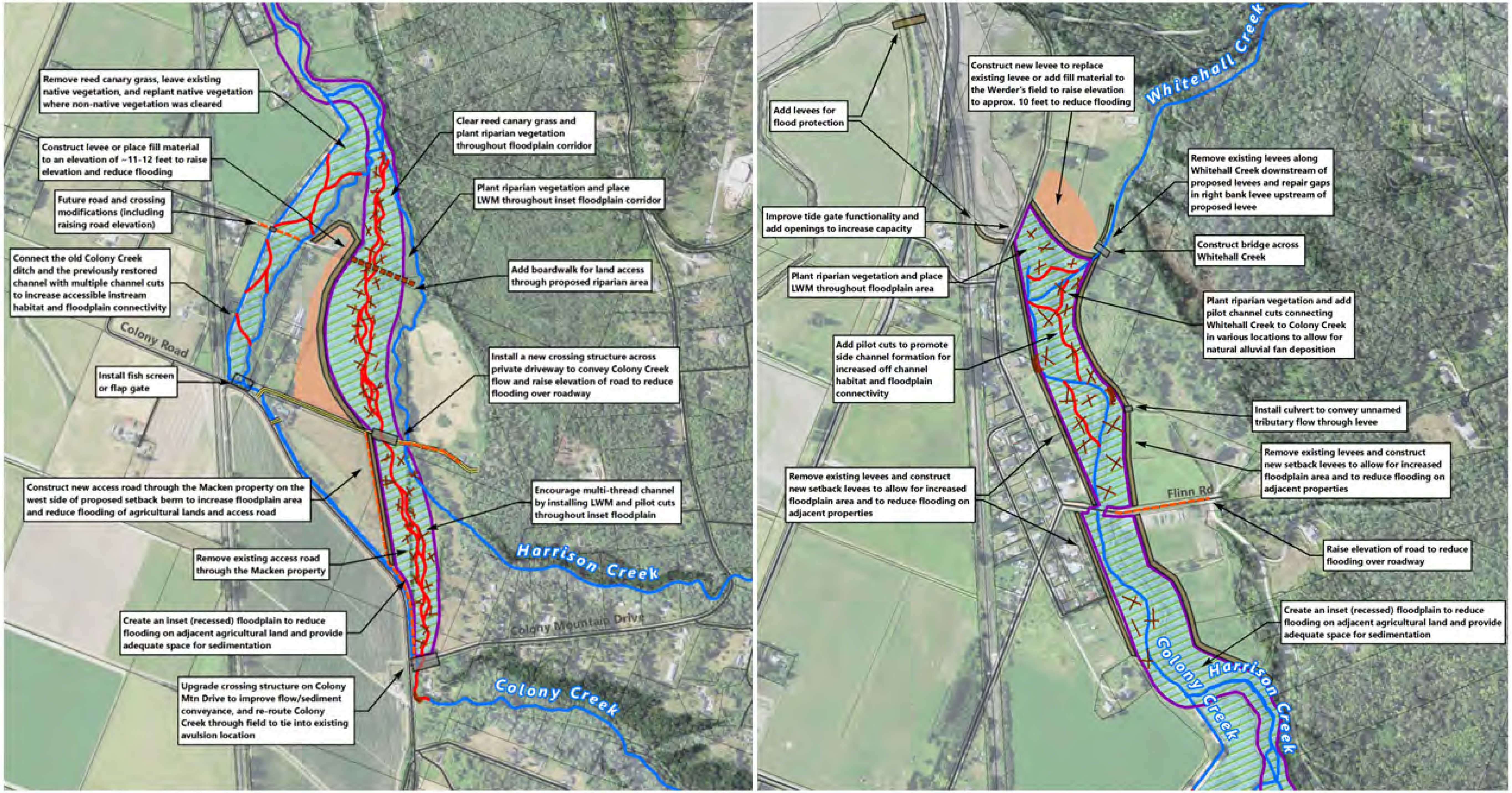
At the private driveway crossing, a new crossing structure will be installed to convey Colony Creek flow downstream; the proposed Colony Creek alignment is located just west of Harrison Creek's existing flow path, so the existing private driveway crossing will continue to convey Harrison Creek flow. To account for the possibility of a future Harrison Creek avulsion, the proposed Colony Creek crossing can be sized large enough to convey the combined flows of Colony Creek and Harrison Creek. The elevation of the private driveway to the east of the crossing structures will be raised to reduce the risk of flooding over the roadway. Downstream of the road crossing, the wide inset floodplain and proposed multithread Colony Creek channel continues, flowing just west of the existing Harrison Creek channel. A setback levee is proposed along the left bank of the inset floodplain to reduce flooding of adjacent property. Riparian plantings and large wood are also proposed through the wide inset floodplain, and a boardwalk is proposed to allow for property access through the proposed riparian area (Figure 3-5).

On the western portion of the upstream project area, restoration actions are also proposed. Like Alternatives 1 and 2, Alternative 3 includes riparian plantings and channel cuts between the previously restored reach and the old Colony Creek ditch to create off-channel habitat. This alternative also includes raising the elevation of South Blanchard Road to reduce roadway flooding and includes installation of a fish screen or flap gate at the upstream end of the previously restored reach to limit risk of fish stranding in the blueberry field.

Downstream Project Area

Aside from the continuation of the inset floodplain in the downstream project area, all other proposed project elements in Alternative 3 are the same as those discussed in the downstream project area for Alternative 2.

Figure 3-5
Alternative 3



3.3.4 *Alternative 4*

Like Alternative 3, conceptual Alternative 4 is intended to evaluate a scenario where Colony Creek is realigned through the Macken field within a wide inset floodplain and does not merge with Harrison Creek until the creek approaches the downstream project area. However, within the downstream project area, the inset floodplain becomes more narrow.

Upstream Project Area

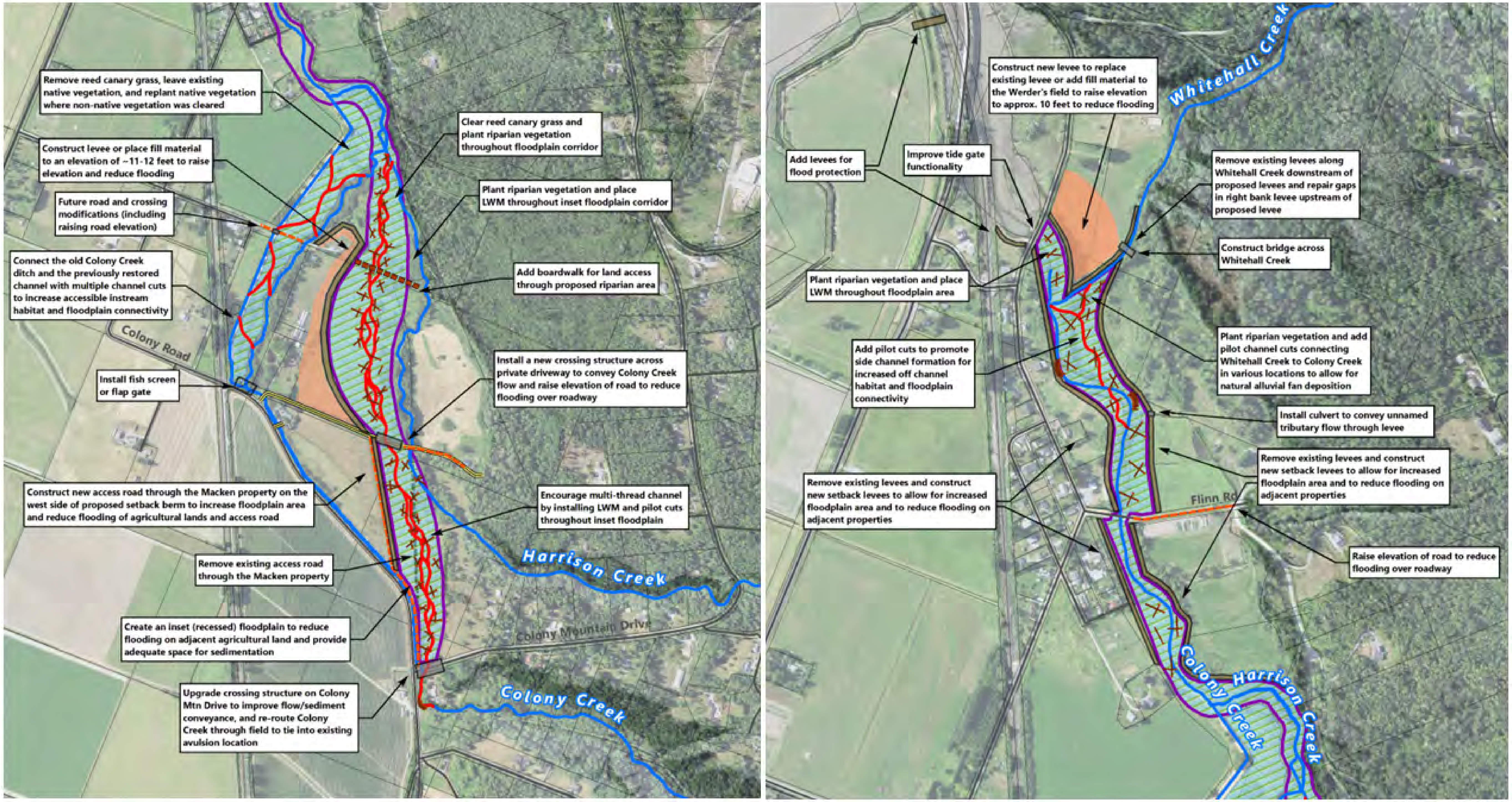
The proposed project elements in the upstream project area for Alternative 4 are identical to those described in the upstream project area for Alternative 3 (Figure 3-6).

Downstream Project Area

Though the proposed project elements in the downstream project area for Alternative 4 are similar to those described in Alternative 3, the downstream project elements for Alternative 4 include a narrower inset floodplain and setback levees that are closer to the Colony Creek channel, thus resulting in smaller overall floodplain area compared to Alternative 3 (Figure 3-6). Upstream of Flinn Road, the proposed left bank setback levee is the same as Alternative 3, but the proposed right bank levee is set closer to the Colony Creek channel, resulting in a narrower inset floodplain. Like the other alternatives, Alternative 4 includes raising Flinn Road to reduce risk of flooding over the roadway.

Downstream of Flinn Road, the proposed right bank levee is the same as Alternative 3, but the left bank levee is set closer to the Colony Creek channel, specifically along the large left bank point bar (center of map, Figure 3-6). Alternative 4 also includes construction of a new right bank levee along the downstream-most reach of Colony Creek; there is an existing levee in this location that would be replaced by a new levee in the same location. Along Whitehall Creek, the existing right bank levee would also be repaired in areas where it has been breached to reduce flooding along the adjacent property. The downstream levees proposed in Alternative 4 would allow for some alluvial fan deposition at the Whitehall Creek mouth, but deposition would be restricted to the left bank floodplain due to the proposed right bank levees. Riparian plantings, large wood, and side channel cuts are proposed throughout the narrow inset floodplain. Lastly, Alternative 4 includes tide gate improvements to the existing Blanchard Road tide gate, as well as two small levees at the downstream end of the project area for flood protection. However, the tide gates were evaluated separately and the levees downstream of the tide gates were not included in the modeling and evaluation.

Figure 3-6
Alternative 4



4 Hydraulic Modeling

The following sections describe the methodology for developing the hydrologic data and 2D hydraulic models used to assess the alternatives.

4.1 Hydrology

Hydrologic inputs developed for this analysis include peak flow data for Colony Creek and its tributaries as well as tidal data for Samish Bay. Hydrologic data was developed using a combination of regression equations and tidal and stream gages. The timing of the streamflow and tidal hydrographs was adjusted to depict situations that tested the various project alternatives' abilities to store and release peak flows and peak tides.

4.1.1 Streamflow Inputs

There are a few tributaries draining to the Colony floodplain channel known as McElroy Slough and emptying into Samish Bay near the town of Blanchard. Colony Creek is the primary tributary, Harrison Creek is a smaller tributary that enters the valley downstream of Colony Creek, and Whitehall Creek is the third major tributary entering the slough just upstream of the Blanchard tide gate. Another unnamed tributary input enters between Harrison Creek and Whitehall Creek, and a final hydrologic input includes agricultural ditches coming from the blueberry fields to the south adjacent to Colony Road.

Initially, the subbasins were delineated using the U.S. Geological Survey (USGS) StreamStats application (USGS 2023a). The hydrology package in ArcMap 10.8.2 was used to manually refine basin delineation (ESRI 2023). The manually delineated basin areas and average annual precipitation from USGS StreamStats were used as inputs to the peak flow regression equations for Western Washington Region 3 to develop hydrologic return intervals (Mastin et al. 2017).

All tributaries to McElroy Slough are ungaged, so the nearby Lake Whatcom tributary, Brannian Creek, was used to develop a simulated hydrograph. The USGS Brannian Creek contained gage data from water year 2001 to present, and a return interval analysis was conducted to find a storm event that was close to the 2-year flow value of 205 cfs (USGS 2023b). The February 4, 2018, storm event on Brannian Creek was smoothed using rolling averaging and scaled to the peak of 225 cfs to develop a unit hydrograph. This unit hydrograph was then multiplied by the return intervals for each of the Colony Creek tributaries to develop a series of synthetic hydrographs for the 2-year storm in McElroy Slough. A similar process was repeated for the 10-year hydrograph.

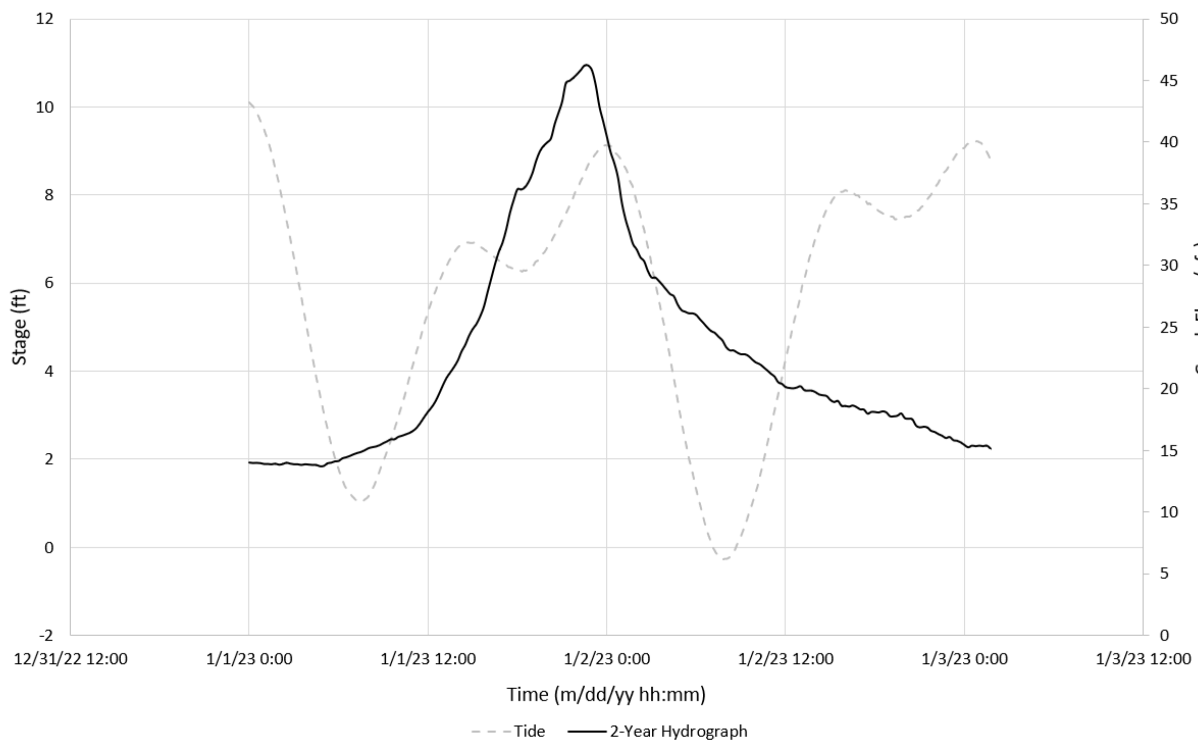
4.1.2 Tidal Influence

Tidal data used in the model was obtained from the nearest continuously operating tidal gage at Cherry Point, Washington (NOAA 2023). Typically, the peak tides or king tides in the year occur near the first of the year when the earth is closest to the sun. The exact 6-minute tidal series from December 31, 2022, to January 2, 2023, was used as the tidal hydrograph for the model. This was considered an acceptable assumption because no continuous tidal data was available for Samish Bay, and tides should be similar. Tidal peaks reached as high as 10.21 feet NAVD88 and peak low tide was -0.27 foot NAVD88.

4.1.3 Combined Tidal and Streamflow Scenario

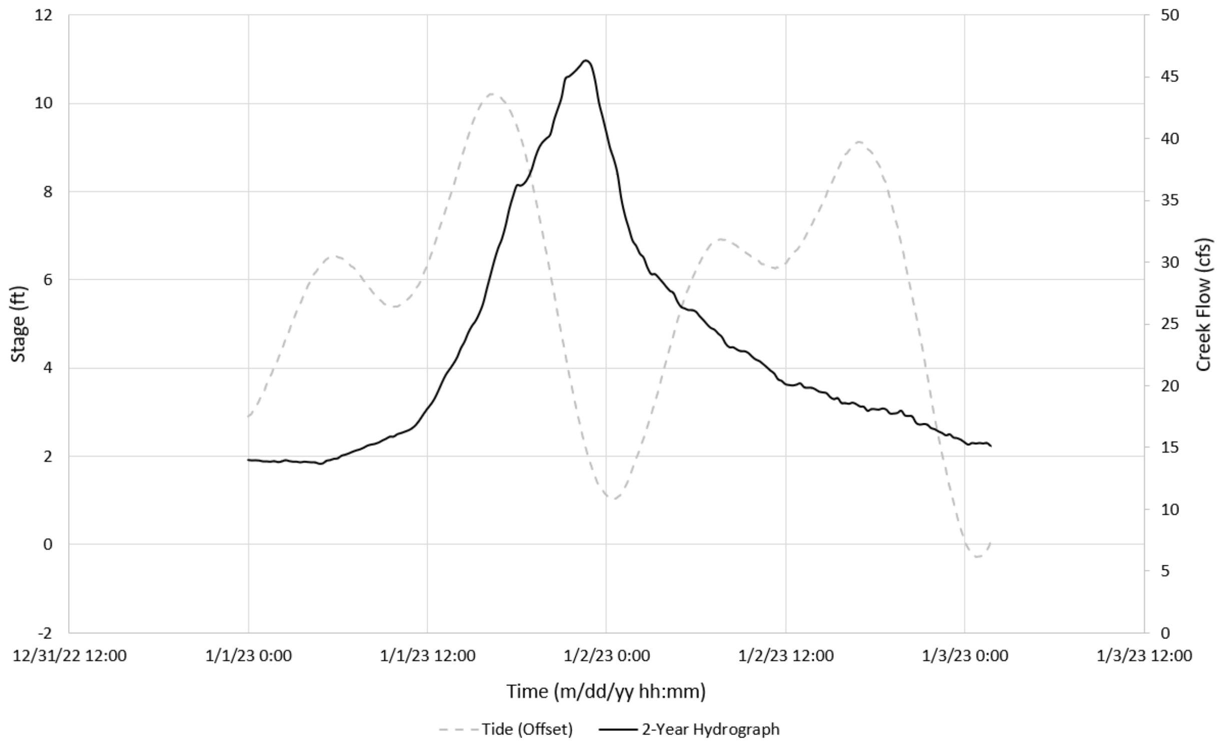
The peaks from the tributary hydrographs were temporally aligned and were slightly offset from the arrival of the peak tide (Figures 4-1 and 4-2). The peak streamflow was aligned to arrive during the falling limb of the tidal hydrograph. This scenario was intended to measure how the tide gate system was able to store flood waters while tides were receding. This scenario is potentially the worst case for an actual storm arriving during the annual peak tide, but this analysis is considered conservative to design restoration alternatives that are designed to function during the largest flood events.

Figure 4-1
Peak Hydrograph Scenario



Note: The shown hydrograph represents a conceptual storm event and does not correspond directly to the actual flow conditions on the dates shown on the x axis of this figure.

Figure 4-2
Offset Hydrograph Scenario



Note: The shown hydrograph represents a conceptual storm event and does not correspond directly to the actual flow conditions on the dates shown on the x axis of this figure.

4.2 Hydraulic Modeling

Hydraulic modeling was performed to assess the potential habitat benefits and inundation extents of the proposed alternatives under different hydrologic and tidal scenarios. All four project alternatives are set up to include both upstream and downstream project elements intended to create habitat, improve sediment storage, and reduce flood risk on adjacent property.

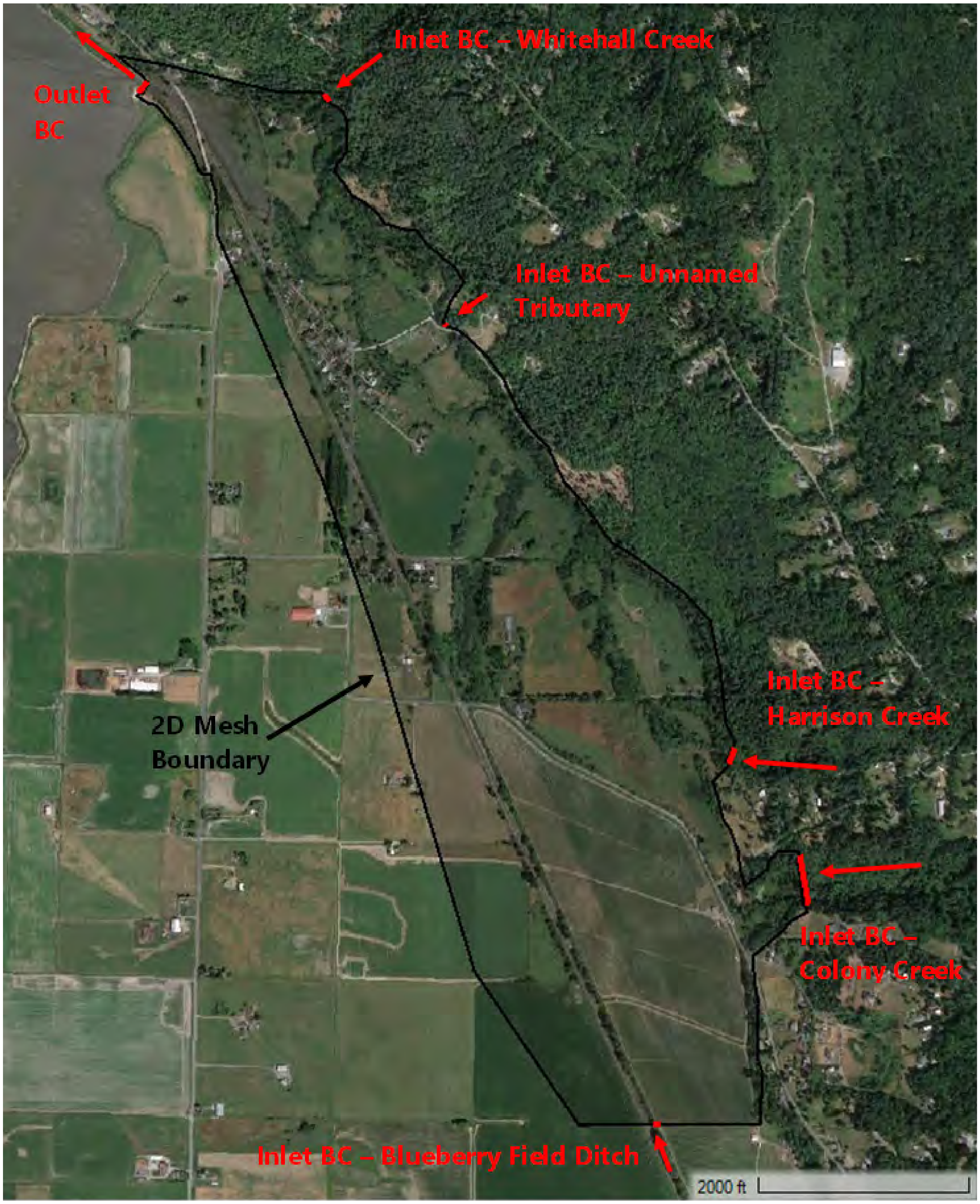
The hydrodynamic modeling platform selected for the analysis was the U.S. Army Corps of Engineers' (USACE) Hydraulic Engineering Center – River Analysis System (HEC-RAS) version 6.3.0. This platform was selected because of a 2D model's computational accuracy and capability to resolve multidirectional floodplain flow, allowing the model to better predict floodplain inundation and connectivity goals of the project. HEC-RAS was also selected because of the ease of integrated surface modification to model proposed conditions.

Model runs were set up to simulate two main hydrologic and tidal conditions; the first condition involved modeling a scenario where the hydrograph peak occurs at the same time as the tidal hydrograph peak, thus showing a somewhat "extreme" inundation scenario in the downstream project area. The second condition involved modeling a scenario where the hydrograph peak and the tidal hydrograph peak are offset, thus showing a less extreme inundation scenario in the downstream project area. For both of these hydrologic/tidal scenarios, models were run for the existing conditions and all four alternatives. Model results are presented and discussed in Section 4.3.

4.2.1 Model Extent and Geometry

A single 2D model grid was developed for the existing conditions and modified for the proposed conditions. The existing conditions 2D mesh contains 103,410 cells and covers an area of 0.85 square mile. The model extents and inlet and outlet boundary conditions are shown in Figure 4-3. The grid was aligned parallel to flow within the channel and active flow paths to improve computational accuracy and efficiency. Levees, roads, and floodplain areas critical to project goals were given increased grid resolution.

Figure 4-3
2D Hydraulic Model Extents



Note: Inlet and Outlet BCs are the model's boundary conditions.

A merged dataset was used as the underlying topographic data for the model. This dataset includes a 3-foot resolution North Puget Sound digital terrain model from 2017 (QSI 2017) and a 1-meter resolution National Oceanic and Atmospheric Administration digital elevation model of the Skagit River Delta from 2019 (NOAA 2020). The merged dataset was used to develop the existing conditions model. The terrain modification tools in HEC-RAS 6.3.0 were used to add modification layers for this existing surface to model project elements proposed in all four alternatives.

Terrain modifications for the four alternatives included adding levees/sediment berm and channel cuts, removing existing levees, raising roads/driveways, and for Alternatives 3 and 4, adding an inset floodplain. The levee/berm and road modifications were made using the *High Ground* line modification in HEC-RAS 6.3.0, while the channel cut, levee removal, and inset floodplain modifications were made using the *Channel* line modification.

4.2.2 Manning's N

Default Manning's roughness values were assigned based on guidance from land cover types within the USGS National Land Cover Database 2019 dataset (USGS 2019) and modeling guidance provided by USACE (USACE 2021). The existing conditions model domain was manually classified into the categories shown in Table 4-1 using guidance from aerial imagery and site visits.

Table 4-1
Existing Conditions Manning's N Values

Category	Manning's N Value
Forest	0.10
Woody Wetlands	0.07
Developed Land, Low Intensity	0.06
Cultivated Crops	0.06
Pasture and Hay	0.05
Channels and Floodplain	0.045
Road	0.03
Delta	0.03

An additional Manning's N value was added to help model the levees/sediment berms (0.06) in the proposed alternatives. Proposed riparian areas were modeled with a value of 0.045, because these areas are considered floodplain. Final proposed conditions model roughness values are shown in Table 4-2.

Table 4-2
Proposed Conditions Manning's N Values

Category	Manning's N Value
Forest	0.10
Woody Wetlands	0.07
Developed Land, Low Intensity	0.06
Levees and Sediment Berms	0.06
Cultivated Crops	0.06
Pasture and Hay	0.05
Channels and Floodplain	0.045
Road	0.03
Delta	0.03

4.3 Model Results

Model runs were set up to simulate two main hydrologic and tidal conditions; the first condition involved modeling a scenario where the hydrograph peak occurs at the same time as the tidal hydrograph peak, thus showing a somewhat "extreme" inundation scenario in the downstream project area (Figure 4-1). The second condition involved modeling a scenario where the hydrograph peak and the tidal hydrograph peak are offset, thus showing a less extreme inundation scenario in the downstream project area (Figure 4-2). For both of these hydrologic/tidal scenarios, models were run for the existing conditions and all four alternatives.

4.3.1 Existing Conditions – Tide Gate Modifications

The two hydrologic/tidal scenarios were also combined with various tide gate conditions to better understand how significantly tide gate aperture affects WSEs in the project area upstream of the tide gates. Existing conditions models were run for both hydrologic/tidal scenarios for three tide gate conditions: existing capacity (10% open), 50% capacity, and full capacity (100% open). Figure 4-4 shows a comparison of the three tide gate conditions with the first hydrologic/tidal condition (peak hydrograph) and Figure 4-5 shows a comparison of the tide gate conditions with the offset hydrograph. In general, for both hydrologic scenarios, the 50% and 100% open tide gate conditions allow water levels to drop more quickly following a peak in the hydrograph. However, it should be noted that the modeled differences in WSE between the 10% scenario and 50%/100% scenarios are relatively small (tenths of a foot) and would not likely create a noticeable difference to inundation at a 2-year event for any of the nearby landowners. These results suggest that under these tide and storm conditions the downstream boundary conditions of the tides are the primary control on the outflow rates, rather than the size or hydraulic capacity of the culverts and flap gates. Other flow scenarios could be evaluated in the future, and these results should be evaluated and calibrated with actual data.

Figure 4-4
Modeled Maximum WSE Over Time Near Tide Gate: Peak Hydrograph

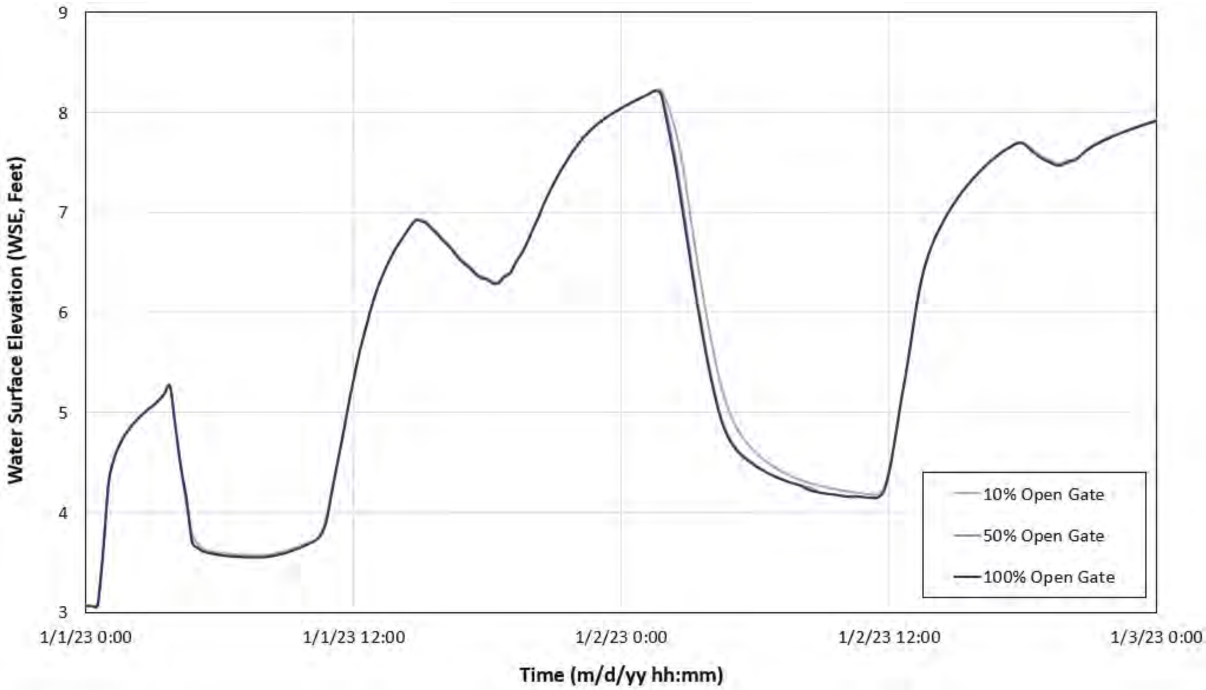
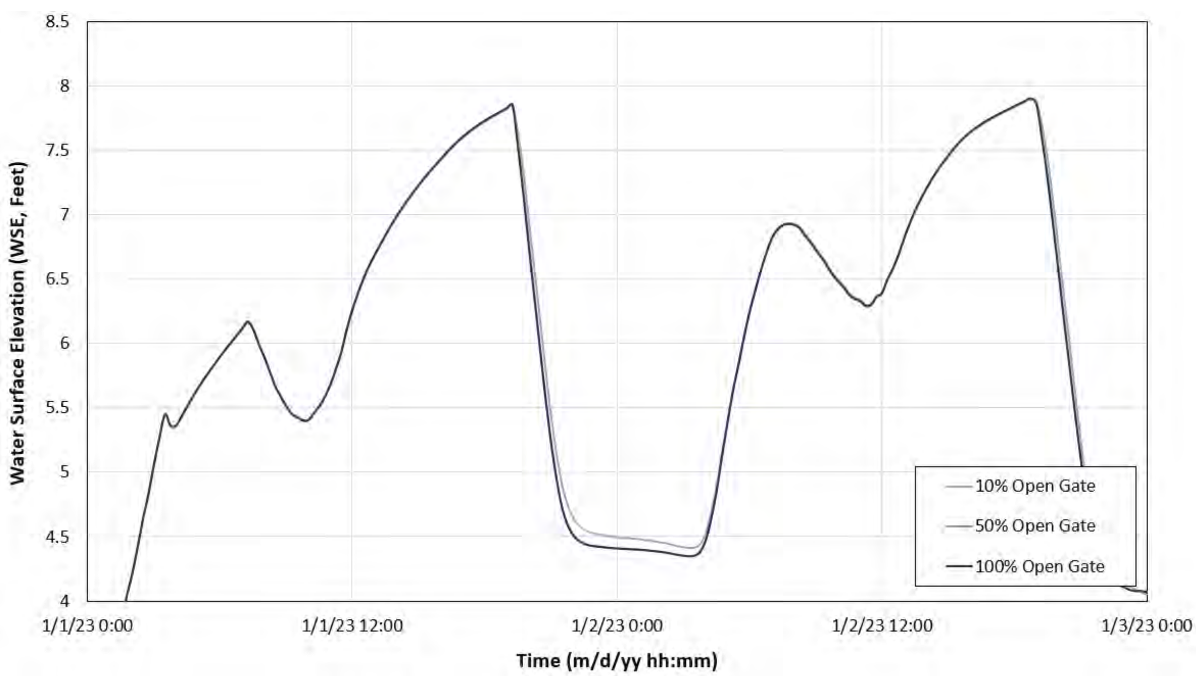


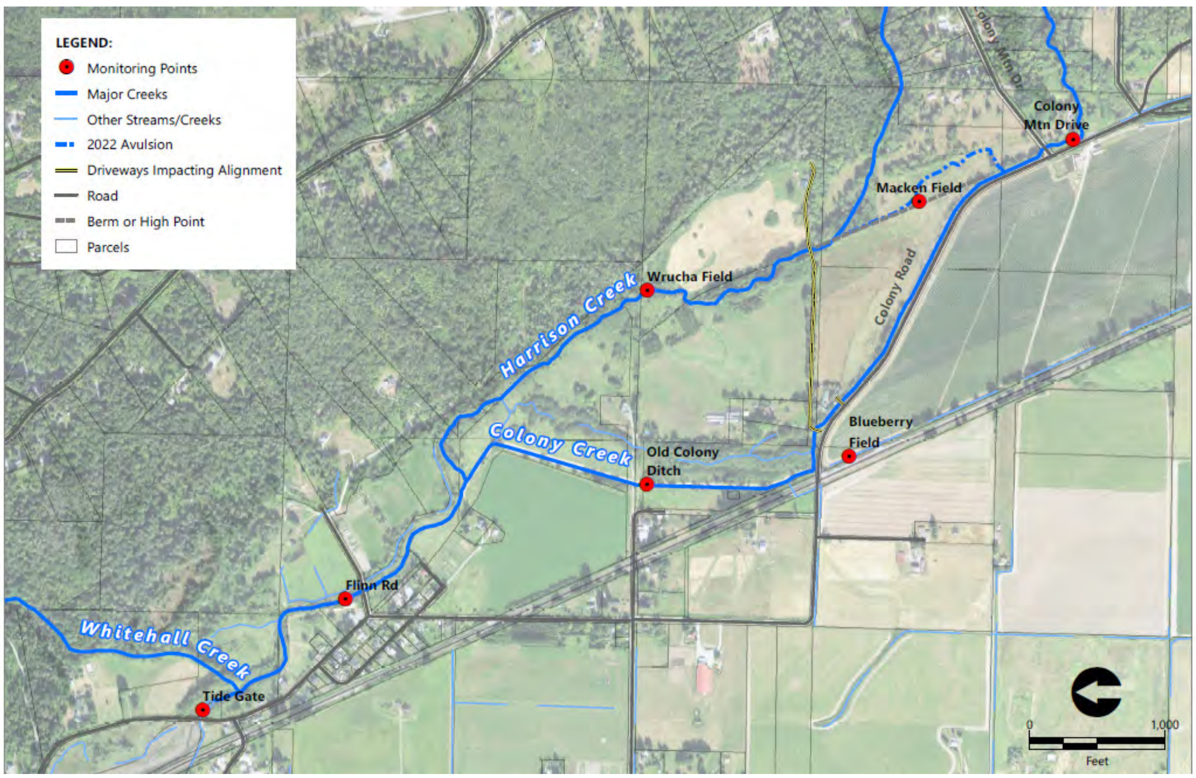
Figure 4-5
Modeled Maximum WSE Over Time Near Tide Gate: Offset Hydrograph



4.3.2 *Proposed Conditions – Monitoring Points*

To quantitively assess how each alternative impacts modeled WSEs throughout the project area, monitoring points were set up at multiple locations within the hydraulic model: in the blueberry field, on the Macken property, immediately upstream of the Colony Mountain Road crossing, within the old Colony Creek ditch, on the Wrucha property, immediately downstream of Flinn Road, and just upstream of the tide gate (Figure 4-6). Maximum WSE values were extracted from existing and proposed conditions model results at each of these monitoring points for both hydrologic/tidal scenarios. Figures 4-7 and 4-8 show comparisons of the maximum WSE model results at each monitoring point.

Figure 4-6
Hydraulic Model Monitoring Points



WSE Monitoring Point Results – Peak Hydrograph

Figure 4-7 shows the modeled maximum WSE for existing and proposed conditions at all monitoring points under the peak hydrograph scenario. Table 4-3 summarizes the modeled maximum WSE results under the peak hydrograph scenario.

Figure 4-7
Modeled Maximum Water Surface Elevation at Monitoring Points: Peak Hydrograph

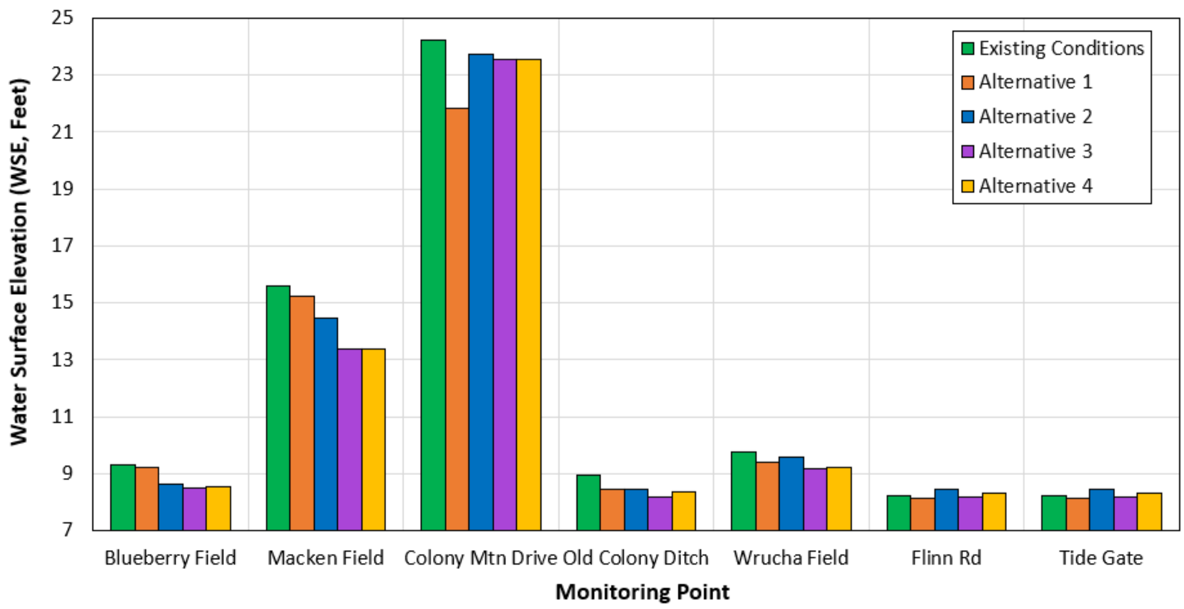


Table 4-3
Modeled Maximum WSE Values at Monitoring Points – Peak Hydrograph Scenario

Monitoring Point Location	Existing WSE (feet)	Alternative 1 WSE (feet)	Alternative 2 WSE (feet)	Alternative 3 WSE (feet)	Alternative 4 WSE (feet)
Blueberry Field	9.31	9.20	8.63	8.50	8.56
Macken Field	15.59	15.24	14.46	13.39	13.39
Colony Mtn Drive	24.23	21.83	23.71	23.57	23.57
Old Colony Ditch	8.97	8.44	8.46	8.18	8.34
Wrucha Field	9.78	9.42	9.59	9.18	9.24
Flinn Road	8.23	8.12	8.44	8.16	8.31
Tide Gate	8.22	8.12	8.44	8.16	8.31

WSE Monitoring Point Results – Offset Hydrograph

Figure 4-8 shows the modeled maximum WSE for existing and proposed conditions at all monitoring points under the offset hydrograph scenario. Table 4-4 summarizes the modeled maximum WSE results under the offset hydrograph scenario.

Figure 4-8
Modeled Maximum Water Surface Elevation at Monitoring Points: Offset Hydrograph

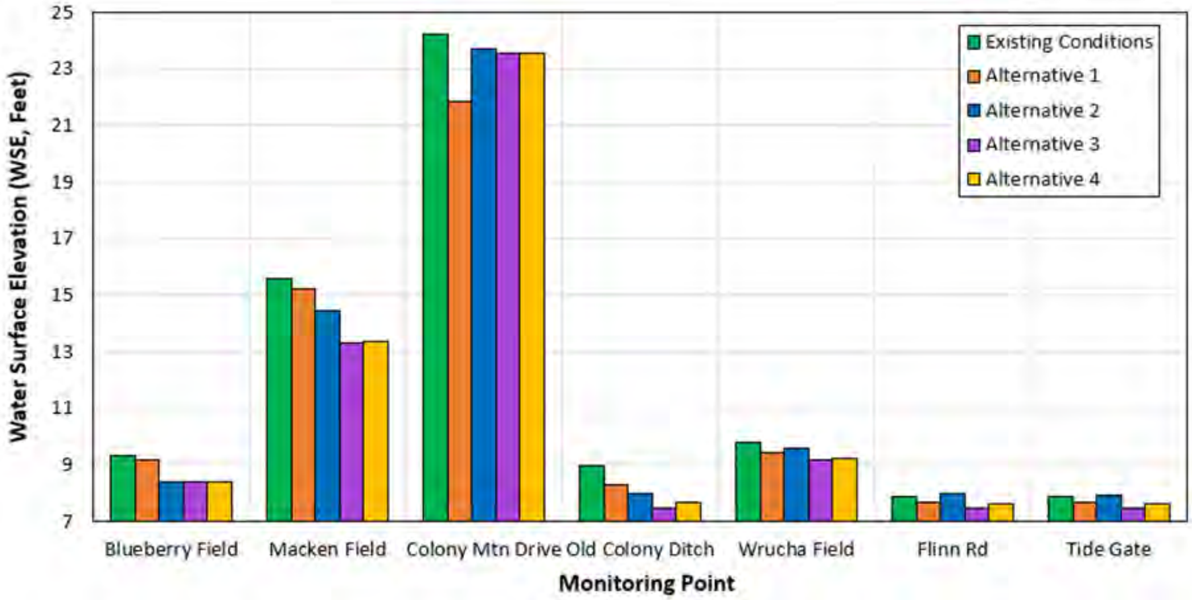


Table 4-4
Modeled WSE Values at Monitoring Points – Offset Hydrograph Scenario

Monitoring Point Location	Existing Conditions WSE	Alternative 1 WSE	Alternative 2 WSE	Alternative 3 WSE	Alternative 4 WSE
Blueberry Field	9.31	9.20	8.41	8.40	8.41
Macken Field	15.59	15.24	14.46	13.34	13.35
Colony Mtn Drive	24.23	21.83	23.71	23.57	23.57
Old Colony Ditch	8.97	8.31	8.01	7.48	7.70
Wrucha Field	9.78	9.42	9.59	9.18	9.24
Flinn Road	7.90	7.69	7.97	7.46	7.65
Tide Gate	7.90	7.69	7.96	7.46	7.65

5 Alternatives Evaluation

The following evaluation describes how well each alternative meets the objectives laid out in Section 3.1 based on results of the hydraulic modeling as well as analyses of proposed terrain differences. Alternatives are compared to one another and to existing conditions. Project recommendations in Section 6 are based on how well each of the alternatives meets the project objectives.

5.1 Flood Storage and Water Surface Elevation

To evaluate flood storage under the proposed conditions, it is important to understand what a flood storage area is. A flood storage area can be defined as the portion of the floodplain where floodwaters can be stored. Under natural conditions, a river may overtop its banks and floodwaters may spread across its floodplain; however, in a modified system, for example, a river with levees, a river may overtop its banks, but the spread of floodwaters would be limited by the river's levees, thus decreasing its flood storage capacity. This understanding helps to distinguish two evaluation criteria for this project: flood storage and flood risk reduction. While proposed setback levees may protect private property from inundation and reduce flood risk, these levees may also limit flood storage.

To assess how different proposed alternatives affect flood storage, modeled maximum WSE data was pulled from seven locations across the project area (Figure 4-6). Modeled maximum WSE data for existing and proposed conditions is described in Section 4.3.2. In general, under both hydrologic conditions, all proposed alternatives reduced maximum WSE compared to existing conditions, aside from Alternative 2 in the downstream project area.

Colony Mountain Road

Though all alternatives result in reductions in maximum WSE compared to existing conditions, Alternative 1 shows the most significant reduction due to the realignment of the channel through the blueberry field and removal of the existing 90-degree bend in the channel; the realignment improves conveyance of water downstream and limits backwatering upstream of the crossing structure. Alternatives 3 and 4, which maintain a similar alignment to existing conditions, show minor reductions in maximum WSE compared to existing conditions; these minor reductions are likely related to the inset floodplains proposed for these alternatives, which increase flood storage downstream of the monitoring point. Alternative 2 shows the smallest reduction in WSE at this location; this could be because Alternative 2 maintains a similar alignment to existing and does not include an inset floodplain downstream of the monitoring point that increases flood storage immediately downstream.

Blueberry Field

All alternatives result in reductions in maximum WSE compared to existing conditions, with Alternatives 3, 4, and 2 being most significant; however, Alternative 1 only shows a small reduction in WSE because this alternative proposes to realign Colony Creek through the blueberry field, thus adding more flow in this area. Despite the realignment, maximum WSE in the field is still lower than existing conditions, suggesting the wide floodplain between the proposed setback levees increases flood storage laterally, thus allowing water to spread out over a larger area, reducing WSE compared to existing conditions.

Macken Property

All four alternatives result in reduced maximum WSE at the Macken property monitoring point, with Alternatives 3 and 4 resulting in the greatest WSE reductions due to the proposed inset floodplains these alternatives include. The inset floodplain not only increases flood storage in the upstream project area by creating a wide floodplain where floodwaters can spread laterally, but the inset feature also creates vertical storage for sediment and water, thus causing a significant reduction in WSE. Alternative 1 does not include any design elements along Harrison Creek; therefore, maximum WSE is higher than other alternatives and there is no significant change in flood storage. Alternative 1's slight reduction in WSE on the Macken property compared to existing conditions is a result of Colony Creek being realigned and not joining with Harrison Creek at the current confluence, but farther downstream. Alternative 2 shows a more significant decrease in maximum WSE compared to existing conditions and Alternative 1; however, because this alternative does not include an inset floodplain, the minor decrease in WSE is likely related to the addition of multiple side channel cuts that allow water to take multiple flow paths when flows are high.

Old Colony Creek Ditch

At the old Colony Creek ditch monitoring point, Alternatives 3 and 4 show the greatest reduction in maximum WSE. Because Alternative 3 reduces WSE more than Alternative 4, this suggests that WSEs are impacted by the proposed inset floodplains downstream. Because the only difference between Alternatives 3 and 4 is the wide inset floodplain/levees in Alternative 3, it is likely that the downstream flood storage created by the inset floodplains is a key controller of WSE in the old ditch. In general, Alternative 1 reduces maximum flood storage the least, likely because this alternative realigns the creek through the blueberry field, thus directing main channel flow closer to the old ditch, which is connected to the main channel with side channel cuts. Though reductions in maximum WSE for Alternative 2 are not as significant as Alternatives 3 and 4, values are lower than existing conditions and Alternative 1; this is likely due to the setback levees in the downstream project area creating more lateral area for flood storage.

Wrucha Property

At the monitoring point on the Wrucha property, changes in maximum WSE values were relatively minor for all alternatives, though all four did show reductions compared to existing conditions. Alternatives 3 and 4 showed the greatest reductions due to the additional lateral and vertical flood storage created by the inset floodplains. Alternative 1 showed the next greatest reduction because of the Colony Creek realignment. Alternative 2 showed the lowest reduction in maximum WSE in this area, likely because, aside from adding a multithread channel in the upstream project area, this alternative does not include elements to increase flood storage, like an inset floodplain. Though they are relatively wide, this alternative also includes setback levees, which limit the lateral spread of floodwaters.

Flinn Road and Tide Gate

In the downstream project area, WSE varies under the two different hydrologic scenarios. Under both scenarios, Alternative 2 actually increases maximum WSE at both downstream monitoring points compared to existing conditions. This is due to proposed Alternative 2 levees limiting flood storage laterally in the downstream reach, thus raising the WSE between the levees. Under existing conditions, because portions of the existing levees are in disrepair, the levees are not entirely effective at limiting flood storage laterally, so flows are able to spread out in areas where levees are overtopped or breached, thus resulting in the lower maximum WSE under existing conditions compared to Alternative 2.

Under the offset hydrograph scenario, Alternatives 3 and 4 show the greatest reduction in maximum WSE in the downstream project area. Because these alternatives include inset floodplains, they create both lateral *and vertical* flood storage, which reduces WSE despite limiting flood between levees. Because Alternative 3 includes a wider inset floodplain than Alternative 4, WSEs are reduced more significantly due to the increased lateral storage. Alternative 1 results in the next greatest reduction in maximum WSE after the inset floodplain alternatives. Unlike Alternative 2, Alternative 1 proposes fewer downstream levees, and the levees that are proposed are wider. This allows floodwaters to spread out over a larger area, rather than restricting flood storage between levees, thus resulting in lower WSE values.

WSE and flood storage conditions are different under the peak hydrograph scenario. Under this condition, a rarer scenario when the peak discharge and peak tide align, Alternative 1 results in the most significant decrease in maximum WSE compared to existing conditions; this is likely because Alternative 1 proposes fewer, wider downstream levees that allow floodwaters to spread out over a wider area. Alternative 3 results in the next greatest decrease in maximum WSE as this alternative proposes both an inset floodplain and relatively wide levees, which both provide flood storage. Under the peak hydrograph scenario, both Alternatives 2 and 4 result in a higher maximum WSE compared to existing conditions. Though the setback levees in Alternative 2 are similar to those proposed in Alternative 3, Alternative 2 does not include an inset floodplain, so it is limiting flood storage laterally with levees, and also not providing vertical flood storage with an inset floodplain. Though Alternative 4 includes an inset floodplain, the proposed inset floodplain is narrower than Alternative 3 and is also limited by narrower levees, thus reducing the potential flood storage and raising the maximum WSE between the levees.

Overall, based on analyses of WSE and flood storage throughout the project area, alternatives that include inset floodplains (Alternatives 3 and 4) generally create the most flood storage; however, alternatives with the least restricted floodplains (Alternative 1) also improve flood storage. Floodplains where floodwaters are restricted by narrow levees generally experience decreases in flood storage. While Alternative 3, which proposes a wide inset floodplain upstream and downstream, reduced maximum WSE significantly throughout the project area, it should be noted that Alternative 1 also reduced WSE in key areas, like the downstream project area. However, reductions in WSE in the upstream project area are difficult to compare because Alternative 1 has an entirely different Colony Creek alignment than the other alternatives. Lastly, it is important to note that the magnitude of reductions in WSE compared to existing conditions is generally very small (see Section 4.3.2), especially within the downstream project area, so drastic changes in WSE should not be expected under any of the proposed conditions.

5.2 Reduced Flood Risk

All four alternatives include design elements aimed at reducing flooding on properties and agricultural lands adjacent to Colony Creek. These design elements generally focus on tide gate modifications, inset floodplains, setback levees/berms, or a combination of these elements. Because all proposed alternative model runs were completed with the same tide gate modifications, in general, proposed levees and inset floodplains are the main design elements that control flood risk for the alternatives. While the main purpose of levees/sediment is preventing flooding of property along a creek, the primary objective for inset floodplains is creating storage for both sediment and flow, which also helps to reduce flooding outside of the designated floodplain. Figure 5-1 shows an example of how adding levees and an inset floodplain can reduce inundation extents in a project area.

This section includes a broad, qualitative discussion of flood risk for each alternative; however, relevant model results for all alternatives are included in Appendix B. Appendix B includes modeled inundation maps for the upstream and downstream project areas for existing conditions and the four alternatives; figures in Appendix B were captured at two different timesteps, one timestep for the upstream reach when inundation appeared to be the most extensive, and one timestep for the downstream reach when inundation appeared to be the most extensive.

Alternative 1 realigns Colony Creek through the blueberry field and includes levees on either side to limit flood extents on the ajdacent agricultural areas. In the upstream project area, this realignment noticably reduces inundation extents through the properties along Colony Creek's and Harrison Creek's existing alignment; however, because this alternative does not include proposed design elements along Harrison Creek, inundation from Harrison Creek is still signifcant though the adjacent properties. Within the downstream project area, inundation extents are reduced in some areas, but because Alternative 1 involves more ambitious design elements, with fewer levees and levees that are set back farther than other alternatives, overall reducitons in inundation are relatively insignificant.

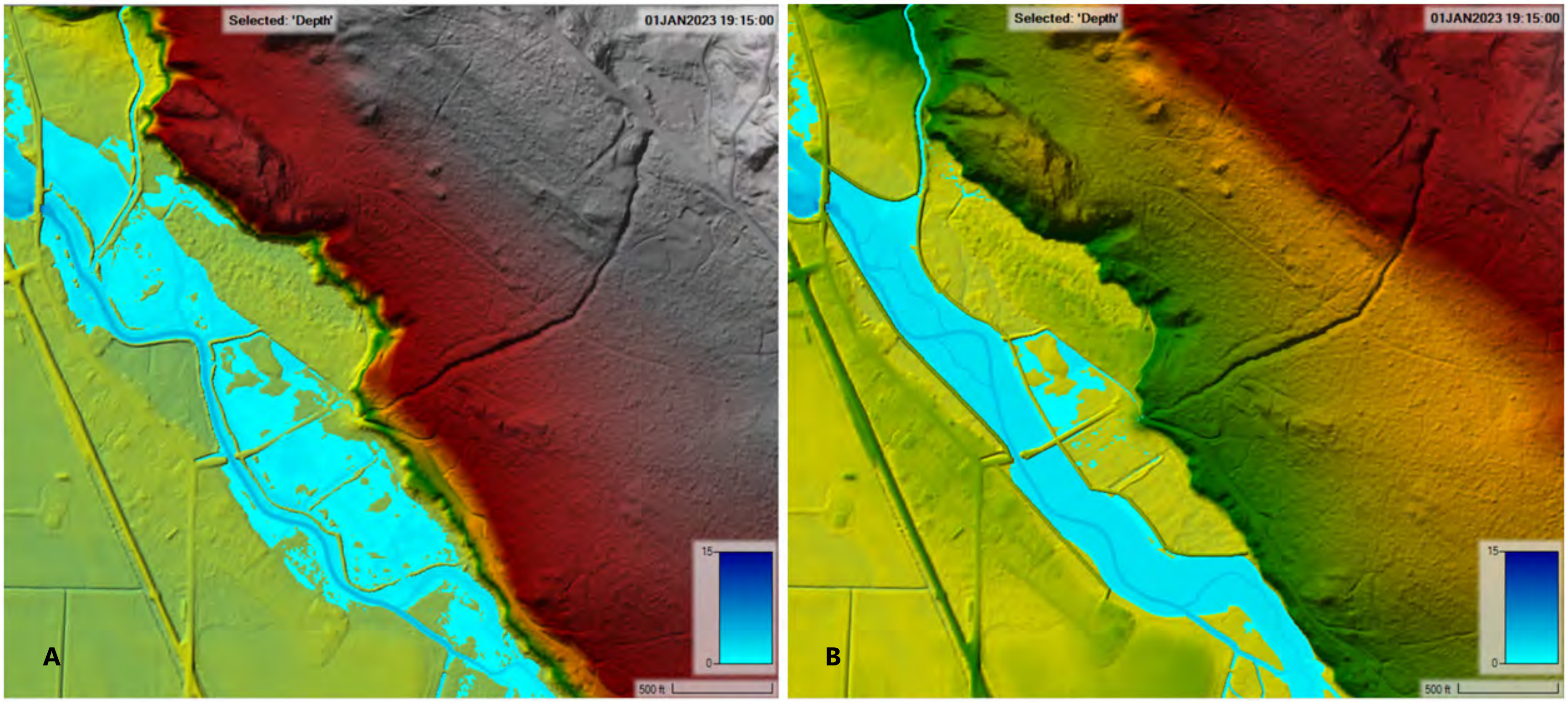
Alternative 2 includes the addition of setback levees in the upstream project area. These levees limit inundation extents from Colony Creek and Harrison Creek significantly along the properties west of the levees (Macken and Thelen properties). Though there are minor reductions in inundation extents along east of the levees (Wrucha property), these reductions are limited because the hydraulic model results show Harrison Creek flow spreading out and overtopping the private driveway on the Wrucha property, despite modeling a raised road up to the Wrucha residence. In the downstream project area, the proposed levees appear to be reducing inundation extents significantly on properties along both the right and left bank levees. Inundation on the property at the base of the hillside where flow from an unnamed tributary joins Colony Creek remains similar under existing and proposed conditions.

Alternatives 3 and 4 include the addition of a left bank setback levee and a wide inset floodplain in the upstream project area. The combination of these design elements significantly reduces inundation extents on properties adjacent to Colony Creek (Macken, Thelen, and Wrucha properties) compared to existing conditions. Based on visual analyses, Alternatives 3 and 4 show the most significant reduction in inundation extents on properties adjacent to Colony Creek in the upstream project area; Alternative 3 shows slightly higher reductions in inundation extents in the upstream project area compared to Alternative 4, likely due to Alternative 3's wider inset floodplain downstream, which increases water storage capacity.

In the dowsntream project area, the proposed levees along the left and right banks in Altenatives 3 and 4 both result in significantly reduced inundation extents on adjacent properties compared to existing conditions. The main difference between the downstream inundation extents for Alternatives 3 and 4 is the width of the inset floodplain. The narrower inset floodplain/levees in Alternative 4 confine flow within a smaller area, resulting in higher WSEs between the narrow levee. Alternative 3 provides a wider inset floodplain, allowing flow to spread out over a larger area, resulting in lower WSEs between the levees.

In general, though levees reduce inundation along adjacent properties, alternatives that include both levees and inset floodplains result in the most significant reductions in inundation extent due to the added water storage capacity the inset floodplains provide.

Figure 5-1
Modeled Flood Reduction Example



Notes: Figure 5-1a shows modeled inundation and water depth under existing conditions in the downstream project area. Figure 5-1b shows modeled inundation and water depth at the same timestep and location under proposed conditions (Alternative 3). Both figures show results from offset tidal hydrograph model runs.

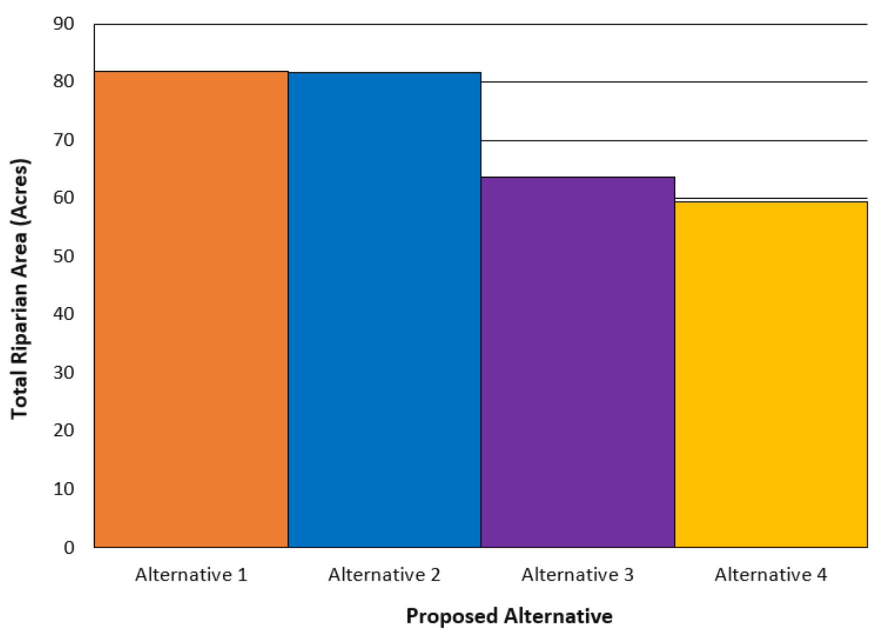
5.3 Riparian Areas

All four alternatives include removal of reed canary grass paired with riparian plantings; however, the extent of the proposed riparian areas vary between alternatives. Figure 5-2 shows the proposed total increase in area covered by riparian plantings over the existing area covered by riparian vegetation for each alternative. Alternative 1 includes realignment of Colony Creek and a wide floodplain through the blueberry field paired with a wide levees downstream, making it the alternative with the highest acreage covered by riparian vegetation. Alternative 2 has a similar, but slightly lower, riparian acreage due to the wide proposed floodplain in the upstream project area and more narrow levees downstream compared to Alternative 1.

Alternatives 3 and 4 offer less proposed total area covered by riparian plantings because these alternatives include slightly narrower but inset floodplains. Though these alternatives are identical in the upstream project area, the proposed levees and riparian/floodplain area in the downstream project area is narrower in Alternative 4, making it the lowest ranking alternative in terms of total proposed riparian area.

It should be noted that though it is not specifically quantified, proposed large wood density is directly related to available riparian/floodplain area, so ranking for proposed large wood density is assumed to be the same as the ranking for total proposed riparian area (Figure 5-2).

Figure 5-2
Total Proposed Added Riparian Area

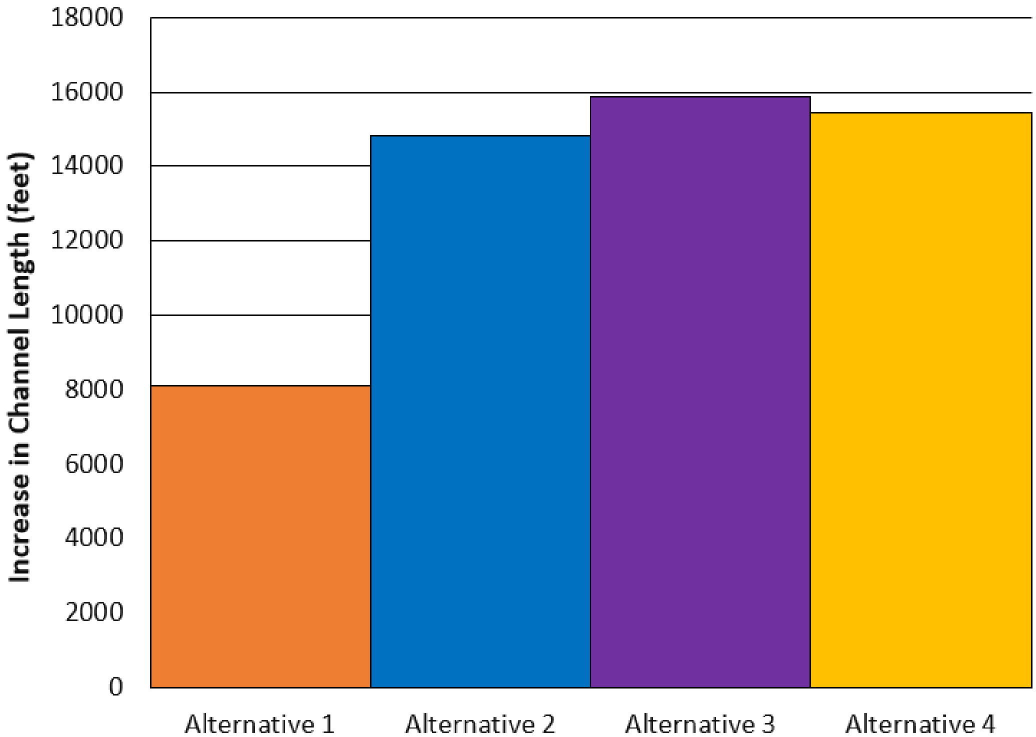


5.4 In- and Off-Channel Habitat

Figure 5-3 shows the increase in total channel length for each alternative compared to existing conditions. In this case, channel length includes both added main channel length and added side channel length because these additions provide in-channel and off-channel habitat for salmonids. All alternatives offer significant increases in channel length compared to the existing conditions. Alternative 1 appears to offer the least amount of added channel length due to the channel realignment not showing significant side channel cuts; additionally, the realignment ties into the previously restored reach that would also be off-channel habitat in the other three alternatives. A likely constructed option for Alternative 1 would have channel lengths that compare more similarly to the other alternatives. Additionally, despite appearing to have the lowest increase in total channel length, Alternative 1 does make use of the previously restored reach by returning main channel flow to this reach where restoration work has already been completed.

Alternative 2 has a more significant increase in channel length compared to Alternative 1, but still ranks lower than Alternatives 3 and 4. Though Alternative 2 includes a multithread channel in the upstream project area, this alternative does involve keeping Colony and Harrison creeks combined and adding additional side channels, while Alternatives 3 and 4 allow Colony and Harrison creeks to remain separated. Keeping Colony and Harrison creeks separated increases the cumulative channel lengths for Alternatives 3 and 4, making these the highest-ranking alternatives for increases in channel length. Though the upstream project area is the same for these alternatives, the downstream project area for Alternative 4 has narrower levees and a smaller floodplain area, resulting in less space for side channels. Alternative 3 results in the most significant increase in channel length, thus providing the most potential in-channel and off-channel habitat for salmonids.

Figure 5-3
Increase in Cumulative Channel Length Compared to Existing Conditions



5.5 Sediment Storage

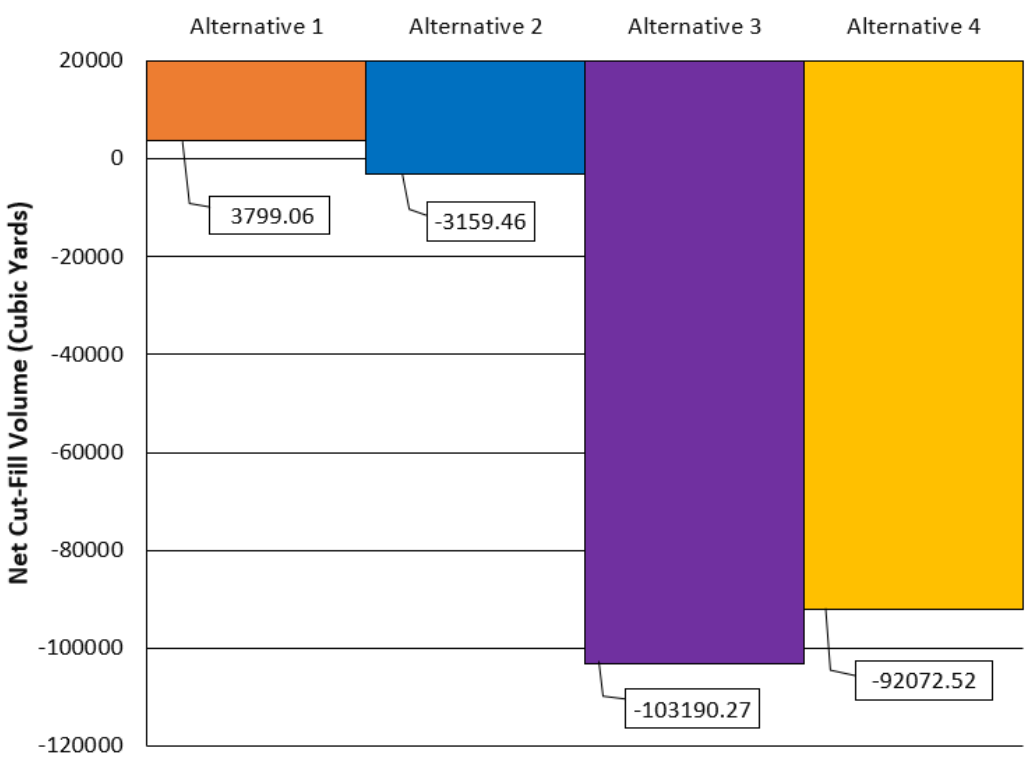
Sediment storage is a known concern within the project area. Due to the unnatural alignment of Colony Creek discussed in Section 2, natural alluvial fan deposition is not possible under the existing conditions. All four alternatives address the sediment storage concerns in different ways, resulting in a range of net cut-fill volumes shown in Figure 5-4. Positive net volume values indicate that more material is added to the project area than is removed, while negative net volumes indicate that more material is removed from the project area than is added.

All alternatives aside from Alternative 1 result in a net decrease in volume, meaning there is more space available for future sediment deposition and storage. While Alternative 2 involves removing material by adding channel cuts, Alternatives 3 and 4 involve removing material by cutting both inset floodplain and by adding channel cuts. Because Alternatives 3 and 4 include cutting large inset floodplains in addition to channel cuts, these alternatives remove significantly more material than other alternatives and provide the greatest amount of potential sediment storage. Because Alternative 3 includes a slightly wider inset floodplain in the downstream project area compared to Alternative 4, Alternatives 3 ranks the highest in terms of potential sediment storage.

Though Alternative 1 results in a net increase in cut-fill volume, this is primarily due to the constructed levees that would allow the channel realignment to occur. Because of the channel realignment, this alternative still results in a net increase in available storage area. It should also be noted that this is the only alternative that addresses a core geomorphic issue at this site: the unnatural alignment. Prior to European settlement in the region, Colony Creek's alignment was likely more similar to the alignment proposed in Alternative 1, which allows the creek to continue straight when it exits the hillside, rather than immediately being routed into an alignment with a 90-degree bend. The proposed alignment in Alternative 1 also is the only alternative that reconnects Colony Creek to its historical alluvial fan by rerouting the channel through the blueberry field and creating a wide floodplain between setback levees where Colony Creek can deposit sediment (Figure 2-1; 3-3).

Though the other three alternatives, particularly Alternatives 3 and 4, provide significant amounts of sediment storage within the inset floodplains, Alternative 1 does realign the channel to a more natural location, and while Alternative 1 does not remove existing material, it does reconnect Colony Creek to its historic alluvial fan and provides a wide floodplain so natural depositional processes can be restored.

Figure 5-4
Proposed Net Cut-Fill Volume



5.6 Level of Effort

The level of effort for each of the proposed alternatives is based on local landowners' willingness to participate in a particular project, and the level of effort it would take to construct the project elements.

Based on feedback received form landowners during the three landowner engagement meetings, Alternative 4 is likely the highest-ranking alternative for landowner participation. In general, most landowners seemed open to the idea of an inset floodplain and understood the sediment and flood storage benefits. Some downstream landowners did voice concerns over the extent of the proposed inset floodplain in Alternative 3, which resulted in the reduced extent of the inset floodplain and more narrow levees presented in Alternative 4. As discussed in Sections 5.3 and 5.4, the fact that the levees are less set back in Alternative 4 decreases the available connected floodplain and riparian areas in these alternatives, which may decrease the potential for future funding desirability.

Because landowners seemed receptive to the idea of an inset floodplain that would address sediment and flood storage concerns, Alternative 3 is likely the second-highest ranking alternative. Though the inset floodplain received positive feedback, as noted previously, some downstream landowners did voice concerns over the extent of the floodplain, so it is not expected to have as much support as Alternative 4. Alternative 2 is likely ranked after Alternative 3 because it has the same proposed floodplain extent in the downstream project area, but with no inset floodplain upstream or downstream.

Based on feedback from landowners, the downstream portion of Alternative 1 is likely the lowest-ranking alternative for landowner participation. This alternative includes a less restricted floodplain in the downstream project area, with fewer proposed levees, and levees that are set back farther than those proposed in other alternatives. Landowners in the downstream project area, particularly along the right bank, may not be willing to participate in all aspects of this alternative. At the upstream end, this alternative would involve realigning Colony Creek through the blueberry field. The owner of the blueberry field has been involved in some initial discussions about implementing this alternative and was open to the possibility. Constructing any potential restoration actions as significant as those shown at the upstream end of Alternative 1 would likely require partial purchase or creation of an easement on the property.

5.7 Alternative Evaluation Summary and Conclusions.

Alternative 2, which focuses on moderately setback levees with only riparian restoration and pilot channel cuts, ranks the lowest based on these evaluation criteria. The primary conclusion from the analysis of this alternative is that only setting back levees is not sufficient to significantly decrease inundation levels. Because many of the existing levees are in some state of disrepair or have incomplete coverage, constructing setback levees that are more effective as shown in Alternative 2 would actually decrease the available flood storage areas. In a similar manner, sediment storage would be decreased, and it is likely that Alternative 2 would be least effective at absorbing future sediment inflows. Positives of Alternative 2 include more riparian areas and in/off-channel habitat, but not significantly more than the other alternatives.

Alternatives 3 and 4 also include significant areas of setback levees, but combine those with creation inset floodplains within the leveed area. The inset floodplains significantly increase the volume available for flood and sediment storage. The primary difference between Alternatives 3 and 4 is the distance and degree to which levees are setback. The levees in Alternative 4 were adjusted based on landowner input, particularly from downstream landowners in the Blanchard area. This results in some decreased capacity for sediment and flood storage and increased WSEs. Alternatives 3 and 4 represent a compromise between habitat and flood benefit and some combination of these may be the most practical to implement solution in the area.

From a geomorphic and sediment storage perspective, Alternative 1 provides the best option by a significant margin. Rerouting Colony Creek into the likely historic flow path would provide significantly more storage area and lateral migration area for the creek, reducing downstream sedimentation problems and in the offset hydrograph scenario reducing downstream WSEs. This alternative also provides the largest improvement to riparian area and off-channel habitat, making it the top alternative for the habitat improvement metrics. While Alternative 1 may provide the best possible solution, it is highly dependent on a likely expensive and logistically difficult channel realignment, making implementation more difficult. Additionally, the downstream portion of Alternative 1 sets levees back to an extreme degree, making it extremely unlikely that downstream landowners would agree to this option.

Ultimately, the best possible action is likely a combination of Alternatives 1 and 3. The channel realignment in the upstream portion of Alternative 1 would allow for the best habitat improvement and natural sediment transport regime. This could easily be combined with the downstream portion of Alternatives 3 or 4 that would moderately setback levees and create an inset floodplain throughout the Blanchard community. This combination of alternatives would likely provide both the best reduction in WSEs, most storage and natural conveyance of sediment, and most improve habitat and riparian areas. The primary barrier to this combination would be the cost and logistics on the upstream channel realignment.

6 Recommendations, Future Work, and Next Steps

This report is not meant to define a finalized best course of action for the Colony Creek area, but rather identify pathways and future implementation strategies for restoration and flood protection as well as to identify where additional study might be needed. This section outlines a set of recommendations based on the collected data and analysis described in this report.

6.1 Coordination with Skagit County

Several aspects of the Colony Creek and McElroy Slough estuary will need to be determined through long-term action or broad policy decisions that would be most effective if implemented at the local government level. The following recommendations would require coordination and cooperation with Skagit County to implement.

6.1.1 Additional Study of Tide Gate and Potential Modifications

At each public meeting landowners emphasized the desire for adjustments to the tide gates. The analysis in this report suggests that improving the flaps on the tide gates would provide only a marginal increase in the tide gates efficiency. However, these results should be confirmed with actual data. Collecting WSE data immediately upstream and downstream of the tide gate would allow an accurate picture of the hydraulic capacity of the tide gates to be established. Additionally, the SRT should be regularly maintained and monitored to ensure that the gate consistently closes at the design 5-foot elevation. Based on these analyses, it is unlikely that any modification to this level for the SRT would result in a significant difference for either flood inundation or habitat values.

6.1.2 Limit Increased Flows from the Upper Watershed

Based on comments from local landowners living along Colony Creek and Harrison Creek, in recent years, development and construction activities within the upper watersheds on the hillside just east of the project area and may be causing an increase in total peaks and flashiness of high flow events in Colony Creek. Although there is insufficient hydrological data to confirm this, a comparison of aerial imagery of the watershed does show an increase in areas that appear to be cleared and developed. Whether or not flow rate offsets have also been constructed with these developments is unknown, but if not, clearing and developing forest hillslopes is known to increase direct storm runoff rates and sediment delivery downstream. A next step to address this potential problem would be a more detailed analysis of recent developments in the watershed and potentially implementing stricter regulations on clearing and development without flow rate mitigation. As development continues within the upper watershed, limiting surface water runoff related to new development and construction activities is recommended to prevent exacerbation of flooding issues in the Blanchard and lower Colony Creek area.

6.1.3 *Maintain Existing Levees, Drainage Paths, and Small Tide Gates*

The existing drainage network was modeled in this analysis to a level of detail necessary to make recommendations for drainage improvements. However, during field observations there were several locations where smaller tide gates were operating inefficiently and allowing tidal backwater to inundate partially behind existing levees. Several levees were pointed out by landowners that regularly overtop and cause flooding in fields and residential areas. Additionally, the tide gate between the blueberry field and Colony Creek under Colony Road has been reported to allow fish into the blueberry field where they can be stranded. Regular monitoring and maintenance of these drainage infrastructure could improve several of the reported problems in the area.

A first step towards maintaining and improving drainage features in lower Colony Creek is simply identification of what and where the issues occur. While this report notes several significant locations where drainage infrastructure is potentially operating incorrectly (such as the tide gate under Colony Rd to the blueberry fields), complete identification of issues with the drainage network is out of the scope of this report. Identification of drainage issues could be a grass-roots type process, with landowners identifying and documenting where drainage issues are occurring. Pertinent information that would be useful for this type of assessment could include location, type of infrastructure (i.e. tide gate, drainage ditch etc.), and whether or not the problem is solely drainage, or if it is linked to a specific water surface elevation being present in the creek. Landowners and the County would likely need to work together on a case-by-case basis to identify who will be responsible for identification of issues and maintenance of these drainage features.

6.2 Additional Analysis

This analysis has focused on developing large-scale alternatives and sets of design elements that could reduce flooding and sedimentation and improve habitat and riparian vegetation. Through this work several additional areas of data collection and analysis have been identified that could further guide and refine these large-scale recommendations.

6.2.1 *Assessment and Mapping of the Drainage Network*

Though the major hydrologic inputs within the Colony Creek project area were included in the hydraulic model (see five main inputs in Figure 4-3), due to the agricultural/developed nature of the project area, there are many other smaller, unmapped surface water and runoff inputs that contribute to Colony Creek. Because of this, stormwater and drainage may play a large role in flooding/inundation behind the levees that is not accounted for is this assessment. Mapping this drainage network and estimating its effects on flooding and inundation to private landowners could provide additional insight into future project implementation in this area. Additionally, because all proposed conceptual alternatives include the construction of levees in the project area, it is important that all hydrologic inputs, even small ditches, are mapped. Because the proposed levees would be effective levees, unlike some existing levees that are in disrepair, if any drainages become blocked by proposed levees and culverts are not proposed to convey flow through the levees, this could cause drainage issues behind the levees. Future work within the project area should include detailed mapping of drainage networks in the project area.

6.2.2 Additional Modeling and Model Calibration

This hydraulic model for this analysis focused on a regularly occurring major storm event (approximately 2-year return interval) which peaked with extreme tidal conditions (see Section 4.1). These model results were calibrated based solely on conditions observed in the field with limited available data. Installing a series of water level data loggers would provide data that could be used to refine the model results. The following locations are recommended at a minimum to provide adequate information for better model calibration:

- Upstream of the McElroy Slough tide gate
- Upstream of the Colony Mountain Road Culvert
- Upstream of the private bridge for the Morse Property on the Colony Creek ditch

In addition to better calibration of the model developed for this assessment, additional modeling runs and scenarios would help provide better recommendations for a range of outcomes. Additional model runs could include flows capture more regular flow events such as a 1-year event and various tidal conditions.

6.3 Potential First Step Projects

Through this analysis and initial discussion with local landowners, several projects that could be implemented and have immediate impact have been identified in this section. Each of these projects will need more detailed design and analysis towards implementation.

6.3.1 Colony Mountain Road Crossing Area

The flooding over Colony Road poses a yearly problem in the area for both safety and accessibility. This assessment has identified three primary drives of this flooding, all of which are interconnected to some degree: 1. low slope in the Colony Creek ditch causing sedimentation and flooding; 2. lack of capacity in the Colony Mountain Road culvert (which is exacerbated by sedimentation); and 3. the artificial right angle turn that Colony Creek must take right as it enters the historic alluvial fan.

The best possible option for this area would be the channel realignment described in Alternative 1. A primary first step action should be to assess the possibility of this further pursuing a channel realignment project from a land acquisition/easement perspective and if possible, progressing to more detailed analysis and design of this option. This first step project would likely need to include all the upstream project elements described in Alternative 1, down to at least where the new channel would cross back under Colony Road. Ideally this project would also include the project elements in Alternative 1 down to the confluence with Harrison Creek.

If the channel realignment in Alternative 1 is not possible, all of the other alternatives propose to replace the culvert under Colony Mountain Road and route the channel through the current field on the Macken property. Some discussion with this landowner has already been started and a project here could likely move quickly to more detailed design and analysis. Projects in this location should focus on creating more slope for Colony Creek by rerouting the channel through the field and should extend at least to the Downstream Access Drive. This project would likely include the elements described in Alternatives 3 and 4, including: replacing Colony Mountain Road culvert, creating left bank levee for new channel alignment, removal of reed canary grass, excavating for inset floodplain, intensive riparian plantings, installation of large woody material and habitat structures, and, finally, replacement of the culvert under the private drive at the downstream end of the Macken property.

6.3.2 Blanchard Community Levee Setbacks and Inset Floodplain Creation

Based on conversation with landowners, there is likely willingness and opportunities for smaller projects within the Blanchard community levee system area. This analysis showed that a combination of levee setbacks and inset floodplain, such as shown in Alternatives 3 and 4, is likely the best way to address flooding and improve riparian habitat in this area.

However, because of the necessity of pairing any setback levees with inset floodplain, removal of reed canary grass, and riparian plantings, projects in this area would be best accomplished across multiple properties, as opposed to in isolation on single properties. Participation of the properties and landowners on both the left and right bank of any reach targeted for a future project would likely be necessary both from a logistics and habitat benefit point of view. The most ideal project for this area would be a single project that incorporates the entire Blanchard area levees and drainage system. This project would likely require a more detailed evaluation of the drainage system as described in Section 6.2.1 and this may be a good first step for any projects in the Blanchard area.

7 References

ESRI. 2023. ArcMap Version 10.8.2.

Google Earth, 2023. 1985 and 2022 Aerial Imagery. Accessed June 2023.

Granite (Granite Precasting & Concrete Inc.), 2012. Colony Road Design Computations for 20'-0" Span x 8'-0" Rise 3-Sided Bridge. Prepared for Skagit County. August 2012.

Mastin, M.C., C.P. Konrad, A.G. Veilleux, and A.E. Tecca. 2017. "Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014." *U.S. Geological Survey Scientific Investigations Report 2016–5118,* Version 1.2, November 2017.

MWG (Montgomery Water Group). 1999 "McElroy Slough Restoration Design Report." Prepared for Skagit Fisheries Enhancement Group. October 1999.

NHC (Northwest Hydraulic Consultants, Inc.), 2007. *Colony Creek Colony Mountain Drive Sediment Management and Flood Protection Evaluation Final Report*. Prepared for Skagit County Department of Public Works. May 2007. Available at: https://www.skagitcounty.net/PublicWorksSurfaceWaterManagement/Documents/ColonyCreek/01%20Colony%20Creek%20Final%20Report%20Text.pdf

NOAA (National Oceanic and Atmospheric Administration Office for Coastal Management), 2020. 2019 NOAA Lidar DEM: Padilla Bay NERR and Skagit River Delta, WA. NOAA National Centers for Environmental Information. Available at: https://www.fisheries.noaa.gov/inport/item/58958.

NOAA, 2023. Tidal Station 9449424 at Cherry Point, WA. Accessed January 2023. Available at: https://tidesandcurrents.noaa.gov/waterlevels.html?id=9449424&units=standard&bdate=20230102&edate=20230103&timezone=GMT&datum=MLLW&interval=6&action=data

QSI (Quantum Spatial, Inc.). 2017. Western Washington 3DEP LiDAR Technical Data Report. Prepared for USGS North Puget Sound. September 29, 2017.

SFEG (Skagit Fisheries Enhancement Group), 2022. McElroy Slough Estuary Restoration Project Summary. Available at: http://www.skagitfisheries.org/Documents/Map/McElroy_Summary.pdf.

Skagit River Journal, 2020. The Birth of Brownsville and Bow, Skagit County. Available at: http://www.skagitriverjournal.com.

SRP (Salmon Recovery Portal), 2022. Lower Samish River. Available at: https://srp.rco.wa.gov/project/280/16047

USACE (U.S. Army Corps of Engineers), 2021. HEC-RAS 2D User's Manual. Available at: https://www.hec.usace.army.mil/confluence/rasdocs/r2dum/latest.

USDA (U.S. Department of Agriculture). 2019. NAIP Aerial Imagery. Available at: https://naip-usdaonline.hub.arcgis.com/

USGS (U.S. Geological Survey National Land Cover Database), 2019. Multi-Resolution Land Characteristics Consortium. Available at: https://www.mrlc.gov/viewer/.

USGS, 2023a. StreamStats in Washington. Available at: https://streamstats.usgs.gov/ss/.

USGS, 2023b. Monitoring Location 12201960, Brannian Creek at S Bay Dr Near Wickersham, WA. Accessed January 2023. Available at: https://waterdata.usgs.gov/nwis/uv?site_no=12201960&legacy=1.

WDFW (Washington Department of Fish and Wildlife), 2023. Washington State Fish Passage Map. Accessed June 2023. Available at: https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html.

Appendix A
Landowner Comments

1605 Cornwall Avenue
Bellingham, Washington 98225
360.733.4311

Memorandum

March 29, 2023

To: Colony Creek and Harrison Creek Landowners

From: Anchor QEA, LLC; Skagit Conservation District

Re: Colony Creek and Harrison Creek Landowner Engagement Meeting Notes

Concept Comments from Landowners (Notes from Anchor QEA, LLC)

Upstream Concepts

- Looking at Concept 1, one landowner mentioned that the county may not be comfortable with the reroute because of the proposed culvert on Colony Road.
- Multiple landowners suggested that Concept 1 will likely be a no-go for the blueberry farmer but noted that we should try to reach out to that landowner.
- Richard, who cares for Julia Wrucha's property, mentioned that Colony/Harrison Creek flow is currently dispersed throughout Julia and George's property, and he has been finding fish throughout the field (he marked up a large poster to show general flow paths). In general, he made it clear that flooding of the Wrucha property is still very much a problem.
- Richard also said there are three new beaver dams through the reach between Julia and George's properties and that the beavers have rebuilt the lodge on the downstream property that appeared to have been removed during the site visit earlier this year.
- One landowner mentioned flooding over the private driveway and that not all flow is going through the private driveway culvert.
- Nora mentioned fish stranding on the Macken property and wondered whether a temporary permit could be used to cut a small flow path that fish could use to get up- and downstream without getting stranded in the fields of reed canary grass (RCG).
- Bev Macken wanted to ensure that cattle would be able to walk from her upper property to the new field. We discussed that this could involve a road along the old creek and an expanded culvert to allow cattle to cross next to the road. Bev also said that she would like to see the levee moved closer to the creek than as shown.

Downstream Concepts

- Distance of levee setback was discussed with several landowners. The Werders do not feel that they can have the levee set back any more than it is on their upstream field and would prefer the levee in the same location because it has already been set back (right bank, downstream of Whitehall/Colony confluence). Several other options for this location were discussed, including raising the field elevation and adding a "flare out" to the levee around

Whitehall Creek. Some degree of setback levee on the Werder's upstream field was discussed as a possibility.

- Several landowners also noted issues with increased runoff and flooding due to hillside development and logging roads. It was also noted that there is an increase in sediment load from Whitehall Creek (over the last 1 to 2 years), likely due to mass wasting along Whitehall Creek.
- On south side of Colony Creek (left bank), landowners generally felt that the setback levee was too far back (particularly at the point bar area) and may not be acceptable to that landowner; however, some also noted that certain landowners along the south bank in this area who were not present may really like the levee idea because they currently have serious issues with flooding.
- In general, downstream landowners agreed that an in-person walk-through of their property to discuss design concepts would be more helpful to get a 3D visual of the changes they would see.
- The inset floodplain idea resonated with a few of the landowners; it made sense to them that this option would remove RCG and provide more room for sediment and water all in one design element.

General Questions/Comments from Landowners (Notes from Emmett)

- Steve requested emailed maps, presentation, and concepts.
  - These have been sent to the mailing list along with these notes. Please let Mike know of any landowners who should be getting this information but haven't.
- Will cut-down channels create more room for king tides, or just flooding?
  - After-meeting answer: Mostly just flooding—although they would provide additional storage for when the king tides are preventing peak flows from leaving the system.
- Seawalls? Need more information about how that would affect storage, tides, and sediment.
  - After-meeting answer: This was discussed for the left-bank (south) side of the estuary downstream of the tide gate for landowners in this location. It would not be expected to affect storage or sediment upstream of the tide gate.
- Is Conservation Easement payment considered income and taxable?
  - After-meeting answer: Yes, this would be taxable income.
- Can a portion of a property be fee-simple purchased in Skagit County for conservation?
  - After-meeting answer: Fee-simple options may be available depending on the funding source.
- Are Conservation Reserve Enhancement Program payments considered taxable income?
  - After-meeting answer: Yes, this would be taxable income.
- What would a culvert under Wrucha's driveway look like? How do you keep it from filling up with sediment or reducing flooding to the rest of the driveway?

  - After-meeting answer: We would look at a range of options to replace the culvert, one of which would be a box culvert, wider and higher than the current culvert, that should allow free passage of sediment. Adding upstream flood storage (and sediment depositional areas) would also help with this.
- It seems important to have a maintenance plan for culverts and drainages that the community could follow up on and hold the county to account.
  - After-meeting answer: Agreed—a set of recommendations for maintenance and county improvements will be part of the final draft. Bill is also going talk to the county about including this in the 2024 county budget.
- Can we get started with tide gate evaluation and begin working toward redesign of the gates now?
  - After-meeting answer: We are looking into this and will be contacting the county and some local experts on tide gates. It seems like a good idea to get this part of the ball rolling.
- Emmett can call Kari Oden at Skagit Land Trust and ask about fee-simple purchase of a portion of a parcel and will also try to ask Lea Forbes at Skagit County about this.

1605 Cornwall Avenue
Bellingham, Washington 98225
360.733.4311

Memorandum

May 26, 2023

To: Colony Creek and Harrison Creek Landowners

From: Anchor QEA, LLC; Skagit Conservation District

Re: Colony Creek and Harrison Creek Landowner Engagement Meeting Notes

Questions from Landowners

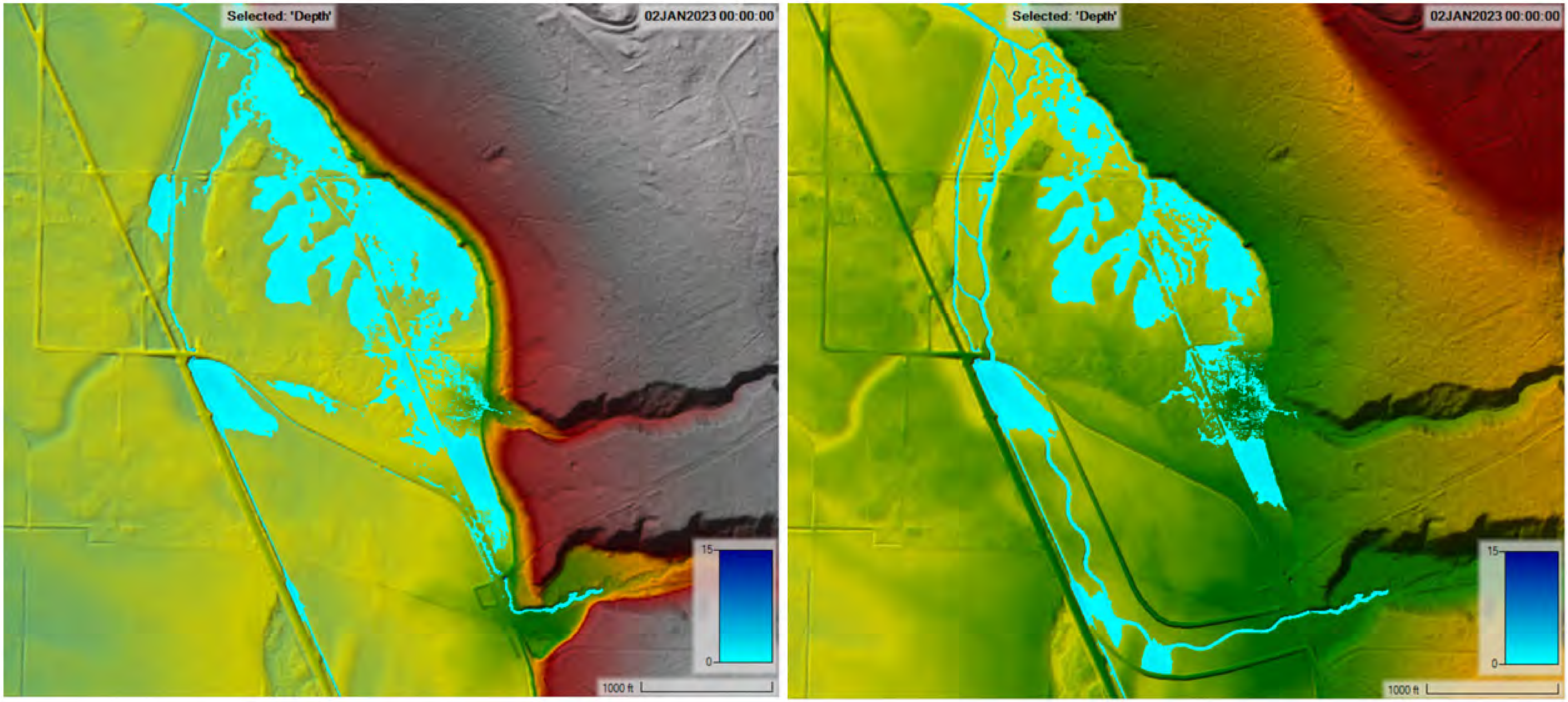
- Regarding the hydraulic model, one landowner asked whether we could flatten the hydrograph and then run it with the tidal hydrograph.
  - Tracy (Anchor QEA, LLC) noted that we use the hydrograph to account for the smaller tributaries that join Colony Creek and the timing of those flows.
- Will the tide gate definitely release water more rapidly? Another person asked whether we had compared the self-regulating tide gate (SRT) and flap gates in the model— how much of the flow going through the tide gate comes through the flap gates versus the SRT?
  - Mike (Anchor QEA) noted that an improved tide gate should release water more rapidly and also that a comparison of the SRT and flap gates in the model would not account for issues with the SRT; the modeled SRT would simulate an SRT functioning properly, so if the SRT did malfunction, the model findings would not reflect that.
- In alternatives where fill is placed outside levees, what is the total volume removed with pilot channel cuts and inset floodplains, and what is the proposed amount to be used for fill (and how deep and other details)? Ultimately, what is the proposed net volume of removal from the project area or the total amount of added capacity from this work?
  - Post-meeting response: The ultimate net volume of each alternative is noted in the final report.
- Would raising Flinn Road would create a dam situation, with water being trapped upstream of it? In the alternatives that raise Flinn Road, how is flow volume and timing managed to allow water backed up behind Flinn Road to escape? Bigger culverts?
  - Mike noted that water would still be conveyed downstream through the existing crossing structure (culvert/bridge).
- Are the water surface elevation (WSE) drops that were being presented even significant enough to make some of these alternatives worth it?
  - Post-meeting response: These model findings are specifically for a 2-year storm event with higher tides. It is likely that with other, more common storm-tide combinations, the net lowering of WSE would be more. However, most of these options also present

benefits beyond lowering WSE, such as more effective setback levees, improved riparian areas, and increased sediment storage.

- What is the long-term plan for certain project elements like repaired levees? Who is responsible for long-term upkeep/maintenance? Will there be funding for long-term maintenance?
  - Post-meeting response: Long-term maintenance will be crucial for the success of any projects implemented here, and this will be noted in the report.
- Does the model or this report include the levees and flooding downstream of the tide gate?
  - Emmett (Skagit Conservation District [SCD]) noted that he met with some landowners down there and looked at the existing dikes that are in disrepair. He will be coordinating with those landowners.
- One landowner noted that following high tide, the low tide isn't that low, and this might impact the model results and findings. The overall consensus from landowners is that getting water back out as quickly as possible is crucial.
- Several landowners noted that the tide gate should be a high-priority project, and it would be nice to complete that project and then monitor how that change impacts flooding.
- One landowner voiced that they believe dredging would be a good solution to the flooding and sediment concerns. They noted that Colony Creek has been dredged in the past, and that was effective, but it has not been dredged again since the 1970s.
  - Mike (Anchor QEA) noted that the inset floodplain alternatives (Alternatives 3 and 4) are intended to allow for more sediment and water storage by lowering the floodplain to around the creek and creating more storage in the existing area.
- Is there a maintenance need for inset floodplains? What is that, and how do you do it (equipment and permitting) and how often?
  - Post-meeting response: Ideally the inset floodplain would be large enough to make long-term maintenance from a sediment perspective less needed. The volume available for sediment depositions will be many times greater than it would be after just dredging the existing channel, and if more lateral area for channel migration is allowed, alternate flow pathways can form without causing harm to private or public property outside of the floodplain area.
- One landowner noted that he is concerned that Alternative 1 will cause properties upstream of the blueberry field area to have additional flooding. The landowner also noted that development on the hillside is already increasing the amount of water in his area.
- In general, multiple landowners voiced concerns about development on the hillside because the increased surface water runoff seems to be a consistent issue for many folks. What can be done with Skagit County regarding upland development and managing/mitigating increased stream flashiness and water volumes as a result of development?

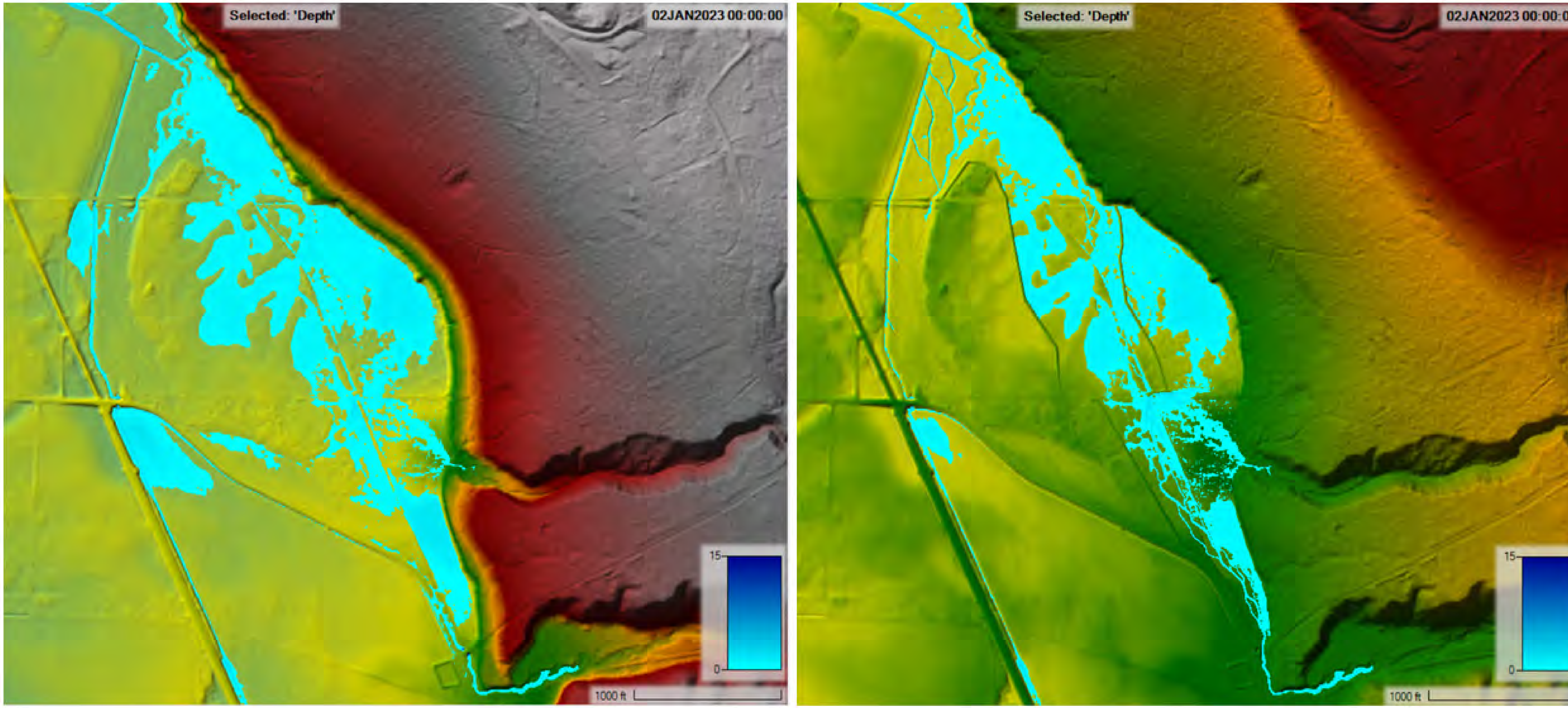
  - A landowner suggested that the Anchor QEA team should model more regular flow events rather than "extreme" events.
  - Mike noted that one of our next steps will be modeling the offset stream and tide hydrograph to simulate a more regular flow event.
- Will the report in June be sent out for comments via email?
  - The report will be uploaded to the SCD website, and a link will be sent out. Michael asked for comments following the meeting before the report is published and after the report is published to inform next steps.

Appendix B
Modeled Inundation Maps



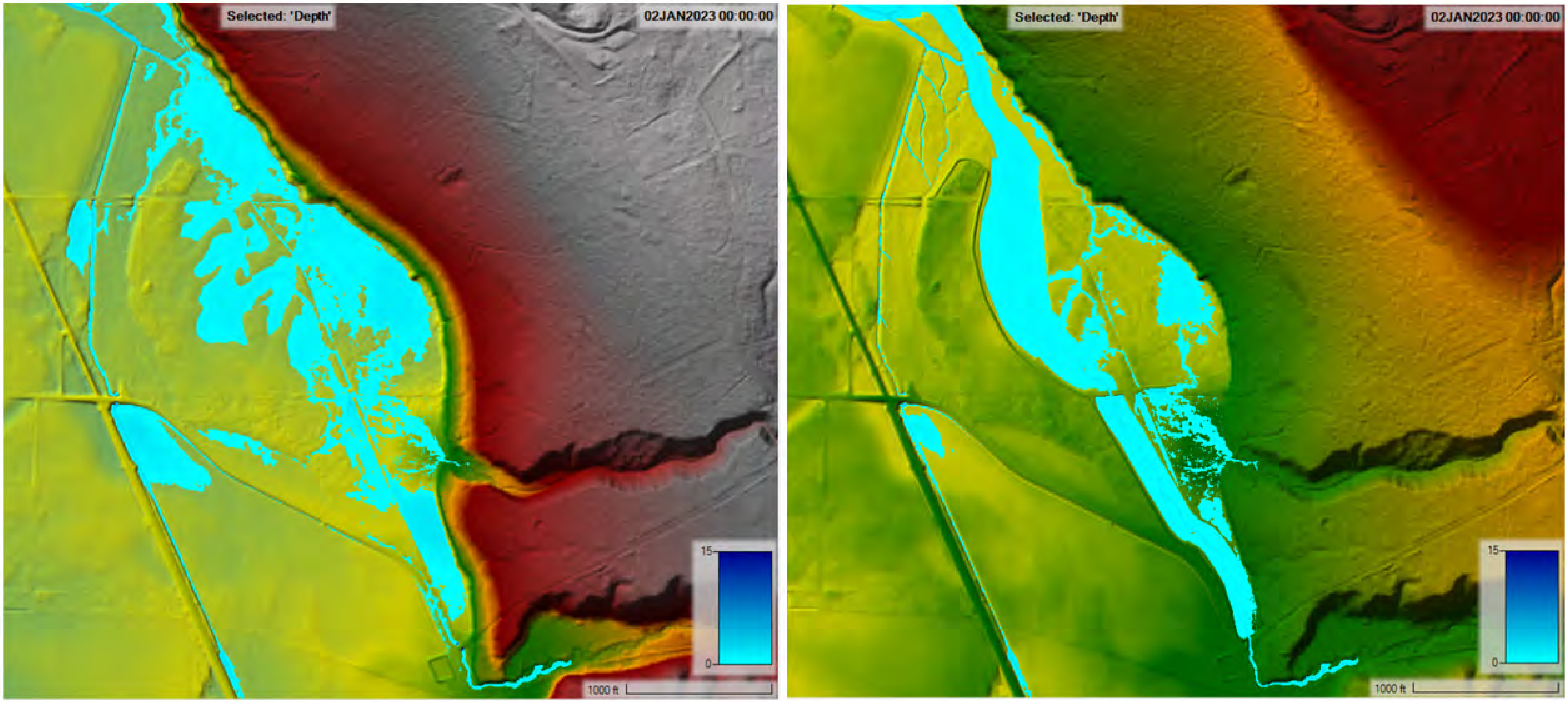
Note: Figure on left shows modeled inundation and depth under existing conditions in the upstream project area. Figure on right shows modeled inundation and depth for Alternative 1 in the upstream project area. Both modeling results were pulled at the 1/2/23 00:00:00 timestep, when inundation appeared to be most extensive in the upstream project area. Figures show model results from the offset tidal hydrograph scenario.

Figure 1
Modeled Inundation – Upstream Project Area



Note: Figure on left shows modeled inundation and depth under existing conditions in the upstream project area. Figure on right shows modeled inundation and depth for Alternative 2 in the upstream project area. Both modeling results were pulled at the 1/2/23 00:00:00 timestep, when inundation appeared to be most extensive in the upstream project area. Figures show model results from the offset tidal hydrograph scenario.

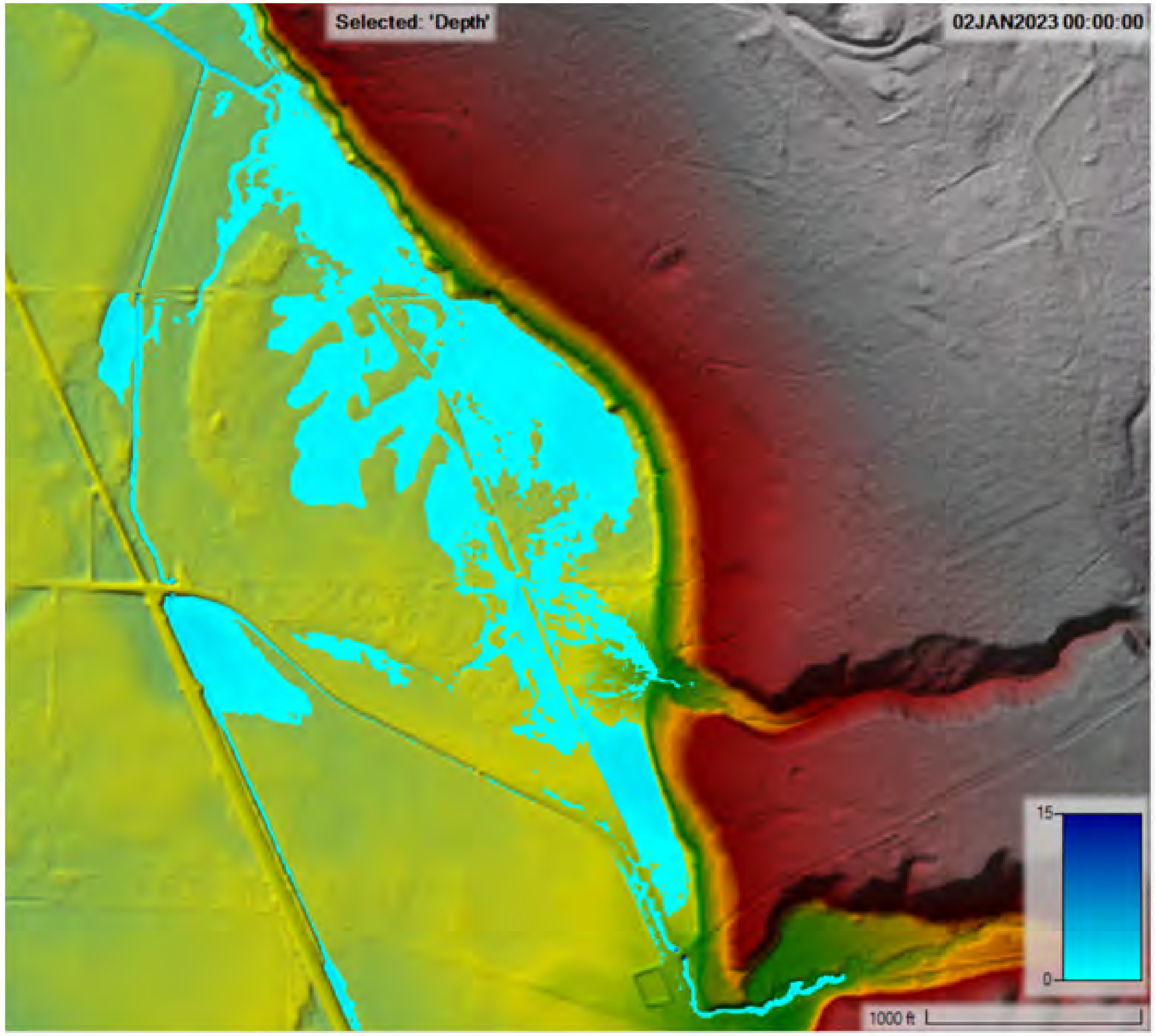
Figure 2
Modeled Inundation – Upstream Project Area

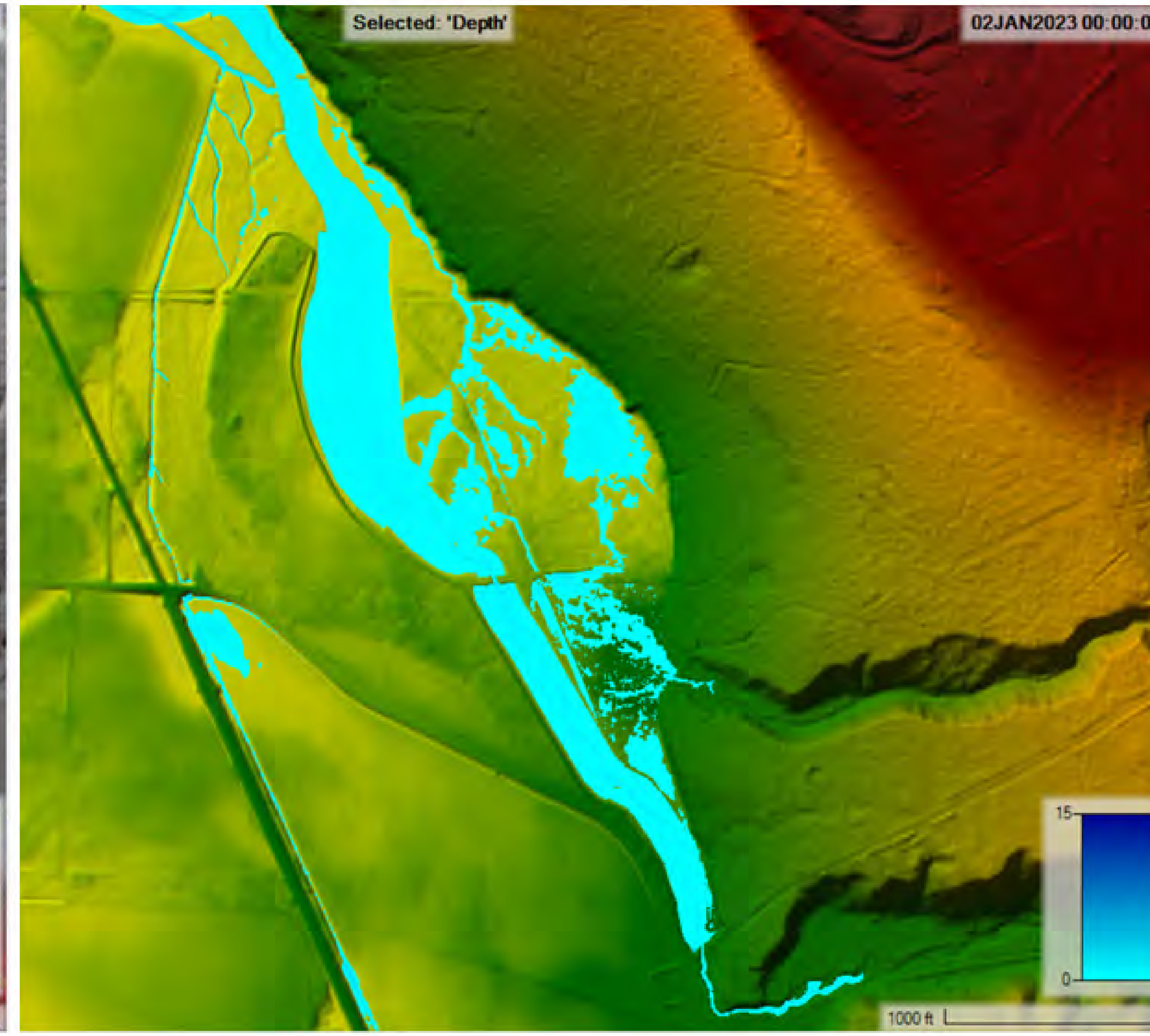


Note: Figure on left shows modeled inundation and depth under existing conditions in the upstream project area. Figure on right shows modeled inundation and depth for Alternative 3 in the upstream project area. Both modeling results were pulled at the 1/2/23 00:00:00 timestep, when inundation appeared to be most extensive in the upstream project area. Figures show model results from the offset tidal hydrograph scenario.

ANCHOR QEA

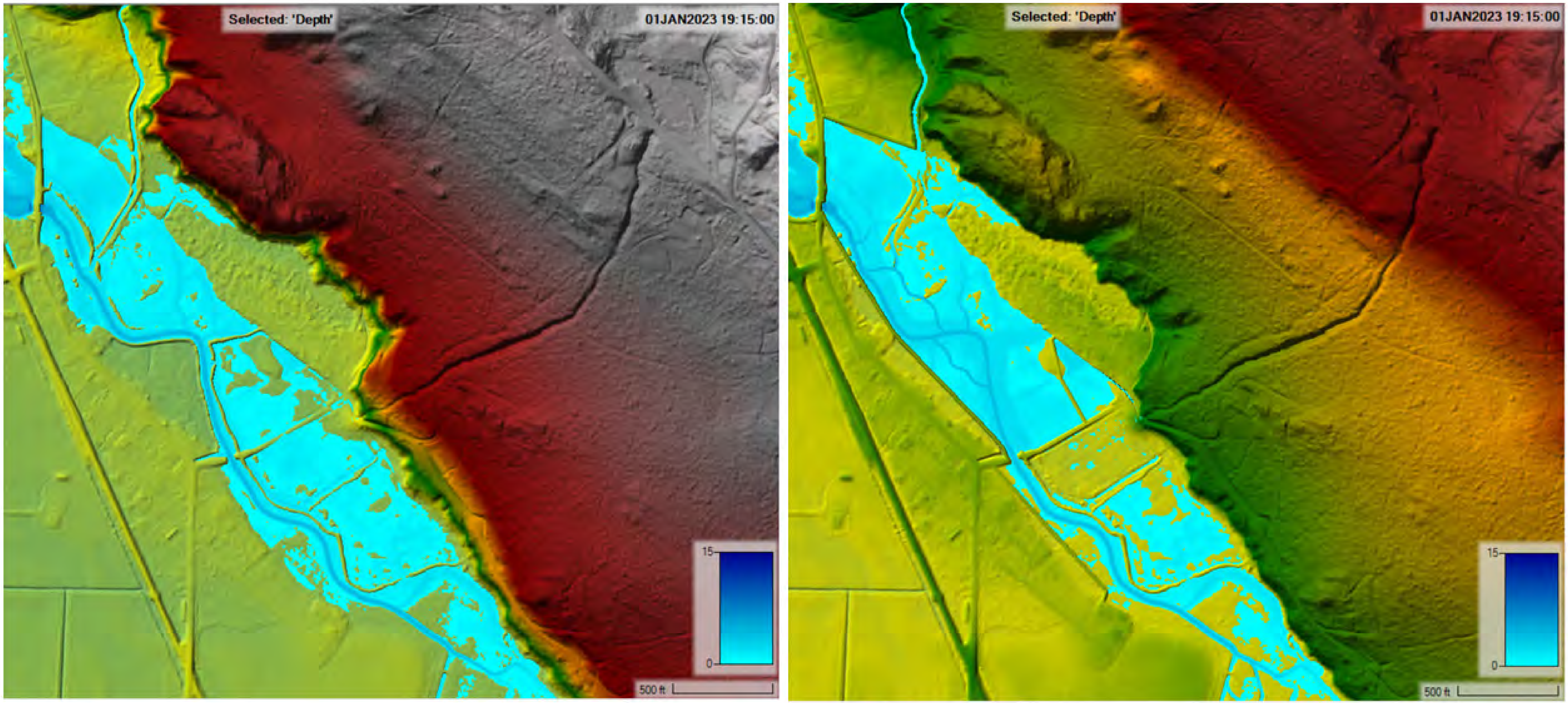
Figure 3
Modeled Inundation – Upstream Project Area



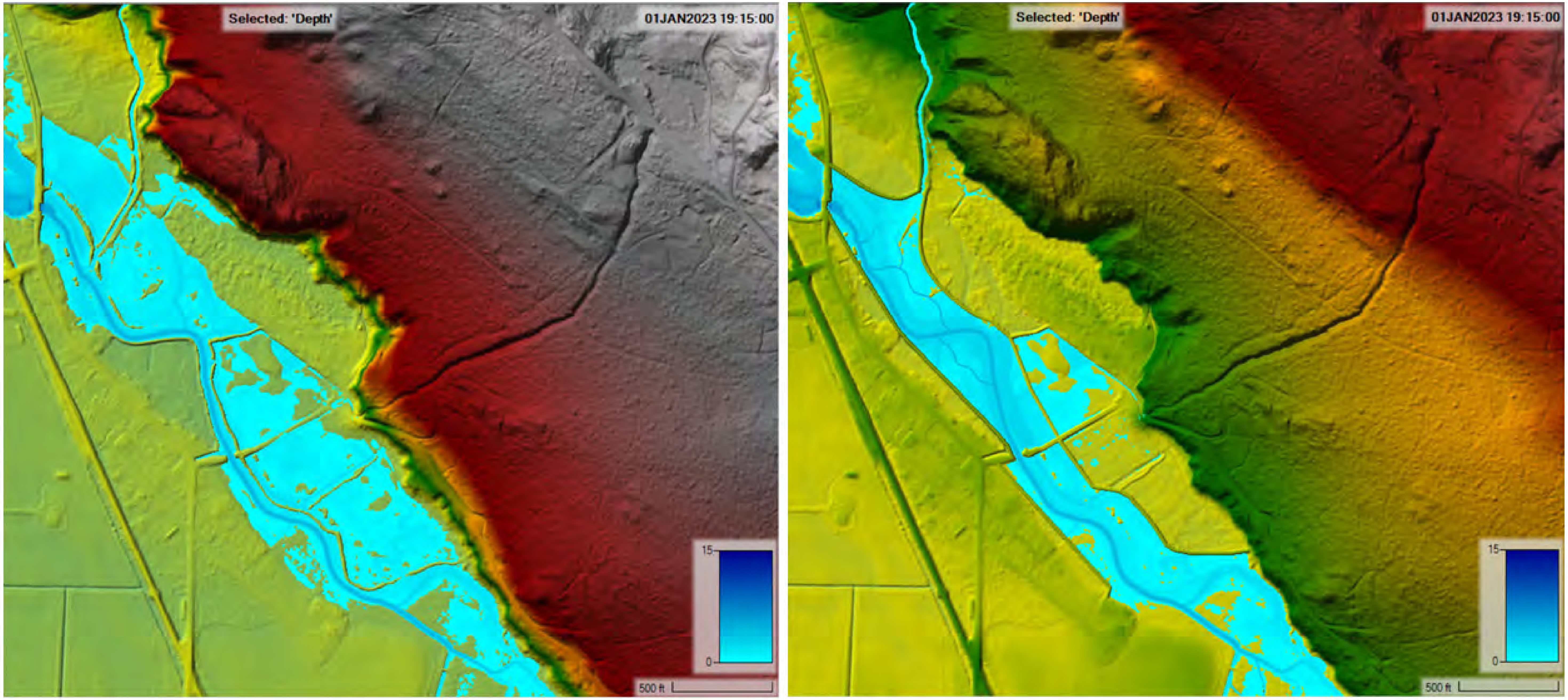


Note: Figure on left shows modeled inundation and depth under existing conditions in the upstream project area. Figure on right shows modeled inundation and depth for Alternative 4 in the upstream project area. Both modeling results were pulled at the 1/2/23 00:00:00 timestep, when inundation appeared to be most extensive in the upstream project area. Figures show model results from the offset tidal hydrograph scenario.

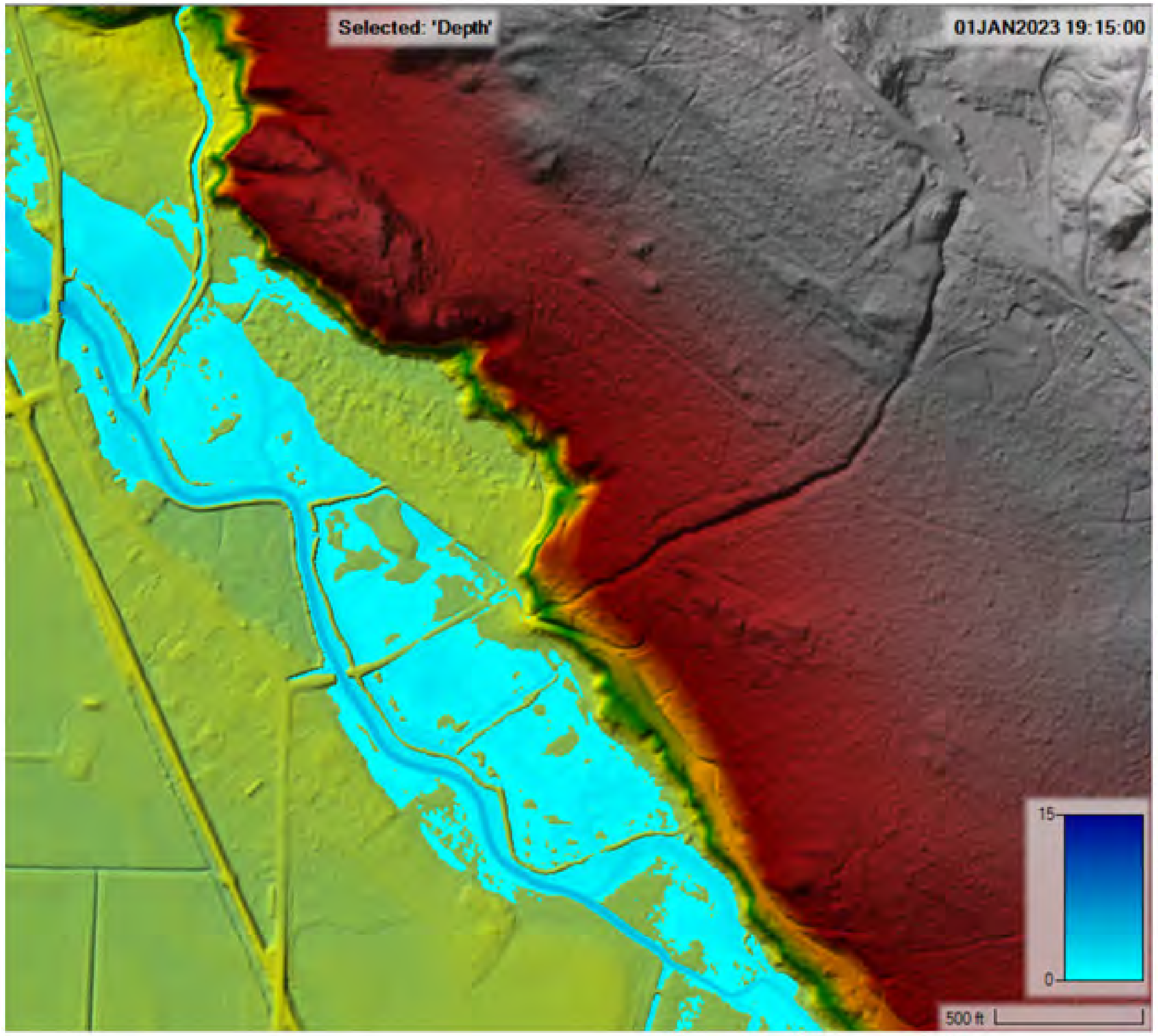
Figure 4
Modeled Inundation – Upstream Project Area

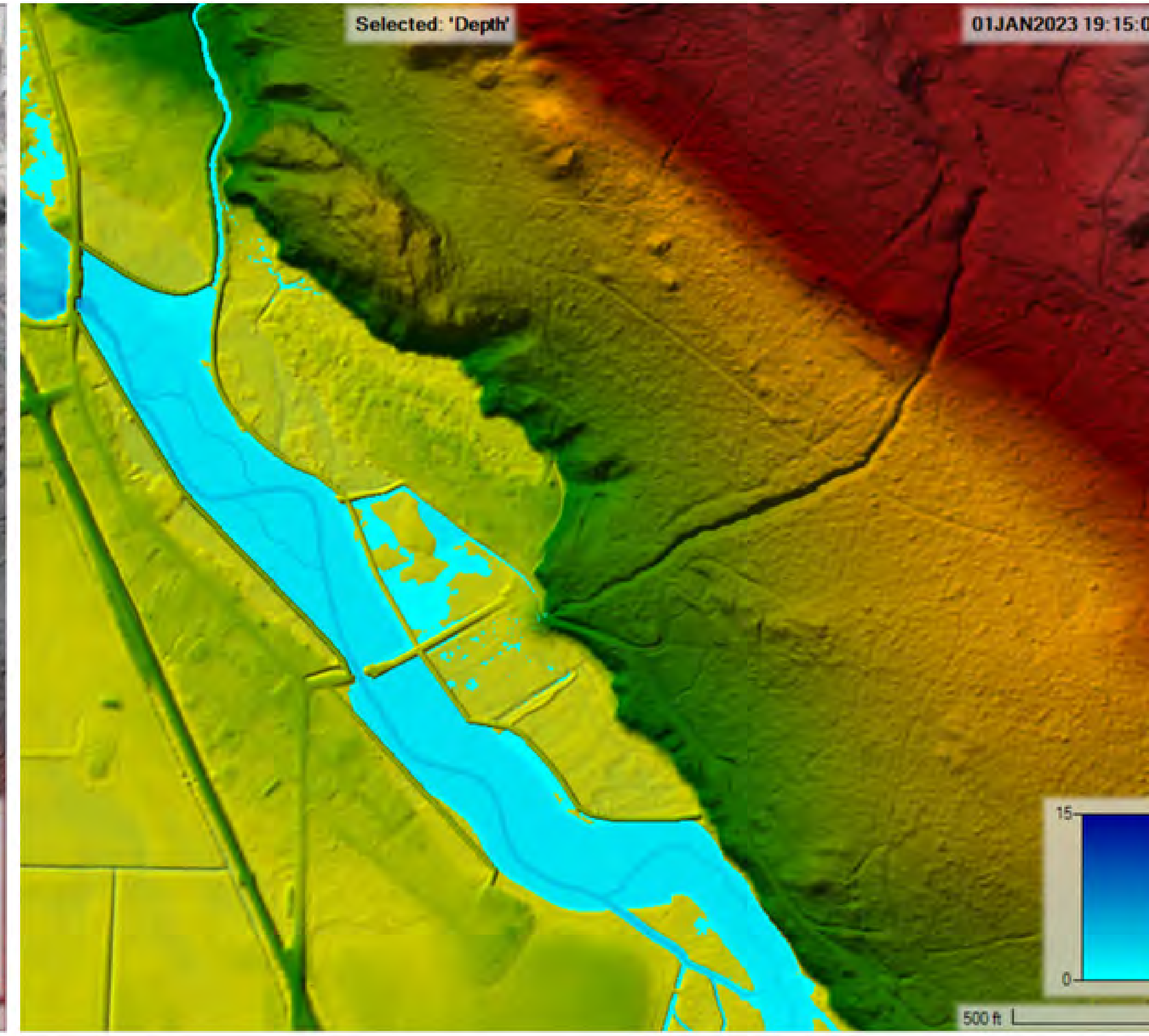


Note: Figure on left shows modeled inundation and depth under existing conditions in the downstream project area. Figure on right shows modeled inundation and depth for Alternative 1 in the downstream project area. Both modeling results were pulled at the 1/1/23 19:15:00 timestep, when inundation appeared to be most extensive in the downstream project area. Figures show model results from the offset tidal hydrograph scenario.

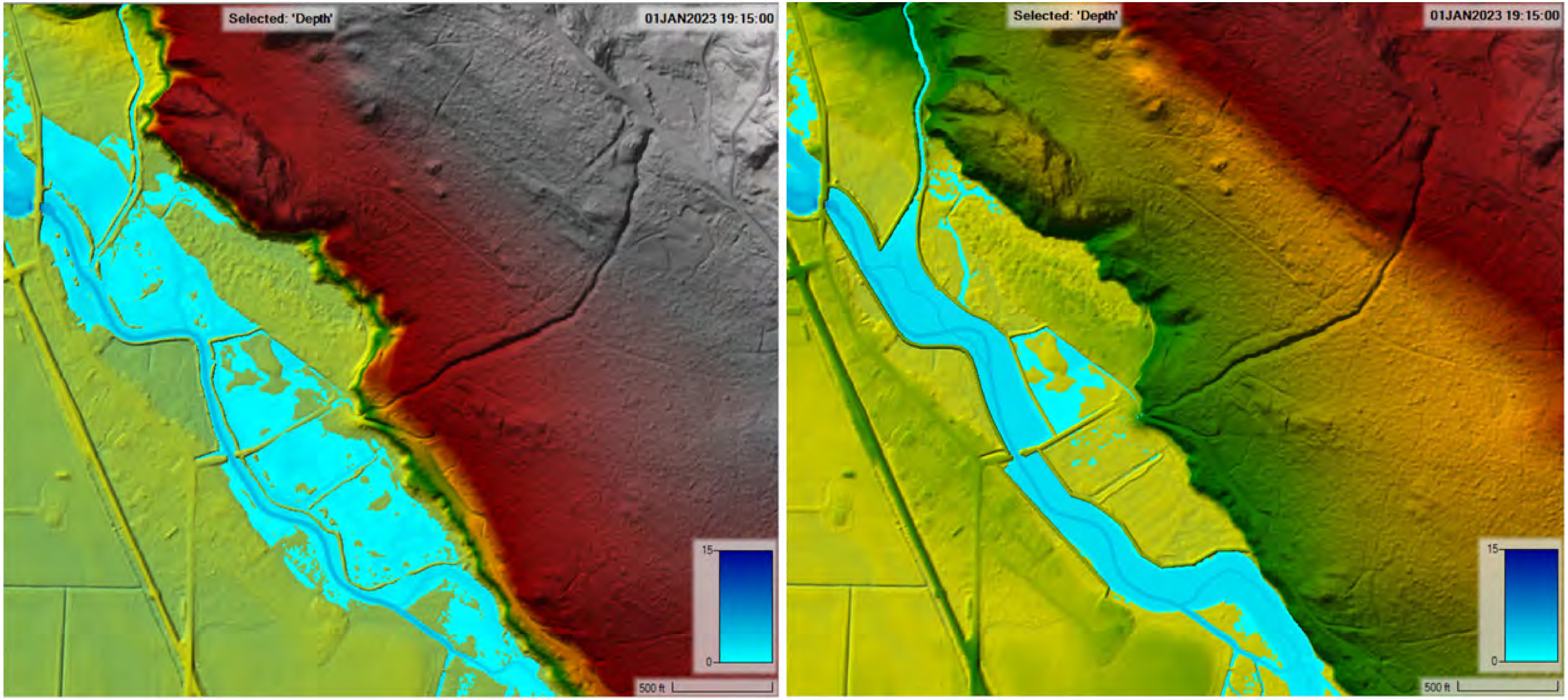


Note: Figure on left shows modeled inundation and depth under existing conditions in the downstream project area. Figure on right shows modeled inundation and depth for Alternative 2 in the downstream project area. Both modeling results were pulled at the 1/1/23 19:15:00 timestep, when inundation appeared to be most extensive in the downstream project area. Figures show model results from the offset tidal hydrograph scenario.





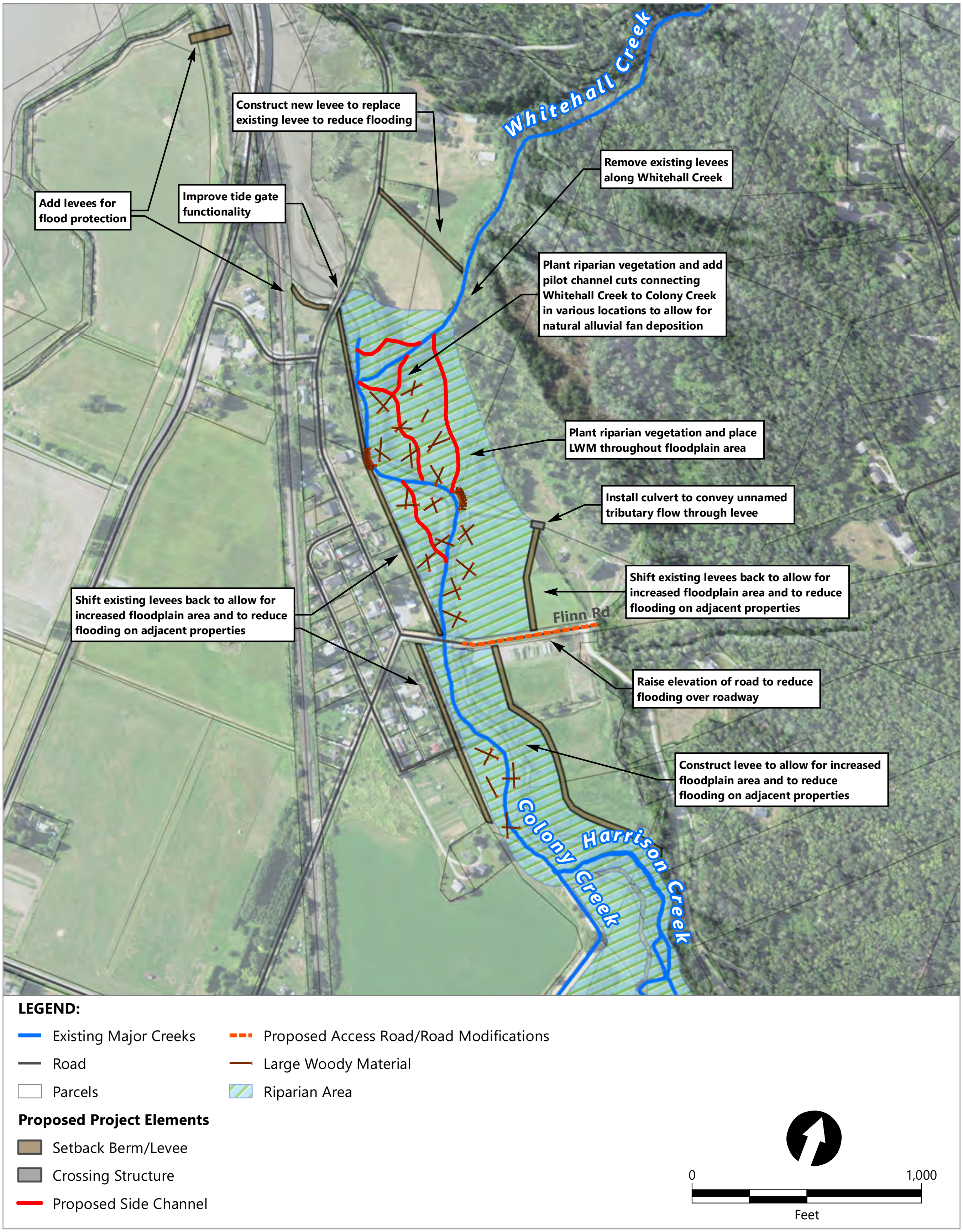
Note: Figure on left shows modeled inundation and depth under existing conditions in the downstream project area. Figure on right shows modeled inundation and depth for Alternative 3 in the downstream project area. Both modeling results were pulled at the 1/1/23 19:15:00 timestep, when inundation appeared to be most extensive in the downstream project area. Figures show model results from the offset tidal hydrograph scenario.



Note: Figure on left shows modeled inundation and depth under existing conditions in the downstream project area. Figure on right shows modeled inundation and depth for Alternative 4 in the downstream project area. Both modeling results were pulled at the 1/1/23 19:15:00 timestep, when inundation appeared to be most extensive in the downstream project area. Figures show model results from the offset tidal hydrograph scenario.

Appendix C
Alternative Maps

Calibration Option - To see how an extreme channel expansion would change modeled results

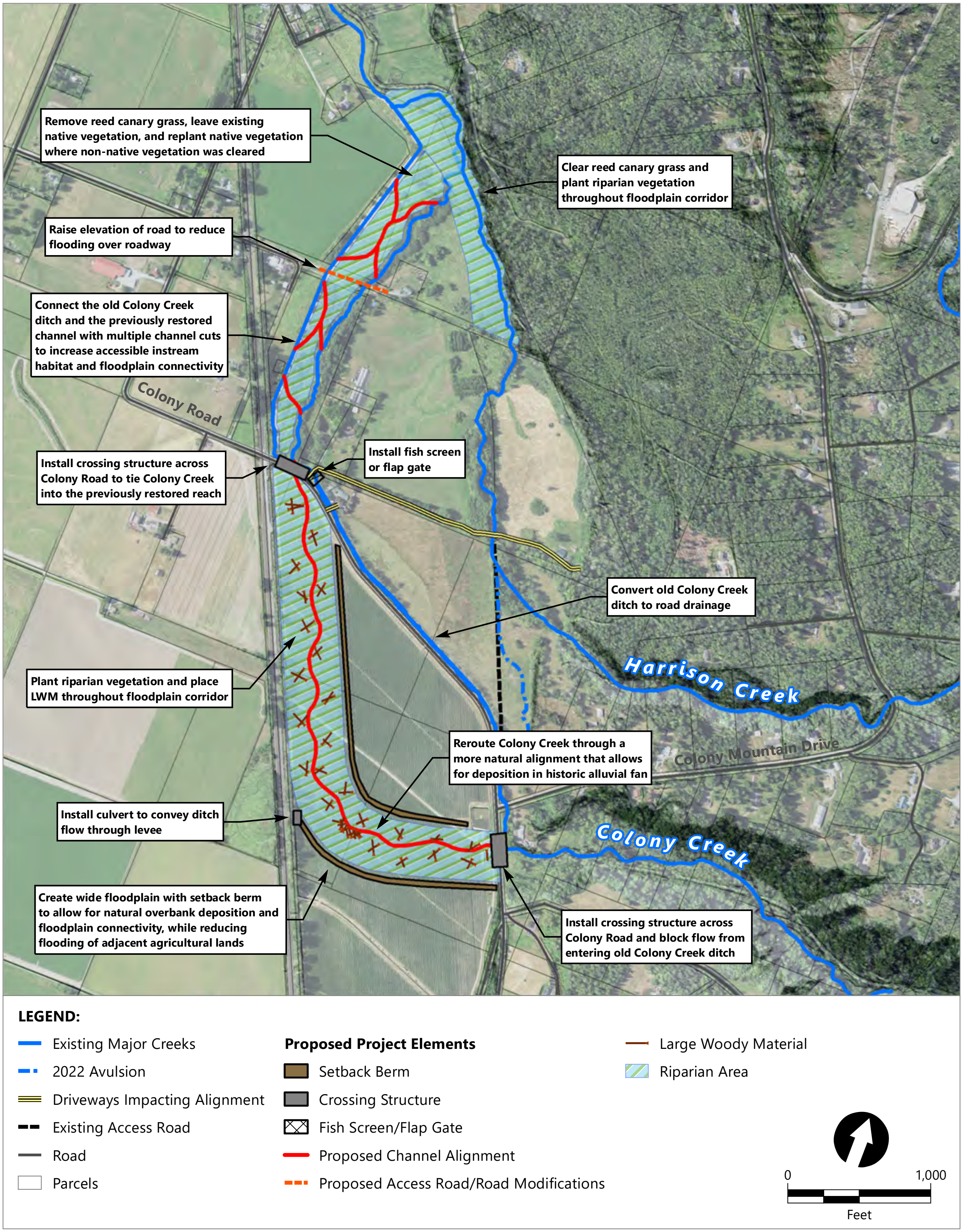


ANCHOR QEA

Alternative 1 - Downstream

Northern Project Area
Colony and Harrison Creek

Reroute and Re-align Colony Creek. Connect Colony Creek and Drainage Ditch

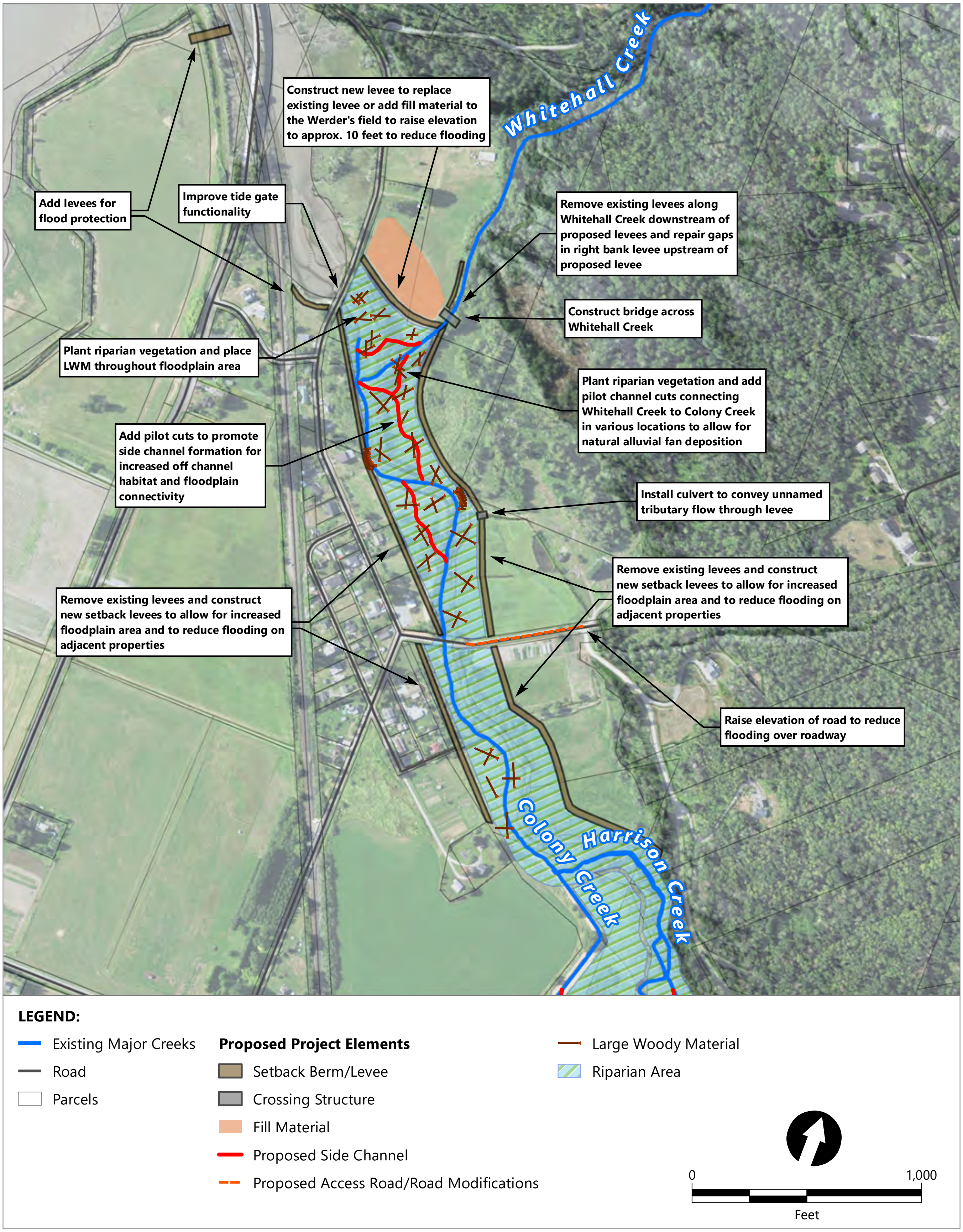


ANCHOR QEA

Alternative 1 - Upstream

Southern Project Area
Colony and Harrison Creek

Levee Setbacks and Improvements. Channel Cuts and Riparian Vegetation Remediation

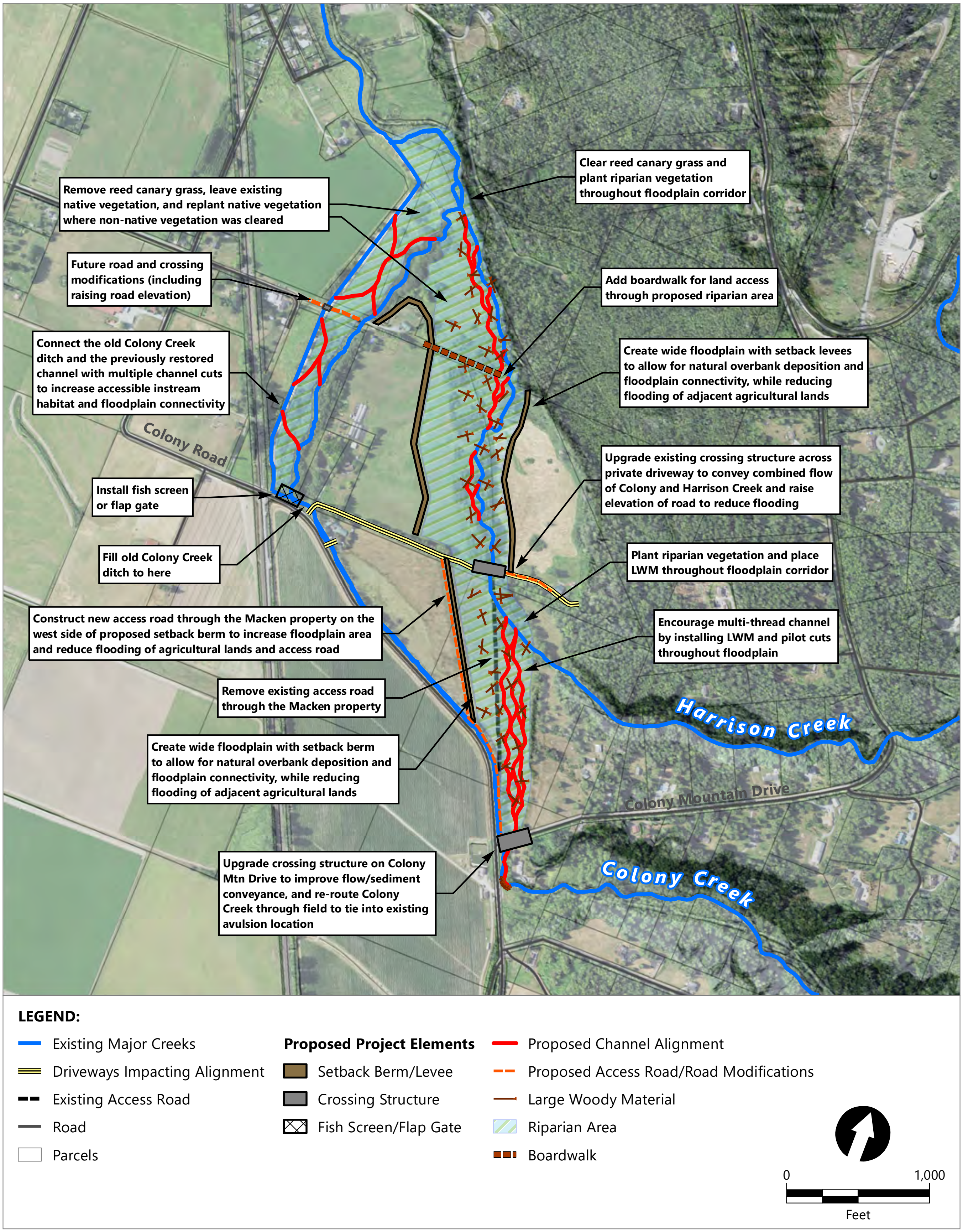


ANCHOR QEA

Alternative 2 - Downstream

Northern Project Area
Colony and Harrison Creek

Keep Colony and Harrison Creek Together. Expand Floodplain and Add Levee Setbacks

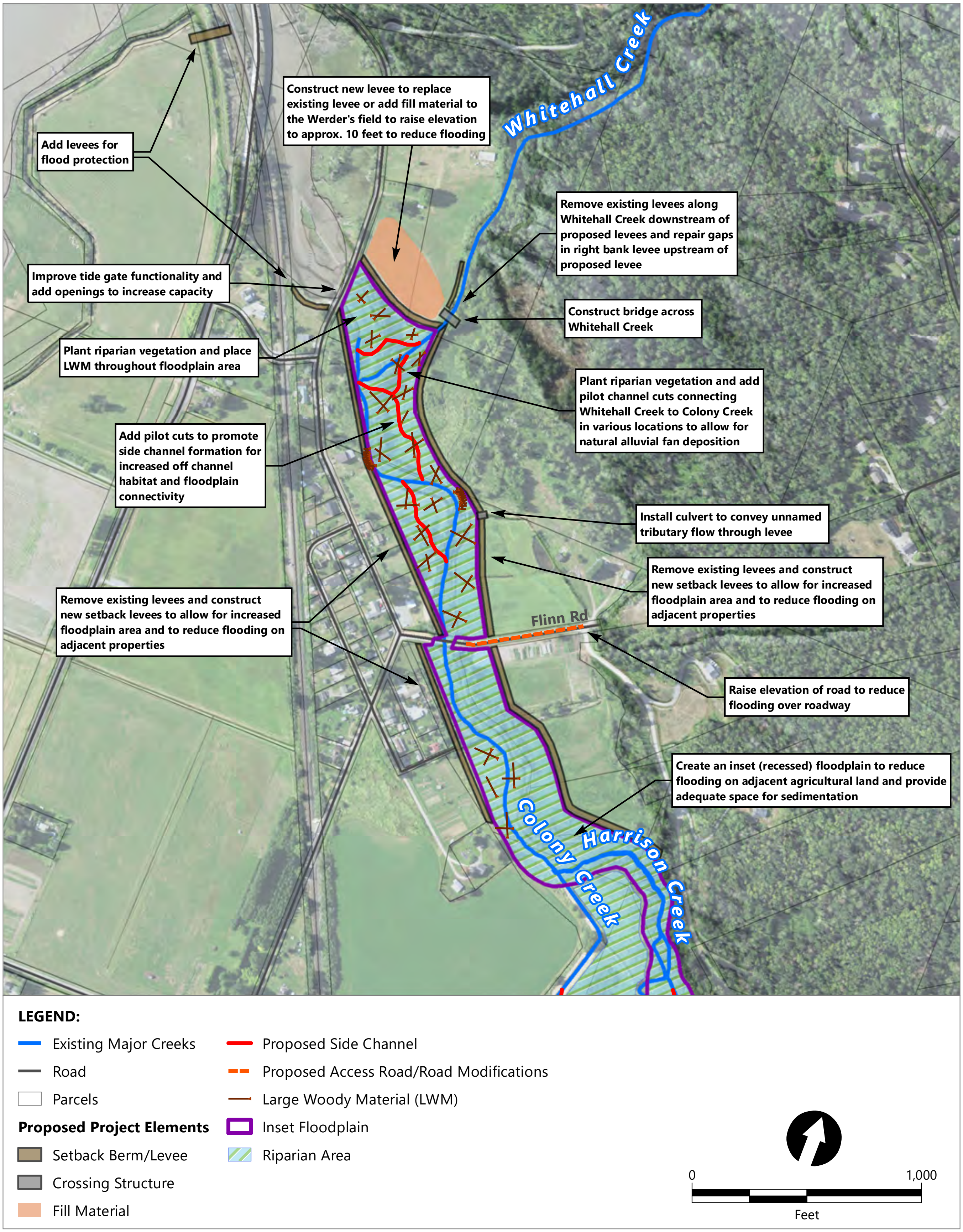


ANCHOR QEA

Alternative 2 - Upstream

Southern Project Area
Colony and Harrison Creek

Levee Setbacks and Improvements. Inset Floodplain and Riparian Vegetation Remediation

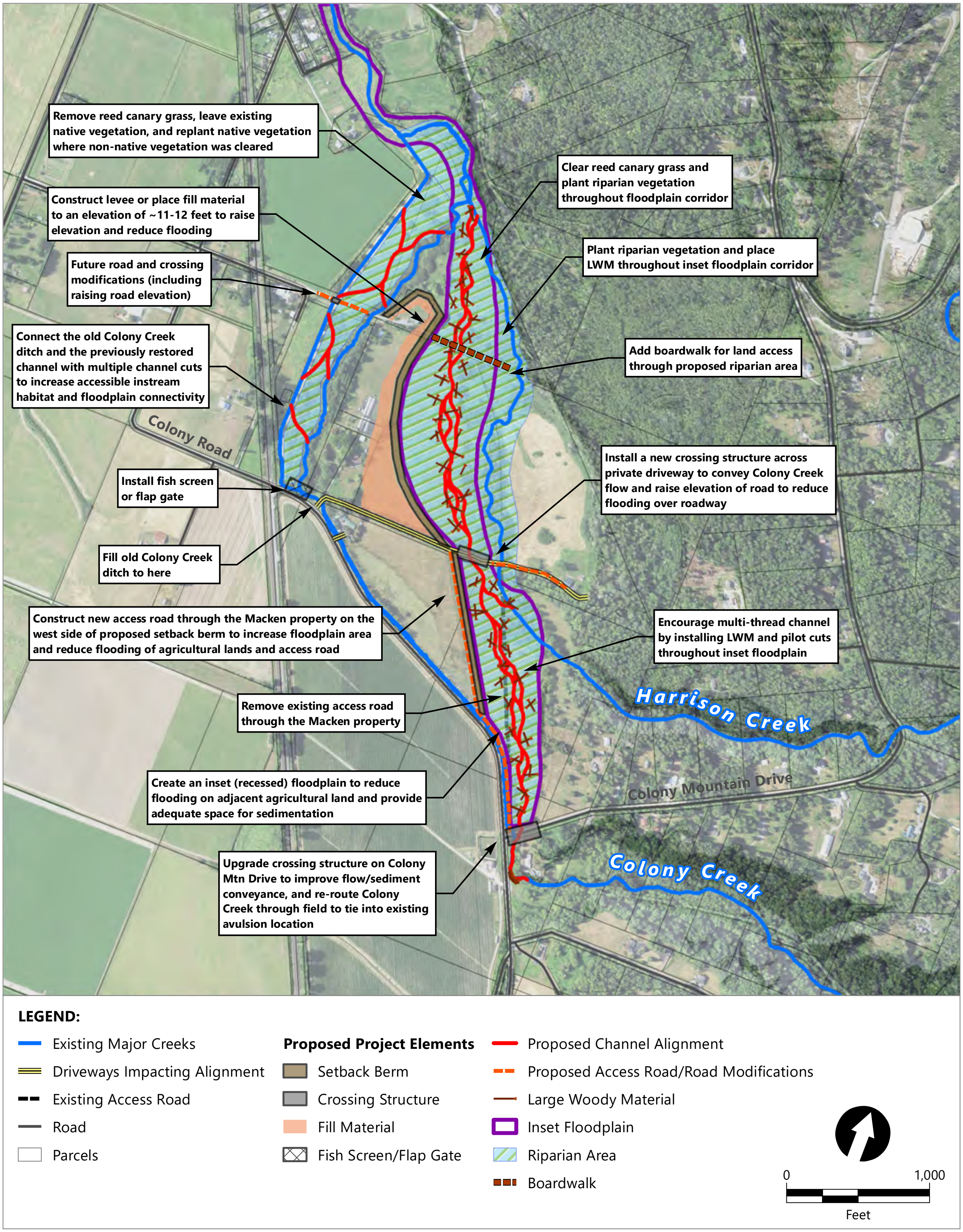


ANCHOR QEA

Alternative 3 - Downstream

Northern Project Area
Colony and Harrison Creek

Separate Colony and Harrison Creeks with Large Inset Floodplain

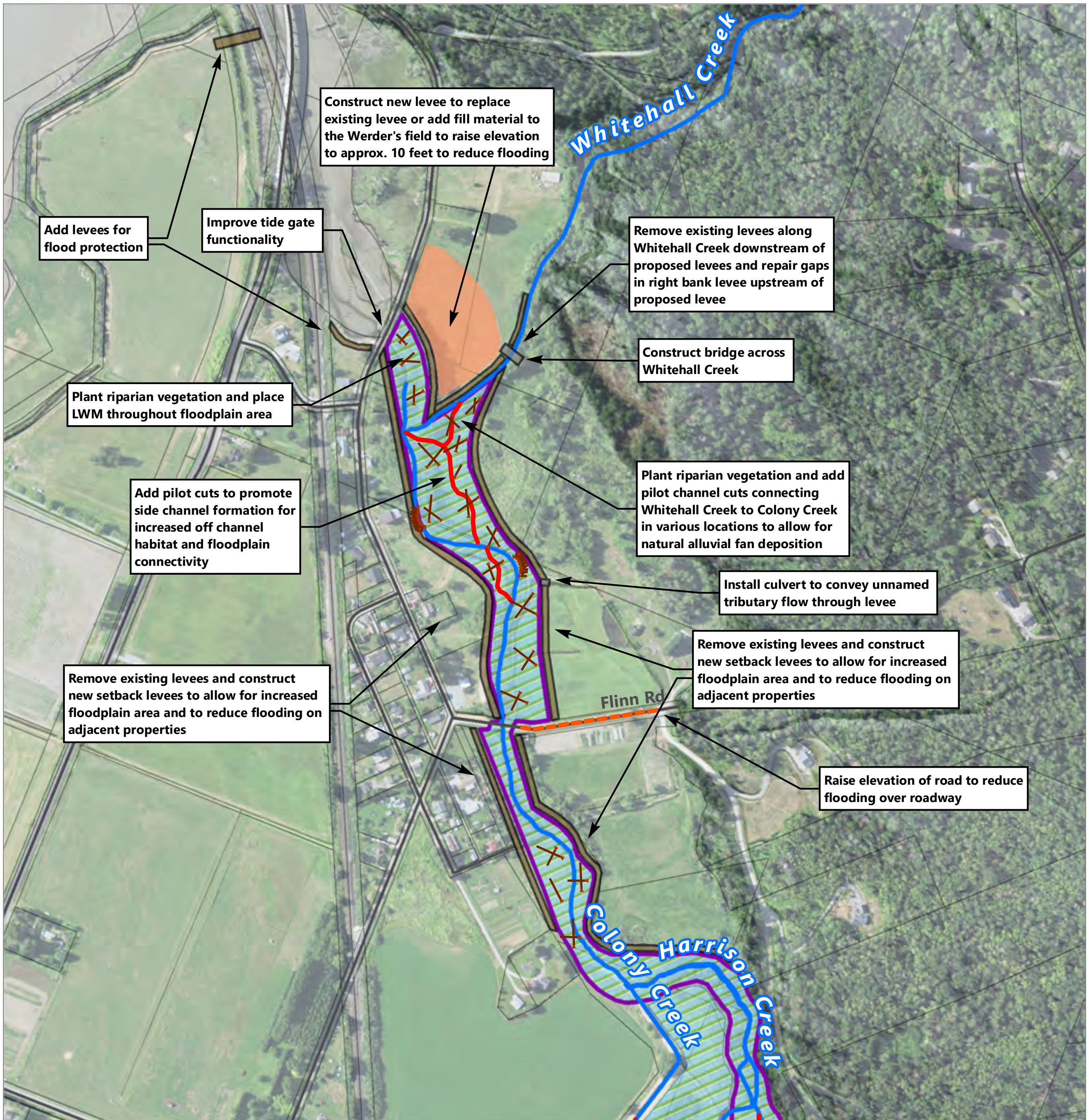


ANCHOR QEA

Alternative 3 - Upstream

Southern Project Area
Colony and Harrison Creek

Levee Setbacks and Improvements. Channel Cuts and Riparian Vegetation Remediation



LEGEND:

- Existing Major Creeks
- Road
- Parcels

Proposed Project Elements

- Setback Berm/Levee
- Crossing Structure
- Fill Material
- Large Woody Material
- Proposed Side Channel
- Proposed Access Road/Road Modifications

- Inset Floodplain
- Riparian Area

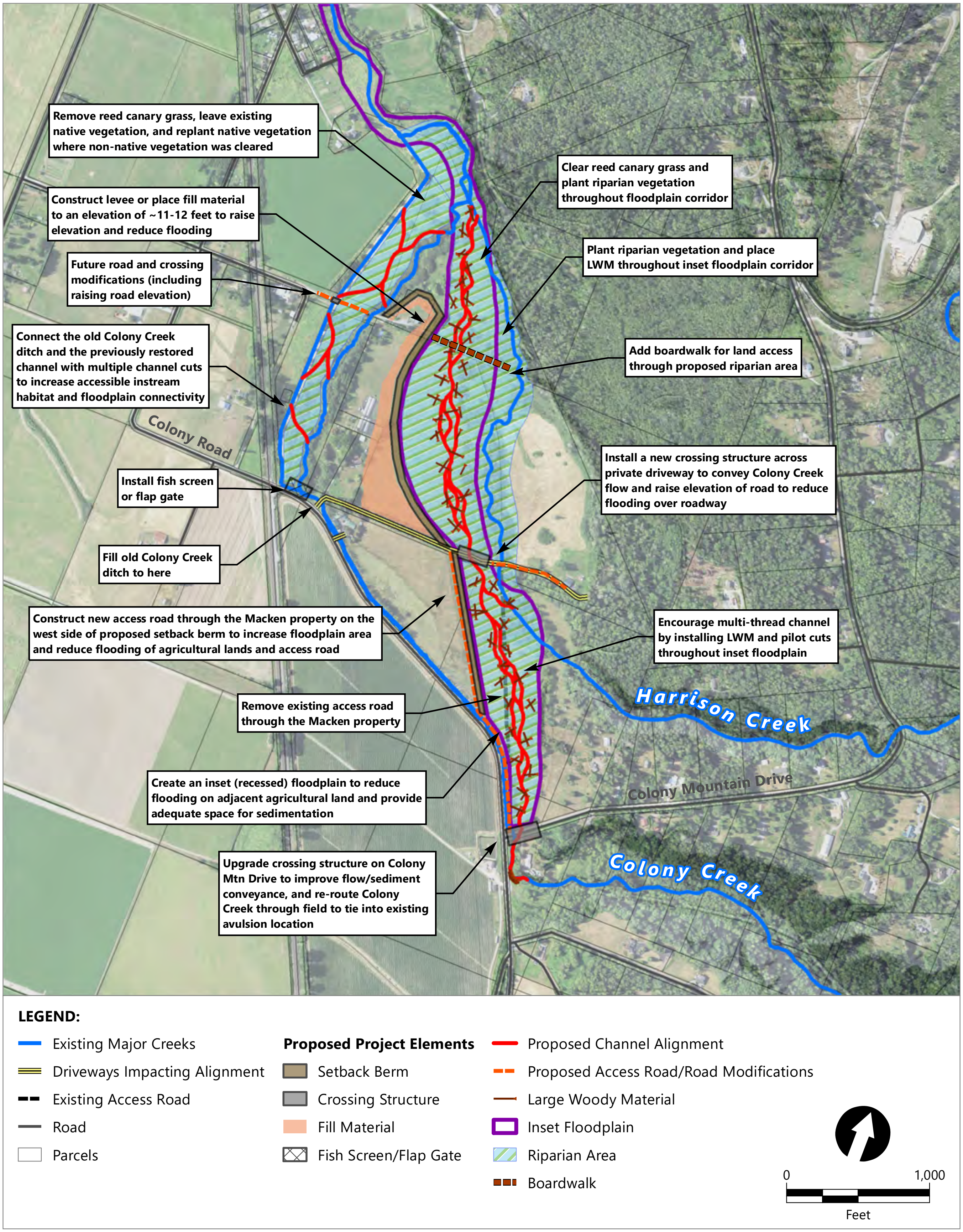
0 1,000
Feet

ANCHOR QEA

Alternative 4 - Downstream

Northern Project Area
Colony and Harrison Creek

Separate Colony and Harrison Creeks with Large Inset Floodplain



ANCHOR QEA

Alternative 4 - Upstream

Southern Project Area
Colony and Harrison Creek