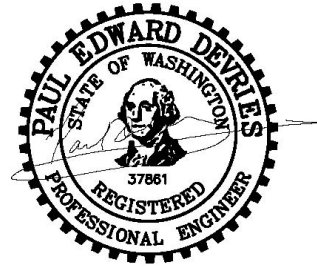


Preliminary Design Report

Tenas Creek Alluvial Fan Process Restoration



Prepared for:

Skagit River System Cooperative

Prepared by:

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With Support From TranTech, LLC

June 2023

Kleinschmidt

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- Appendix A – Conceptual Design Plans and Sections of Options
- Appendix B – Construction Cost Estimate Breakdowns by Sub-Option
- Appendix C – Conceptual Design Plans and Sections of Selected Option

1.0 BACKGROUND AND PURPOSE

The Skagit River System Cooperative (SRSC) contracted Kleinschmidt Associates (KA) to perform a study to identify and evaluate the feasibility of options to realign the Tenas Creek channel and alluvial fan at the Suiattle River Road/U.S. Forest Service (USFS) Road 26 crossing. KA was contracted to perform a restoration feasibility assessment, assist with selecting a preferred option, and develop a corresponding preliminary design. TranTech LLC (TT) provided bridge design support under subcontract to KA.

Tenas Creek is one of nine tributaries to the Suiattle River that support spring Chinook Salmon (*Oncorhynchus tshawytscha*) spawning and represents a high priority restoration target because it provides cold, clear water to a river with naturally high sediment levels. The SRSC's goal is to improve habitat conditions for Chinook Salmon and other fish species, restore natural geomorphic processes that form and maintain that habitat, and reduce or avoid maintenance and emergency repairs associated with an existing Forest Service roadway.

The Suiattle River Road (USFS Road #26) crosses lower Tenas Creek with an 80 feet long concrete bridge in an area where the floodplain and historic channel migration zone are approximately 600-700 feet wide. Habitat conditions are degraded because the channel was artificially straightened and constrained with a training levee and rip-rap structure when the bridge was constructed in 1962-1963 and the road was relocated (Figure 1-1 and Figure 1-2). The historic road and bridge were abandoned and replaced with the current bridge and road prism in response to erosion problems, where it is suspected that Tenas Creek was generally forced by topography into the base of the east side road prism. The levee was constructed to train the channel under the new bridge, and extends approximately 800 feet upstream from the roadway on the left bank. It was constructed with the documented expectation that the levee and channel would require annual routine maintenance. During flooding in 1995, the primary Tenas Creek channel avulsed and flowed over the roadway approximately 430 feet from the current bridge, but construction crews returned it to the leveed channel. Flows have also gone around the existing levee during more recent flood events. Erosion is progressing in the upstream direction and undercutting several large trees at the upstream limit of the levee. The project was initially brought to SRSC's attention by a USFS hydrologist who recognized the habitat opportunity and the risk of the channel avulsing at the head of the levee and connecting with two insufficiently sized culverts and isolated relic channels to the east of the existing bridge. The culverts and relic channels are indicative of former floodplain

habitat that has been isolated by the levee. Downstream of the bridge, the channel avulsed completely during the November 2006 flood and abandoned its historic channel approximately 200 feet downstream of the current crossing and has remained in its new course since.

An initial set of options was identified by the SRSC in collaboration with the USFS, Seattle City Light (SCL), and other stakeholders. Options that were considered by the SRSC prior to contracting with KA include removing hydromodifications along the channel to restore or enhance channel migration processes without adversely affecting the integrity and use of the road, replacement or relocation of the bridge and road alignment, and constructing additional bridges (Figure 1-3). The KA team's feasibility assessment (KA 2022) subsequently helped guide SRSC towards selecting the simplest alternative with lowest cost that met the goal of restoring floodplain and alluvial fan processes. The selected alternative involves removing the levee, partially removing fill downstream of the levee, replacing the existing bridge with a longer span structure, removing road prism fill, and constructing a second, longer span bridge. The longer span bridge structure will allow restoration of the channel to its historic bankfull width and the levee removal and second bridge will allow the stream to occupy almost all of its historic floodplain as fluvial processes like flooding, sedimentation, or erosion processes lead to avulsion events that were historically common in this reach. A small section of road fill will remain where the stream is unlikely to flow in the future while the road prism fill will be removed over the rest of the fan surface.

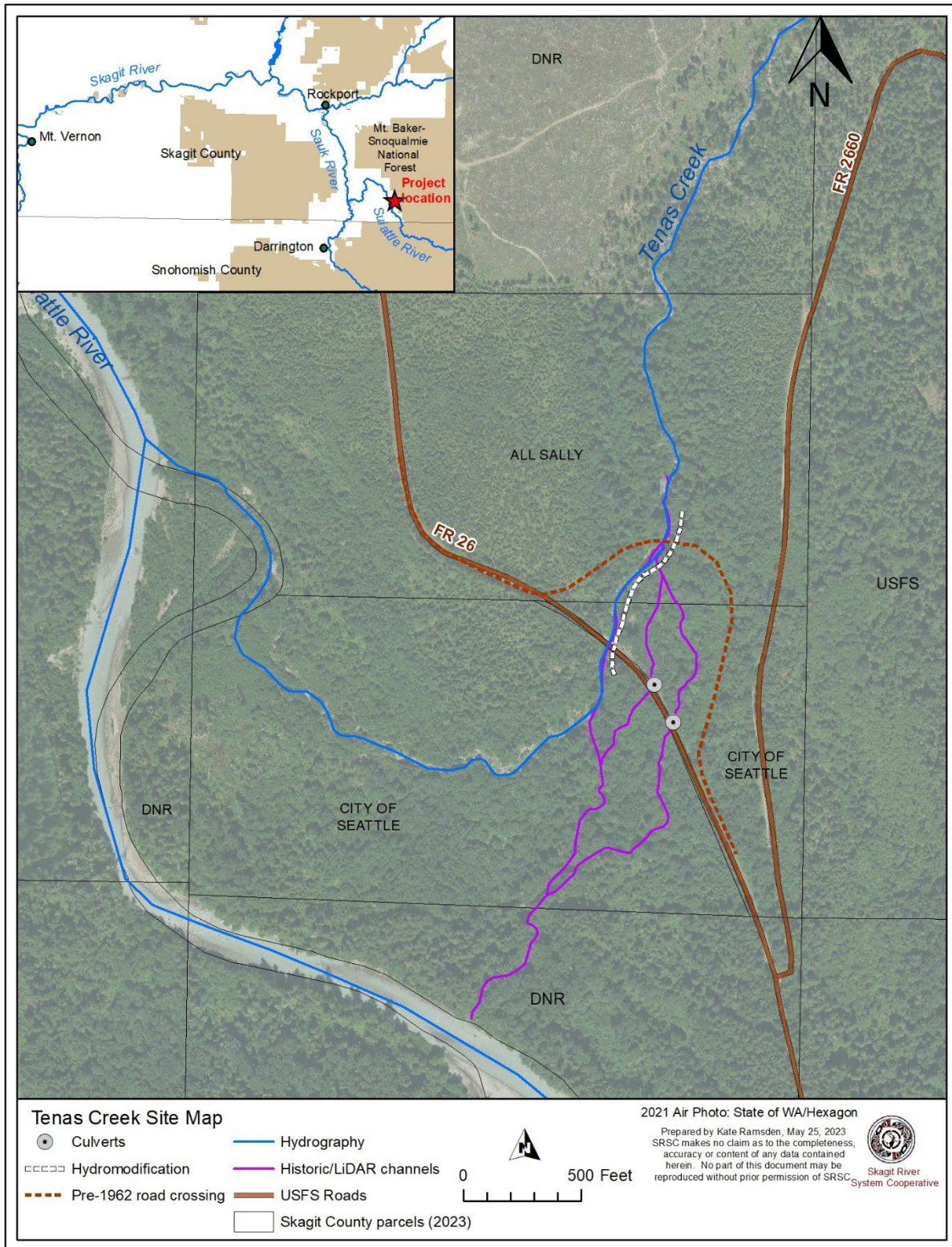


Figure 1-1 Current and Historic Flow Paths, Road Crossing Locations, and hydromodifications in lower Tenas Creek



Figure 1-2 Views of Construction of Current Tenas Creek Bridge, Ca. November 1962 (from USFS)

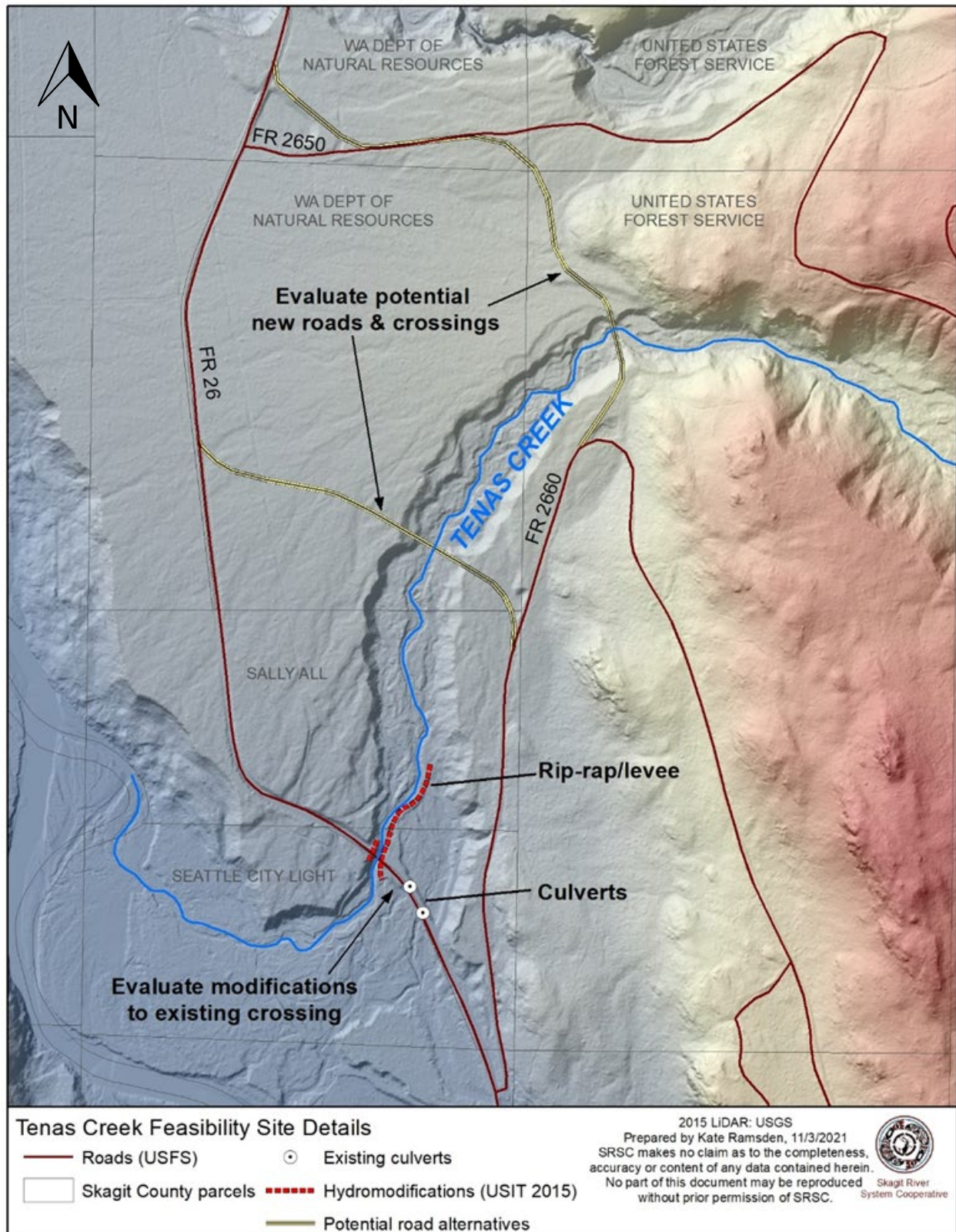


Figure 1-3 Approximate Locations of Alluvial Fan Process Restoration Options Initially Considered by SRSC for early conceptual development

The remainder of this report includes the following information:

- Describes analyses used as the basis for identifying and evaluating options, including an assessment of reach scale geomorphic processes, estimation of flood hydrology, and hydraulic modeling of flood flows and flood conveyance;
- Identifies the options considered;
- Summarizes physical attributes, design needs, constructability and permitting aspects of selected options, and expected costs to design, permit, and construct;
- Describes the development of the preliminary design of the selected alternative and identifies requirements for developing and permitting a final design; and
- Presents proposed preliminary design plans.

2.0 FEASIBILITY ASSESSMENT ANALYSES

The feasibility assessment analyses focused on identifying potential floodplain channel flow paths, 100-year flood extents, and large-scale geomorphic processes and conditions in the vicinity of candidate crossing locations that may influence civil, geotechnical, and bridge assessments and design. Light Detection and Ranging (LiDAR) data from 2016 (provided by SRSC) and historic aerial photography were used to generate terrain maps and topographic profiles in CAD for evaluating geomorphic properties of Tenas Creek, map current and potential flow paths, and laying out options schematically with plan and section views. The resulting terrain model was also used to develop a hydraulic model for predicting 100-year flood extents under existing and selected potential future conditions.

A scoping-level geotechnical assessment was also performed to identify potential geologic hazards at the site and to identify geotechnical considerations that may influence the design and construction of the new bridge and roadway. The geotechnical assessment was performed with available geologic and geotechnical information, primarily from the State of Washington's Department of Natural Resources Geology Portal site (DNR 2022).

2.1 Hydrology

There are no historical gage data for Tenas Creek. Flood hydrology was estimated using the US Geological Survey's StreamStats regional regression website (<https://streamstats.usgs.gov/ss/>). The drainage area (DA) at the existing bridge was calculated to be approximately 10.4 mi², with a mean annual precipitation of 125 inches. The resulting flood magnitudes were compared against peak flow data available at two smaller basins in the sub-region, Straight Creek (USGS Station 12188300; DA=4.3 mi²) and Iron Creek (USGS Station 12184300; DA=1.7 mi²) and corresponding StreamStats estimates. The ratio of regression estimates to gage-based estimates was computed for each gage, and applied to the StreamStats estimate for Tenas Creek. The resulting adjusted values for Tenas Creek flood flows were then averaged (Table 2-1). The corresponding estimate for the 100-year flood was comparable to an estimate of 1,800 cfs derived using the sub-region regression relation Veldhuisen and Haight (2001). The average adjusted values were taken as the best estimate of flood hydrology for the project reach.

Table 2-1 Flood Hydrology Estimates for Tenas Creek at Suiattle River Road

Recurrence Interval (years)	StreamStats Regression Estimate for Tenas Creek (cfs)	Adjusted Based on Straight Creek Gage: Regression (cfs)	Adjusted Based on Iron Creek Gage: Regression (cfs)	Average Adjusted Value for Tenas Creek (cfs)
2	885	512	1,174	843
5	1,330	665	1,464	1,065
10	1,630	815	1,630	1,223
50	2,260	1,130	2,260	1,695
100	2,540	1,270	2,540	1,905
500	3,200	1,600	3,200	2,400

2.2 Geomorphic Assessment

The feasibility of a new road crossing option is strongly dependent on compatibility with reach and local scale processes affecting lateral and vertical stability of the channel. Accordingly, a reach scale geomorphic assessment was performed to assess how natural channel sediment transport processes in the vicinity of proposed crossing locations may influence, or be influenced by proposed actions. LiDAR data collected in 2016 were provided by SRSC and supplemented by available historical aerial photography in Google Earth. SRSC staff collected supplemental survey data for use in ground-truthing LiDAR bare earth model elevations, as well as representative bedload grain size distribution data. The information was used to assess the longitudinal profile for identifying equilibrium reach grade and vertical stability characteristics, compare existing with expected unconfined bankfull width, and to infer expected natural channel migration process and general planform tendency absent a confining levee.

Figure 2-1 depicts the current large scale longitudinal elevation profile along the existing channel, including the pre-2006 avulsion channel downstream, historical relic channels disconnected by the levee, and the levee itself. There is a large-scale slope break approximately 1,500 feet upstream of the existing crossing. This break indicates the head of the Tenas Creek alluvial fan that progrades onto the Suiattle River floodplain. While still relatively steep, this reach can be expected over the long term to be depositional for larger substrates delivered from upstream, including via debris flows that originate periodically in the upper basin.

The longitudinal profiles also show an incised subreach within the larger scale alluvial reach below the slope break (Figure 2-1). The incision is indicated by a regression line

(4.7% slope) extending through the profile of the historical channel downstream of the 2006 avulsion point (and the profiles of the two primary relic floodplain channels flowing through the two culverts east of the bridge) that is offset above a second regression line (5.0% slope) extending through the current streambed profile. The incision extends downstream to the avulsion point below the bridge and upstream to above the levee, is greatest downstream of the existing bridge, and becomes progressively smaller moving in the upstream direction within the section confined by the levee. As further evidence of incision, a relic riverbed surface was seen on river left underneath the bridge approximately 8-9 feet above the channel thalweg, where the elevation difference approximates the difference between the 4.7% and 5.0% grade lines in Figure 2-1 at the same location.

Empirical channel planform relations based on the characteristic bedload grain size distribution median particle size $D_{50} = 104$ mm (Figure 2-2), average slope around 5 percent, and 2-year flood equal to 843 cfs generally indicate Tenas Creek should be a braided or stable branched channel (Leopold and Wolman 1957; Millar 2005; Eaton et al. 2010). However, if braiding processes were active, empirical bankfull width equations predict a total channel width of 150 feet or more (Millar 2005) and multiple shallow braids (Egozi and Ashmore 2009; Eaton et al. 2010). Castro and Jackson's (2001) empirical geomorphic channel geometry equations for single thread channel predict an alluvial channel bankfull width of 69 feet for the Pacific maritime mountains region. Other predictions of bankfull width include 60 feet (Lee and Julien 2006) and 57 feet (Parker et al. 2007) for gravel bed channels. However, the bedload does not represent the underlying framework material in the fan, which consists of spatially varying patches of larger cobble and boulders and smaller, coarse grained glacial deposits such as silts, sands and gravels. Channel forming processes cannot therefore be classified as strictly alluvial. Consistent with this information, Montgomery and Buffington's (1997) channel classification system predicts the project reach to be a cascade channel type based on slope, which tends to be confined. The above empirical predictions provide a range of expected bankfull widths if and when the channel is free to move about and appear to be representative of the channel downstream of the levee, where the LiDAR data indicate a naturally formed bankfull width of approximately 65-75 feet. Wohl and Merritt (2005) empirical relation for step-pool channels, which are typically lower gradient than cascade channels, predicts a bankfull width of approximately 40 feet, similar to the most confined sections of Tenas Creek where the bankfull width is between approximately 45-50 feet. Collectively, these observations indicate the levee and bridge have confined the channel and constrained it

to its present cascade/step-pool form. In turn, this confinement appears to have induced incision within the vicinity of the levee, and this incision is causing channel instability to progress upstream, consistent with observed erosion patterns.

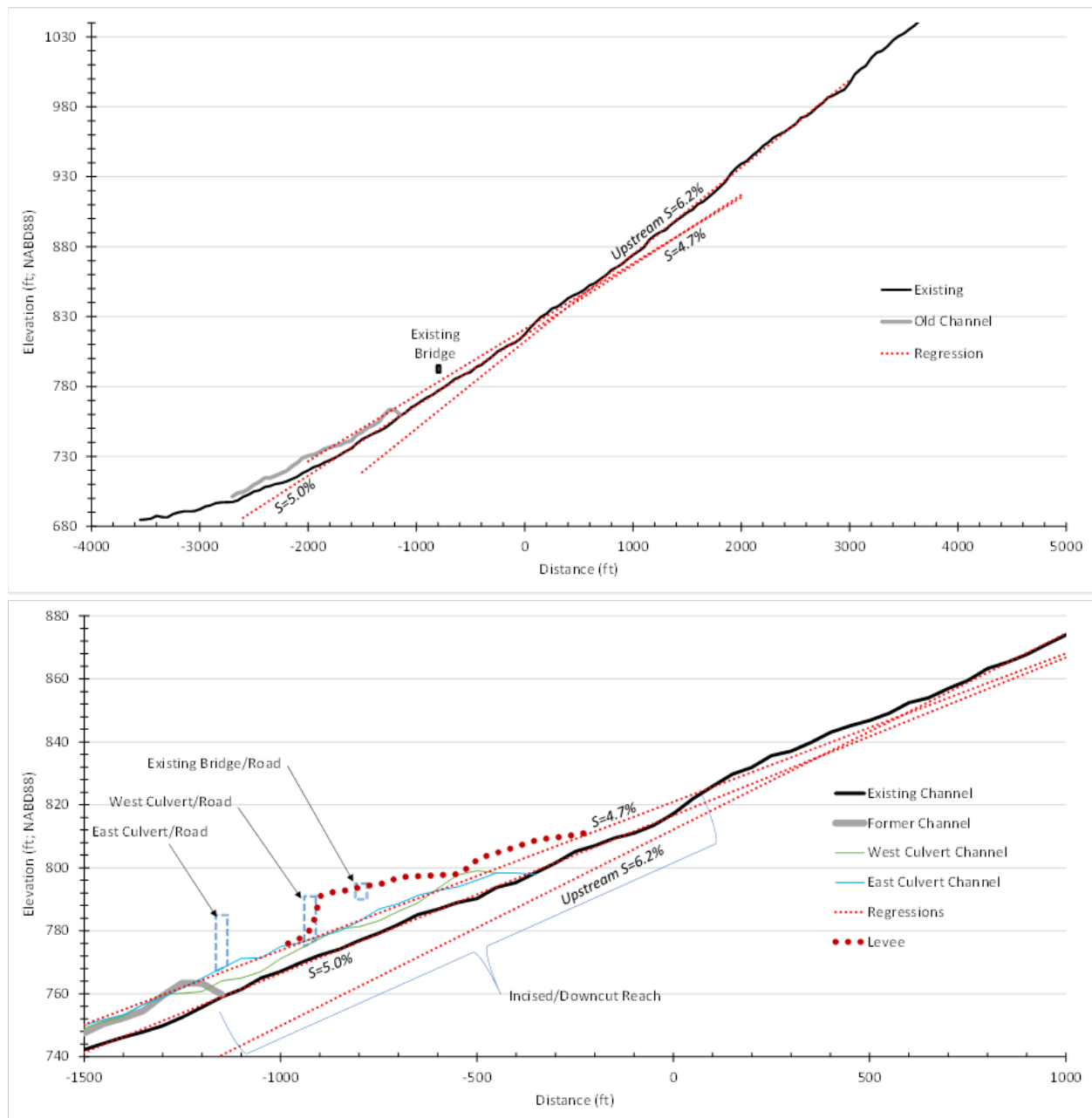


Figure 2-1 Longitudinal Elevation Profiles of Tenas Creek at larger (top) and Local (bottom) Scales

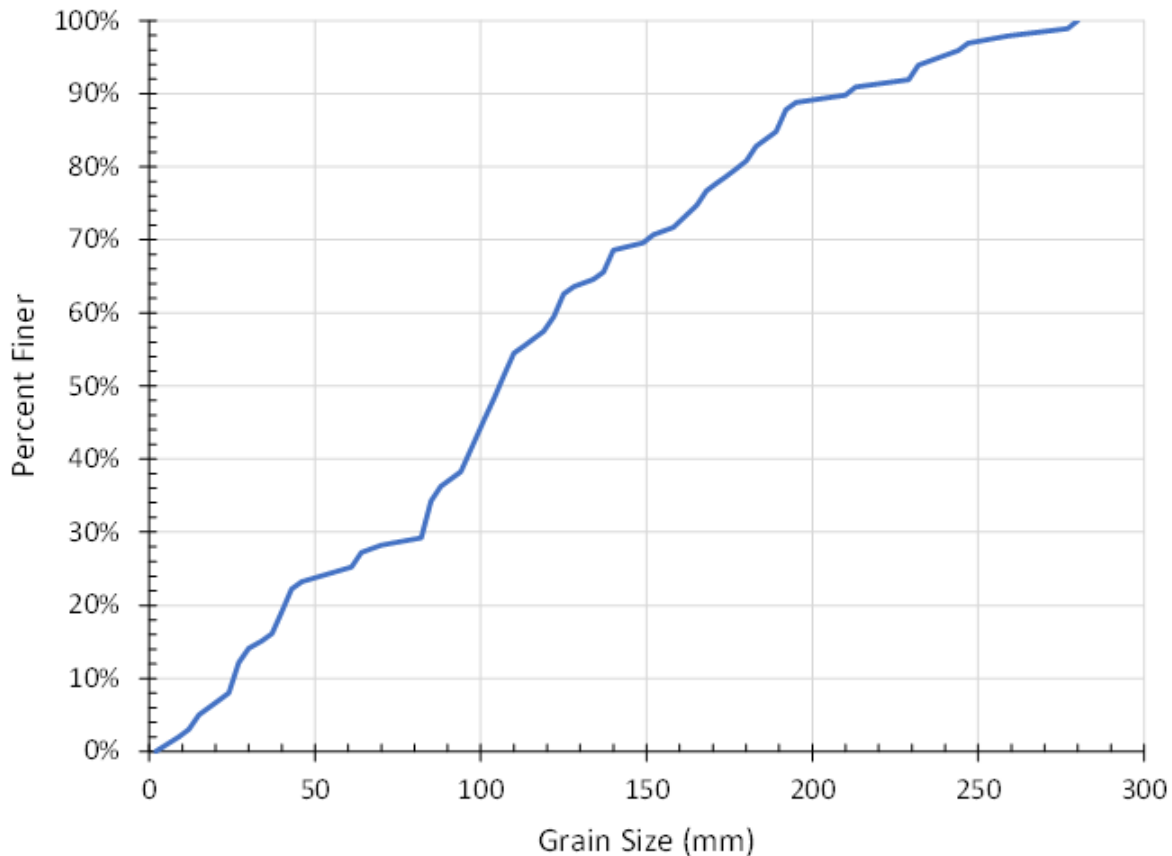


Figure 2-2 Grain Size Distribution of the Tensas Creek Streambed in an Unconfined Reach in Vicinity of 2006 Avulsion Location

Channel migration history indicated by the LiDAR data, available aerial photographs, and field observation indicate that Tensas Creek naturally forms a single channel held in place by large clasts, and moves over its fan primarily through avulsion rather than braiding or meander migration processes. Figure 2-3 depicts channel locations over roughly the past 80 years, and likely older channel locations. It appears that the channel switches location after a catastrophic flood event, where the former channel is filled and a new channel is cut rapidly.

The implications of the above observations important to consider for design are:

- Removal of the existing bridge and levee will require constructing an approximately 70-75 feet wide bankfull channel;
- If the current road alignment is maintained, the existing bridge will need to be replaced with a longer span to accommodate a wider bankfull channel;
- Removal of the levee down to surrounding fan ground elevation will not facilitate channel avulsion or floodplain connectivity in the near term (say 20-30 years)

until the current channel has filled through longer term deposition and debris flows; and

- It is unlikely that a braided channel morphology will form when floodplain connectivity is restored, the channel will continue to be single thread and switch location periodically through a rapid channel fill and avulsion process.

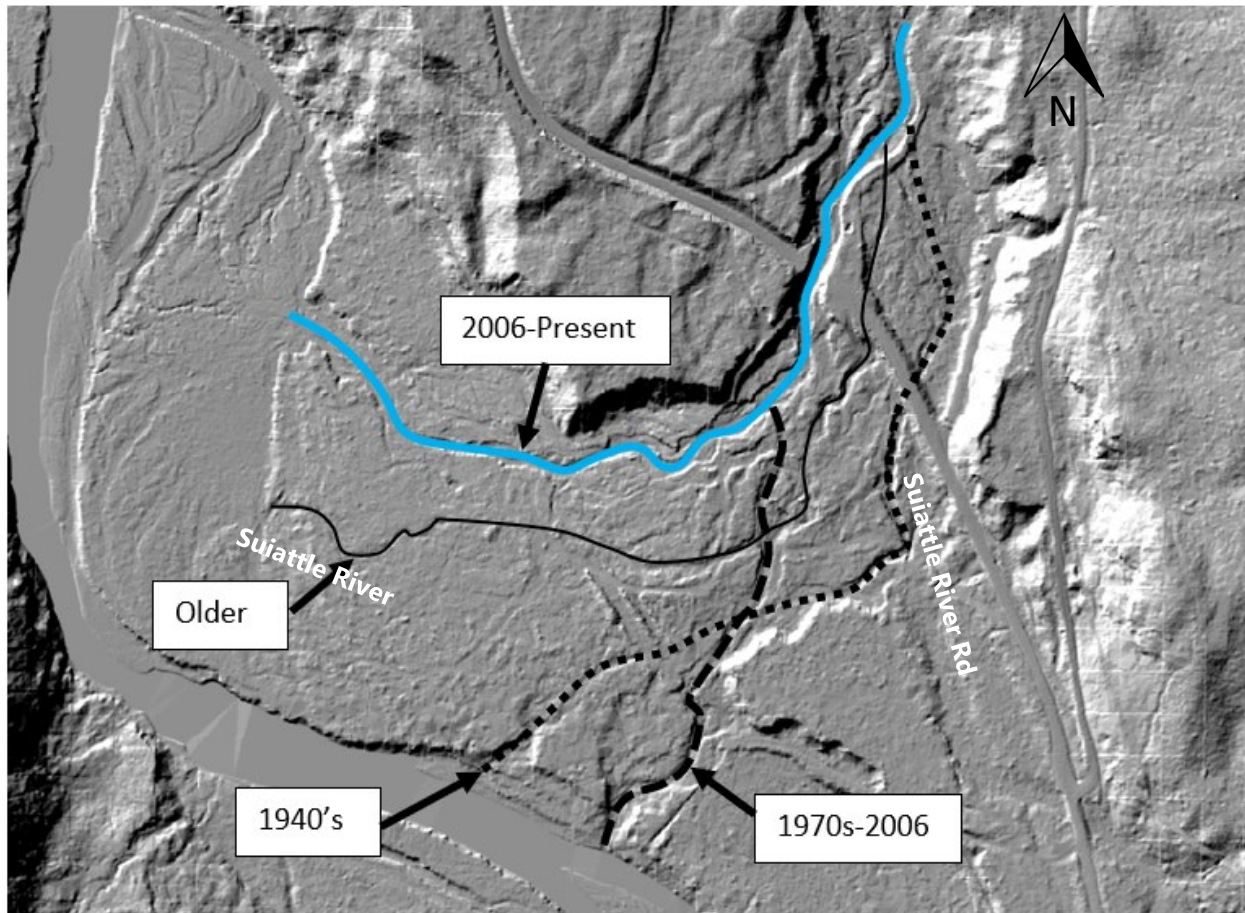


Figure 2-3 Locations of Tenas Creek Channel Inferred from Lidar Terrain, Aerial Photographs, and Field Observations

2.3 Hydraulic Modeling

A 2-D HEC-RAS model of the existing channel was developed using the LiDAR terrain. The accuracy of the LiDAR elevations was evaluated against field surveyed points in the channel, on the levee, along relic channels, and along the road. LiDAR coordinates and elevations were extracted for the four corners of the bridge, and the corresponding values used to establish local survey control. The survey data were adjusted to LiDAR projection (NAD83 WA State Plane North) and elevation datum (NAVD88) based on the road and

bridge survey points. Comparisons of adjusted survey point data with corresponding LiDAR elevations indicated that the levee and open ground, main channel, and relic channel elevations in the 2-D model terrain were accurate to within +/- 0.5 feet, +/- 1 foot, and +/- 1.5 feet, respectively. The difference in main channel elevations likely reflect elevation changes since the LiDAR data were collected, and also reflect the steep slope and highly irregular topography in the channel making comparison of survey against LiDAR elevations more variable. Elevations in the relic channels reflect ground vegetation influence on the LiDAR data. The LiDAR elevations on the levee and open ground areas on the fan appear to be of highest accuracy. The model runs were therefore considered sufficient for a scoping level evaluation of 100-year flood extents and freeboard constraints at proposed road crossing locations for selected options. The main uses of the resulting model predictions were to (i) identify approximate extents of bridge abutments that would not significantly encroach on the 100-year flood, (ii) evaluate the extent to which floodplain connectivity could be achieved through levee removal, and (iii) identify minimum low chord elevation of a structure that would meet a 3 feet freeboard criterion following Washington State's Water Crossing Design Guidelines (Barnard et al. 2013).

Figure 2-4 depicts the domain extent of the hydraulic model. Figure 2-5 depicts the model geometry for existing conditions for the entire model domain. The channel Manning's roughness coefficient value was set to $n=0.08$ based on Jarrett's (1984) equation. The levee, fan surface, and road prism values were set to $n=0.06$, $n=0.12$, and $n=0.04$, respectively based on professional judgment using values in Chow (1959). Scalped levee surfaces were assigned $n=0.06$.

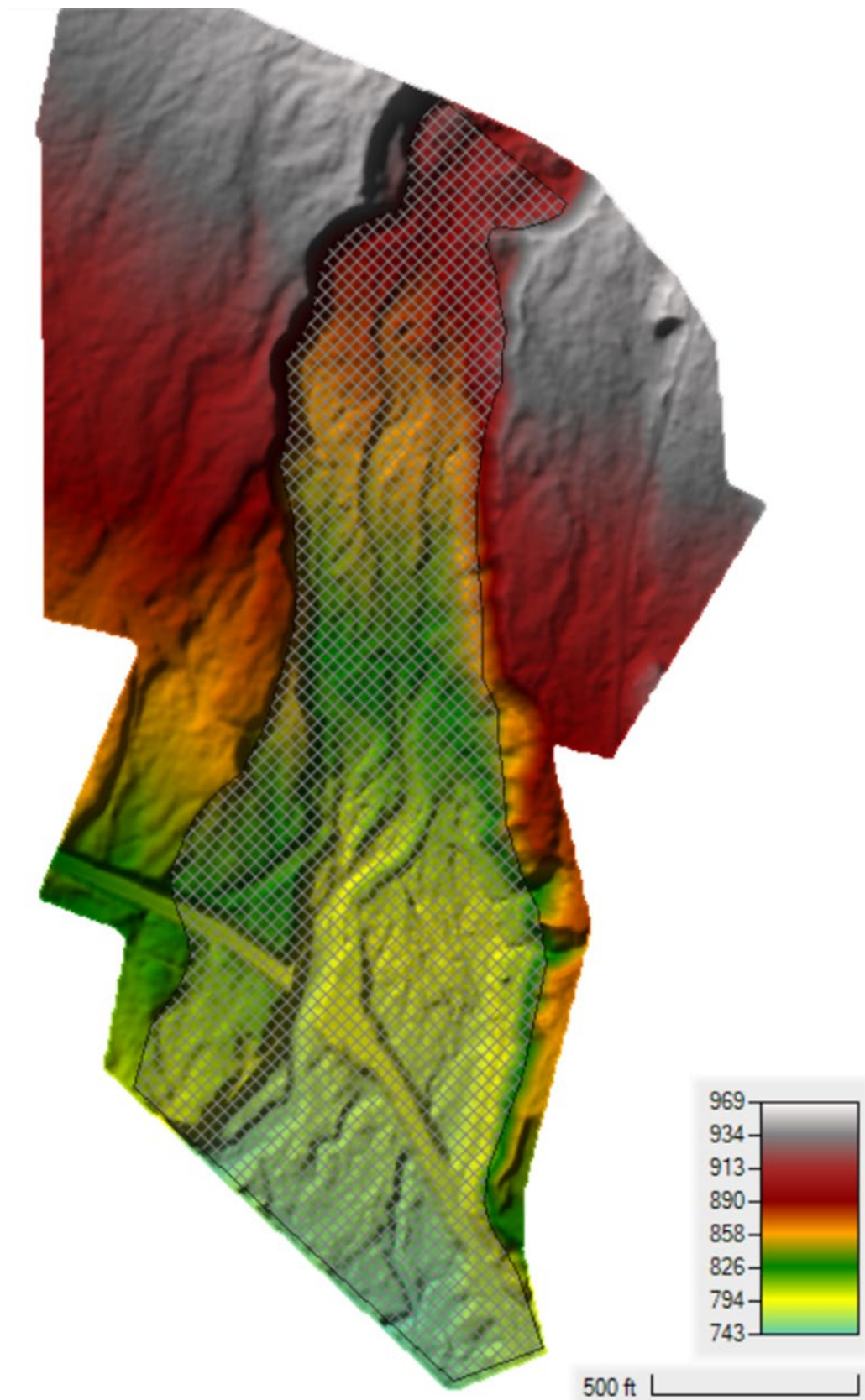


Figure 2-4 2-D HEC-RAS Model Mesh Domain Developed to Evaluate 100-Year Flood Hydraulics

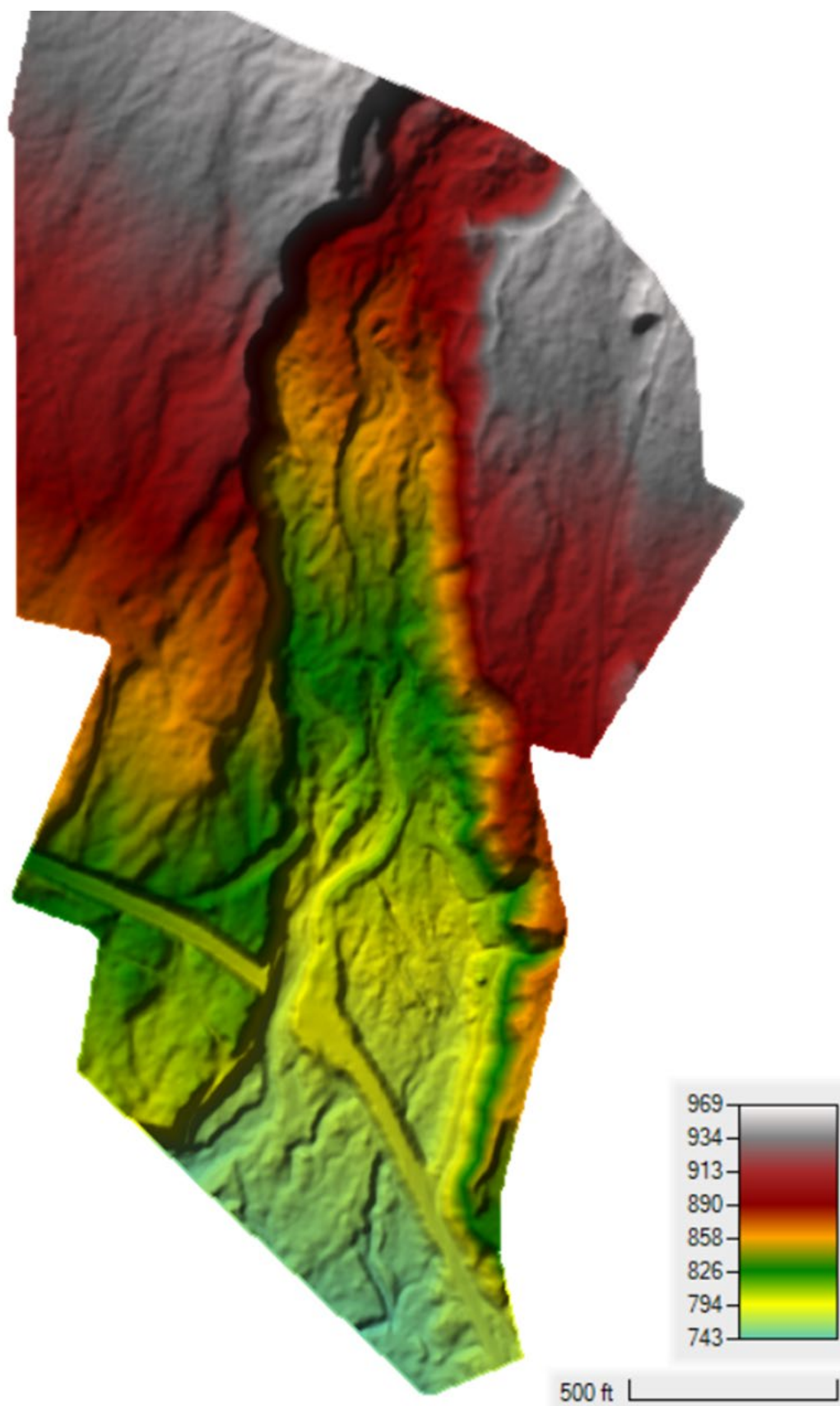


Figure 2-5 2-D HEC-RAS Model Terrain, Existing Conditions

2.4 Geotechnical Assessment

2.4.1 Regional Geology and Geologic Hazards

The project site is situated within the North Cascades complex, which is part of the larger yet younger volcanic Cascade Range that stretches from northern California to southern British Columbia. The North Cascades is a complex assembly of rock and terranes and consists more of plutonic and metamorphic rock than the volcanic rock typical of the Cascades (Haugerud and Tabor 2009). Bedrock in the project area is comprised predominately of metamorphic schist, which is considered to be relatively weak, is prone to rapid weathering, and can be highly fractured. Past earthwork activities in this area such as timber harvesting and road construction have encountered mass wasting and hillslope failures due to the degradation of this rock. Geologic maps of the project area show the near-surface geology at the project site to be underlain by laharc deposits from the Holocene and Pleistocene epochs, generated from eruptions by Glacier Peak (Tabor et al, 2002). A geologic map of the project area is presented in Figure 2-6.

During the last ice age (approximately 15,000 years ago), large glacial outwash was deposited on top of lacustrine clays, creating unstable hillslopes and terraces. Streamflows caused deep, channelized incisions, that often create very steep, unstable side slopes. This condition is not as present within Tenas Creek but is present in the adjacent watersheds. Based on the Washington State Department of Natural Resources (DNR) *Geological Information Portal*, there are no mapped landslides immediately within the hillsides for the proposed crossing options. However, landslides are present in the surrounding areas. Landslides are attributed to steep slopes and high rainfall. In the lower sections of Tenas Creek, the susceptibility to landsliding is considered to be low, indicating stable terrain. However, in the upper portions of the watershed the susceptibility to landsliding increases, particularly along the exposed streambanks. The proposed roadway alignment for this option as it connects to NF-26 road, is considered to be stable.

The project site is situated in a high seismic zone, with large crustal faults passing near the site that are capable of producing earthquakes that can exceed moment magnitude (Mw) of 6. In the lower portions of Tenas Creek, near the existing NF-26 road, unconsolidated alluvium deposits are present. Under saturated conditions (below groundwater table), these deposits are identified as having a medium to high susceptibility to liquefaction based on the DNR *Geological Information Portal*.

2.4.2 Previous Geotechnical Information

There are no records of geotechnical investigations for the existing USFS NF-26 bridge across Tenas Creek. Additionally, no geotechnical investigations such as borings or monitoring wells are listed in the DNR *Geological Information Portal*.

However, as-builts for the existing bridge, Tenas Creek Bridge No. 1, were provided by the USFS. The bridge was originally built in 1962, and from the as-builts, the original design had anticipated that the foundations would bear on coarse alluvium such as sand, gravel and boulders below an elevation of EL 105.1 ft NGVD29. In the original design, each abutment would be supported by four, 4.25-ft square footings with a maximum design bearing pressure of 6,000 psf. However, during construction, the foundation soils were identified as a silty clay with some sand, gravel and boulders, and were not suitable for the original design bearing pressure. The abutment foundation was changed to a deep foundation system consisting of 15 timber piles capped with an 8-ft by 28-ft reinforced concrete pile cap. The timber piles were estimated to be approximately 40-ft in length and had a pile bearing value of 20 tons.

2.4.3 Assessment of Site Conditions

Findings from the 1962 as-built bridge drawings and the regional geological information provided by DNR's *Geologic Information Portal* indicate that the generalized subsurface conditions at the site, from the ground surface down, consist of a coarse-grained embankment fill, underlain by coarse-grained alluvium such as sand, gravels, cobbles and boulders, and then underlain by fine-grained silty clay intermixed with some coarse alluvium.

Geologic hazards such as landsliding are not considered a direct threat to the site but may impact conditions upstream of the bridge crossing.

The existing bridge has shown no signs of significant settlement over its 60-year span at the site. This observation may indicate that the fine-grained soils are not compressible or prone to consolidation settlement for the existing service loads at the site.

Given the close proximity to crustal faults in the region, strong ground motions may occur at the site during a large earthquake. However, subsurface conditions that consist of dense, coarse alluvium or stiff fine-grained material are not subject to liquefaction and associated strength loss.

A geotechnical investigation is recommended to further characterize the site and to assess the foundation conditions of the proposed bridge crossings. Note that at the time of this

writing, a geotechnical investigation has been performed and the findings are currently being summarized in a separate report that will be submitted after this Preliminary Design Report. Further details of the investigation are summarized in Section 4.2 of this report.

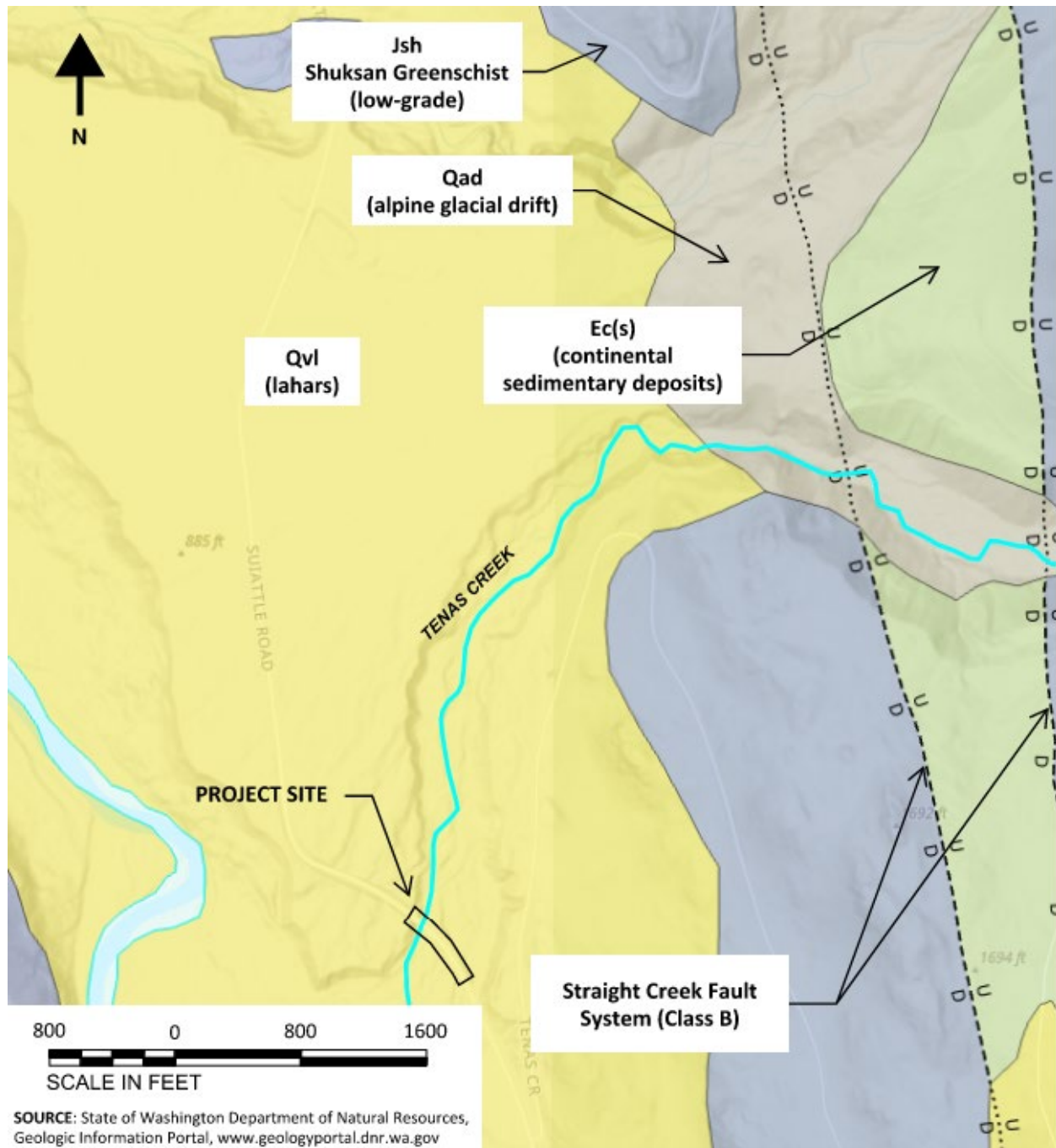


Figure 2-6 Geologic Map of the Project Area (Note only Option 1 is shown in the figure above)

3.0 EVALUATION OF OPTIONS

3.1 Identification of Options

The overall objective of the Tenas Creek Alluvial Fan Process Restoration project is to remove hydromodifications along the channel to restore or enhance channel migration processes without adversely affecting the integrity and use of the road. Four options were identified during initial review of available information and the LiDAR-derived terrain, and in discussions with SRSC staff. The options under review are described below (Figure 3-1).

- **Option 1:** Replace existing bridge and road prism, with two sub-options:
 - Sub-Option 1a: Replace existing bridge with a longer geomorphically appropriate bridge span, construct second longer span bridge over east and west culvert floodplain, scalp most of levee that was built when the channel was confined for the existing bridge, and remove most of the associated road prism leaving an 'island' between both bridges; and
 - Sub-Option 1b: Replace existing bridge with new bridge spanning across entire floodplain, scalp all of levee and road prism.
- **Option 2:** Remove existing bridge, roadway prism, and levee, build new bridge at geologic choke point in canyon upstream, re-route road to connect with Tenas Creek Road, with two sub-options:
 - Sub-Option 2a: A longer, higher bridge with less road cut; and
 - Sub-Option 2b: A shorter, lower bridge with more road cut.
- **Option 3:** Remove existing bridge, roadway prism, and levee, build new bridge at head of alluvial fan at crossing location upstream used prior to construction of the current bridge, resurface historic road prism along periphery of hillslope.
- **Option 4:** No Action.

Two alternate locations were considered initially for Option 2. The farther upstream location initially considered (Figure 1-3) was omitted from further assessment after it was noted that the new road and bridge span lengths would be much greater than for the downstream location and because slopes, cut/fill balances, and the presence of old growth forest would dramatically increase costs and cause greater environmental impact.

Option 3 was identified as likely being the least expensive replacement option because it ties into an existing road base and stays out of the existing 100-year floodplain. It was removed from further consideration in initial discussions with US Forest Service staff

because of concerns with future expensive and environmentally destructive road maintenance if the stream avulses and runs along the base of the road. If avulsion were to occur, it would require subsequent bank stabilization which is counter to the project objective of restoring alluvial fan processes.

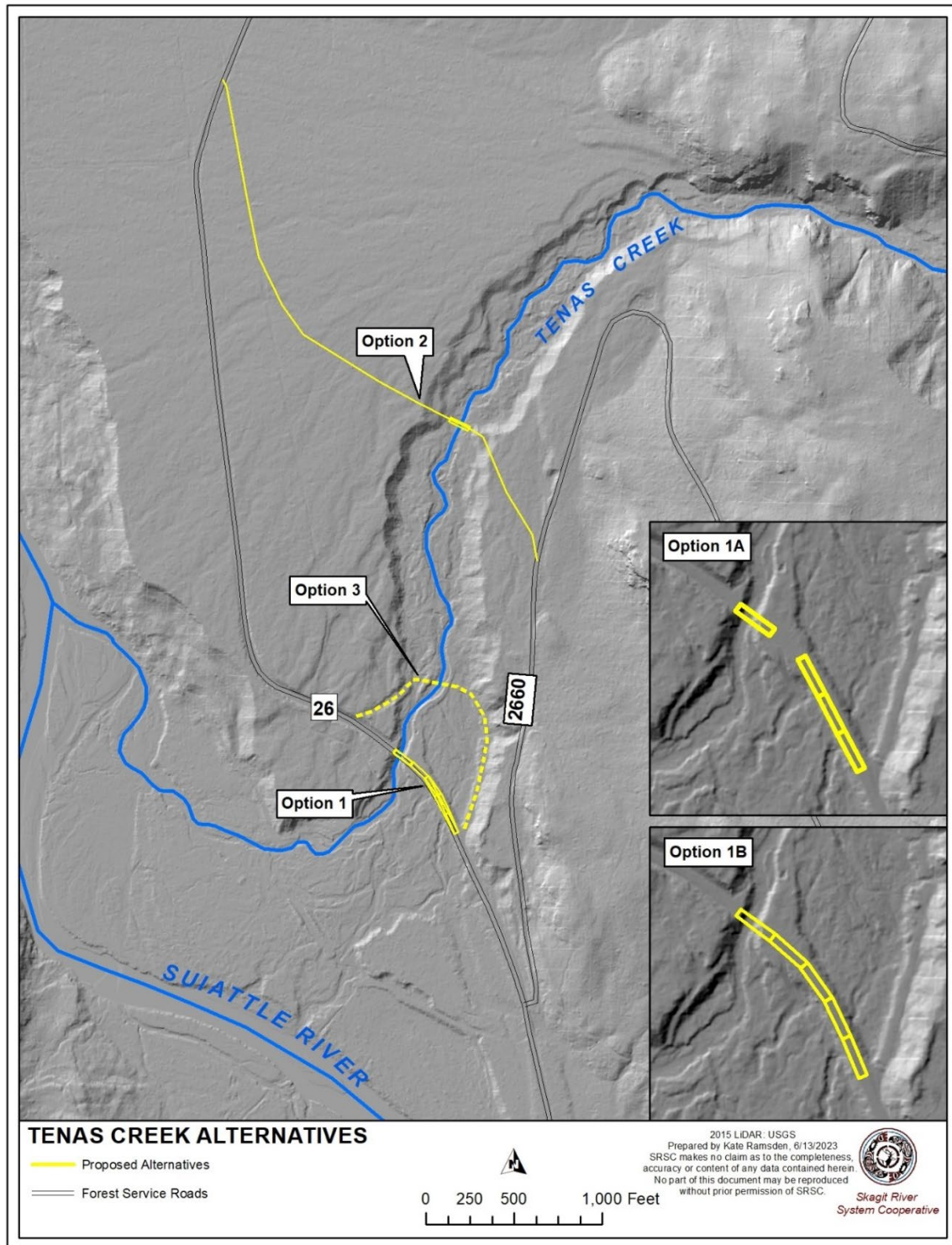


Figure 3-1 Locations of Options 1 through 3 Considered Potentially Feasible

Option 4 (no action) does not accomplish the key project objective of restoring alluvial fan channel migration processes without adversely affecting the integrity and use of the road because it can be expected to be associated with continued incision in the project reach and increased avulsion potential at the upstream end of the levee, threatening the integrity of the Suiattle River Road.

For these reasons, Options 3 and 4 are not discussed further in this report. Plan and section views of each sub-option are presented in Appendix A.

3.2 Refinement of Options

Options 1 and 2 were laid out in CAD model space over a 1 feet interval elevation contour base map generated from the LiDAR terrain. Various bridge lengths and road alignments were laid out over the CAD base map. Replacement bridge lengths and layouts were refined iteratively based on the topography and initial hydraulic model predictions of the 100-year flood extent. It was decided based on information provided by USFS's road engineer that the maximum length of a bridge segment should be around 120 feet, which reflects the maximum practical length that can be transported to the site along the Suiattle River Road and also allows for a wider bankfull channel and 100-year floodplain. Once an approximate bridge footprint was determined for each sub-option, grading contours were then laid out for road and levee cut and fill areas associated with each option. Sections were cut from the terrain along the proposed alignment of each option, and used to identify reasonable road approach grades, and the top elevation of the replacement structures. A maximum road grade of 7% was selected based on discussion during a site visit with Lucas Silvis (USFS road engineer). New road surfaces were specified to have a minimum 22 feet wide surfacing, and 2 feet wide gravel shoulders. The CAD file was then used to measure lengths of new and existing road prisms, lay out a reasonable starting road elevation profile, compare the bridge elevation against the 100-year flood elevation predicted by the model, and estimate cut and fill volumes.

Two corresponding hydraulic model geometries were created for final assessment of floodplain connectivity potential: partial removal of levee and road prism (Figure 3-2), which is associated with Sub-Option 1a, and full removal of road prism (Figure 3-3), which is associated with Sub-Options 1b, 2a, and 2b. The model was then run to predict the spatial extent of the 100-year flood associated with each sub-option, and to inform abutment and pier placement. Figure 3-4 shows that the modeled inundation extent of the 100-year flood under existing conditions is generally confined to the existing channel. Figures 3-5 to 3-7 depict approximate predicted inundation extents associated with

Options 1 and 2. Full removal of the road prism (Sub-Option 1b and Option 2) would be associated with slightly more floodplain engagement than the partial removal (Option 1a) in the vicinity of the road footprint, but no substantial difference in terms of increased avulsion potential upstream. Velocity predictions do not affect selection of the preferred alternative at this stage and will be evaluated in subsequent designs of streambed stability.

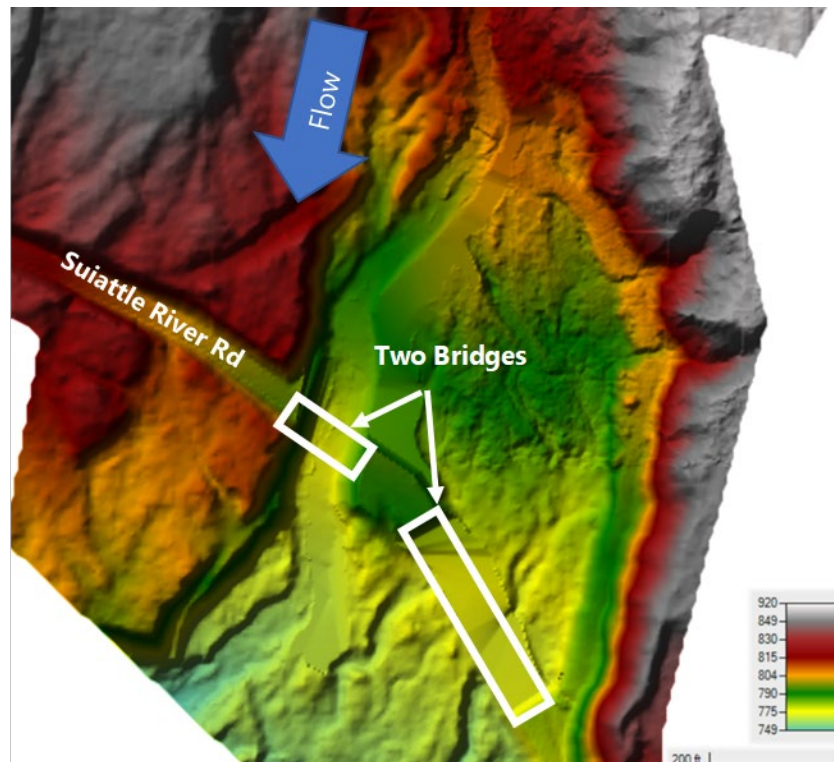


Figure 3-2 2-D HEC-RAS Model Terrain in Vicinity of Road, with Partial Removal of Levee and Road Prism (Sub-Option 1a). Elevation scale bar NAVD88 Feet

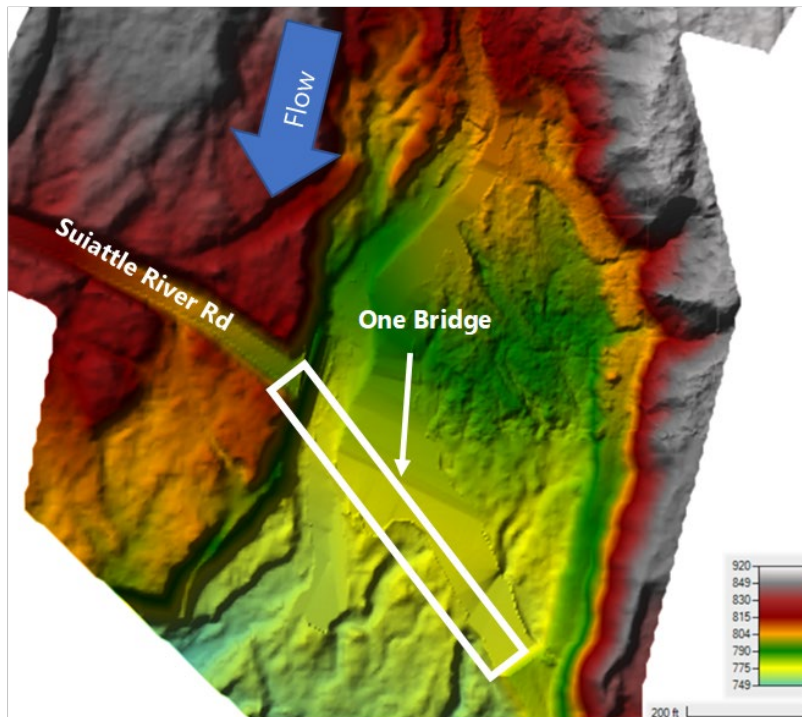


Figure 3-3 2-D HEC-RAS Model Terrain in Vicinity of Road, with Full Removal of Levee and Road Prism (Sub-Options 1b, 2a, 2b). Elevation scale bar NAVD88 Feet

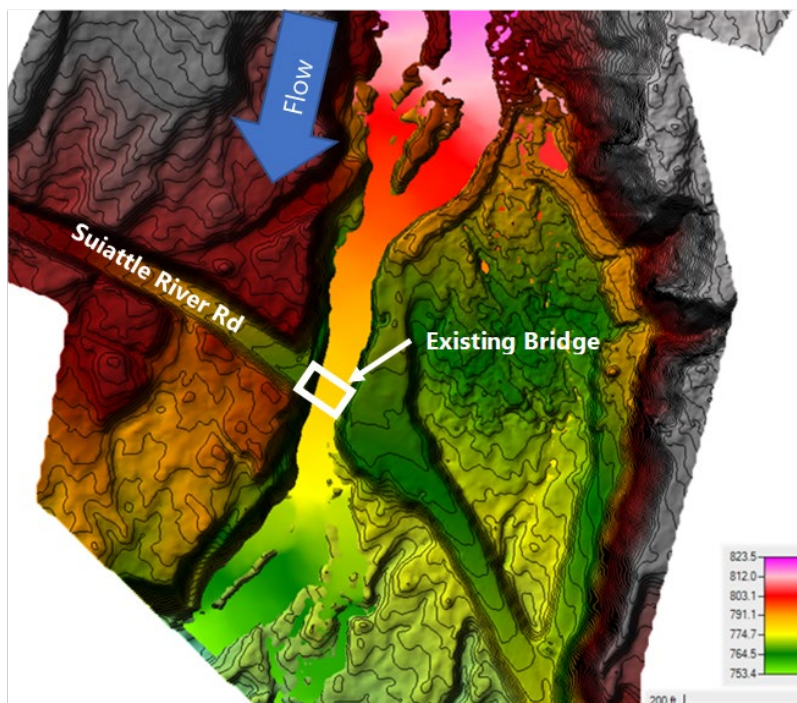


Figure 3-4 2-D HEC-RAS Model Predictions of 100-Year Flood Extent in Vicinity of Existing Road, Existing Conditions. Elevation scale bar NAVD88 Feet

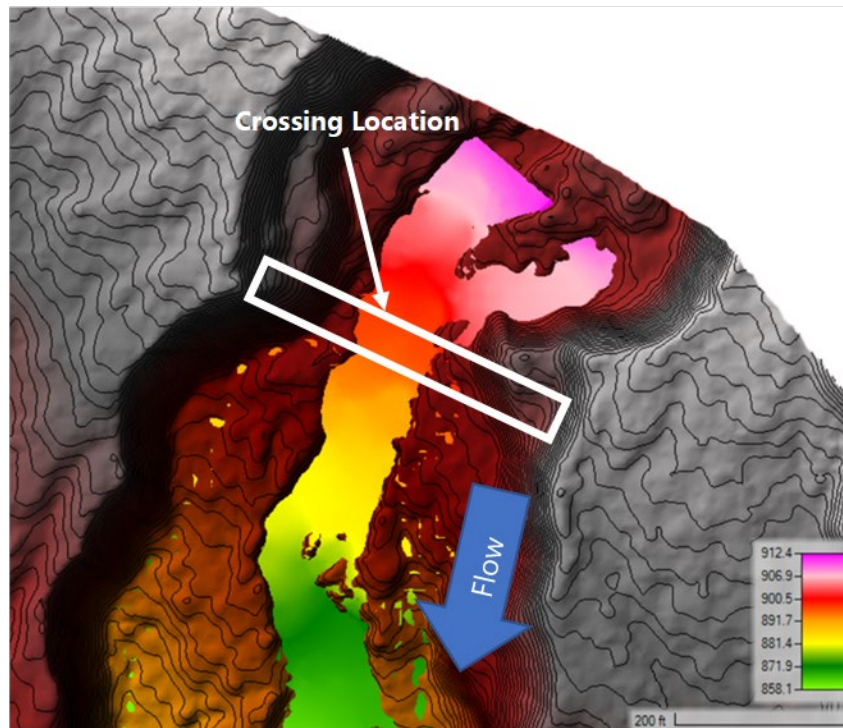


Figure 3-5 2-D HEC-RAS Model Predictions of 100-Year Flood Extent in Vicinity of Sub-Options 2a, 2b Crossing, Existing Conditions. Elevation scale bar NAVD88 Feet

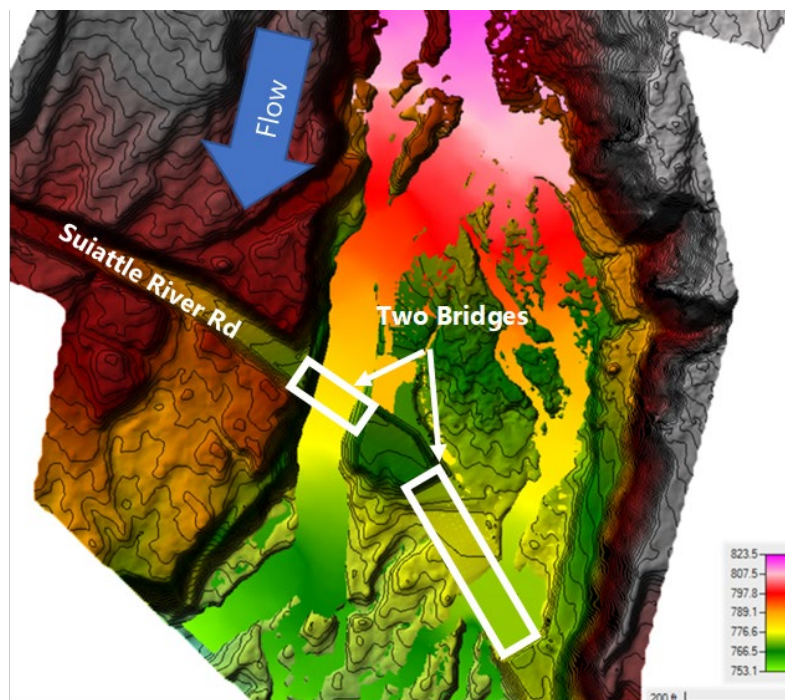


Figure 3-6 2-D HEC-RAS Model Predictions of 100-Year Flood Extent in vicinity of existing road crossing for Sub-Option 1a (Partial Removal of Levee and Road Prism). Elevation scale bar NAVD88 Feet

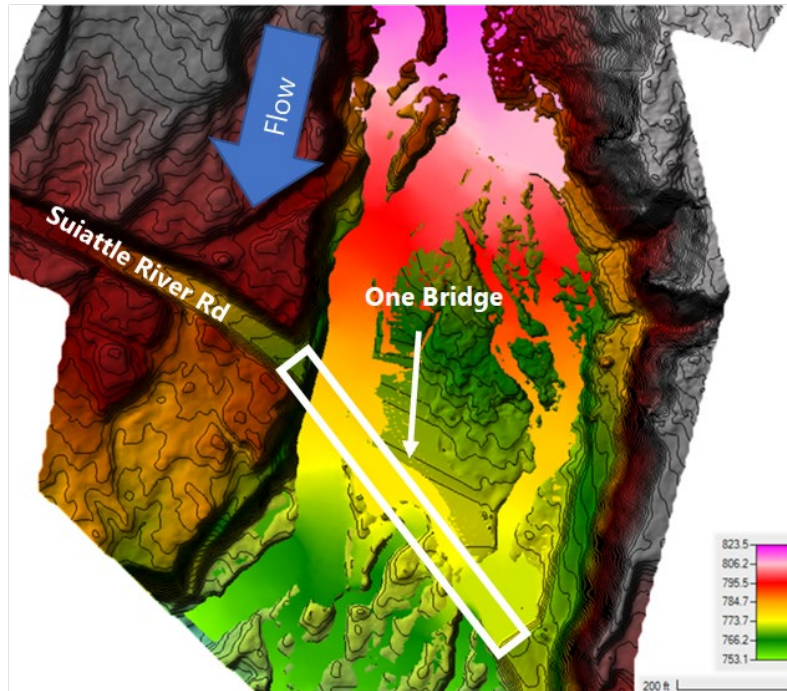


Figure 3-7 2-D HEC-RAS Model Predictions of 100-Year Flood Extent in vicinity of existing road crossing for Sub-Option 1b (Full Removal of Levee and Road Prism). Same results would apply to Option 2. Elevation scale bar NAVD88 Feet

3.3 Comparison of Option Attributes

A summary matrix of attributes is presented in Table 3-1 for Sub-Options 1a, 1b, 2a, and 2b, including key physical characteristics, features influencing constructability, permitting aspects, and estimated costs from design through construction. This table was used to compare and discuss option pros and cons, and assist in the selection of a preferred option. Additional details regarding geotechnical and roadway/bridge/civil design are provided below.

A more detailed breakdown of construction cost opinions is provided for each Sub-Option in Appendix B. The cost estimates are based on WSDOT guidelines and TT project experience, and are comparable to AACE Class 4 level estimates appropriate for a feasibility study and preliminary screening level design with project definition up to what can be considered a 5% level for bridge design. The accuracy of the cost estimates at this level for bridge design are likely within +/- 20 percent. The estimates include escalation over a five-year period. Engineering design costs for the bridge and roadway are estimated as 25 percent of the core construction cost.

3.3.1 Geotechnical

For each of the proposed options, it is anticipated that the abutment and pier foundations will consist of a deep foundation system, utilizing either driven piles or drilled shafts. A deep foundation system will provide sufficient axial and lateral capacity for the bridge, and be resilient against any potential scour impacts. However, for Options 2a and 2b, the foundation system may require a more complex solution due to the steep slopes. Additional geo-structural elements such as tieback anchors and soil stabilization methods may be required for the abutment and roadway sections.

For the roadway along Options 2a and 2b, significant cuts are required during grading of the site. These exposed, cut slopes will require soil stabilization or retention systems such as reinforced soil slopes or retaining walls when steeper than 1.5H:1V. No such methods are required for Options 1a and 1b, except near the abutments. However, it is anticipated that these areas would be lined with riprap to provide slope protection.

Foundation alternatives will be evaluated following the geotechnical investigation once subsurface conditions are better understood.

3.3.2 Road and Bridge Design Considerations

Options 1a and 1b involve roadway and civil design considerations similar to the existing roadway, and do not substantially change stormwater drainage, sight distance, approach grades, and traffic speeds. Options 2a and 2b will involve substantial changes to stormwater drainage, sight distance, approach grades, and traffic speeds. The profiles for options 2a and 2b concentrate stormwater towards the bridge, and will require design of additional energy dissipation and erosion protection. Options 2a and 2b will also require a relatively tight turn excavated at the east side bridge approach, which will influence traffic speed. In addition, the design will need to consider access by logging trucks and the potential for long bridge construction higher up in the Suiattle River valley in the future.

During construction, options 1a and 1b would require either a one-lane temporary bypass detour utilizing generator-powered portable traffic signals, or a two-lane bypass detour with reflective markings and signing for speed reduction and no-passing zone.

The superstructure for all options is expected to be composed of cast-in-place concrete deck on top of either a precast prestressed concrete girders or on spliced post-tensioned precast pre-stressed girders spaced at approximately 6.5 feet on center. Superstructure depth is not limiting with respect to meeting 100-year flood freeboard requirements for

any of the options.

Options 2a and 2b would be designed to have abutments and piers located outside the 100-year flood extent. However, the piers of option 2a and abutments of option 2b could include additional protection by scour countermeasures utilizing riprap. Similarly, scour countermeasures could be implemented for the abutments and piers of options 1a and 1b. The depth of all abutments and piers would need to be sufficiently below projected scour depth.

3.4 Selection of Preferred Option

Option 1A was selected by SRSC as the preferred option. Key factors influencing the selection were lowest estimated cost while achieving project goals, least amount of ground disturbance, uncertainties regarding obtaining an easement, maintaining tribal access to the affected allotment parcel, and mitigation required to build across DNR-owned land. In addition, while the option would not remove all fill from the floodplain, it was still compatible with restoring geomorphic processes and should not significantly restrict the channel from migrating across its historical fan surface. The remaining fill is in alignment with a naturally elevated portion of the floodplain that would be unlikely to be engaged in any near-term avulsion pathway. The option consists of the following key changes to existing conditions:

- Excavating the levee fill material down to adjoining floodplain grade, leaving a central portion of existing road prism and adjoining fill between two bridges that is in line with natural upstream floodplain flow split topography;
- Excavating along the left bank to increase channel width at overly constricted locations to approximately the natural bankfull width estimated for the site;
- Replacing the existing 80 feet long bridge with a 120 feet ("West") long bridge and two abutments, matching existing road grade at the western edge of the alluvial fan with minimal disturbance of the existing side slopes on the western edge, and excavating a portion of the road prism and adjoining fill in line with upstream and downstream channel widening, leaving 2H:1V side slopes on the eastern edge aligned with upstream and downstream;
- Excavating/removing portion of the road prism to match upstream and downstream grades of the historical alluvial fan and channels, removing two culverts, starting at the eastern edge of the alluvial fan and extending the excavation to the west to fit a second bridge, with 2H:1V side slopes at both edges;

- Constructing pile and cap foundations for piers and abutments (pending further geotechnical exploration); and
- Constructing a second 330-feet ("East") long bridge matching existing road grade at the eastern edge of the alluvial fan, with two piers and two abutments supporting three 108 feet long bridge sections.

Large wood can be placed independent of the bridge design at various locations in the channel via fit-in-the-field construction to increase habitat complexity and sort gravels. The wood placement should not be expected to result in aggradation over the near term, because its effect will be secondary to levee removal and aggradation will likely depend primarily on the occurrence of episodic mass wasting and transport events from upstream.

Table 3-1 Attributes of Options Evaluated for Feasibility of Restoring Tenas Creek Alluvial Fan Processes

Option	1a (Two Span Replacement Bridge)	1b (One span Replacement Bridge)	2a (Longer New Bridge)	2b (Shorter New Bridge)
Physical Characteristics				
Span Length (ft)	120 + 360 (3 x 120)	600 (5 x 120)	60,120,60	120
Abutment Height Above Foundation (ft)	20, 20, 20, 10	20, 10	8-10	14-16
Number of Abutments	4	2	2 (upper terrace)	2 (lower terrace)
Likely Min. Pier Height Above Foundation (ft)	20, 15	35, 30, 25, 20	30	0
Likely No. of Piers	2	4	2	0
Length of New Road Prism (ft)	0	0	2,950	3,140
Length of Existing Road to Pave (ft)	140	20	2,600	2,600
Road Alignment	Same as Existing	Same as Existing	Reroute Suiattle River Road to join Tenas Creek Road	Reroute Suiattle River Road to join Tenas Creek Road
Approach Grade	Same as Existing	Same as Existing	Max 5%	Max 7%
Levee Cut Volume (CY)	22,600 (combined)	31,900 (combined)	31,900	31,900
Road Cut Volume (CY)			19,200	Min 27,500
Abutment/Road Fill Volume (CY)	0	0	76 (east approach)	1,460

Option	1a (Two Span Replacement Bridge)	1b (One span Replacement Bridge)	2a (Longer New Bridge)	2b (Shorter New Bridge)
Area of Alluvial Fan Fill Retained (Acres)	0.67	0.03	0.03	0.03
Design Aspects				
No. Geotechnical Borings	Min 6 (Min 1 at each abutment and pier)	Min 6 (Min 1 at each abutment and pier)	Min 10 (min 2 at each abutment, 1 at each pier, 4 along road)	Min 10 (min 2 at each abutment, 6 along road)
Topographic Survey Needs	Levee, Existing Road Prism	Levee, Existing Road Prism	Levee, Existing Road Prism, New Roads, Topography	Levee, Existing Road Prism, New Roads, Topography
Primary Foundation Alternatives	Deep foundation system consisting of either pile or shaft-supported abutments and piers	Deep foundation system consisting of either pile or shaft-supported abutments and piers	Abutments likely require tiebacks and/or pile-supported foundation. Piers are to be pile-supported	Abutments likely require tiebacks and/or pile-supported foundation
Roadway Geotechnical Design Considerations	n/a	n/a	Retaining walls/slope stabilization likely needed from steep slope cuts	Retaining walls/slope stabilization likely needed from steep slope cuts

Option	1a (Two Span Replacement Bridge)	1b (One span Replacement Bridge)	2a (Longer New Bridge)	2b (Shorter New Bridge)
Roadway Traffic Design Considerations	Maintain similar traffic speed as existing	Maintain similar traffic speed as existing	Vertical transition from steep approaches, low speed bend at east side will affect grading	Vertical transition from steep approaches, low speed bend at east side will affect grading
Stormwater Drainage	Positive Drainage, Similar to Existing	Positive Drainage, Similar to Existing	Additional stormwater drainage routing from inset approach roadways	Additional stormwater drainage routing from inset approach roadways
Constructability				
Temporary Bypass Diversion Required?	Yes	Yes	No	No
Staged Construction Possible?	No	No	Yes	Yes
120' Prestressed Girder Delivery?	Yes	Yes	Yes	Yes
Permitting Considerations				
Non-Federal Land Parcels Affected	Seattle City Light, Sally All (Tribal)	Seattle City Light, Sally All (Tribal)	DNR, Sally All (Tribal)	DNR, Sally All (Tribal)
DNR Timber Mitigation Needed?	No	No	Yes	Yes
DNR RMZ Impacts?	No	No	Yes	Yes

Option	1a (Two Span Replacement Bridge)	1b (One span Replacement Bridge)	2a (Longer New Bridge)	2b (Shorter New Bridge)
Evaluate SCL Deed Restrictions	Yes	Yes	No	No
Cultural Resources Surveys	Yes	Yes	Yes	Yes
Wetland Delineation	Yes	Yes	Yes	Yes
Biological Surveys	Yes	Yes	Yes	Yes
Cost				
Bridge/Road Design	\$1,768,000	\$2,191,000	\$2,027,000	\$1,994,000
Geotechnical Engineering	\$75,000	\$75,000	\$110,000	\$110,000
River Engineering	\$40,000	\$40,000	\$40,000	\$40,000
Permitting	\$50,000	\$50,000	\$50,000	\$50,000
Construction	\$19,763,000	\$24,487,000	\$22,750,000	\$22,324,000
Total	\$21,696,000	\$26,843,000	\$24,977,000	\$24,518,000

4.0 PRELIMINARY DESIGN OF SELECTED OPTION

This section summarizes key considerations in developing the preliminary design for option 1a (Two span replacement bridge), and identifies selected critical steps needed to advance the selected option to 100% design.

4.1 Hydraulic Design

The following hydraulic design criteria were developed based on the hydrologic, hydraulic modeling, and geomorphic analyses. Additional hydraulic modeling will be performed in subsequent design stages to refine the criteria using more detailed topographic survey data when available.

4.1.1 Hydraulic Opening

The 120 ft span replacement structure with excavated and planted 2H:1V side slopes between abutments was determined appropriate for the existing channel location, based on the proposed bankfull channel width/depth and the current incised grade under the existing structure. The hydraulic modeling performed for the feasibility assessment indicates that extreme flood events will not be concentrated under the structure. A substantial fraction of the total flow will be diverted over the re-opened fan surface to the east, with little difference in flow split proportions whether the remnant fill between the two bridges is present or not (cf. Figure 3-5 and Figure 3-6).

The second, 360 feet span structure is more than sufficient to allow for all of the 100-year flood to pass underneath should the existing channel fill completely above and/or in the vicinity of the current crossing location, and will also accommodate channel migration in the future. The two piers will be designed sufficiently deep to accommodate scour that could potentially occur if a logjam forms or the channel avulses upstream and then migrates to and past them (see section 4.1.6).

4.1.2 Channel Bankfull Width and Depth

It was determined in the geomorphic assessment above that the channel bankfull top width under the existing bridge replacement structure should be between 70 feet and 75 feet. A bankfull depth of approximately 2.0 feet would contain the 2-year flood, based on 70 feet bankfull width, 2H:1V side slopes, and normal depth approximation with 5% slope and Manning's n roughness coefficient = 0.08. Geomorphic relations predict a bankfull depth ranging between 2.4 feet and 3.0 feet (Castro and Jackson 2001; Lee and Julien 2006; Parker et al. 2007). Recommended design bankfull depth is approximately 2.5 feet

as a mid-point within the range of values.

The dimensions of channels under the second bridge can be excavated to match upstream and downstream morphology. An excavation with bankfull width and depth matching the channel under the replacement bridge is not necessary, where the stream will carve a new channel of appropriate dimensions when it is ready to do so.

An inset floodplain terrace is not strictly necessary for the channel flowing under the existing bridge replacement structure. The channel will be free to overtop its banks upstream and route extensively over the fan such that excessive flood flow concentration is not expected at the crossing.

4.1.3 Riverbed Slope

The existing channel bottom can simply be widened under the replacement structure in line with upstream and downstream, with no change in grade.

4.1.4 Riverbed Grade, Material

If excavation of the left side of the existing channel encounters material smaller than in the current riverbed, then material of a similar size should be placed on the excavated bottom. Existing steps should be extended across the expanded channel with large boulders salvaged locally or from the road fill. Unless geotechnical exploration indicates otherwise, no additional imported material is warranted for lining channels excavated under the second structure footprint. The underlying material is expected to be similar to upstream and downstream in the fan surface and subsurface. However, any boulders and cobble salvaged from the road prism could be retained onsite for additional armoring if needed.

4.1.5 Minimum Clearance

The low chord of the replacement bridge should be higher than approximately elevation 784.5 ft (NAVD88) to achieve a minimum 3 feet high freeboard at the 100-year flood. The low chord of the second bridge should be higher than approximately elevation 776.0 ft to meet the criterion.

4.1.6 Scour Depth

Given the depositional nature of the fan and large size native boulder and cobble material, scour is expected to occur primarily in the form of local scour, which is expected to scale with largest boulder size present, around 5 feet or less. Long term degradation scour is not expected given the site is situated on an alluvial fan. Accordingly, the foundation top

elevations should be at or below the approximate values in Table 4-1, which are approximately 5 feet below the preliminary design ground elevation after excavation. The results of recently completed geotechnical exploration will inform scour analysis and bridge foundation design further in the next design stage; those results will be reported separately from this report.

Table 4-1 Estimated maximum elevations of top of bridge abutment and pier foundations (NAVD88 datum).

Location	Elevation (ft)
West Bridge, West Abutment	771
West Bridge, East Abutment	771
East Bridge, West Abutment	775
East Bridge, West Pier	769
East Bridge, East Pier	766
East Bridge, East Abutment	767

4.2 Geotechnical Design

4.2.1 Summary of Preliminary Geotechnical Conditions

An assessment of the geologic hazards at the site and a summary of the existing geotechnical information was provided in Section 2.4 of this report.

From the available information, a preliminary summary of the geotechnical conditions to consider for design are summarized as follows:

- There are no significant geologic hazards, specifically landsliding, that have been identified within the proposed project area that pose a direct threat to the bridge crossings.
- The subsurface conditions at the proposed bridge abutments and piers are underlain by coarse-grained fill and alluvial materials in the upper portions of the soil profile. From the drawings of the existing USFS bridge, it is understood that fine-grained silt and clay may be present below elevation EL 108± ft (NGVD29). This material composition required the USFS to change the original bridge foundation design from a shallow spread footing to a pile-supported system.
- The coarse-grained alluvium and embankment fill may be susceptible to liquefaction if the material is loose and saturated. There are no construction records indicating how these were constructed and compacted. No preliminary

screening analysis has been performed to confirm susceptibility. However, it is recommended that liquefaction, including seismic-induced settlement of the foundation, reduced bearing capacity from liquefied foundation soils, and increased loading from lateral spreading from surrounding soils be addressed following the geotechnical investigation. It is unclear if the existing soils are loose enough and of sufficient grain size to liquefy under design seismic conditions. However, the susceptibility of the native materials can be assessed following the collection of field and laboratory data from the geotechnical investigation.

- Foundations must account for potential settlement due to consolidation of the silty clay in the foundation soils. The total thickness of these soils is unknown and consequently, total settlement is unable to be estimated. However, based on the historical performance of the existing bridge, there has been minimal settlement in the pile-supported foundations over the last 60 years of service. If the design loads are similar to existing loads, no significant settlement is anticipated to occur. However, if the loads have increased, the additional load must be addressed during design of the foundation system.

4.2.2 Design Criteria

The geotechnical design criteria for the bridge foundation are based on AASHTO (2020); WSDOT (2022a,b), and USGS (2014), and are described below.

4.2.3 Seismic Design

Seismic activity in Western Washington is associated with the subduction of the Juan de Fuca plate under the North American plate. The area is subject to three potential seismic sources, including interface (shallow and large magnitude earthquakes directly associated with the subduction zone), intraplate (deep earthquakes within the subducted Juan de Fuca plate) and shallow crustal earthquakes within the North American plate. However, at the project site, the seismic hazard is controlled by smaller magnitude crustal faults, with a design moment magnitude of approximately Mw 5.8. Long duration, large magnitude subduction zone earthquakes comprise approximately 10-percent of the overall seismic hazard for the 975-year recurrence interval, but all design spectral accelerations are controlled by the crustal faults.

The nearest fault is the Straight Creek Fault, located approximately 0.8 miles east of the project and identified as Class B (not active). The nearest active fault is the Devils Mountain Fault Zone, located approximately 11 miles southwest of the project.

For preliminary design, it is anticipated that the bridge(s) for this project will be designed for similar expected bridge seismic performance as an “Ordinary Bridge, Not Lifeline, Western Washington”, as listed in Table 4.1-1 of WSDOT (2022b). Based on this requirement, the bridge(s) shall be designed for two different seismic scenarios:

1. The Safety Evaluation Earthquake (SEE), which allows for “significant” post-earthquake damage and is expected to be out of service following an earthquake until repaired or replaced. The design spectrum for the SEE is based on a seismic event with a 7-percent probability of exceedance in 75 years (approximately 975-year recurrence interval).
2. The Functional Evaluation Earthquake (FEE), which allows for “minimal” post-earthquake damage and the bridge is to remain in “full service” following an earthquake. The design spectrum for the FEE is based on a seismic event with a 30-percent probability of exceedance in 75 years (approximately 210-year recurrence interval).

Amplification of the bedrock ground motions are to be based on site-specific soil conditions, as represented by the site class determined through a geotechnical investigation. Based on the site location, seismic setting and anticipated soil conditions, the preliminary seismic design parameters are listed in Table 4-2.

4.2.4 Foundation System

Based on the as-builts for the existing NF-26 Tenas Creek Bridge, deep foundations are anticipated for the foundation system of the proposed bridge. These deep foundations may consist of either driven steel piles or drilled shafts and will be utilized for both the abutments and the intermediate piers. Of the options, drilled shafts are the preferred foundation system given the ability to reduce the number of foundation elements within the waterway. The final preferred method will be selected based on the data collected during the geotechnical investigation and from preliminary cost estimates.

Design of the deep foundation system will follow the recommendations and methodology presented by the FHWA, WSDOT and the current version of the AASTHO Bridge Design Specifications. Substructure loads and serviceability (displacement) criteria have not been established yet but will follow the requirements of both WSDOT and AASHTO. The foundation system is to be designed for both axial and lateral loading.

Table 4-2 Preliminary Seismic Design Parameters for SEE and FEE Scenarios (per 2022 WSDOT Bridge Design Manual)

Seismic Parameter	Safety Evaluation Earthquake (SEE)	Functional Evaluation Earthquake (FEE)
Latitude, Longitude	48.3281°N, 121.4372°W	
Return Period (years)	975	210
Mapped Peak Ground Acceleration, PGA	0.242	0.110
Mapped Spectral Response Acceleration for Short Periods, S _s	0.550	0.245
Mapped Spectral Response Acceleration for 1-Second, S ₁	0.152	0.066
Site Class (assumed)	D	
Site Amplification for Peak Ground Acceleration, FPGA (AASHTO, 2020, Table 3.10.3.2-1)	1.32	1.44
Short Period Site Coefficient, F _a (AASHTO, 2020, Table 3.10.3.2-2)	1.36	1.50
1-Second Site Coefficient, F _v (AASHTO, 2020, Table 3.10.3.2-3)	2.2	2.45
Design Spectral Peak Ground Acceleration (A _s = FPGA PGA)	0.318	0.158
Design Spectral Response Acceleration for Short Periods (SDS = F _a S _s)	0.748	0.390
Design Spectral Response Acceleration for 1-Second Period (SD ₁ = F _v S ₁)	0.334	0.168
Design Earthquake Magnitude, M _w (based on mode from 2022 USGS deaggregation)	5.5	5.1

4.2.5 Recommendation for Additional Geotechnical Explorations

There is insufficient subsurface data to develop design and construction recommendations for the proposed bridge crossings. It is recommended that a geotechnical investigation is performed to define the subsurface conditions at each of the proposed bridge foundations, and to collect soil and rock samples for laboratory testing to develop geotechnical engineering properties for use in design.

A geotechnical investigation will be performed in accordance with the 2020 AASHTO LRFD Bridge Design Specifications and the State of Washington Administrative Code 173-160. The 2020 AASHTO LRFD Bridge Design Specifications require borings advanced for bridge piers and abutments supported by deep foundations to extend to a minimum depth of 20 feet below the anticipated pile or shaft tip elevation, or a minimum of 10-ft if bearing directly on rock. Based on this requirement, a limited geotechnical site investigation is proposed, with borings advanced at each of the proposed bridge foundations, extending to an approximate depth of 90 feet based on the interpreted conditions from the as-builts.

All borings will be advanced along the USFS NF-26, Suiattle River Road, either within the roadway or within the shoulder. At a minimum of two days prior to the start of any field activities, the proposed boring locations will be marked with white spray paint and the utility locating services will be notified per Revised Code of Washington (RCW) 19.122 – Underground Utilities.

Drilling will be performed using either hollow-stem auger or rotary wash methods, equipped with the necessary equipment to perform standard penetration tests (SPT) to be performed in accordance with ASTM D1586. Soil sampling is to be performed at 2.5-foot intervals for the upper 15 feet of the soil profile to characterize the near-surface soils within the embankment fill. At depths greater than 15 feet, sampling is to be performed at 5-foot intervals. If soft soils are encountered, samples will be collected with a Shelby tube (undisturbed sampling method) following ASTM D1578.

Based on the geologic maps, rock is not anticipated to be encountered for the proposed drilling depths. If rock is encountered shallower than the planned bottom of boring, the boring will be advanced as deep as possible until practical refusal occurs, and rock coring will be performed to penetrate a minimum of 10 feet into the rock mass. Recovered rock cores will be collected and stored in core boxes. Rock coring will be performed in accordance with ASTM D2113.

During drilling, all recirculating fluid is to be compliant with the State of Washington Administrative Code regulations. Following completion of the borings, the borings will be backfilled with a lean grout mix and bentonite chips up to about three feet from the roadway surface. Aggregate base will be placed to match the thickness of the roadway, and then asphaltic-concrete (AC) cold patch will be placed to repair the asphalt section. Prior to backfilling, water levels, if encountered, will be recorded.

Depending on the site and subsurface conditions encountered, the boring locations and depths may be adjusted once the investigation starts in order to collect the most relevant data for the project. Laboratory testing will be performed on select soil samples to characterize soils, assess soil strength, compressibility and suitability for use as backfill materials. The data collected from the geotechnical investigation will be summarized in a geotechnical data report.

Note that at the time of this writing, a geotechnical investigation has just been completed at the project site. Following the requirements from AASTHO (2020) for a geotechnical investigation, a total of six borings were advanced along NF-26, with one boring advanced within the proposed footprint of each abutment and pier for the bridge crossings. The borings were advanced to a depth of 90 feet, and samples were collected for classification and laboratory testing. A geotechnical data report will be published following the completion of the laboratory testing and will be used to support the remainder of the design phase. No rock was encountered in any of the borings. At this time, no additional geotechnical investigations are required along this proposed alignment.

4.3 Civil/Roadway Design

4.3.1 Vertical Curves and Sight Distance

A preliminary profile was developed based on available LIDAR topo, with an initial sag curve leading to a tangent grade of approximately 2.2% over each bridge. This profile provides satisfactory drainage over the elevated structures and satisfies sight distance needs of the roadway. Furthermore, the vertical profile is sufficient to provide adequate freeboard between the 100-year water surface elevation and the bottom of the bridge girders.

The roadway alignment and profile meet the requirements of chapter 1220 of the WSDOT Design Manual M 22-01.19 and Equations 3-48 to 3-51 on page 3-173 of AASHTO Policy on Geometric Design of Highways and Streets.

4.3.2 Typical Section

The roadway cross section was developed within the footprint of the proposed bridges using Skagit County roadway standards for a minor collector. It also makes sense to minimize the roadway cross-section as much as possible across the Tenas Creek, thus minimizing impacts to the creek, wetlands, and wetland buffer areas. Figure 4-1 depicts the proposed general design criteria for roadway sections.

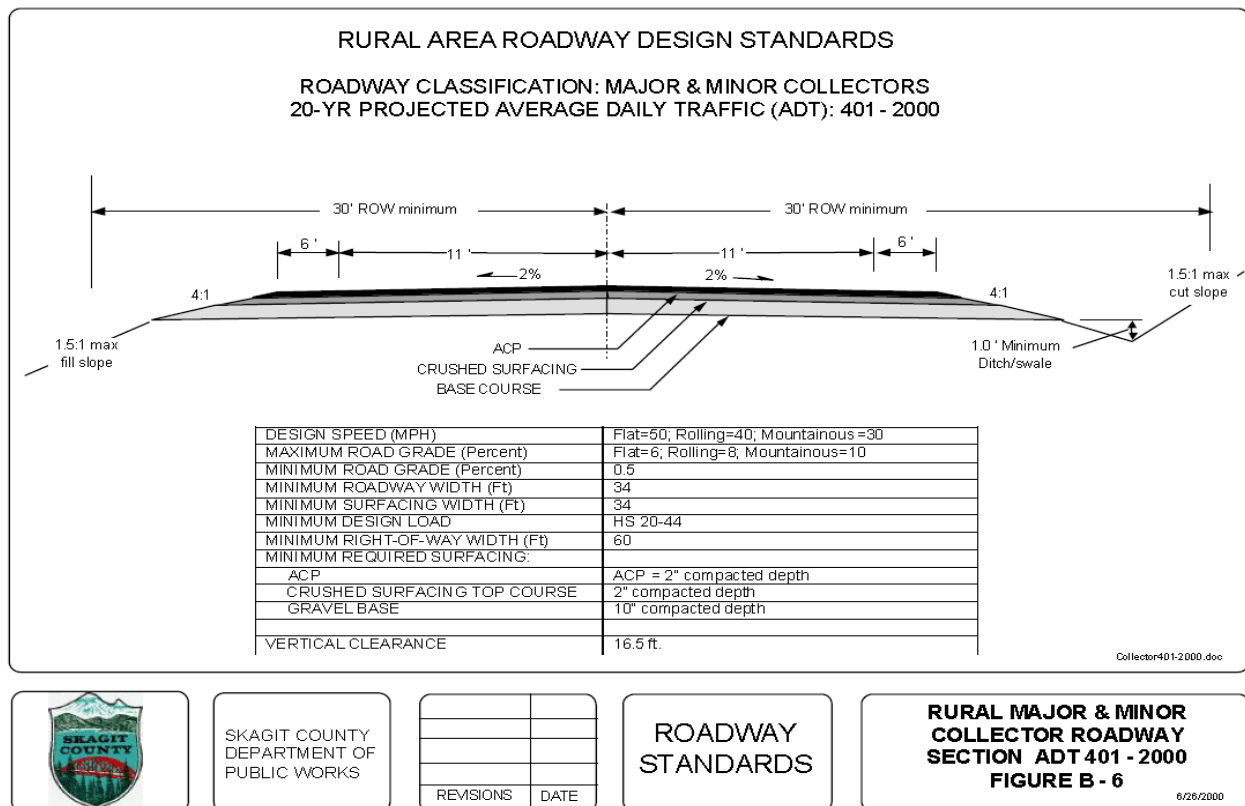


Figure 4-1 Proposed roadway section design criteria.

4.4 Stormwater Management

Application of stormwater management techniques varies highly from project to project. Stormwater management would apply particularly to wetlands, wetland buffers, OHWM, and stream buffers. The following summarizes anticipated stormwater design needs.

4.4.1 Design Criteria

The current WDOE (2019) Stormwater Management Manual for Western Washington is consistent with Skagit County's Storm Drainage Ordinance (SDO) and should be used for assessing all stormwater management impacts of the project and for developing

appropriate types and sizing of facilities. Stormwater conveyance sizing should be in accordance with SDO section 14.32.080(9).

4.4.2 Stormwater Management Methods

The specific methods to be applied will depend on additional topographic and wetlands surveys. In accordance with SDO Section 14.32.060(4), the project is required to prepare a formal Erosion and Sediment Control Plan for approval. Section 14.32.060(5) requires that the project meet the appropriate Large Development Erosion and Sedimentation Control Plan Minimum Requirements. Water quality treatment of stormwater runoff could be achieved through the use of low maintenance "Type 1 Media Filter Drains", as described in WSDOT's Highway Runoff Manual (HRM). As an alternative treatment approach in areas near and adjacent to wetlands, the use of constructed stormwater wetlands may be appropriate. Coordination with the permitting agencies will be necessary to evaluate whether repurposing of wetlands for stormwater management will be acceptable prior to implementation. The primary modes of stormwater conveyance are expected to involve sheet flow and either infiltration through dispersion or discharge to adjacent wetlands. A significant amount of upland conveyance piping is not anticipated.

4.4.3 Utilities

Currently the existing bridge carries no utilities. It is not known at this time if there will be a future need for utilities to be carried by the bridges.

4.5 Structural Design

The selected alternative entails construction of two bridges on the existing alignment to enhance Tenas Creek's channel. The two bridges are a single-span 120 feet long by 30 feet wide (out-to-out) bridge and a three-span 324 feet long by 30 feet wide bridge. A stay-in-place steel corrugated decking system and gravel surfacing for travel lanes was considered as a less expensive option for the superstructure. This type can be cost-effective for rural roadways (i.e., Average Daily Traffic [ADT] of less than 400) but it is not recommended for this project because non-composite steel superstructures will have higher future maintenance, are susceptible to corrosion and are more challenging for routine inspections. The proposed superstructure of both bridges instead consists of pre-stressed precast concrete girders composited with a 7.5" cast-in-place deck that provides a more durable surface. This alternative is consistent with WSDOT guidelines and only provides space for a two-layer rebar mat that has proper clearances and covers but also provides a 0.5" of additional concrete for wearing surface. The envisioned girders are wide

flange type that do not require any formwork which will save time in construction. The substructure of both bridges will be composed of deep shafts and columns. Regarding any required structural walls, to the extent feasible, the walls will be composed of free draining Structural Earth (SE) walls, which are both cost-effective and blend well into the environment by allowing vegetation to cover them.

Proposed plans, elevations and sections for both bridges are presented in Appendix C.

4.6 Construction Sequencing

It is assumed that the existing roadway will be fully closed for construction purposes and a by-pass will be built for temporary traffic maintenance, where the Contractor may be able to use excavated road prism material for backfilling and detour construction. The engineer's proposed detour plan is presented in Appendix C. An alternate detour plan could entail reducing traffic to a single (the eastbound) lane and offsetting the new bridges slightly to the north with partial cut and shoring of the road prism; that detail should be evaluated as part of subsequent design.

A two-year summer construction season is anticipated that should minimize impacts to traffic using the upper basin, and not require a lengthy temporary closure. The following summarizes the proposed construction sequence assuming a constructed detour:

Year 1:

1. Place temporary erosion and sedimentation control (TESC) measures.
2. Install stream diversion/water management measures.
3. Clearing, grading, rock surfacing, temporary bridge placement, traffic safety/control along detour route.
4. Remove existing bridge, abutments.
5. Excavation/grading on east side of channel/road fill.
6. Construct foundations for west bridge.
7. Construct west bridge substructures.
8. Construct west bridge superstructure.
9. Place west bridge deck.
10. Backfill approaches as needed.
11. Construct west bridge approach slabs (if required).
12. Install west bridge railing.
13. Partial excavation/grading road prism removal for east bridge.
14. Temporary rock surfacing for winter traffic.
15. TESC measures for overwintering.
16. Remove temporary bridge for winter.

Year 2:

1. Install water management measures.
2. Temporary bridge placement, traffic safety/control along detour route.
3. Residual excavation/grading road prism removal for east bridge
4. Construct foundations for east bridge.
5. Construct east bridge substructures.
6. Construct east bridge superstructure.
7. Place east bridge deck.
8. Backfill approaches as needed.
9. Construct east bridge approach slabs (if required).
10. Install east bridge railing.
11. Levee removal excavation/grading.
12. Remove temporary bridge, supports, and culvert/fill from relic channel; construct terminal berms at ends of detour route.
13. Final site grading, cleanup, restoration.
14. Open new roadway to traffic.

A local staging area is feasible on the north side of road on the remaining road fill area between bridges. There are likely available staging areas upslope to the west near the alternate route location for Option 2.

4.7 Permitting

Consultation has been initiated with the USDA Forest Service and the U.S. Army Corps of Engineers for the Tenas Creek Alluvial Fan Process Restoration. At this time, we anticipate the project will require a Washington State Joint Aquatics Resources Permit (JARPA). This permit application includes a streamlined review for environmental analysis for a number of commonly used permits. For this project, the following permits will likely be included in the JARPA application:

- U.S. Army Corps of Engineers Section 404 permit;
- Washington Department of Ecology 401 Water Quality Certification;
- Washington Department of Fish and Wildlife (WDFW) Hydraulic Project Approval (HPA);
- Washington State Environmental Policy Act (SEPA); and
- Skagit County Shoreline Management Permit.

This project may qualify for a streamlined HPA process in addition to the JARPA application, exempting it from SEPA and any local government permits. This streamlined HPA process involves applying for coverage under a Fish Habitat Enhancement Project to

WDFW.

Additional activities associated with construction and permitting the project may include:

- Endangered Species Act Section 7 consultation with National Marine Fisheries and U.S. Fish and Wildlife Service;
- Washington State Department of Archeology and Preservation consultation under Section 106 of the National Historic Preservation Act (including Tribal consultation);
- Critical Areas Assessment;
- Wetlands Delineation and Stream OHWM; and
- Biological Assessment or Biological Opinion.

Permit applications can be submitted with a minimum of 30% design. It is recommended to engage with agencies as early as possible to ensure acceptance of a complete application and timely issuance of the permit(s).

5.0 FINAL DESIGN AND CONSTRUCTION SUPPORT SCOPING

Development of a final design is expected to involve nine work elements to be performed by the selected design team, as detailed below. It is assumed that all work performed by the Consultant will be in accordance with the WSDOT Local Agency Guidelines (LAG) Manual, and that reports and plans shall be developed in accordance with the latest edition and amendments of the following guidelines and documents, to the extent feasible:

- AASHTO 2001, "A Policy of Geometric Design of Highways and Streets"
- Washington State Department of Transportation, "Standard Specifications for Road and Bridge Construction"
- Washington State Department of Transportation, "Design Manual"
- Washington State Department of Transportation, "Bridge Design Manual"
- AASHTO LRFD Bridge design Specifications – Ninth Edition
- Washington State Department of Transportation, "Materials Laboratory Outline"
- Washington State Department of Transportation, "Construction Manual"
- Washington State Department of Transportation, "Local Agency Guidelines"
- Highway Research Board's Manual entitled "Highway CapaClient"
- United State Department of Transportation and Federal Highway Administration (FHWA) "Manual on Uniform Traffic Control Devices for Streets and Highways"
- AASHTO "Guide for the Development of Bicycle Facilities"
- WSDOT Highway Runoff Manual
- WSDOT Hydraulics Manual
- King County 2016 Edition of the King County Surface Water Design Manual (KCSWDM)

The nine work elements are described in greater detail below. Table 5-1 summarizes estimated design costs by work item. Services may also include support with respect to Ad-ready Construction Documents and construction Phase Services; these are not considered part of the design phase and are not included in Table 5-1.

Table 5-1 Estimated level of effort and cost for design work items to bring project forward to 100% design and ready for construction solicitation

Work Element	Cost
1 - Project Management	\$100,000
2 - Surveying	\$100,000
3 - Geotechnical Engineering	\$75,000
4 - Hydrology, Hydraulics and Geomorphology	\$40,000
5 - Environmental Permitting	\$60,000
6 - Constructability Review, Construction Schedule and Estimation	\$60,000
7 - Traffic Control Plan	\$42,000
8 - Type, Size and Location Report	\$360,000
9 - 30%, 60%, 90% and 100% Plans, Specifications and Estimate (PS&E)	\$1,244,000
Total	\$2,031,000

5.1 WORK ELEMENT 1 – Project Management

This work element includes administration of the contract between the Consultant and the Agency, and preparation of monthly progress reports and quality control as necessary for the Project. The task includes all administrative services required to coordinate with the sub-consultant/s and to complete the Project on time and within budget. The following are the categorized activities associated with this work element:

- Project Schedule Updating.
- Meetings and Meeting Minutes – approximately 10 team meetings are assumed for the duration of the design activities.
- Monthly Progress Reports, and Invoicing. Progress reports will contain a narrative that identifies and describes significant activities performed in the previous month and the significant planned activities for the upcoming month.
- Design Team Management:
 - a. Prepare schedule and coordinate with design team.
 - b. Prepare sub-consultant agreements, coordinate, budget and review the project progress and submittals.
 - c. Prepare, monitor, and update project schedule. Monitor project budget.
 - d. Prepare monthly billings, progress reports, and updated monthly project schedule.

- e. Maintain regular informal contact telephone discussions, and electronic mail.
- f. Obtain, with assistance from the Client, rights of entry necessary for geotechnical studies, etc.

Deliverables:

- Progress Reports
- Meeting Minutes
- Monthly Invoicing
- Project Schedule

5.2 WORK ELEMENT 2 – Surveying

This Work Element is performed to provide topographic survey and engineering base maps of Tenas Creek, the FR26 Roadway, and its surroundings, including pick-ups of flagging for Ordinary High-Water Mark (OHWM) of the river and topographic mapping of the riverbank 100 feet east and west of the existing bridge and 500 feet from the north and south approaches. Survey shall extend laterally to the apparent right-of-way. Relevant subtasks are defined below.

Survey PM, Admin, QA/QC

This task includes the survey project management, administrative duties, and quality control required for a project of this complexity and magnitude.

Survey Control

This task includes the establishment of survey control, or the recovery of existing survey control, as required for the project. Survey control will be set, found, or referenced utilizing Real Time Kinematic (RTK) GPS (GNSS) and the Washington State Reference Network (WSRN) in conformance with industry standards. This survey control is then propagated, as required, utilizing standard terrestrial total station measurements.

Survey work shall reference the Washington State Plane Coordinate System of 1983 as established in accordance with Chapter 58.20 Revised Code of Washington. Vertical Datum shall reference the North American Vertical Datum of 1988 (NAVD88).

Cadastral Survey Control

Public Land Survey System monumentation is assumed to be required for right-of-way resolution.

Field Surveying and Mapping

This task includes the field surveying and mapping required for this specific effort. The consultant shall locate and map visible features necessary for the creation of an engineering design base map. Typical features will likely include:

- Topographic and Planimetric, including channelization.
- Edge of Pavement, gravel, grass, concrete, etc.
- Signs and signals, poles and appurtenances.
- Trees, 8" in diameter or greater, and edges of significant vegetation.
- Walls, riprap, and fences (or faces of).
- Ground measurements to generate a digital terrain model at one-foot contours.
- Visible improvements situated within the described mapping limits.
- Existing bridge abutment/pier, corner, and soffit elevations.

Utility Surveying Services

This task includes the mapping of utilities throughout the survey limits. The Consultant shall arrange for underground 'conductible' utility locating, by means of a private utility firm.

Office Processing

This task includes the office processing of the collected survey data, data extraction, field book reductions, CADD drafting, and other duties required for the generation of the deliverable(s).

Right-of-Way and Boundary Resolution(s)

- Right-of-Way – Resolve right-of-way within the project limits.
- Parcel Resolution – Resolve boundaries for parcels.

Costing Assumptions:

- Rights-of-Entry will be coordinated by the Client.
- Traffic control, if required, will be a uniformed officer and billed as an invoiced ODC.
- Tree Tags, driplines/canopies are not a part of the scope services.
- Setting of property corners is not a part of the scope of services.
- A record of Survey is not a part of the scope of services.

- Up to 60 Ordinary High-Water Mark flags, set by others, to be located.
- Title reports with underlying documents for parcels to be provided by the Client.

Deliverables:

- Topographic Survey with 1-foot contour intervals (electronic copy).
- AutoCAD Surfaces (DTM Files) (electronic copy).
- ASCII file of control points.

5.3 WORK ELEMENT 3 – Geotechnical Engineering

The purpose of this Work Element is to provide geotechnical engineering recommendations and reporting to support the design team. A geotechnical investigation program has been performed recently in concurrence with this report and the results will be documented separately. The geotechnical engineering effort will include the following activities:

- Review Existing Geotechnical Information.
- Geotechnical Support Related to Preparation of the Type, Size, and Location (TS&L) Report (see work element 8).
- Geotechnical Investigation Program, including a Geotechnical Data Report.
- Geotechnical Engineering Analysis, including foundation design for the bridge abutment and piers, and roadway modifications.
- Draft and Final Geotechnical Reports, including design and construction recommendations.

Costing Assumptions:

- Geotechnical investigation will only include one phase of work. Note that this investigation has already been scoped and is currently underway. The costing does not include this investigation in the total estimate.
- One round of design analysis.

Deliverables:

- Geotechnical Data Report summarizing the investigation, which will include a draft and final copy (electronic). Note that this data report has already been scoped and is currently underway. The costing does not include this investigation in the total estimate.
- Geotechnical Design Report summarizing the analysis and recommendations for design and construction, which will include a draft and final copy (electronic).

5.4 WORK ELEMENT 4 – Hydrology, Hydraulics and Geomorphology

The purpose of this Work Element is to provide hydraulic design engineering support informing design of bridge clearance and foundation, and of riverbed stability in the vicinity of the structures.

Hydrology

The selected design team will want to review the hydrology estimates developed in this preliminary design report.

Hydraulic Modeling

The 2-dimensional hydraulic model developed for this report will have its terrain updated using survey data, and the levee removal geometry will be refined.

Scour Analysis/Design

The geomorphic assessment performed for this report will be reviewed further for long term aggradation/degradation risk. This information together with hydraulic modeling and geotechnical sampling results will be used to estimate scour depth in the vicinity of the piers of the east bridge, and within the enlarged existing channel. Scour countermeasures will be identified as needed.

Riverbed Stability Analysis/Design

More detailed field surveying of surface materials upstream and downstream of the proposed crossings will be evaluated with the results of the hydraulic modeling and geotechnical sampling to determine if riverbed material needs to be specified and potentially imported to ensure general riverbed stability as the channel network evolves.

Costing Assumptions:

- The topographic Survey will be used to generate DEM for hydraulic model.
- The hydraulic model will be developed using the HEC-RAS platform, not SRH-2D.
- One round of design analysis.

Deliverables:

- Draft and Final Hydraulic Design Reports, detailing methods, assumptions, and specification of final parameter values listed in Section 4.1.

5.5 WORK ELEMENT 5 – Environmental Permitting

This Work Element will provide environmental permitting documentation support for National Environmental Policy Act (NEPA) and applicable local permits/approvals. Based on preliminary discussions with the U.S. Army Corps of Engineers in accordance with Section 404 permitting, it is assumed that the Corps will be the lead coordinator for NEPA. This work element relies on a minimum of 30% design plans for the permit applications. Additional tasks associated with environmental permitting support are assumed to include:

- Jurisdictional Determination Support.
- Review of JARPA forms and materials for Sections 404 and 301 of the Clean Water Act.
- Preconstruction biological surveys.
- Agency Preapplication Meetings.
- Ongoing agency consultation as needed.
- Permit Matrix.

Deliverables:

- An electronic (Adobe PDF) copy of the NEPA form.

5.6 WORK ELEMENT 6 – Constructability Review, And Estimation

This work element provides constructability review, construction schedule, and construction estimation services based on the design team's prepared TS&L Report and Plans, & Estimate (P&E) package at 30% design level.

Deliverables:

- Constructability Review and Estimation for Type Size & Location (TS&L) Report (see work element 8).
- Constructability Review and Estimation for 30% P&E design level.

5.7 WORK ELEMENT 7 – Traffic Control

This work element is to provide traffic analysis, traffic control, and detour plans for the Contractor's use in constructing the proposed bridge and roadway improvements. The Consultant will evaluate existing and future traffic conditions and prepare a final report that summarizes the results of the traffic analysis, evaluation of alternatives, and the

Project Team's recommendations. Following one round of comments from the Client, the report will be finalized.

The Consultant will prepare traffic control plans, special provisions, and engineer's opinion of cost for constructing the proposed bridge and roadway improvements. It is assumed the Consultant will attend a total of three team meetings to discuss what type and duration of closures are needed for which phase of the bridge reconstruction, and up to two stakeholder meetings to present and discuss detour and closure plans.

The exact limits of the traffic control will be determined jointly between the Client and the Consultant. The plans will conform with USFS and/or WSDOT/County procedures and standard plans.

Costing Assumptions:

- The USFS shall provide all current and historical traffic count data available to assist in determining an approximate 20-year ADT projection. It is assumed a formal traffic count will be conducted as part of this scope of work.

Deliverables:

- Concept drawings.
- Summary traffic analysis report.
- Traffic Control packages for TS&L, 30% (assumed to be the same as TS&L), 60%, 90%, and 100%/bid-ready design level.

5.8 WORK ELEMENT 8 – Type, Size, Location (TS&L) Report

Based on the Client's input and based on the results from the engineering activities associated with work elements 1 through 6, the consultant will provide structural, civil, roadway, and drainage engineering services with the goal of preparing a TS&L Report that satisfies current WSDOT Bridge Design Manual Section 2.1.5 requirements. All activities associated with this task will be closely coordinated with the Client and the design team will work as an extension of the Client staff for evaluating alternative bridge and roadway design features.

An evaluation matrix will be developed for purpose of comparing the costs, construction feasibility, staged construction flexibility, and other criteria as may be developed during the work. Selection of the final bridge and roadway design alternative will be made by the stakeholders, and the preferred alternative will be carried forward in the design as described in work element 9.

The following design subtasks are expected to be associated with this work element.

Civil/ Roadway Design

Consultant will prepare horizontal and vertical alignment alternatives for the project. The horizontal alignment for the project has been determined by the existing roadway alignment. However, the exact alignment remains to be fixed based on detailed survey information.

Consultant will prepare the preliminary alignment and ROW plan to include proposed right-of-way acquisitions, proposed preliminary permanent easements layout, and proposed preliminary temporary construction easements (TCEs) layout, for each studied road alternative.

A preliminary Site Preparation and Demolition plan will be prepared for each of the studied bridge and road design alternatives. These plans will show topography, existing utilities, existing surface features and items for demolition, removal, or salvage.

A preliminary Plan and Profile plan will be prepared for each of the studied road alternatives in accordance with Client and AASHTO design standards as appropriate for the projected 20-year ADT level of traffic.

Construction of a new bridge and approaches will require pavement replacement. A conceptual stormwater management approach will be developed to identify whether stormwater runoff treatment and/or stormwater flow control thresholds will be exceeded. For each road alternative the Low Impact Development Performance Standard will be evaluated and possible scenarios for meeting this requirement will be explored.

Structural Design

Based on input from prior tasks the Consultant's structural team will perform preliminary structural design associated with viable bridge replacement alternatives for each alignment. The design will follow the most current WSDOT Bridge Design Manual (BDM), AASHTO, and Client requirements. The structural design will incorporate low impact design approaches like noise reduction, minimization of traffic impacts, Life Cost Analysis based on Client-desired parameters, and environmental protection. Bridge design activities start with a review of the gathered data provided by team members including survey, geotechnical, hydrology, traffic, civil, etc.

Throughout the structural assessment/design of the bridge replacement alternatives, the Consultant will be in continuous communication with the USFS for consultations on

parameters like structure location, length and vertical clearance. Also, required roadway elevations would be addressed. The team will recommend one bridge replacement alternative for a preferred alignment that possesses most of the USFS-desired attributes to advance to full design stage.

All engineering work will be done per most current AASHTO LRFD Bridge Design Specifications, WSDOT Standard Specifications, WSDOT Bridge Design Manual M 23-50, June 2019 and current Client Standards.

Deliverables:

- Alternative roadway/bridge plans and profiles
- Opinion of Cost for each roadway/bridge alternative
- Evaluation matrix
- Draft TS&L Report.
- Final TS&L Report.

5.9 WORK ELEMENT 9 – Plans, Specifications, and Estimates (PS&E)

This work element will provide 30%, 60%, 90%, and 100% Ad-Ready PS&E documentation in accordance with WSDOT's LAG Manual.

30% Plans and Opinion of Cost

This work element item encompasses all the activities associated with the preparation of the 30% Plans and engineer's opinion of construction cost Estimate (P&E) documents. Constructability Review and QA/QC activities are an inherent part of this element.

Deliverables:

- Electronically delivered plan sheets in pdf format.
- Electronic copy of the estimate's quantities opinion of construction cost.

60% Plans, Specifications, Drainage Report - Technical Information Report (TIR), and Opinion of Cost

This work element item encompasses all the activities associated with the preparation of the 60% Plans, Technical Information Report (TIR), Special provisions, and engineer's opinion of construction cost Estimate (PS&E) documents. Full specifications will not be provided. Only special provisions for review will be provided at the 60% submittal.

Constructability Review and QA/QC activities are an inherent part of this element.

Deliverables:

- Electronically delivered plan sheets in pdf format.
- Electronic copy of the estimate's quantities opinion of construction cost.
- Electronic copy of preliminary Special provisions anticipated.
- Electronic copy of the preliminary TIR.

90% PS&E

This task encompasses all the activities associated with the preparation of the 90% Plans, TIR, Special Provisions and engineer's opinion of construction cost Estimate (PS&E). Constructability Review and QA/QC activities are an inherent part of this element.

Deliverables:

- Electronically delivered plan sheets in pdf format.
- Electronic copy of the estimate's quantities opinion of construction cost.
- Electronic copy of Special provisions.
- Electronic copy of the updated TIR.

100% PS&E – Bid-Ready

This work element item encompasses all the activities associated with the preparation of the 100% Bid-ready Plans, TIR, Special Provisions and engineer's opinion of construction cost Estimate (PS&E). Constructability Review and QA/QC activities are an inherent part of this element.

Assumptions:

USFS to provide:

- Title block and CAD standards if needed.

Deliverables:

- One half size electronic copy of the Bid-ready set of Plans.
- One full size originally signed copy of the Bid-ready set of Plans.
- Electronic copy of the Specification Manual at 100% level document per LAG, WSDOT and USFS templates, in MS Word format.

- One electronic copy of the quantities Estimate and opinion of construction cost and a signed original of the opinion of construction costs.
- AutoCAD and/ or Civil 3D complete electronic drawing files.
- Electronic copy of the TIR – stamped and signed.

Table 5-2 presents representative Ad-ready plan sheets that may need to be developed for the project, for each structure.

Table 5-2 Estimated number of plan sheets in construction set.

Sheet Name	PS&E Number of Sheets	TS&L Number of Sheets	PS&E Submittal Phase		
			30%	60%	90%/100%
Cover Sheet	1		X	X	X
Index Legend and Abbreviations	2			X	X
Civil and Structural Demo Plans	4			X	X
Site Prep and TESC	4			X	X
Roadway Plan and Profile	8	4	X	X	X
Striping and Paving	8			X	X
Roadway Typical Sections and Details	3	1	X	X	X
ROW	2	2	X	X	X
Drainage	3	1		X	X
Utilities	2			X	X
Construction Detour Plan	6	1		X	X
Traffic Control	6	1		X	X
Roadside Restoration	2			X	X
Bridge Plan and Elevation	2	4	X	X	X
Bridge Demo	4			X	X
General Notes	1			X	X
Bridge Construction Sequencing	5		X	X	X
Temporary Shoring	2		X	X	X
Bridge Foundation Layout	2	4	X	X	X
Shaft Details – PierS	2			X	X
Pier Layout (Plan and Elevation)	2		X	X	X
Pier Details	4			X	X
Abutment Layout (Plan and Elevation)	4		X	X	X
Abutment Details	8			X	X
Framing Plan	2			X	X
Bridge Typical Sections	2		X	X	X

Sheet Name	PS&E Number of Sheets	TS&L Number of Sheets	PS&E Submittal Phase		
			30%	60%	90%/100%
Girder Details	8			X	X
Diaphragms Details	4			X	X
Deck Reinforcing	6			X	X
Bearing Details	3			X	X
Expansion Joint Details	3			X	X
Bridge Drainage Details	3			X	X
Bridge Barrier Details	3			X	X
Bridge Railing Details	2			X	X
Throw Fence Details	3		X	X	X
Bridge Approach Slabs	2			X	X
Retaining Wall Layouts	4		X	X	X
Retaining Wall Details	2			X	X
Bar Bending Sheets	4				X
Guardrail	3			X	X
Perm. Signage and Attachments	2			X	X

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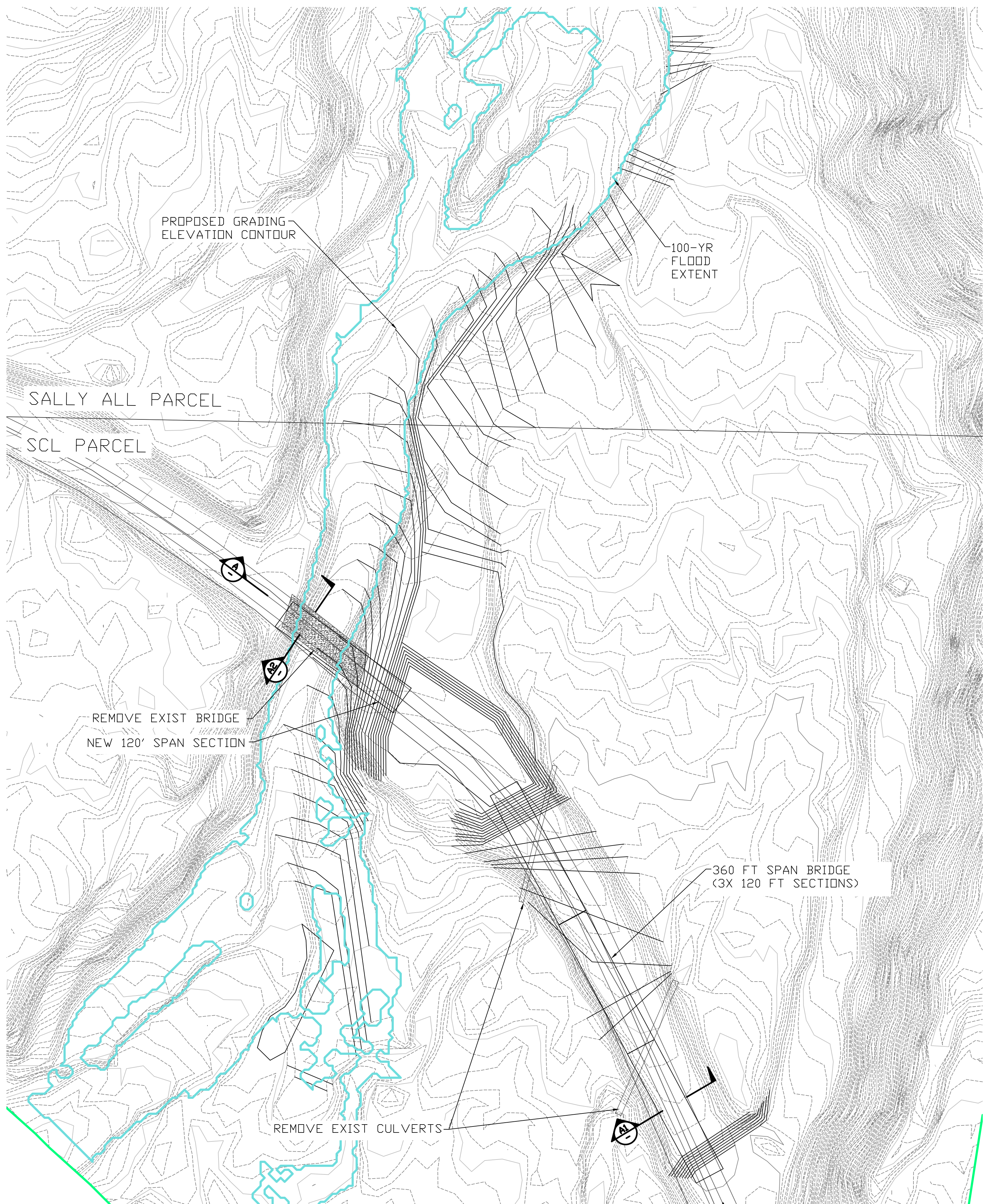
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APPENDIX A

CONCEPTUAL DESIGN PLANS AND SECTIONS OF OPTIONS

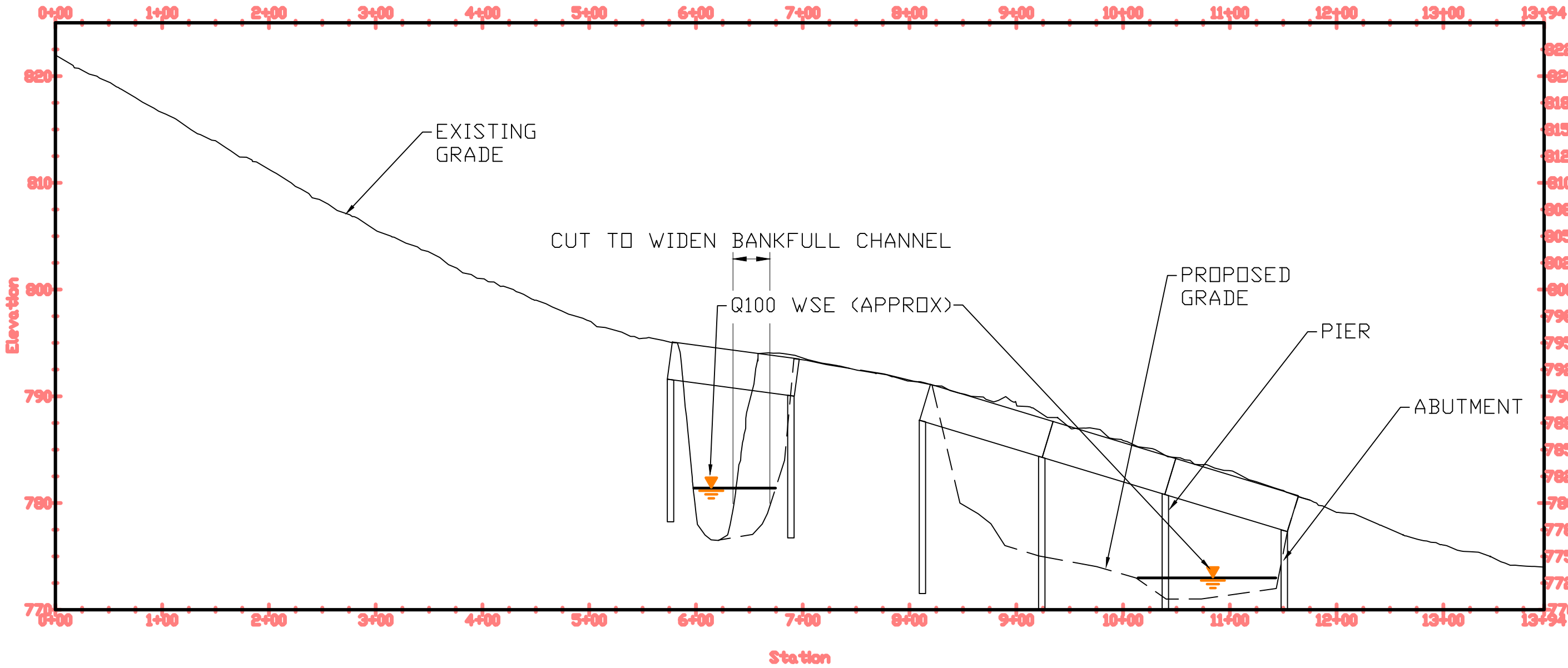
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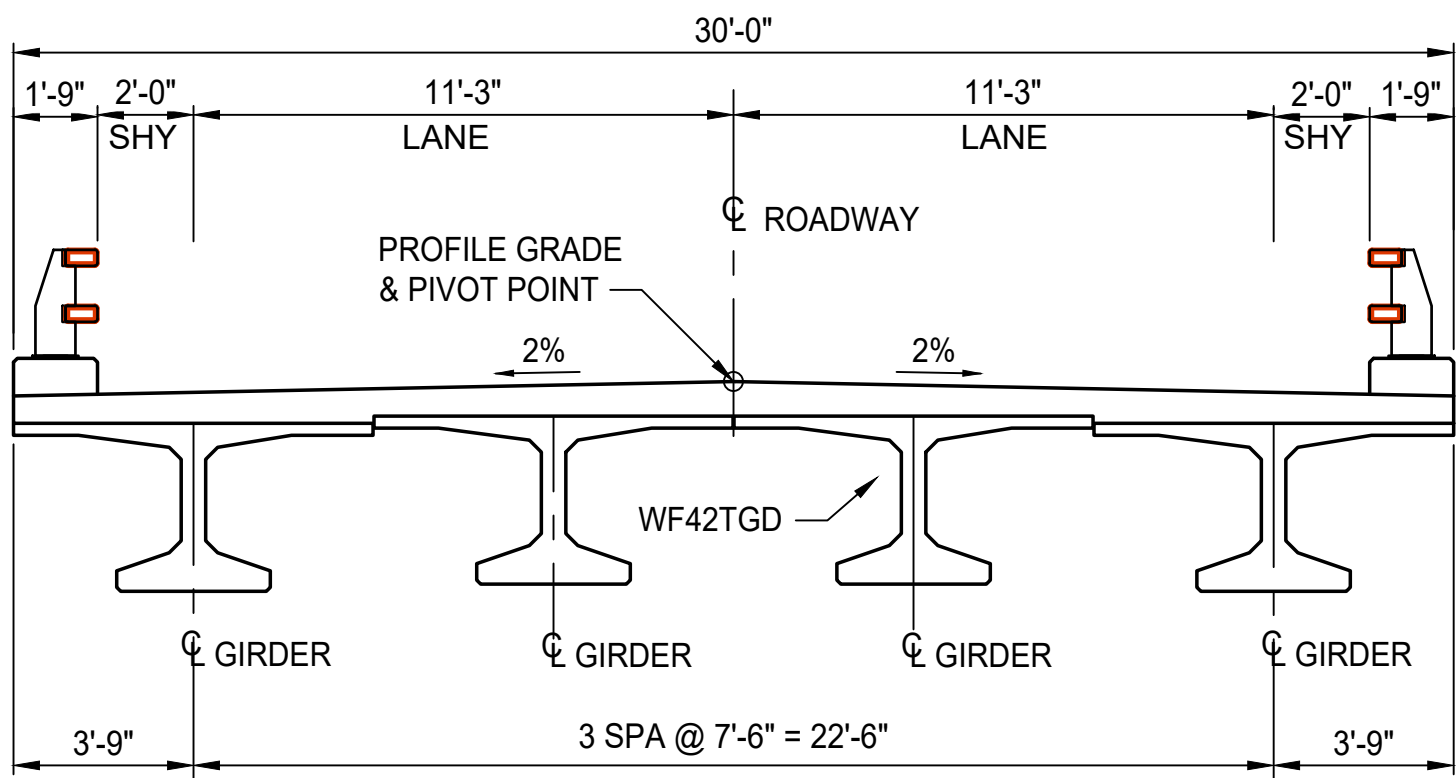


OPTION 1a PLAN

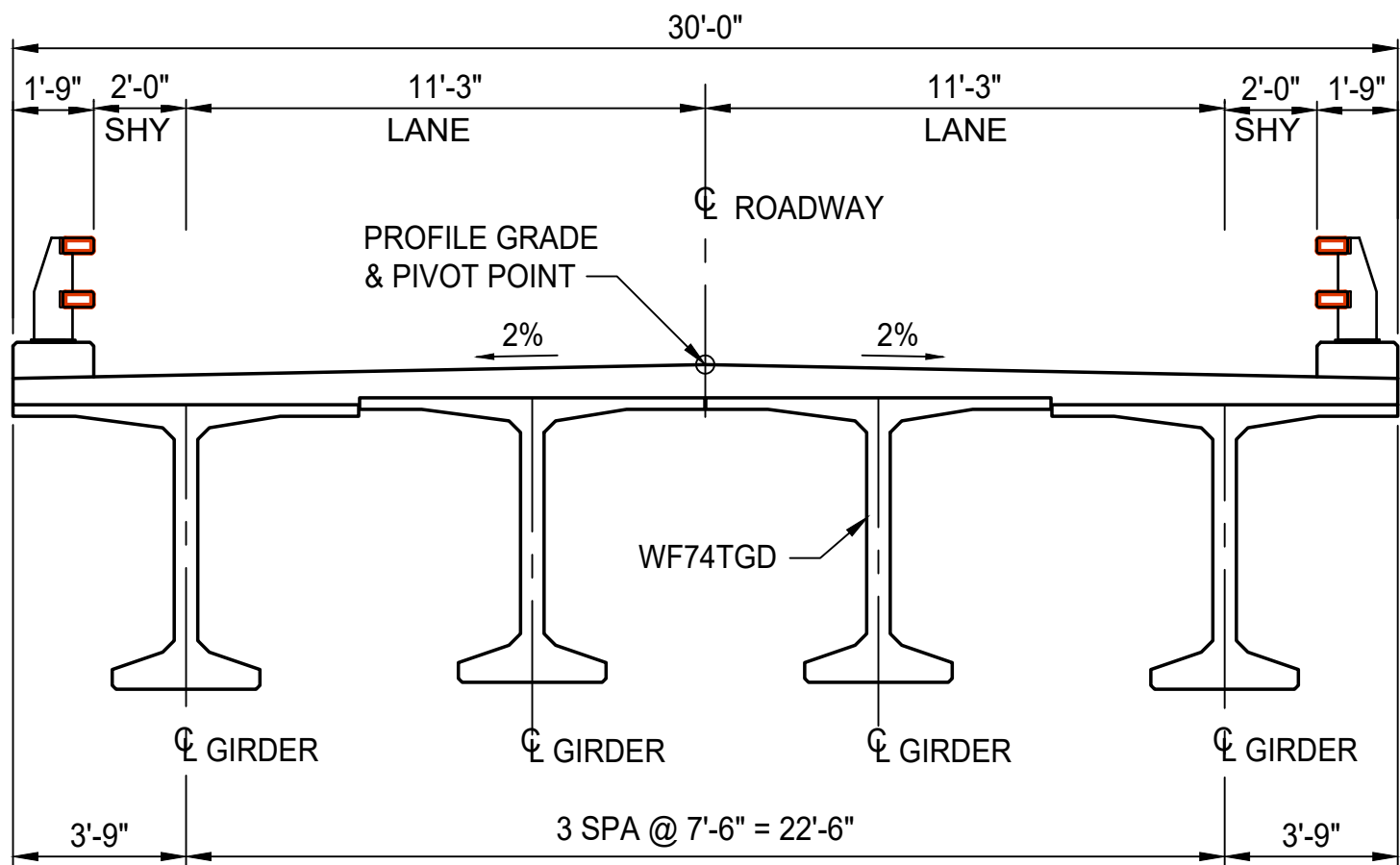
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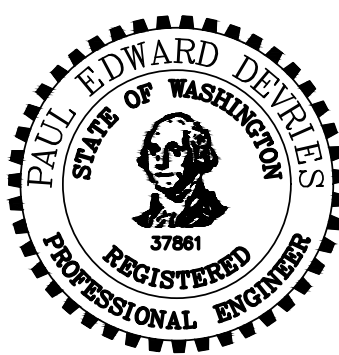
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SCALE IN FEET (VERT) 10 0 10 20



SECTION A1
MULTI-SPAN



SECTION A2
SINGLE SPAN



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SKAGIT RIVER SYSTEM COOPERATIVE				
TENAS CREEK ALLUVIAL FAN RESTORATION FEASIBILITY				
OPTION 1a CONCEPT PLAN & SECTION				
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Project No. 4976-238	Date Revised 05-25-23	Drawing No. ###-##		

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SALLY ALL PARCEL

SCL PARCEL

100-YR
FLOOD
EXTENT

REMOVE EXIST BRIDGE

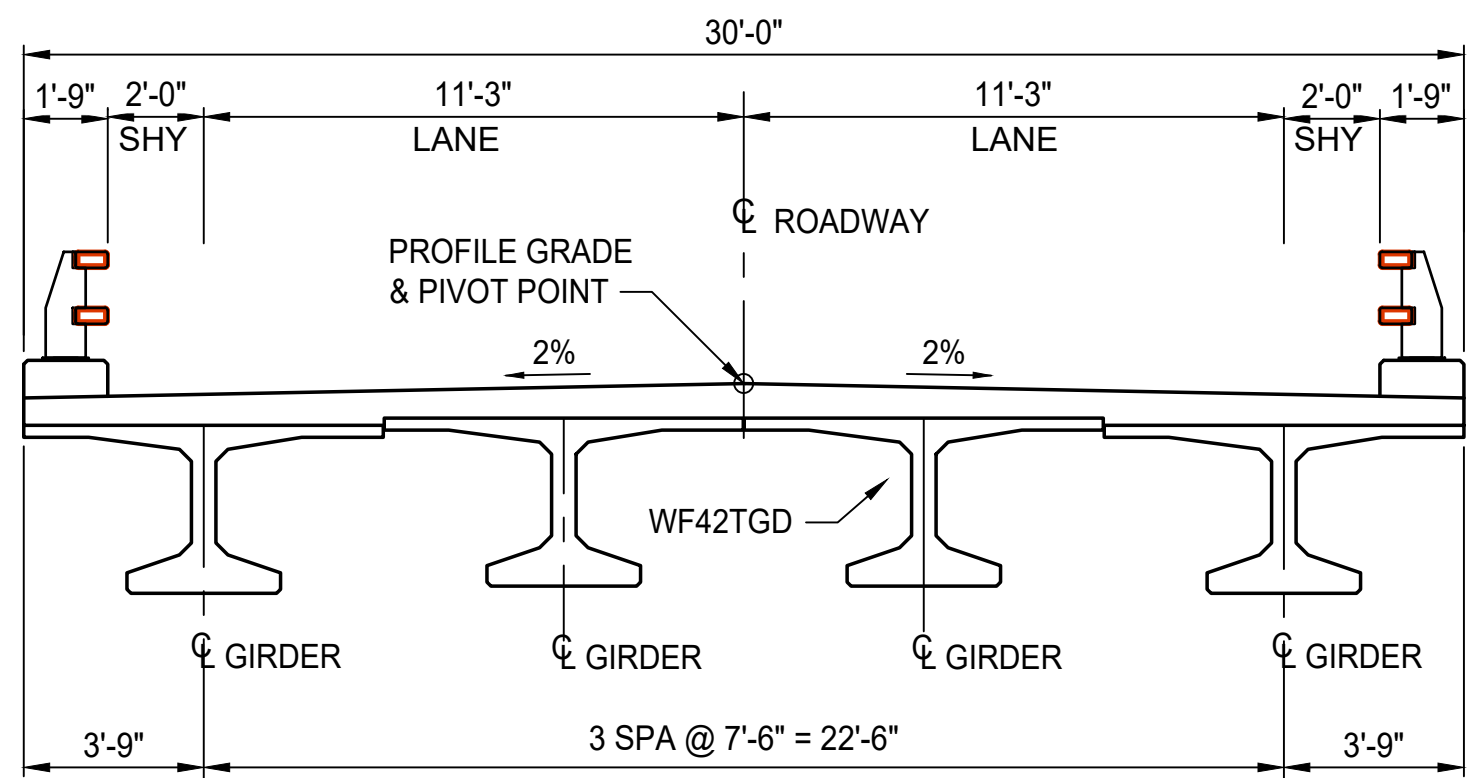
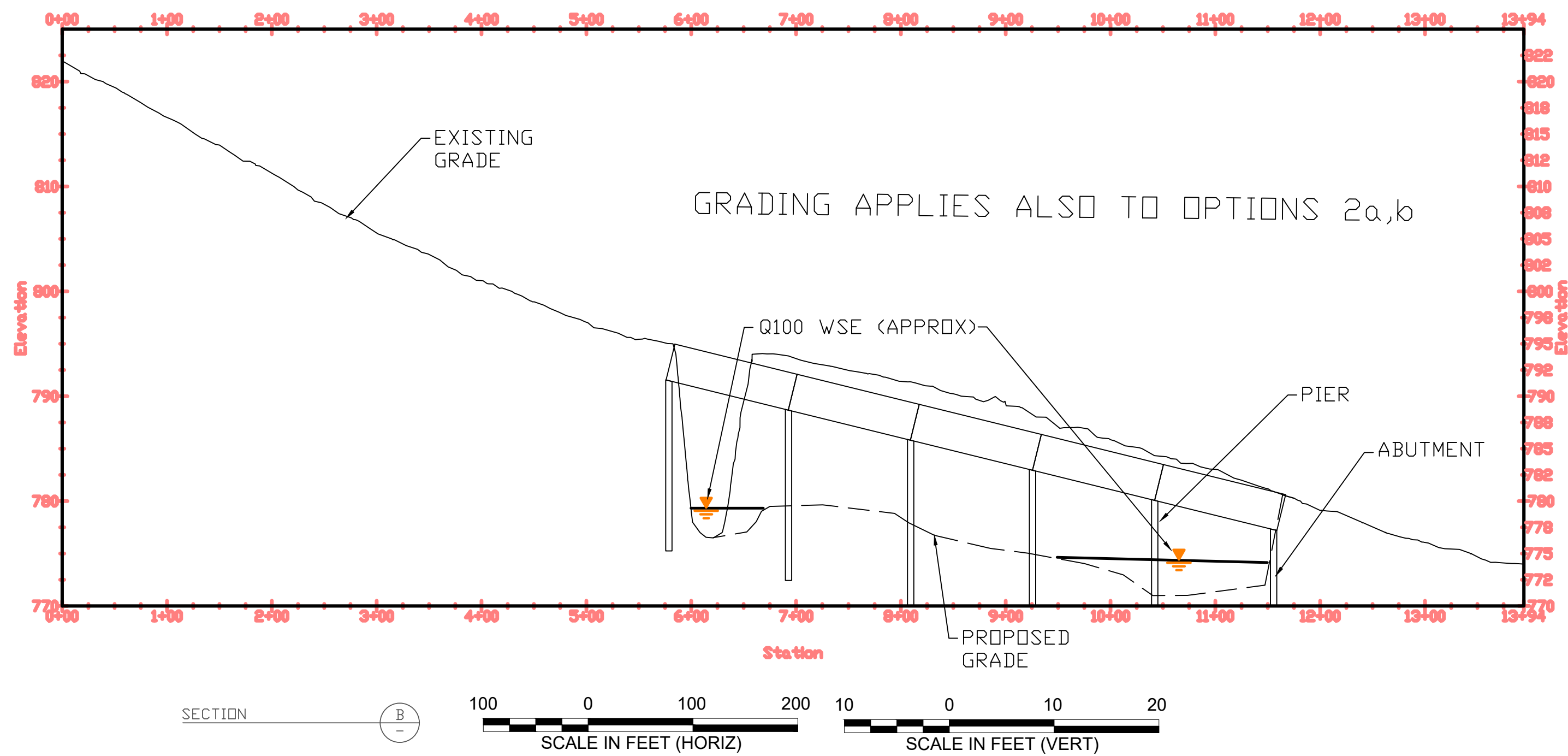
5 NEW 120' SPAN SECTIONS

600 FT SPAN BRIDGE
(5X 120 FT SECTIONS)

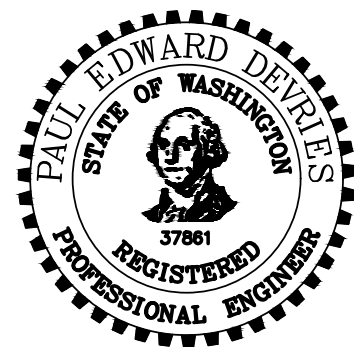
REMOVE EXIST CULVERTS

OPTION 1b PLAN

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SCALE IN FEET, 1 FT CONTOUR INTERVAL



SECTION
MULTI-SPAN



No.	Revision	Date	Drawn	Checked
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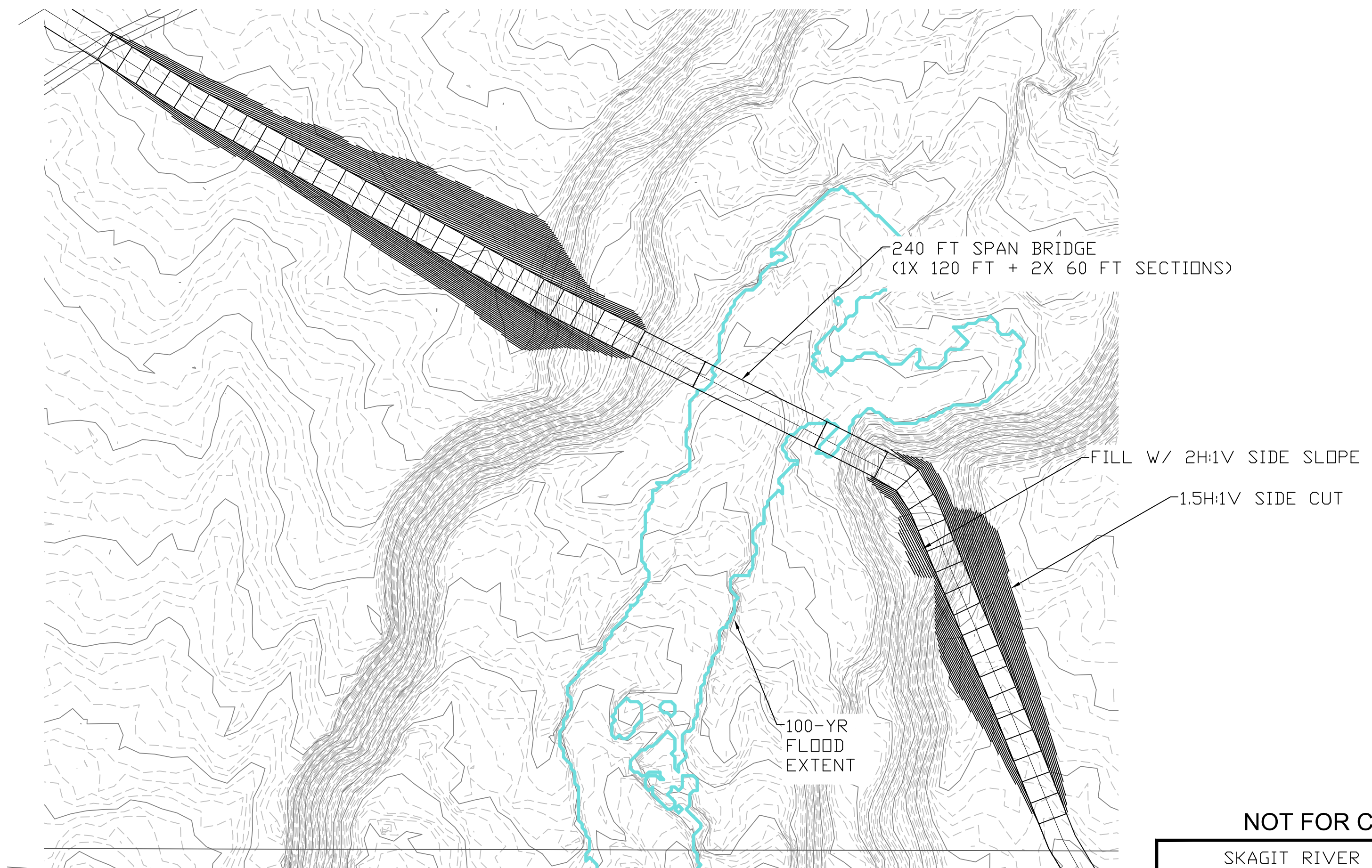
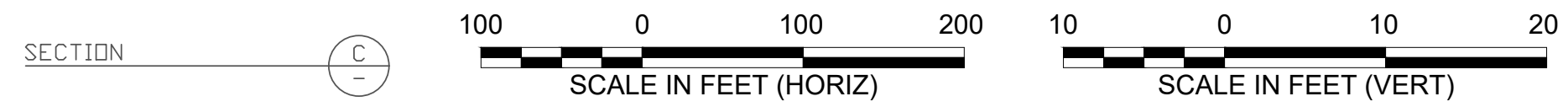
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Project No. 4976-238	Date Revised 05-25-23	Drawing No. ###-##

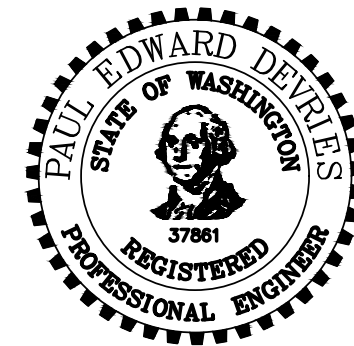
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A topographic map of a study area. The map features contour lines indicating elevation. A proposed road, shown as a thick black line with a dashed center, runs from the bottom left towards the top right. The road is labeled with 'DNR PARCEL' and 'SALLY ALL PARCEL' along its path. A vertical line on the right side is labeled 'USFS PARCEL'. A north arrow is located in the top left corner. A blue dot is marked on the right side of the map.

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SCALE IN FEET, 1 FT CONTOUR INTERVAL



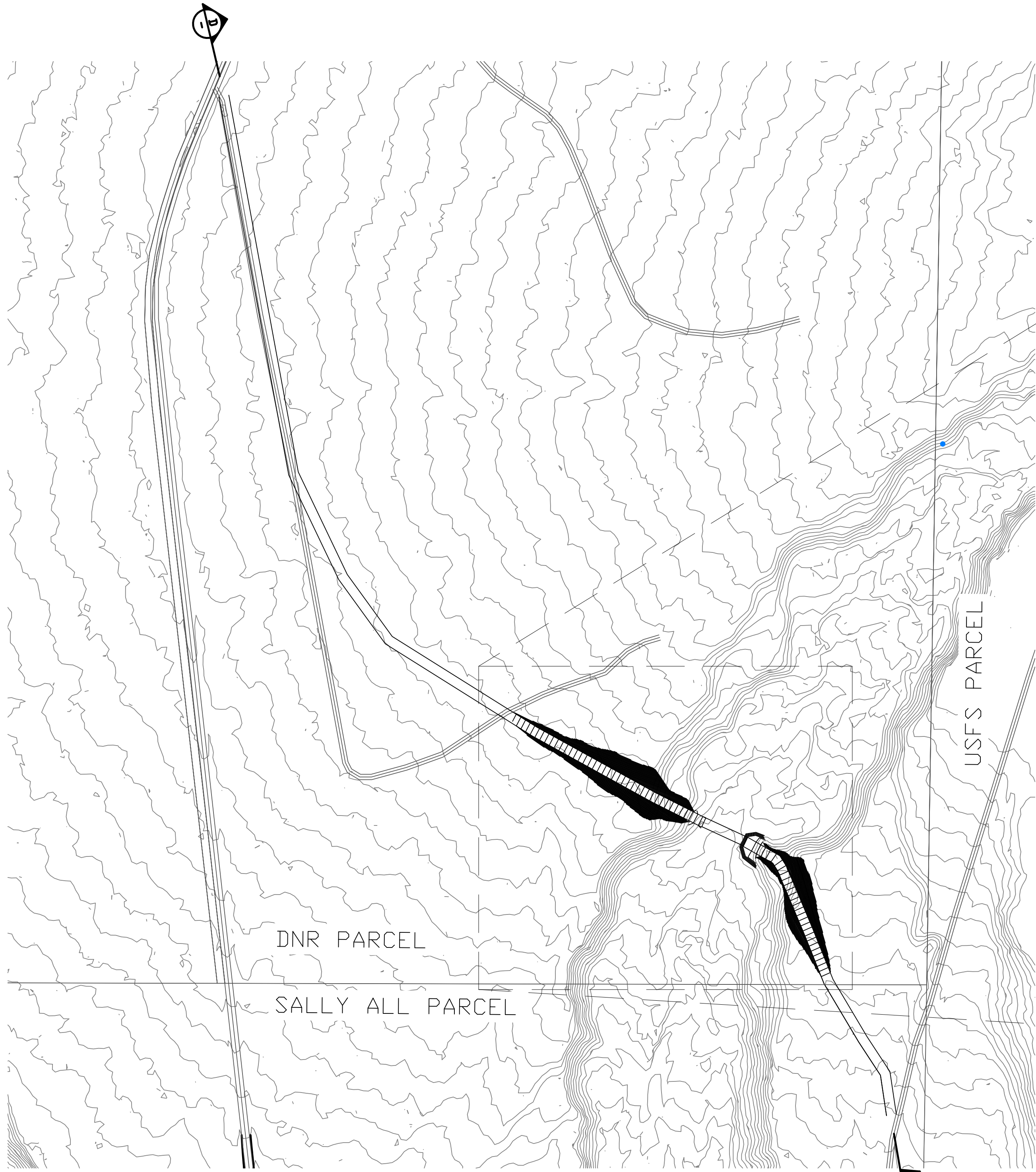
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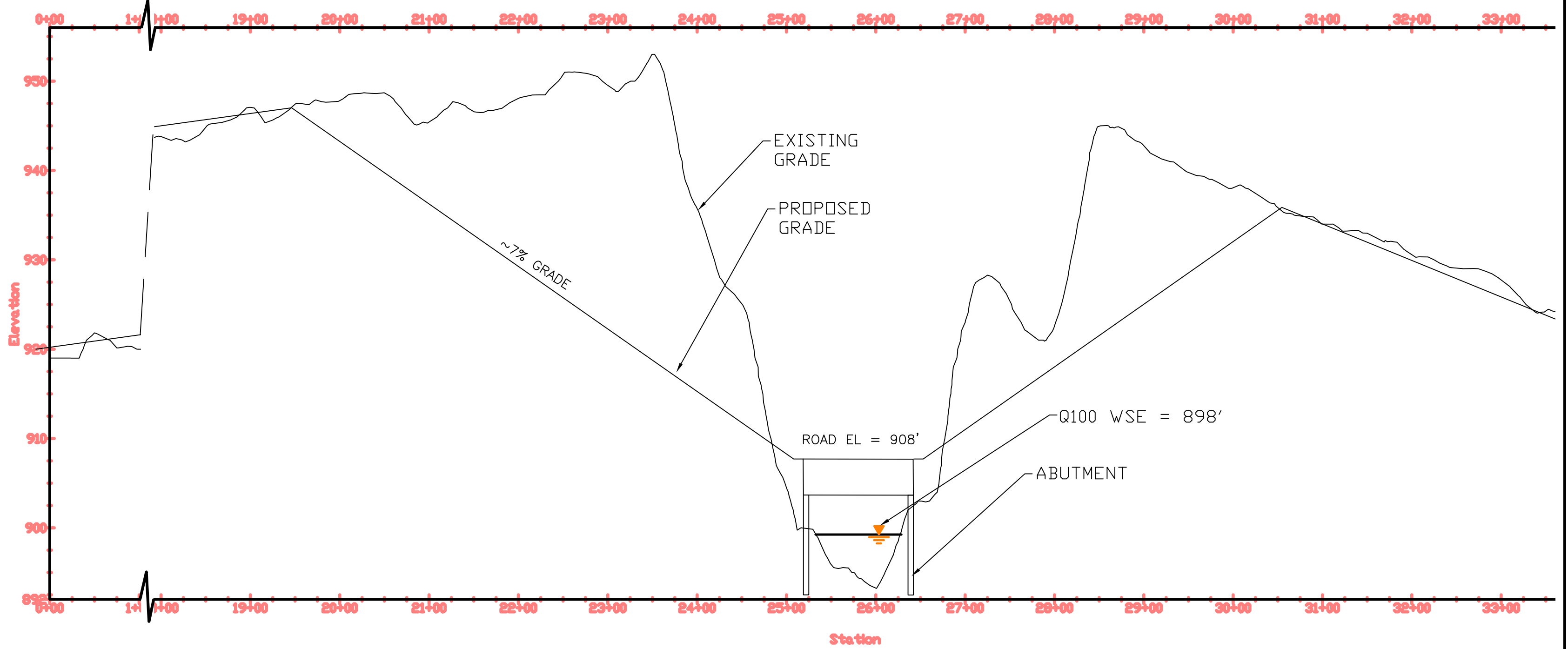
3"
2"
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SIMILAR SINGLE SPAN CROSS-SECTION AS OPTION 1a

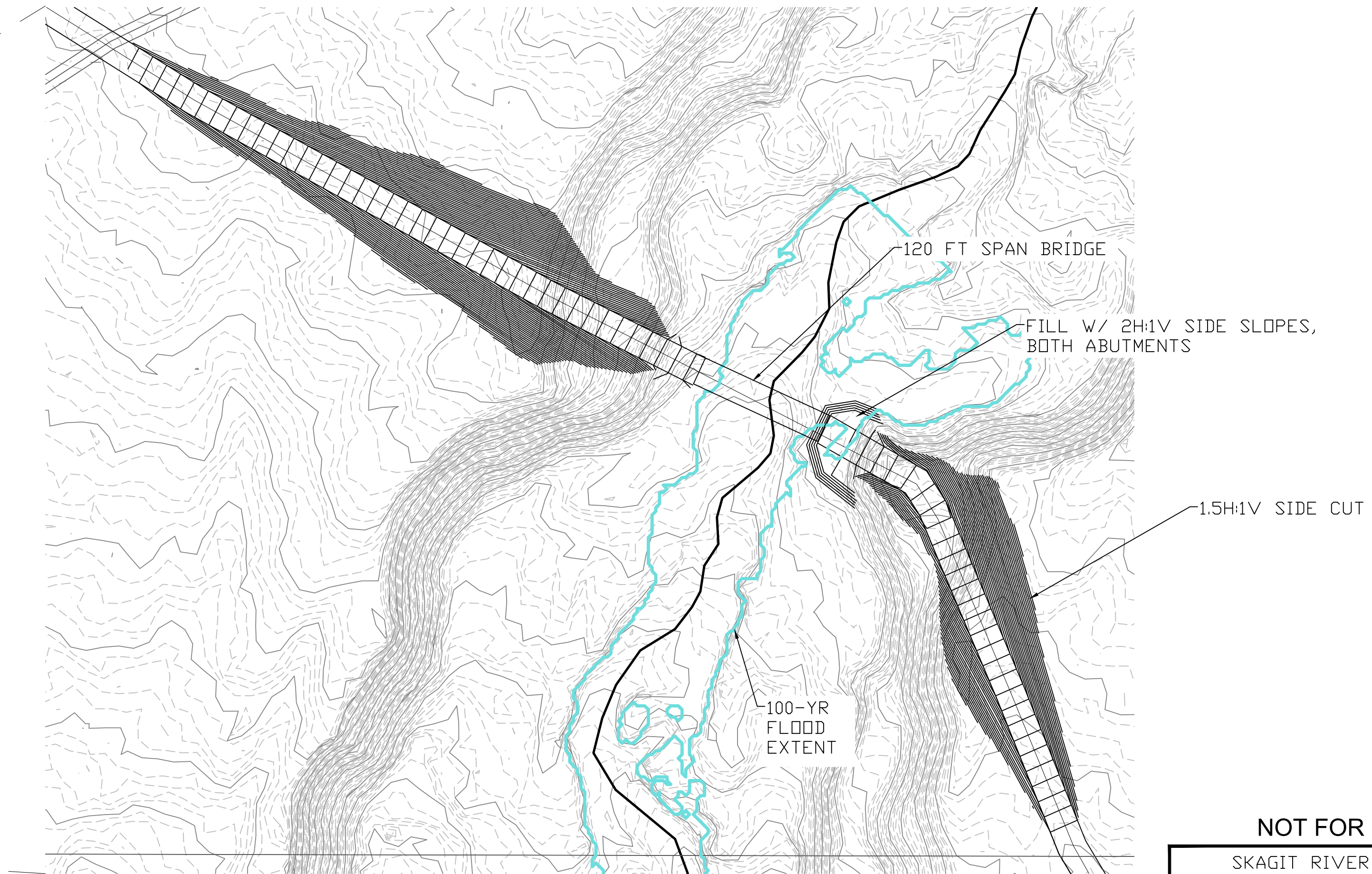


OPTION 2b PLAN

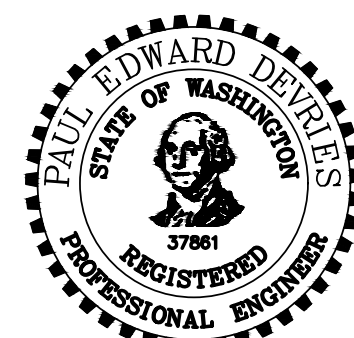
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SECTION 100 0 100 200 10 0 10 20
SCALE IN FEET (HORIZ) SCALE IN FEET (VERT)



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SCALE IN FEET, 1 FT CONTOUR INTERVAL



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Designed PDV
Drawn PDV
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TENAS CREEK ALLUVIAL FAN RESTORATION FEASIBILITY				
OPTION 2b CONCEPT PLAN & SECTION				
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APPENDIX B

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST FOR OPTIONS 1A, 1B, 2A, 2B

The cost estimates presented in this appendix were based on available project and site information and WSDOT guidelines, and do not represent a 'take-off' from a detailed design where specific structural and civil engineering specifications, materials and construction constraints and methods are identified. The estimates were developed as part of the preceding feasibility assessment and may change in the future. The estimates included escalation over the next five years and are suitable for project screening at more developed stages, alternative scheme analysis, and confirmation of economic and technical feasibility for proceeding to the next stage of design that will require more specific site information including detailed geotechnical sampling and topographic surveying.

Tenas Creek - Option 1a

Pay Item No.		Pay Unit	Estimated Quantity	Unit Price	Unit Price
1	Surveying and Grading	LS	1	\$ 150,000	\$ 150,000
2	Temporary Erosion Control	LS	1	\$ 50,000	\$ 50,000
3	Clearing and Grubbing	ACRE	6	\$ 25,000	\$ 150,000
4	Remove Existing Bridge, Culverts, Asphalt	LS	1	\$ 250,000	\$ 250,000
5	Temprary Bypass	LS	1	\$ 1,250,000	\$ 1,250,000
6	Remove Levee+Road Fill, Haul	CY	22,600	\$ 55	\$ 1,243,000
7	New Road Excavation	CY	0	\$ 50	\$ -
8	Structural Fill/Backfill	CY	150	\$ 40	\$ 6,000
9	Earthwork Geotextile	SY	373	\$ 10	\$ 3,733
10	Aggregate Subbase	TON	185	\$ 55	\$ 10,164
11	Aggregate Base (including 2' gravel shoulders)	TON	92	\$ 55	\$ 5,082
12	Asphalt Surfacing (22' wide)	TON	92	\$ 450	\$ 41,580
13	Bridge (single span 120' long)	LS	1	\$ 1,890,000	\$ 1,890,000
14	Bridge (three spans, total 360 long)	LS	1	\$ 5,400,000	\$ 5,400,000
15	Bridge Retaining Walls	CY	119	\$ 2,000	\$ 237,037
16	SWPPP	LS	1	\$ 5,000	\$ 5,000
17	Schedule	LS	1	\$ 5,000	\$ 5,000
18	Permanent Erosion Control	LS	1	\$ 35,000	\$ 35,000
19	Misc Civil Items @ 10% of above itmes	LS	1	\$ 1,058,160	\$ 1,058,160
	Core Construction Cost				\$ 11,789,756
	Mobilization (10%)				\$ 1,178,976
	Contingencies (30%)				\$ 3,536,927
	Inflation (5% annually for 5 years)				\$ 3,257,292
	Total Cost				\$ 19,762,951

Tenas Creek - Option 1b

Pay Item No.		Pay Unit	Estimated Quantity	Unit Price	Unit Price
1	Surveying and Grading	LS	1	\$ 75,000	\$ 75,000
2	Temporary Erosion Control	LS	1	\$ 40,000	\$ 40,000
3	Clearing and Grubbing	ACRE	6	\$ 25,000	\$ 150,000
4	Remove Existing Bridge, Culverts, Asphalt	LS	1	\$ 250,000	\$ 250,000
5	Temprary Bypass	LS	1	\$ 1,250,000	\$ 1,250,000
6	Remove Levee+Road Fill, New Road Haul	CY	31,900	\$ 55	\$ 1,754,500
7	New Road Excavation	CY	0	\$ 50	\$ -
8	Structural Fill/Backfill	CY	75	\$ 40	\$ 3,000
9	Earthwork Geotextile	SY	14,000	\$ 10	\$ 140,000
10	Aggregate Subbase	TON	-	\$ 55	\$ -
11	Aggregate Base (including 2' gravel shoulders)	TON	-	\$ 55	\$ -
12	Asphalt Surfacing (22' wide)	TON	9	\$ 450	\$ 4,158
13	Bridge (five spans, total 600' long)	LS	1	\$ 9,450,000	\$ 9,450,000
14	Bridge Retaining Walls	CY	59	\$ 2,000	\$ 118,519
15	SWPPP	LS	1	\$ 5,000	\$ 5,000
16	Schedule	LS	1	\$ 5,000	\$ 5,000
17	Permanent Erosion Control	LS	1	\$ 35,000	\$ 35,000
18	Misc Civil Items @ 10% of above itmes	LS	1	\$ 1,328,018	\$ 1,328,018
	Core Construction Cost				\$ 14,608,194
	Mobilization (10%)				\$ 1,460,819
	Contingencies (30%)				\$ 4,382,458
	Inflation (5% annually for 5 years)				\$ 4,035,975
	Total Cost				\$ 24,487,447

Tenas Creek - Option 2a

Pay Item No.		Pay Unit	Estimated Quantity	Unit Price	Unit Price
1	Surveying and Grading	LS	1	\$ 75,000	\$ 75,000
2	Temporary Erosion Control	LS	1	\$ 40,000	\$ 40,000
3	Clearing and Grubbing	ACRE	8	\$ 25,000	\$ 200,000
4	Remove Existing Bridge, Culverts, Asphalt	LS	1	\$ 250,000	\$ 250,000
5	Remove Levee+Road Fill, Haul	CY	31,900	\$ 55	\$ 1,754,500
6	New Road Excavation	CY	19,200	\$ 50	\$ 960,000
7	Structural Fill/Backfill	CY	75	\$ 40	\$ 3,000
8	Earthwork Geotextile	SY	14,000	\$ 10	\$ 140,000
9	Aggregate Subbase	TON	3,894	\$ 55	\$ 214,170
10	Aggregate Base (including 2' gravel shoulders)	TON	1,947	\$ 55	\$ 107,085
11	Asphalt Surfacing (22' wide)	TON	1,716	\$ 350	\$ 600,600
12	Bridge (three spans, total 240' long)	LS	1	\$ 3,780,000	\$ 3,780,000
13	Bridge Retaining Walls	CY	59	\$ 2,000	\$ 118,519
14	Roadway Retaining Walls	SF	13500	\$ 300	\$ 4,050,000
15	SWPPP	LS	1	\$ 5,000	\$ 5,000
16	Schedule	LS	1	\$ 5,000	\$ 5,000
17	Permanent Erosion Control	LS	1	\$ 35,000	\$ 35,000
18	Misc Civil Items @ 10% of above itmes	LS	1	\$ 1,233,787	\$ 1,233,787
	Core Construction Cost				\$ 13,571,661
	Mobilization (10%)				\$ 1,357,166
	Contingencies (30%)				\$ 4,071,498
	Inflation (5% annually for 5 years)				\$ 3,749,600
	Total Cost				\$ 22,749,925

Tenas Creek - Option 2b

Pay Item No.		Pay Unit	Estimated Quantity	Unit Price	Unit Price
1	Surveying and Grading	LS	1	\$ 75,000	\$ 75,000
2	Temporary Erosion Control	LS	1	\$ 40,000	\$ 40,000
3	Clearing and Grubbing	ACRE	8	\$ 10,000	\$ 80,000
4	Remove Existing Bridge, Culverts, Asphalt	LS	1	\$ 250,000	\$ 250,000
5	Remove Levee+Road Fill, Haul	CY	31,900	\$ 55	\$ 1,754,500
6	New Road Excavation	CY	27,500	\$ 50	\$ 1,375,000
7	Structural Fill/Backfill	CY	1,460	\$ 45	\$ 65,700
8	Earthwork Geotextile	SY	14,000	\$ 10	\$ 140,000
9	Aggregate Subbase	TON	4,145	\$ 55	\$ 227,964
10	Aggregate Base (including 2' gravel shoulders)	TON	2,072	\$ 65	\$ 134,706
11	Asphalt Surfacing (22' wide)	TON	1,716	\$ 350	\$ 600,600
12	Bridge (single span 120' long)	LS	1	\$ 1,800,000	\$ 1,800,000
13	Bridge Retaining Walls	CY	59	\$ 2,000	\$ 118,519
14	Roadway Retaining Walls	SF	18000	\$ 300	\$ 5,400,000
15	SWPPP	LS	1	\$ 5,000	\$ 5,000
16	Schedule	LS	1	\$ 5,000	\$ 5,000
17	Permanent Erosion Control	LS	1	\$ 35,000	\$ 35,000
18	Misc Civil Items @ 10% of above itmes	LS	1	\$ 1,210,699	\$ 1,210,699
	Core Construction Cost				\$ 13,317,687
	Mobilization (10%)				\$ 1,331,769
	Contingencies (30%)				\$ 3,995,306
	Inflation (5% annually for 5 years)				\$ 3,679,431
	Total Cost				\$ 22,324,194

APPENDIX C

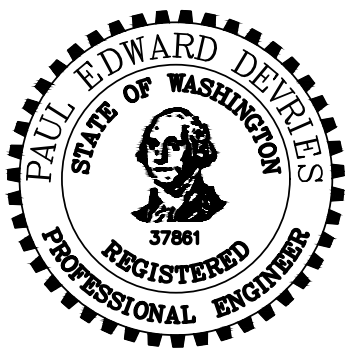
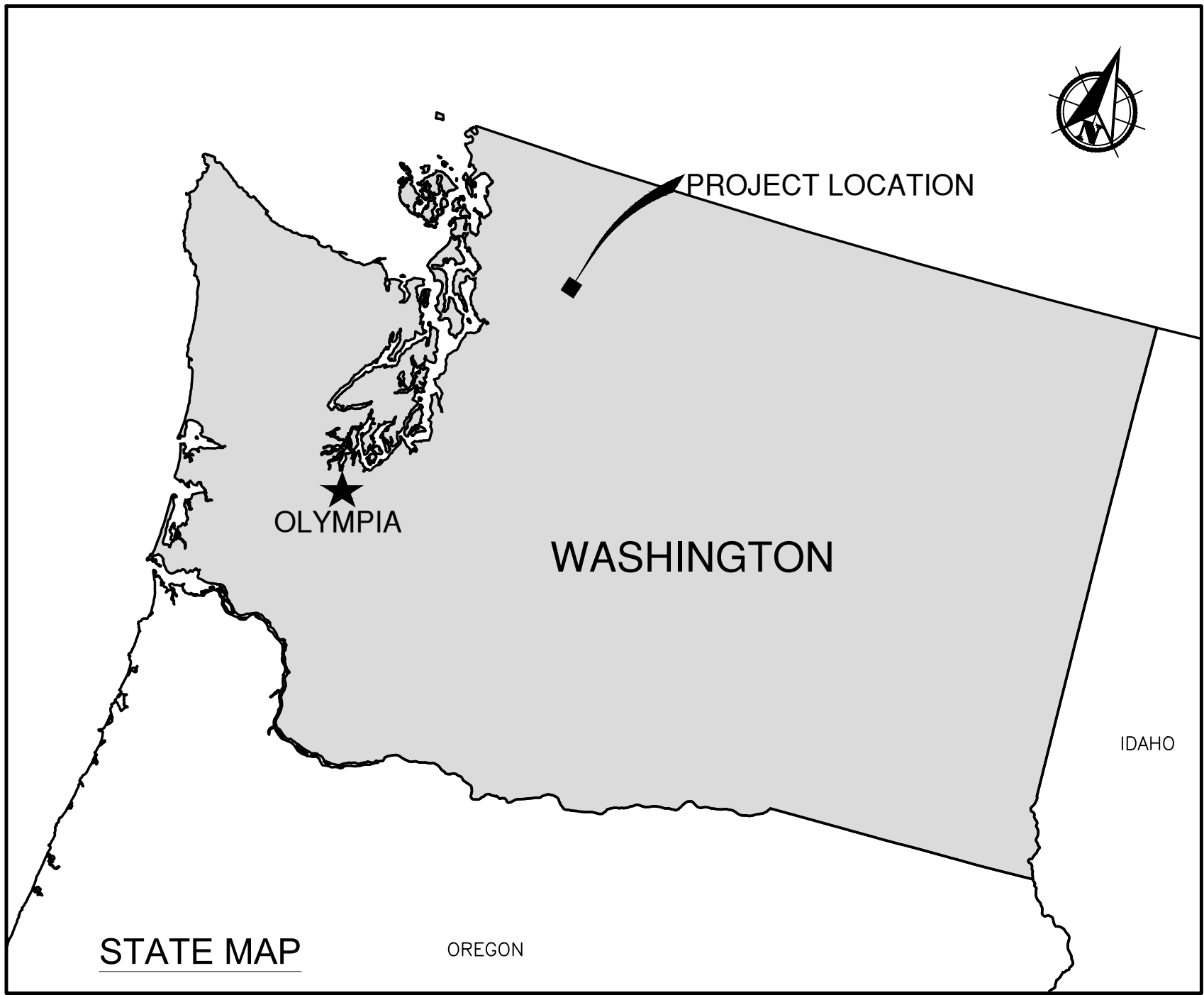
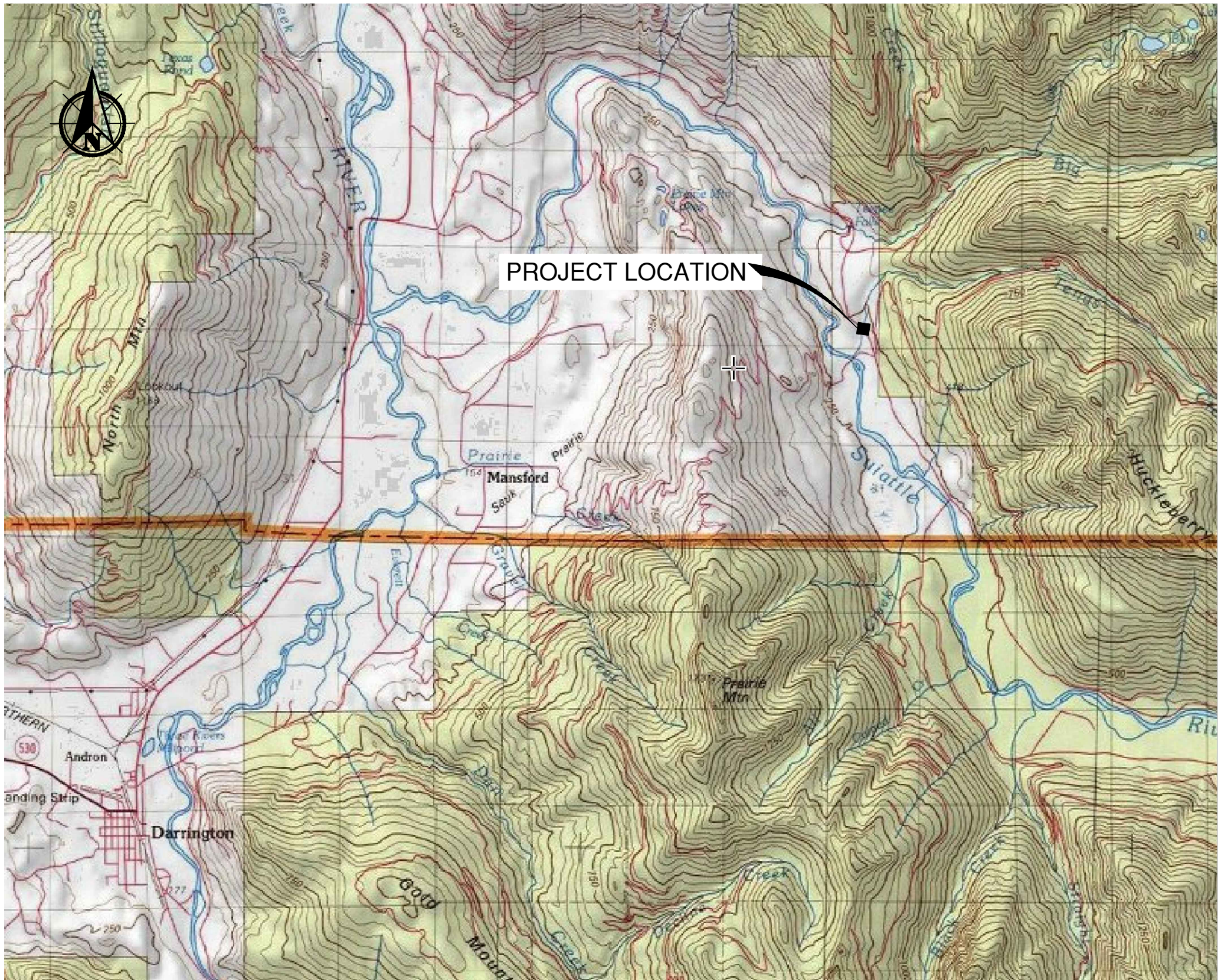
CONCEPTUAL DESIGN PLANS AND SECTIONS OF SELECTED OPTION

22x34 = FULL SCALE

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SKAGIT RIVER SYSTEM COOPERATIVE TENAS CREEK ALLUVIAL FAN RESTORATION PRELIMINARY DESIGN

DRAWING LIST				
SHEET NO.	SHEET DESCRIPTION	DATE	REVISION	STATUS
1	GENERAL NOTES, LEGEND	05-25-23	-	PRELIMINARY
2	EXISTING SITE, ACCESS, OWNERSHIP: PLAN	05-25-23	-	PRELIMINARY
3	DETOUR PLAN, CONSTRUCTION SEQUENCING	05-25-23	-	PRELIMINARY
4	PROPOSED PROJECT ELEMENTS: PLAN	05-25-23	-	PRELIMINARY
5	GRADING PLAN	05-25-23	-	PRELIMINARY
6	WEST BRIDGE SUPERSTRUCTURE PLAN, ELEVATION, SECTION	05-25-23	-	PRELIMINARY
7	EAST BRIDGE SUPERSTRUCTURE PLAN, ELEVATION, SECTION	05-25-23	-	PRELIMINARY



PRELIMINARY
NOT FOR
CONSTRUCTION

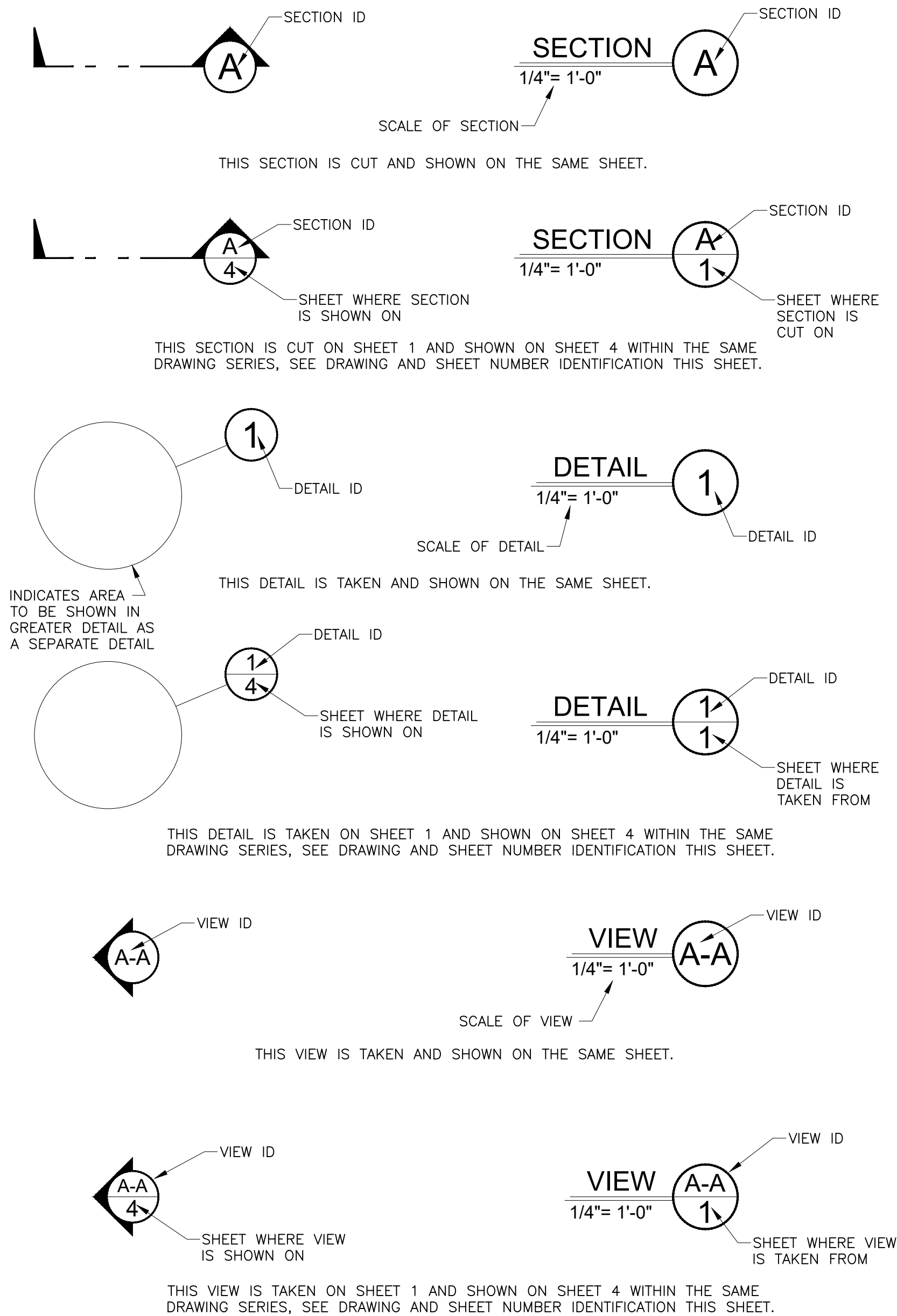
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Designed	Drawn	Checked	Project No.	Date Revised
PDV	PDV	CM	4976-238	05-25-23

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SKAGIT RIVER SYSTEM COOPERATIVE				
TENAS CREEK ALLUVIAL FAN RESTORATION FEASIBILITY				
COVER SHEET				
Kleinschmidt		888-224-5942 KleinschmidtGroup.com		
Drawing No.	00			

22x34 = FULL SCALE

0 1" 2" 3"

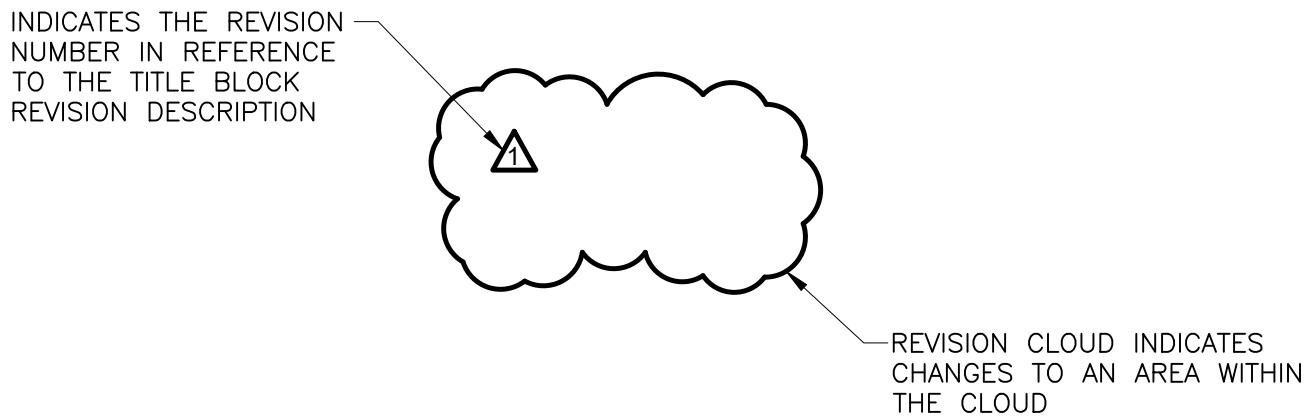
SECTION, DETAIL AND VIEW IDENTIFICATION SYMBOLS



SECTION, DETAIL AND VIEW IDENTIFICATION SYMBOLS NOTES:

1. SECTIONS ARE ALPHABETICAL.
2. DETAILS ARE NUMERICAL.
3. VIEWS ARE DOUBLE ALPHABETICAL.
4. SHEET REFERENCE NUMBER FOR SECTIONS AND DETAILS OCCUR WITHIN THE SAME DRAWING SERIES.

REVISION IDENTIFICATION



SYMBOLS

EARTH/SOIL	
ROCK	
CENTERLINE	
DIAMETER	
CRITICAL ELEVATION OR WORK POINT (W.P.)	
WATER LEVEL	
COLUMN LINE IDENTIFIER	
REVISION NUMBER	
REVISION CLOUD	

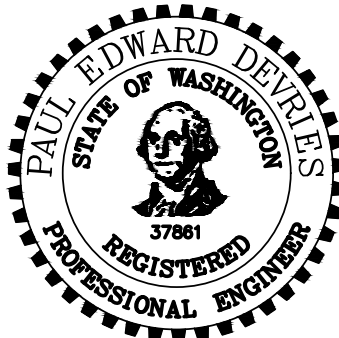
NOTICE OF RISK

RESTORATION DESIGN LIMITATIONS

THE DESIGNS ON THESE PLANS ARE BASED IN PART ON ENGINEERING ANALYSES OF MOBILE BOUNDARY RIVER HYDRAULICS AND FLUVIAL GEOMORPHOLOGY, AND THE GOAL OF FACILITATING NATURAL RIVERINE PROCESSES. THERE IS INHERENT UNCERTAINTY IN THESE ANALYSES AND GOAL THAT PRECLUDE ASSURING ABSOLUTELY THAT A PROJECT AS DESIGNED WILL NOT BE ASSOCIATED WITH UNANTICIPATED/UNDESIED CHANNEL CHANGES. CHANNEL ADJUSTMENT OF BED AND BANKS IS THE USUAL RESPONSE TO SPATIAL AND TEMPORAL CHANGES IN FLOW AND SEDIMENT TRANSPORT PATTERNS, IRRESPECTIVE OF WHETHER THE PROJECT IS CONSTRUCTED. UNLESS OTHERWISE NOTED, THE ELEMENTS INCLUDED IN THESE PLANS WERE CONCEIVED AND DESIGNED WITH THE CONCURRENT GOALS OF CHANGING FLOW AND SEDIMENTATION PATTERNS WHILE AT THE SAME TIME REDUCING RISK OF IMPACTS FROM FLOODING OR CHANNEL CHANGES TO THE EXTENT PRACTICABLE AND FEASIBLE. THE DESIGN ACCORDINGLY CANNOT ELIMINATE THESE RISKS COMPLETELY IN BOTH SPACE AND TIME. THE EXISTENCE OF THESE RISKS INCLUDES, BUT IS NOT LIMITED TO, CASES WHERE: (I) AN EVENT UPSTREAM OR DOWNSTREAM SUCH AS A LANDSLIDE, DEBRIS FLOW, CHANNEL AVULSION, SIGNIFICANT BANK EROSION, TREE FALL, OR OTHER NATURAL OR ANTHROPOGENIC EVENT OCCURS IN A WAY THAT AFFECTS THE FLOW RATE AND SEDIMENT DEPOSITION/TRANSPORT/EROSION RATES AND PATTERNS INTO, THROUGH, AND BELOW THE PROJECT REACH; (II) SOME DEGREE OF BANK EROSION AND/OR TREE FALL OCCURS AT LOCATIONS WITHIN THE PROJECT REACH WHERE RIGID BANK PROTECTION IS NOT DESIGNED SPECIFICALLY; (III) AN UNPREDICTABLE EVENT OCCURS IN THE VICINITY OF A DESIGNED STRUCTURE THAT CAUSES THE RIVER TO PERFORM AN END-RUN AROUND THE STRUCTURE; (IV) THE RIVER ABANDONS THE STRUCTURE THROUGH CHANNEL MIGRATION OR AN AVULSION ASSOCIATED WITH AN EXTREME FLOOD EVENT, OR (V) VANDALISM OCCURS. IN ADDITION, ALL STRUCTURES AND DESIGNS INVOLVING BIODEGRADABLE MATERIALS HAVE A FIXED MATERIAL LIFESPAN THAT AFFECTS FUTURE PERFORMANCE AND PERSISTENCE, AND THAT IS NOT PREDICTABLE WITH HIGH CERTAINTY. THE DESIGNS ON THESE PLANS WERE DEVELOPED WITH DUE DILIGENCE IN CONSIDERATION OF THESE POTENTIAL OUTCOMES TO THE EXTENT THAT THEIR LIKELIHOOD OF OCCURRING IS REDUCED QUALITATIVELY BUT NOT ELIMINATED QUANTITATIVELY. IN ADDITION, GEOTECHNICAL EXPLORATION WAS NOT A PROJECT REQUIREMENT, WHERE SUBSURFACE CONDITIONS ARE UNKNOWN. THE BRIDGE FOUNDATION AND SUPPORT DESIGN REFLECTS THIS UNCERTAINTY, WITH MEASURES INCLUDED TO REDUCE THE UNCERTAINTY AS MUCH AS REASONABLY POSSIBLE.

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CONSTRUCTION



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SKAGIT RIVER SYSTEM COOPERATIVE

TENAS CREEK ALLUVIAL FAN
RESTORATION FEASIBILITY

GENERAL NOTES, LEGEND

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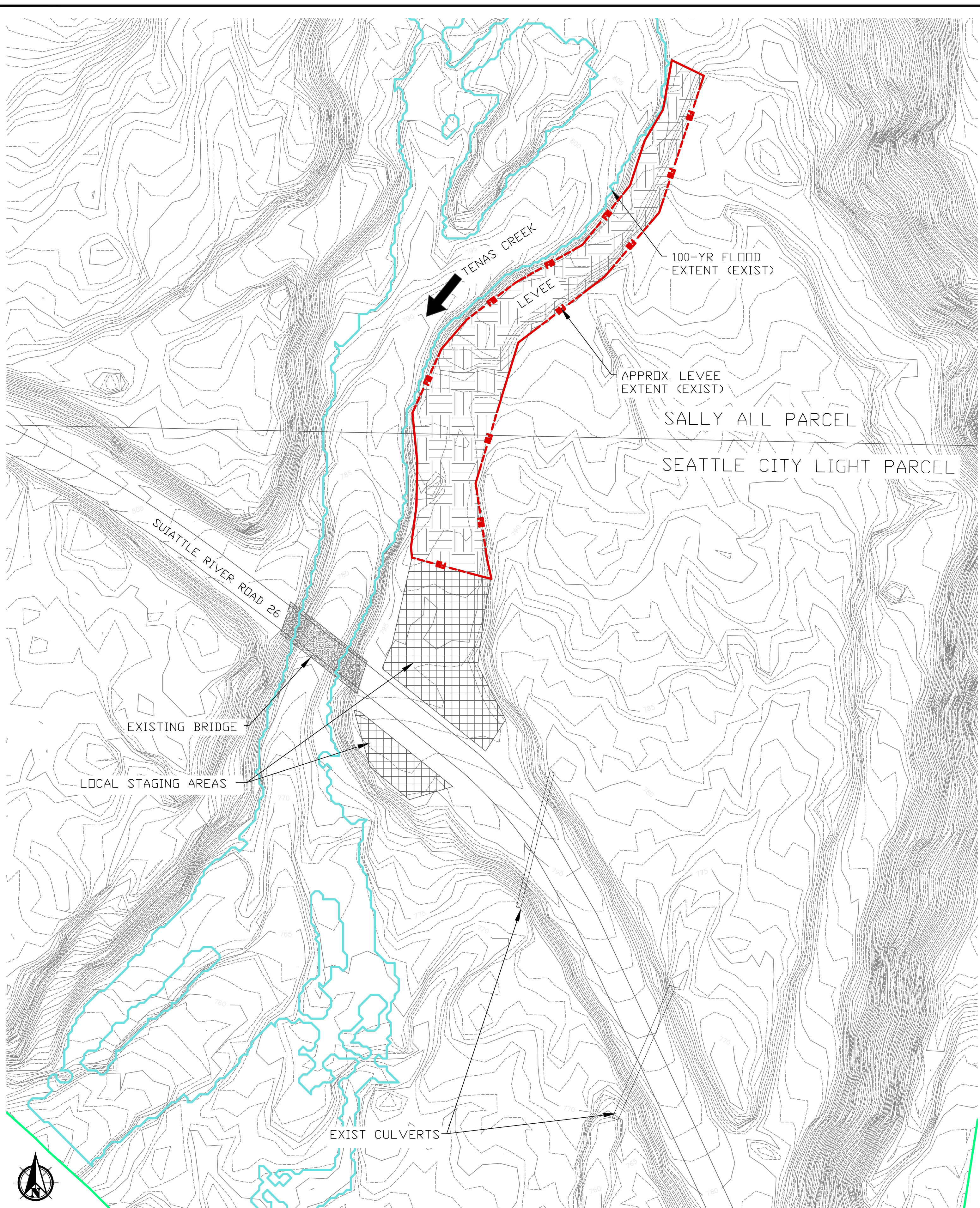
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Project No. 4976-238
Date Revised 05-25-23
Drawing No.

01

22x34 = FULL SCALE

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EXISTING SITE PLAN

50 0 50 100
SCALE IN FEET, 1 FT CONTOUR INTERVAL

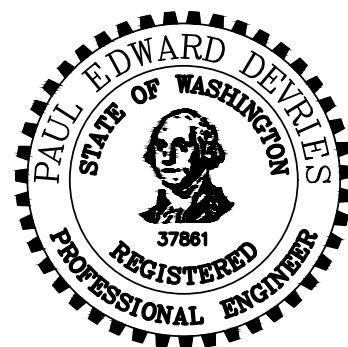


OFFSITE STAGING PLAN (NTS)

~1000 FT

- NOTES:
1. OFF-SITE STAGING AREA LOCATION SUBJECT TO DNR APPROVAL.

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SKAGIT RIVER SYSTEM COOPERATIVE

TENAS CREEK ALLUVIAL FAN
RESTORATION FEASIBILITY

EXIST SITE PLAN
STAGING, ACCESS, OWNERSHIP

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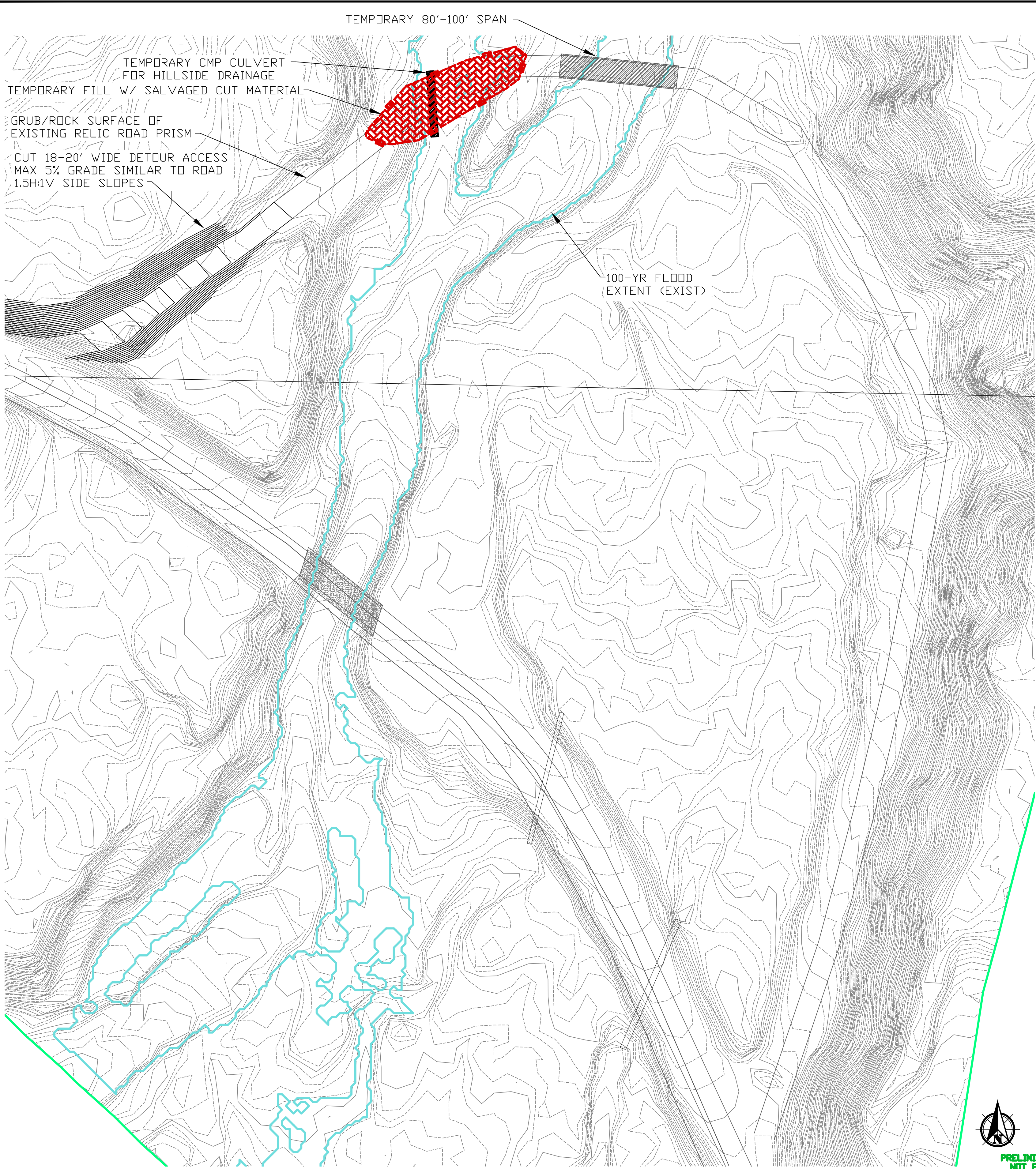
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02

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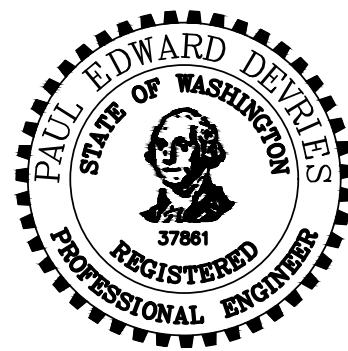


TEMPORARY DETOUR PLAN

50 0 50 100
SCALE IN FEET, 1 FT CONTOUR INTERVAL



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CONSTRUCTION SEQUENCING

YEAR 1:

1. PLACE TEMPORARY EROSION AND SEDIMENTATION CONTROL (TESC) MEASURES.
2. INSTALL STREAM DIVERSION/WATER MANAGEMENT MEASURES.
3. CLEARING, GRADING, ROCK SURFACING, TEMPORARY BRIDGE PLACEMENT, TRAFFIC SAFETY/CONTROL ALONG DETOUR ROUTE.
4. REMOVE EXISTING BRIDGE, ABUTMENTS.
5. EXCAVATION/GRADING ON EAST SIDE OF CHANNEL/ROAD FILL.
6. CONSTRUCT FOUNDATIONS FOR WEST BRIDGE.
7. CONSTRUCT WEST BRIDGE SUBSTRUCTURES.
8. CONSTRUCT WEST BRIDGE SUPERSTRUCTURE.
9. PLACE WEST BRIDGE DECK.
10. BACKFILL APPROACHES AS NEEDED.
11. CONSTRUCT WEST BRIDGE APPROACH SLABS (IF REQUIRED).
12. INSTALL WEST BRIDGE RAILING.
13. PARTIAL EXCAVATION/GRADING ROAD PRISM REMOVAL FOR EAST BRIDGE.
14. TEMPORARY ROCK SURFACING FOR WINTER TRAFFIC.
15. TESC MEASURES FOR OVERWINTERING.
16. REMOVE TEMPORARY BRIDGE FOR WINTER.

YEAR 2:

1. INSTALL WATER MANAGEMENT MEASURES.
2. TEMPORARY BRIDGE PLACEMENT, TRAFFIC SAFETY/CONTROL ALONG DETOUR ROUTE.
3. RESIDUAL EXCAVATION/GRADING ROAD PRISM REMOVAL FOR EAST BRIDGE
4. CONSTRUCT FOUNDATIONS FOR EAST BRIDGE.
5. CONSTRUCT EAST BRIDGE SUBSTRUCTURES.
6. CONSTRUCT EAST BRIDGE SUPERSTRUCTURE.
7. PLACE EAST BRIDGE DECK.
8. BACKFILL APPROACHES AS NEEDED.
9. CONSTRUCT EAST BRIDGE APPROACH SLABS (IF REQUIRED).
10. INSTALL EAST BRIDGE RAILING.
11. LEVEE REMOVAL EXCAVATION/GRADING.
12. REMOVE TEMPORARY BRIDGE, SUPPORTS, AND CULVERT/FILL FROM RELIC CHANNEL; CONSTRUCT TERMINAL BERMS AT ENDS OF DETOUR ROUTE.
13. FINAL SITE GRADING, CLEANUP, RESTORATION.
14. OPEN NEW ROADWAY TO TRAFFIC.

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SKAGIT RIVER SYSTEM COOPERATIVE

TENAS CREEK ALLUVIAL FAN
RESTORATION FEASIBILITY

DETOUR PLAN, CONSTRUCTION
SEQUENCING

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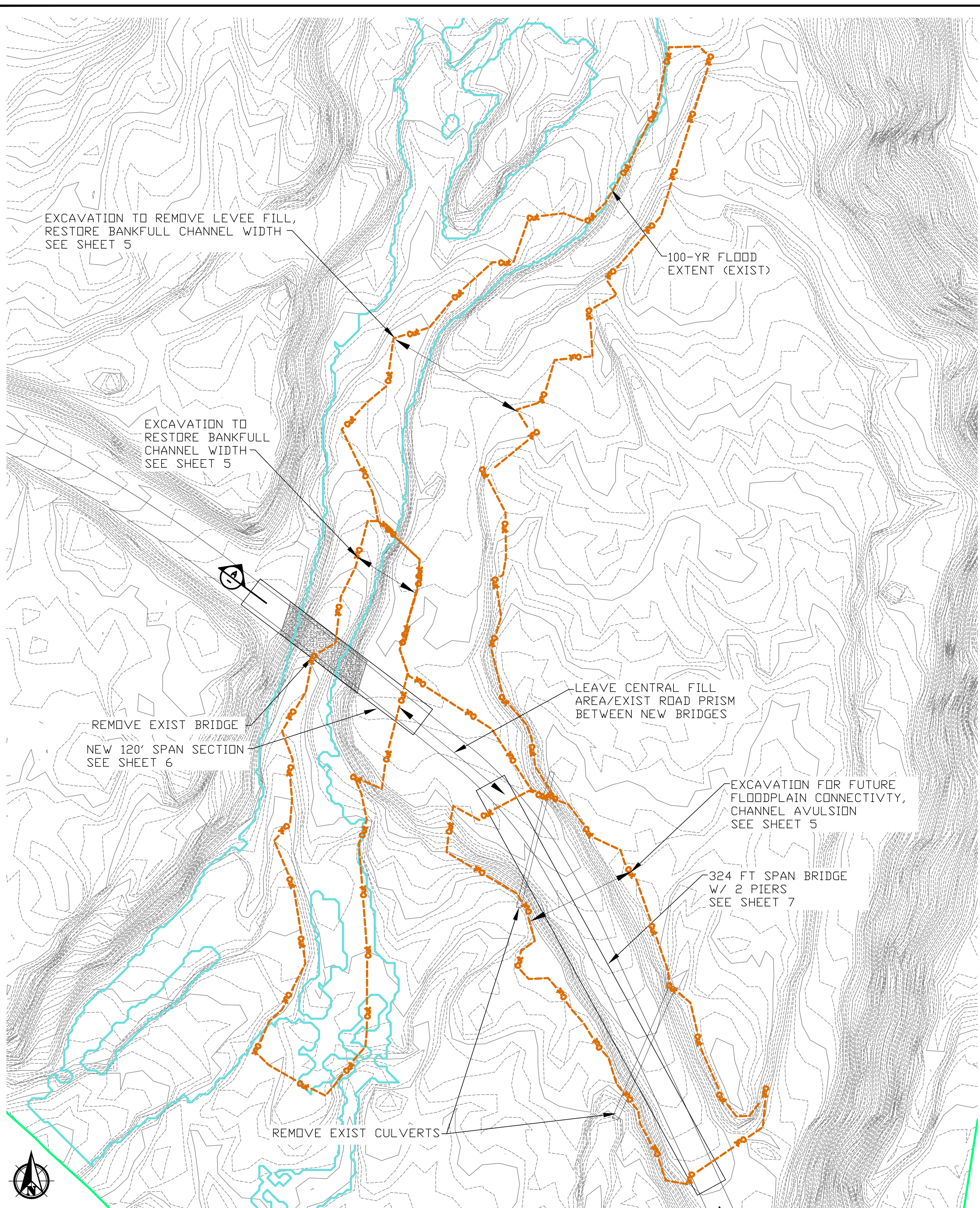
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Drawing
No.

03

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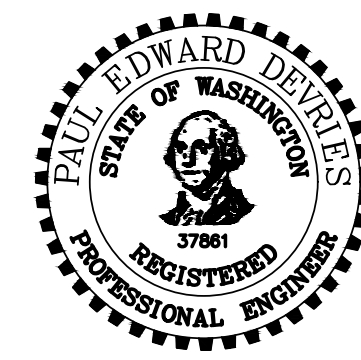
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PROPOSED PLAN



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SKAGIT RIVER SYSTEM COOPERATIVE

TENAS CREEK ALLUVIAL FAN
RESTORATION FEASIBILITY

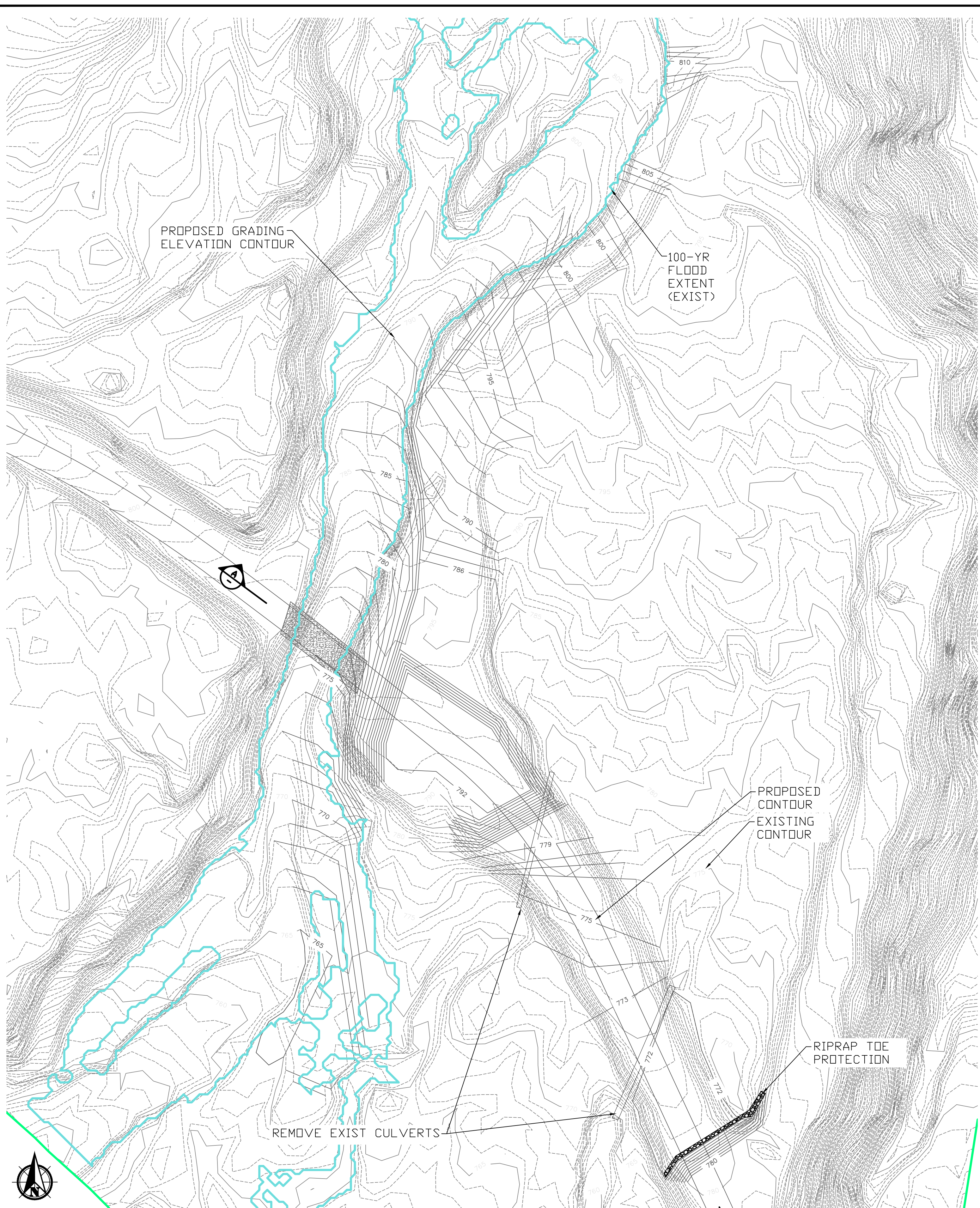
PROPOSED PROJECT ELEMENTS
PLAN

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Project No. 4976-238
Date Revised 05-25-23
Drawing No. 04

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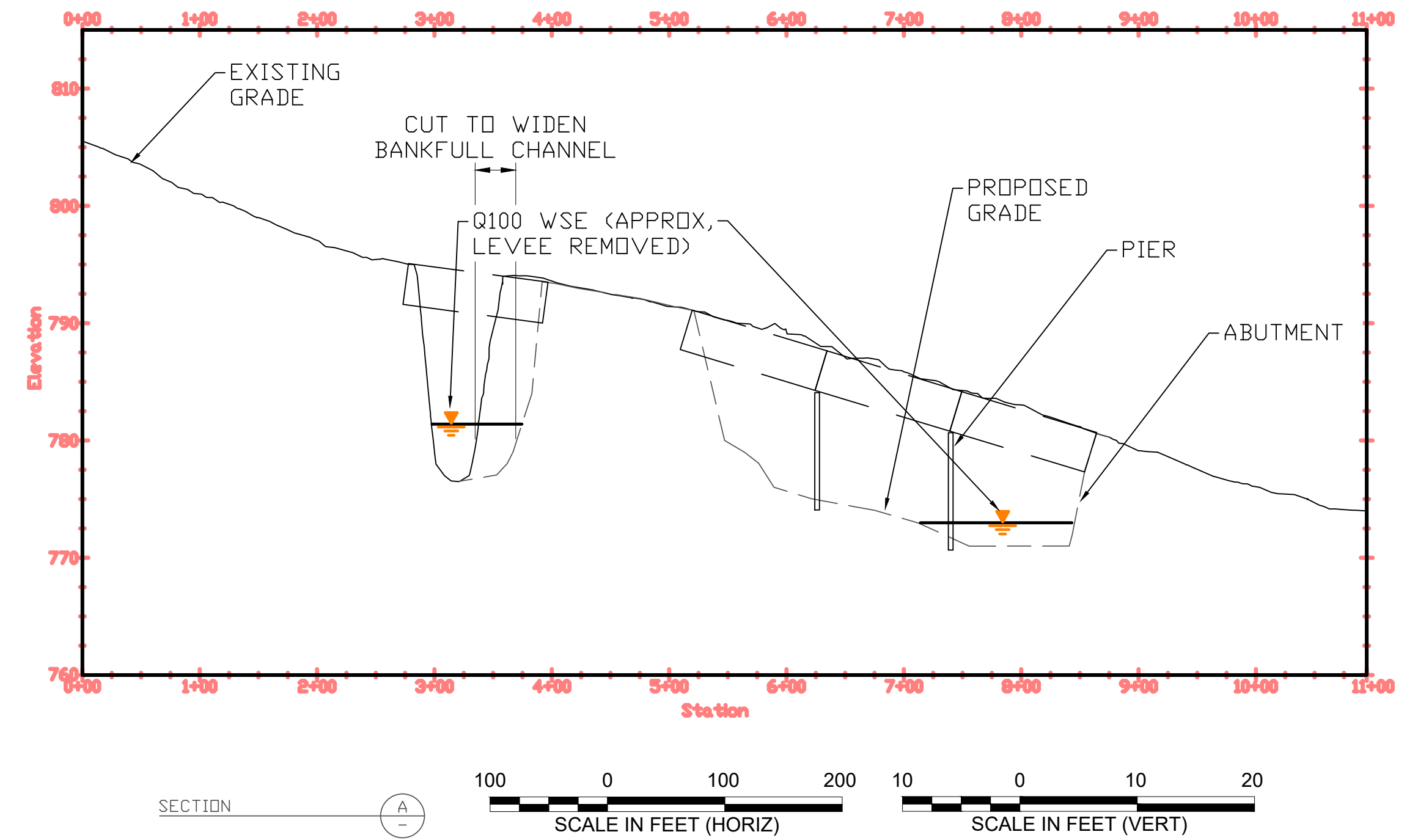
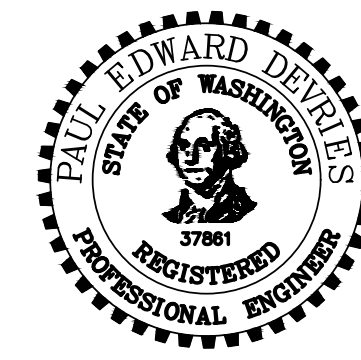
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GRADING PLAN



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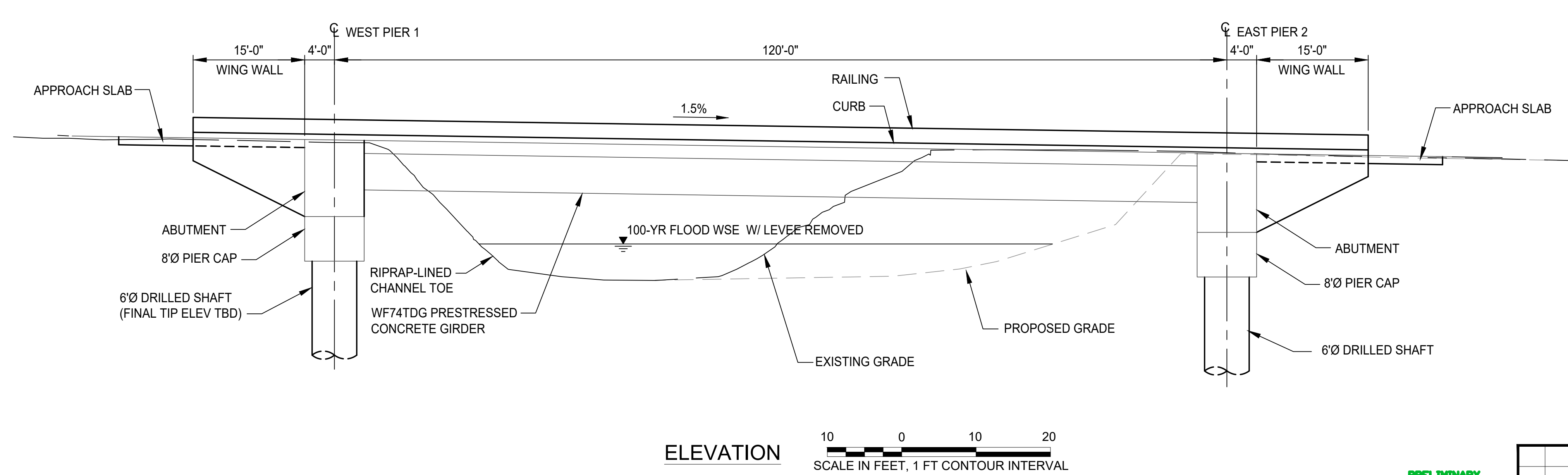
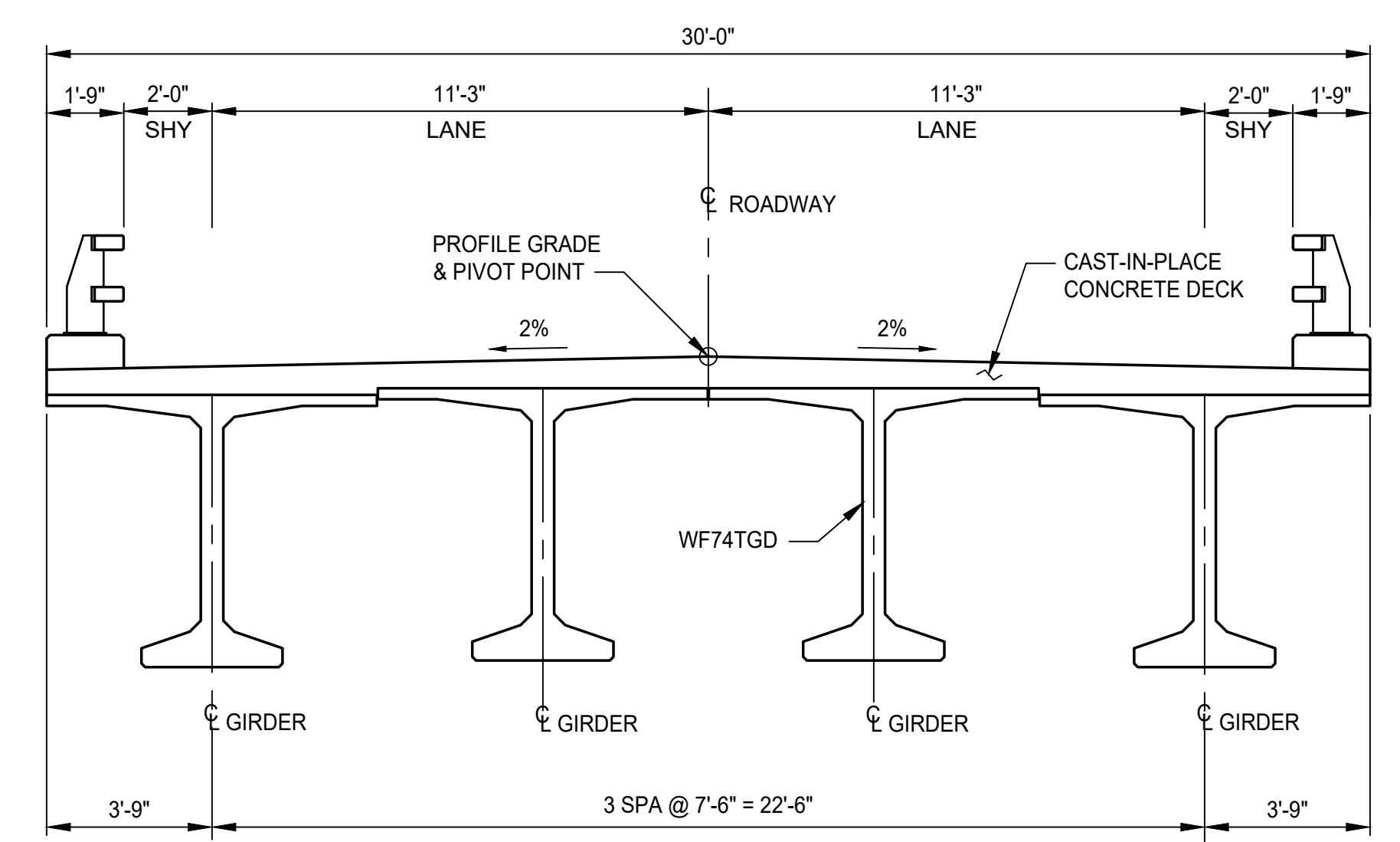
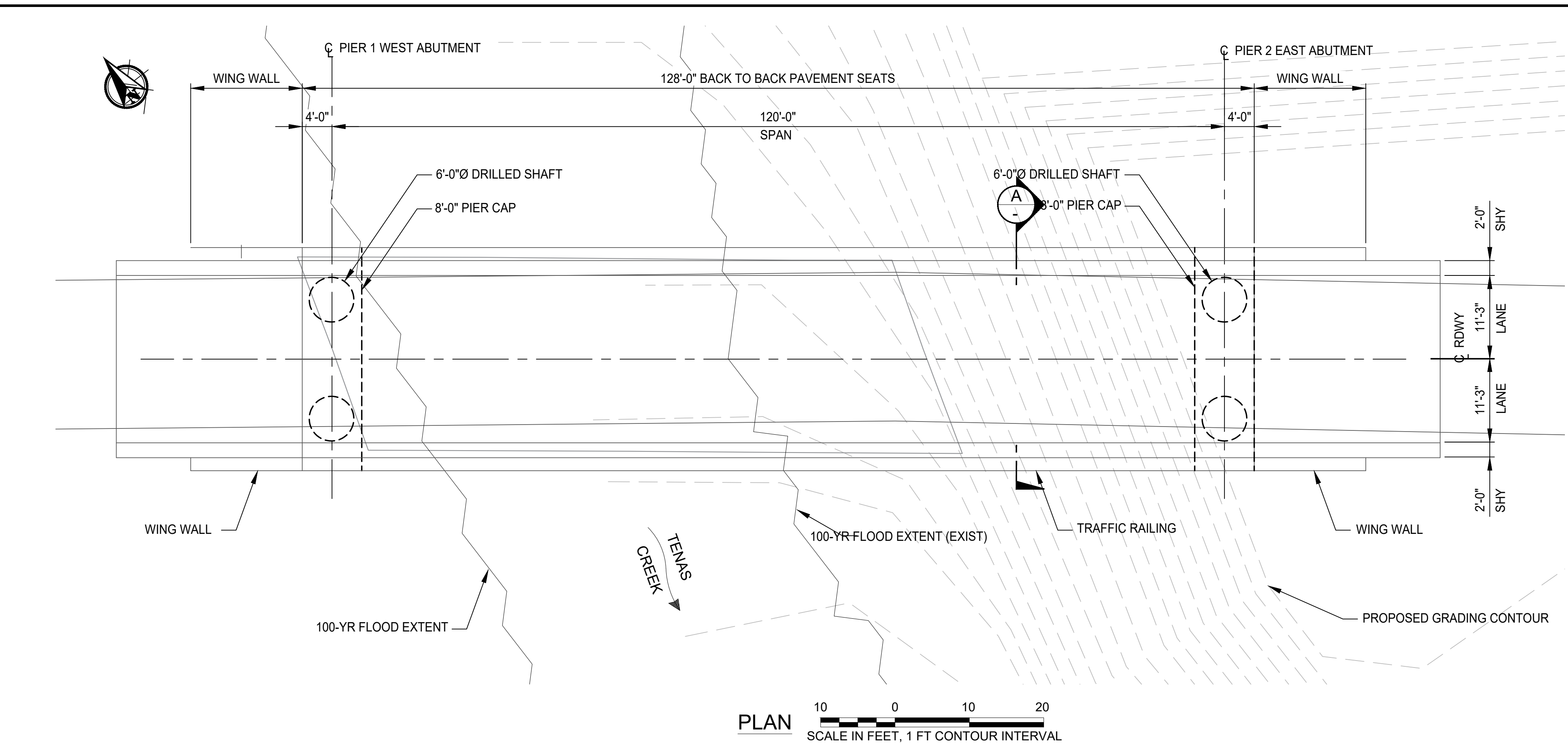


- NOTES:
1. OFF-SITE DISPOSAL LOCATION FOR SPOILS TO BE IDENTIFIED AND APPROVED BY US FOREST SERVICE.

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SKAGIT RIVER SYSTEM COOPERATIVE				
TENAS CREEK ALLUVIAL FAN RESTORATION FEASIBILITY				
GRADING PLAN & SECTION				
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TENAS CREEK ALLUVIAL FAN
RESTORATION FEASIBILITY

WEST BRIDGE SUPERSTRUCTURE
PLAN, ELEVATION & TYPICAL SECTION

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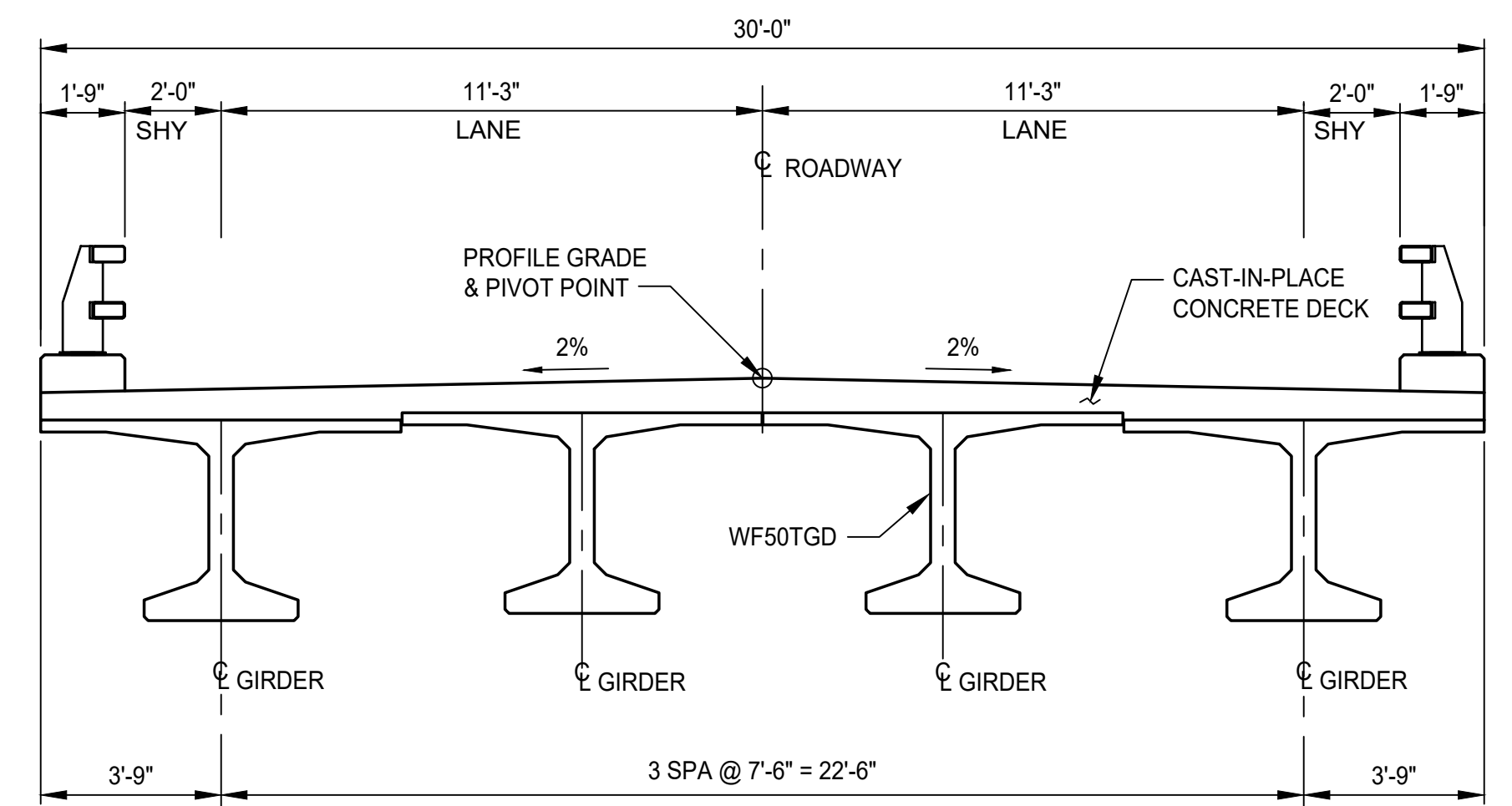
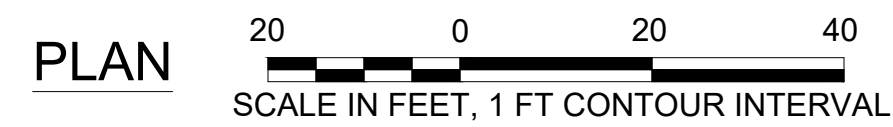
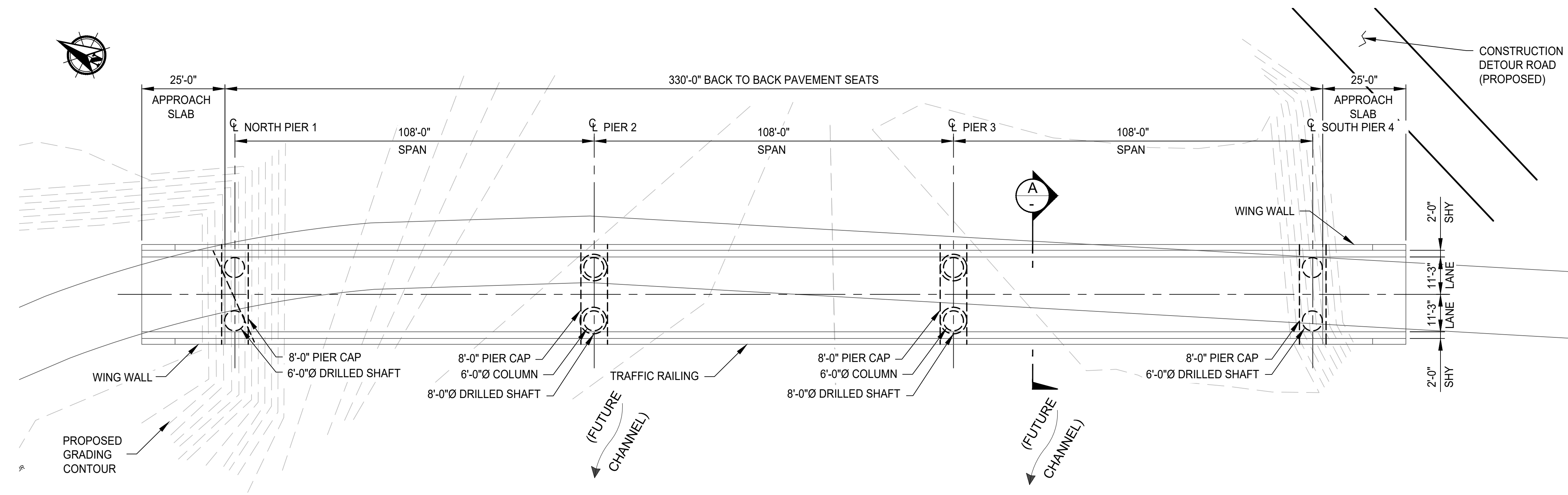
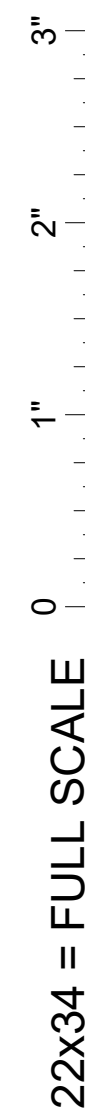
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4976-238

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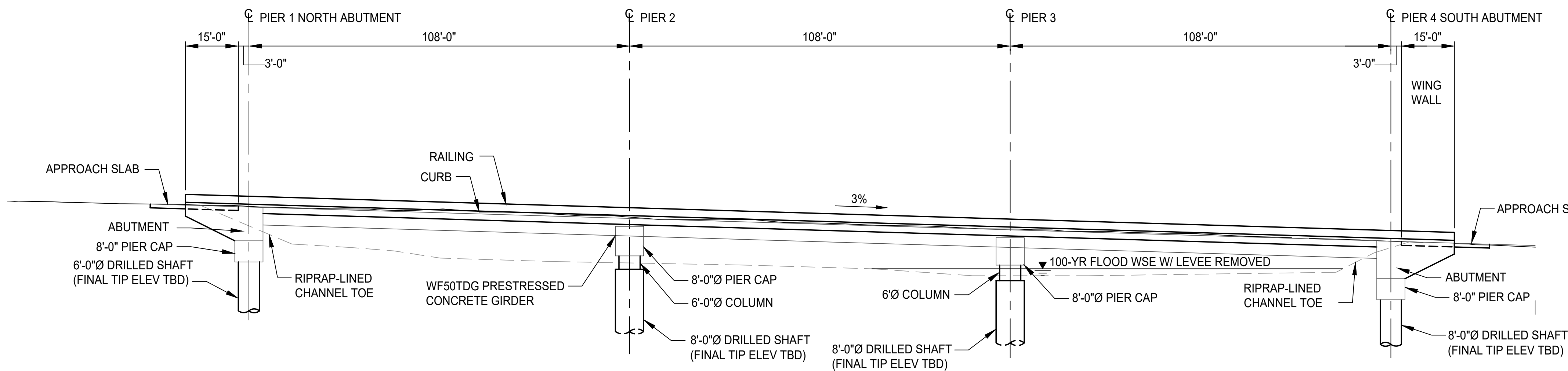
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TYPICAL BRIDGE SECTION (A)



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