Last Chance Grade Permanent Restoration Project

Geotechnical Studies to Evaluate Feasibility of Alternative F-Short

Submittal SUB#075

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Caltrans

LAST CHANCE GRADE

CONTENTS

FIGURES

PLATES

ACRONYMS AND ABBREVIATIONS

FoS	Factor of Safety
KJFbf	Franciscan Complex Broken Formation
LCG	Last Chance Grade
PGDR	Preliminary Geotechnical Design Report
SEM	Sequential Excavation Method

See also Plate 1 for abbreviations used on Plates.

1 INTRODUCTION

1.1 Objective

Alternative F-Short has been proposed as a tunnel alignment which would be shorter, and potentially have less environmental impact, than the longer Alternative F-Long tunnel alignment. The objective of these geotechnical studies was to evaluate uncertainties associated with this alternative which could affect the feasibility of Alternative F-Short to meet the Last Chance Grade (LCG) Permanent Restoration Project purpose and need.

1.2 Purpose

The two-fold purpose of these geotechnical studies was:

- To use existing geotechnical data to characterize site geologic conditions in greater detail to reduce uncertainty and evaluate the location of the proposed Alternative F-Short alignment location for tunnel design and construction.

  For long-term stability, the tunnel should be below and behind the basal failure surface. Two areas of areas of particular uncertainty are: 1) near the proposed south portal where the alignment may cross the interface of the Franciscan Complex Melange and the Broken Formation; and 2) near the proposed north portal where the alignment is near a postulated basal failure surface.

- To quantitatively assess the seismic stability of the proposed tunnel and approach structures.

  The site is within a seismically active region. The seismic performance of the proposed tunnel structure will be evaluated as fatal flaw check. Strains induced in the tunnel lining under earthquake loading should be within acceptable limits, allowing the tunnel to safely withstand a seismic event. The portal approach areas are also critical for stability because of their length and location. The proposed excavation at the south portal approach presents a particular challenge because of the presence of earthflow and Melange.

1.3 Scope

1.3.1 Geologic Studies

A total of 14 geologic cross sections (presented on Plates 4a through 4n) and one geologic profile (presented as Plate 5) were developed across and along the proposed Alternative F-Short alignment. The purpose of these cross sections was to further characterize the landslide geometries and general geology relative to the proposed Alternative F-Short tunnel alignment.

The cross sections and profile were used to develop interpretations of potential landslide geometries to evaluate landslide scenarios that could impact the proposed tunnel alignment.

1.3.2 Seismic Stability Studies

The seismic stability studies included the following analyses:

1. Loading analyses and conceptual design of Alternative F-Short south portal approach
2. Fatal flaw analysis for racking and ovaling of proposed Alternative F-Short Sequential Excavation Method (SEM) tunnel
3. Stability analysis of Alternative F-Short north portal area

Results of analyses were compiled and assessed for an overall evaluation of seismic stability of Alternative F-Short tunnel and portal approaches.

1.4 Limitations

Because of Caltrans schedule constraints for alternative selection, these geotechnical studies were completed in just a few weeks. Consequently, the level of detail is less than desirable for a more advanced design level. The results of these studies are intended only as screening tools.

Subsurface geologic interpretation was developed using data extrapolated from significant distances from the applicable cross section lines. Geologic conditions could vary significantly from what is shown graphically and discussed below. Future exploration plans should focus on filling key data gaps identified from this study that may impact project design and construction methods and sequencing.

2 GEOLOGIC STUDIES

To further characterize landslide geometries relative to the proposed F-Short alignment, 14 geologic cross sections and one alignment profile were developed to supplement the four geologic cross sections prepared for the Draft Preliminary Geotechnical Design Report (C) (Caltrans, 2021). Cross section locations are shown relative to the alignment stationing on Plate 6.

The alignment currently designated as “Alternative F-Short” was known as “Alternative F1” at the start of this study. Plates still retain the “Alternative F1” designation but do refer to Alternative F-Short.

Due to limited subsurface data available for the project, cross sections were developed using conservative geometries to assess typical, worst-case landslide scenarios with potential to impact the alignment. Section development utilized the following data sets:

- Previous geologic mapping
- Geomorphic interpretation of the 2020 LiDAR-generated contours and Bare Earth Digital Elevation Model
- Boring and downhole monitoring instrumentation data where available and applicable

Of particular importance to the assessment of the proposed F-Short alignment is the characterization of the contact/interface between the Wilson Creek Complex and the Earthflow Complex to the south, particularly in the vicinity of F-Short alignment Stations 65+00 to 70+00. Interpretation of existing geomorphology indicates the uppermost headscarp of the Wilson Creek

Complex extends south into/beneath the Earthflow Complex, and the southern side margin of the Wilson Creek Complex is effectively concealed by the over-riding Earthflow Complex as indicated on the oblique LiDAR interpretation in Plate 3.

The narrow, east-west trending ridge forming the north margin of the Earthflow Complex in this area exposes resistant sandstone, likely derived from the Franciscan Complex Broken Formation. Its topographic expression, physical appearance and current position/location suggest that the ridge potentially represents a displaced block, translocated westward in the direction of landslide movement, rather than a knife-blade thin in-place bedrock exposure. The area immediately south of the ridgeline is mantled by the Earthflow Complex, derived from the underlying Franciscan Complex Melange (argillite). This interpretation implies the following two conditions:

- A pre-existing, northeast-trending, southeast-dipping lithologic/geologic contact between the Broken Formation sandstone and the Melange exists in the vicinity of this ridgeline interface.
- Activation of the Wilson Creek Complex displaced this contact to the west, locally translocating a block composed of sandstone overlain by Melange and/or earthflow deposits.

The presence of dominantly sandstone bedrock north of the contact/landslide margin implies the contact dip is likely vertical to moderately steep toward the southeast. Based on limited boring data (boring RC-20-006, location shown on Plate 2) and cross-sectional analysis, a potential dip of approximately 50 degrees to the southeast is conceivable, as indicated on Plates 4b through 4e.

The proposed F-Short south portal approach structure (initiating at Station 52+00) will be constructed within the active Earthflow Complex. The alignment pierces the postulated earthflow basal failure surface at approximately Station 55+70, allowing for construction of the tunnel portal at Station 58+00 approximately 50 feet below the active failure surface and within in-place Franciscan Complex Melange bedrock. At its most proximal point in this southern segment, the alignment passes within approximately 60 feet of the postulated basal failure surface of the Wilson Creek Complex in the vicinity of Geologic Cross Sections 5 (Station 67+29, Plate 4e) and 6 (Station 64+21, Plate 4f).

Elsewhere to the north, the tunnel alignment is well within what is considered in-place stable bedrock. The Alternative F-Short alignment transects the anticipated contact between the Franciscan Complex Melange bedrock and the Broken Formation sandstone bedrock at approximately Station 66+30, assuming a 50-degree southeast dip orientation, as indicated on the Alternative F1 (F-Short) Tunnel Geologic Profile, Plate 5. Increasing the assumed dip magnitude will shift the contact location progressively up-station.

The alignment remains within the Broken Formation through the north portal (Station 116+00) and approach structure, which terminates at Station 118+00. At the northern end, the alignment spans a colluvial drainage with a proposed bridge structure between Stations 119+28 to 120+38, and ultimately terminates at the proposed conform at Station 126+91.

3 DESIGN CONCEPT AND SEISMIC STABILITY STUDIES

Three aspects of Alternative F-Short were identified for further study to validate its geotechnical viability. These were the design of the south portal approach structure in the earthflow, the stability of a two-lane tunnel in the Melange, and the stability of the proposed Alternative F-Short north portal area.

3.1 South Portal Approach Structure

3.1.1 Design Concept

The rejection of the initial Alternative F alignment was based on the uncertainly associated with locating the south portal approach structure in the active earthflow area. A recently developed concept, utilizing deformable materials, provides a practical means to limit earthflow loads and allow the approach structure to be situated in the earthflow.

The south portal approach structure for Alternative F-Short is situated in an earthen slope that is undergoing downslope movement, or creep, Figure 3-1. For stationary structures, such as this approach structure, the earth pressures associated with such downslope movements theoreticality exceed the full passive pressure of the upslope soils. To limit the level of the downslope loading and to provide certainty as to that loading, it is proposed to use engineered collapsible columns to absorb the downslope deflection while limiting the structural loading to a prescribed value. The application of engineering collapsible concrete is relatively new; however, the technology has been perfected for the design of airport overrun areas and highway errant truck arrestor beds. Formulations have been and can be developed to provide reliable strength/collapse characteristics.

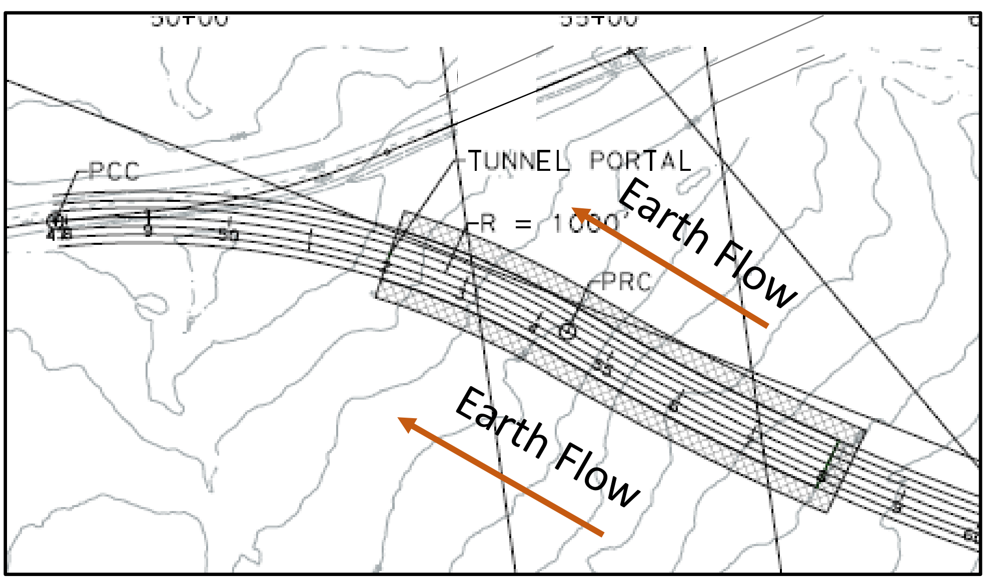


Figure 3-1. Alternative F-Short South Portal Approach Structure

3.1.2 Analytical Approach

3.1.2.1 Earthflow Characteristics

The earthflow extends from approximately Alternative F-Short Station 68+20 to south of the southern project limit. It has a history of erratic behavior with both lateral and vertical motions occurring in seemingly random locations and times. For this study it has been assumed that the average movement is 2 inches per year. Note that this value can be increased without jeopardizing the overall mitigation concept by widening the collapse column treated area.

The earthflow's predominant movement is down slope and roughly perpendicular to the slope contours. At the Alternative F-Short south portal approach structure the motion is southwest and approximately aligns with the centerline axis of the approach structure.

The earthflow materials consist of decomposed sandstone and argillite with properties like a stiff sandy clay with blocks of intact rock (Caltrans, 2021; 2022b). The depth of the earthflow's basal failure surface is approximately 75 feet at the Alternative F-Short south portal approach structure location. The limited data available indicates that the water table is a few feet above the earthflow basal failure surface.

3.1.2.2 Design in Earthflow Materials

As originally conceived, the loading that would be imposed on a south portal approach structure embedded in the earthflow materials would have been enormous and would have been unmanageable. The reason these loads are extremely high is due to the engagement of earthflow materials on either side of the south portal approach structure. The frictional properties of soil cause the "anchoring" effects of an immovable object to engage not only the soil immediately upslope from the object, but also significant volumes of adjacent soils. There is an opposite effect when the object is flexible. As a flexible object deflects, the upslope soils arch around the object shedding the load to the soils on either side. This is often referred to as the "trap door" effect. Figure 3-2 illustrates this phenomenon.

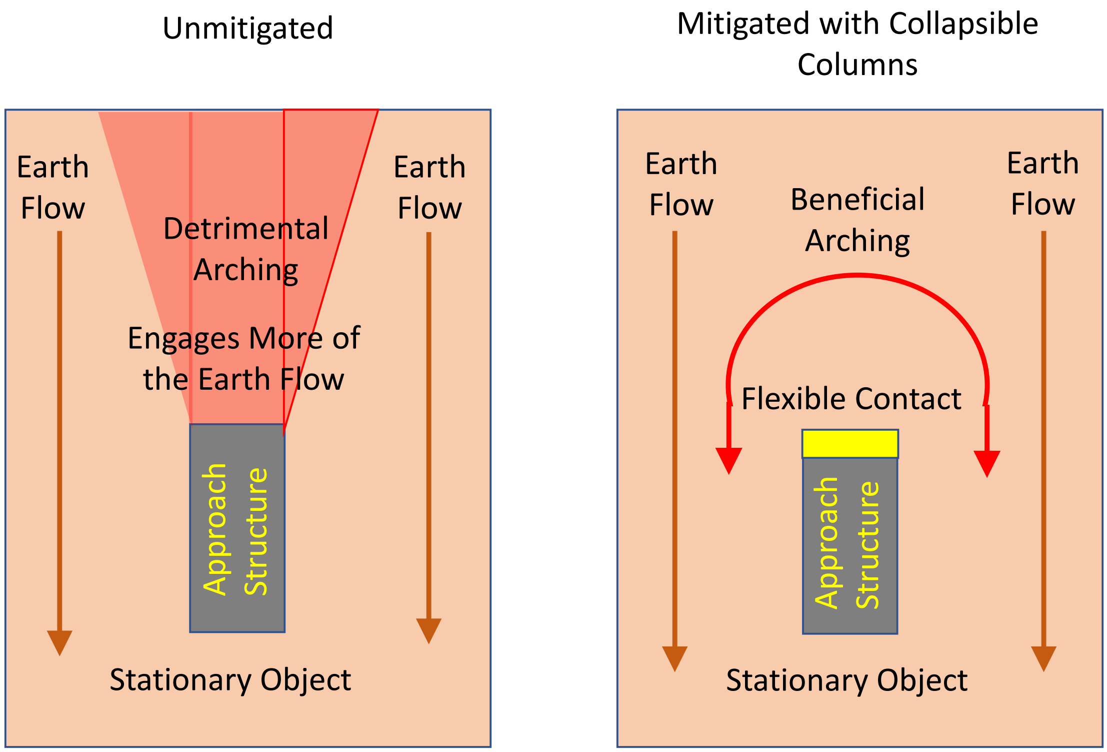


Figure 3-2. Earthflow Loading

To limit the loads on the south portal approach structure to approximately the current surrounding earth pressures an innovative solution employing collapsible concrete columns has been developed. With this approach the potentially impacted walls are surrounded by collapsible concrete columns. The strength of the collapsible concrete would be formulated to be slightly stronger than the existing soils. This is necessary to not diminish the current stability of the earthflow mass.

To establish the collapse strength of the columns it is necessary to determine the current earth pressures in the surrounding earthflow soils. Theoretical calculations suggest the corresponding earth pressure coefficient should be approximately 0.74, based on a Coulomb analysis. In-situ pressuremeter tests taken in the earthflow (Caltrans, 2021b) indicate earth pressure coefficients in the range of 0.7 to 0.85. This close correlation between theory and practice provides confirmation and a reasonable level of confidence in the selection of the column strength criteria. For the purposes of this study an earth pressure coefficient of 0.8 was used, and a stepped strength profile as shown in Figure 3-3 was used for modeling.

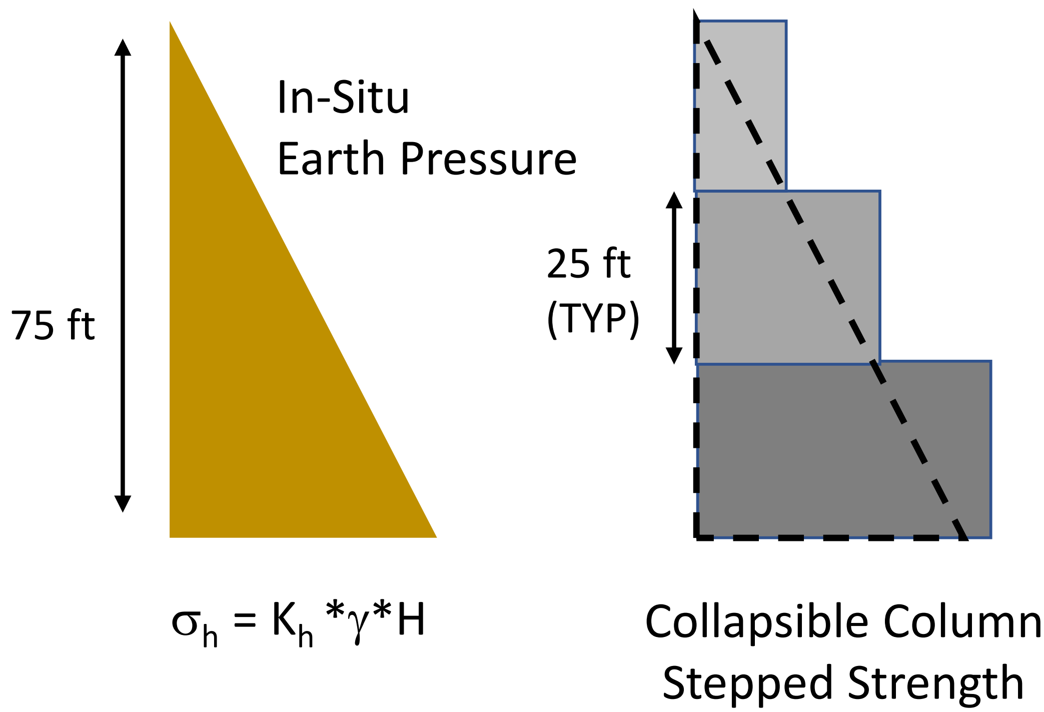


Figure 3-3. Stepped Strength Profile

By providing a zone of crushable material along the exposed sides of the south portal approach structure, further downslope movement will impose loads limited to the strength of the collapsible columns. As the earthflow migrates downslope the columns are progressively crushed to absorb the motion. The width of the collapsible column treatment zone is dependent upon the projected downslope movement of the earthflow over the life of the structure. For this study this dimension was established by using an estimated yearly down slope movement extended over the service life of the tunnel. These have been taken as 2 inches per year and 75 years. This translates into a deflection of 12.5 feet but considering the unpredictable nature of the earthflow a collapsible width of 25 feet has been selected. Note that should yearly deflections exceed predictions, or the service life extended, additional columns could be added to extend the functional life of the structure.

3.1.3 South Portal Approach Structure Design and Modeling Results

The Alternative F-Short south portal approach structure will need to be approximately 600 feet long to initiate the tunnel construction a sufficient distance below the earthflow basal failure surface. Figure 3-4 illustrates this conceptual configuration. For this study it has been assumed that the walls of the structure would be constructed of large diameter (4 to 5 feet), interlocking secant pile walls founded at least 25 feet below the invert slab and keyed into the Melange. To avoid the use of tiebacks in the unstable earthflow material, the approach structure would be constructed using a top-down methodology with permanent floor slabs providing the required internal support. Collapsible columns would be installed along the walls of the approach structure that would be subjected to flow loads, either compressive or shear.

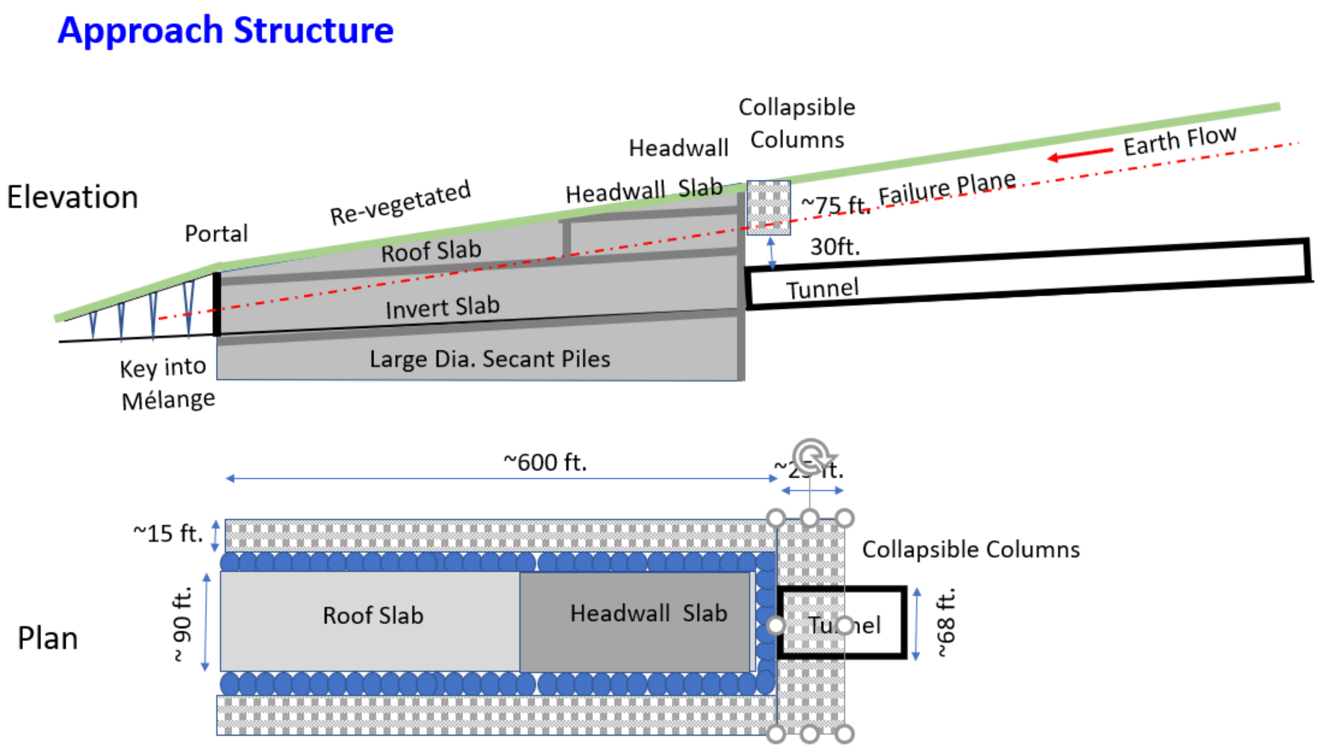


Figure 3-4. South Portal Approach Structure - Conceptual Configuration

The collapsible columns would be prefabricated, transported to the site and the inserted in pre-drilled holes. The treatment depth would be to the top of the earthflow failure surface or approximately 75 feet. As mentioned earlier, the columns would be pe-fabricated in shorter sections, say 25 feet, and their strengths “tuned” to the corresponding earth pressure. Due to the nature of collapsible concrete, the prefabricated columns will have to be cast in horizonal orientation to prevent collapse of the foam concrete under its own weight. The column segments would then be lowered into a pre-drilled hole with any annular space grouting to ensure contact with the surrounding soils. Further study is required to establish the handling and placement requirements for the column sections.

This concept has been modelled using MIDAS GTS and cross checked with hand calculations. The results indicate that the loads imposed on the structure can be prescribed and effectively transmitted to the portions of the secant piles embedded (keyed) in the Melange. In addition, the stress levels in the Melange and the corresponding deflections are well within acceptable limits. Figure 3-5 is a half-section cut away of the MIDAS model.

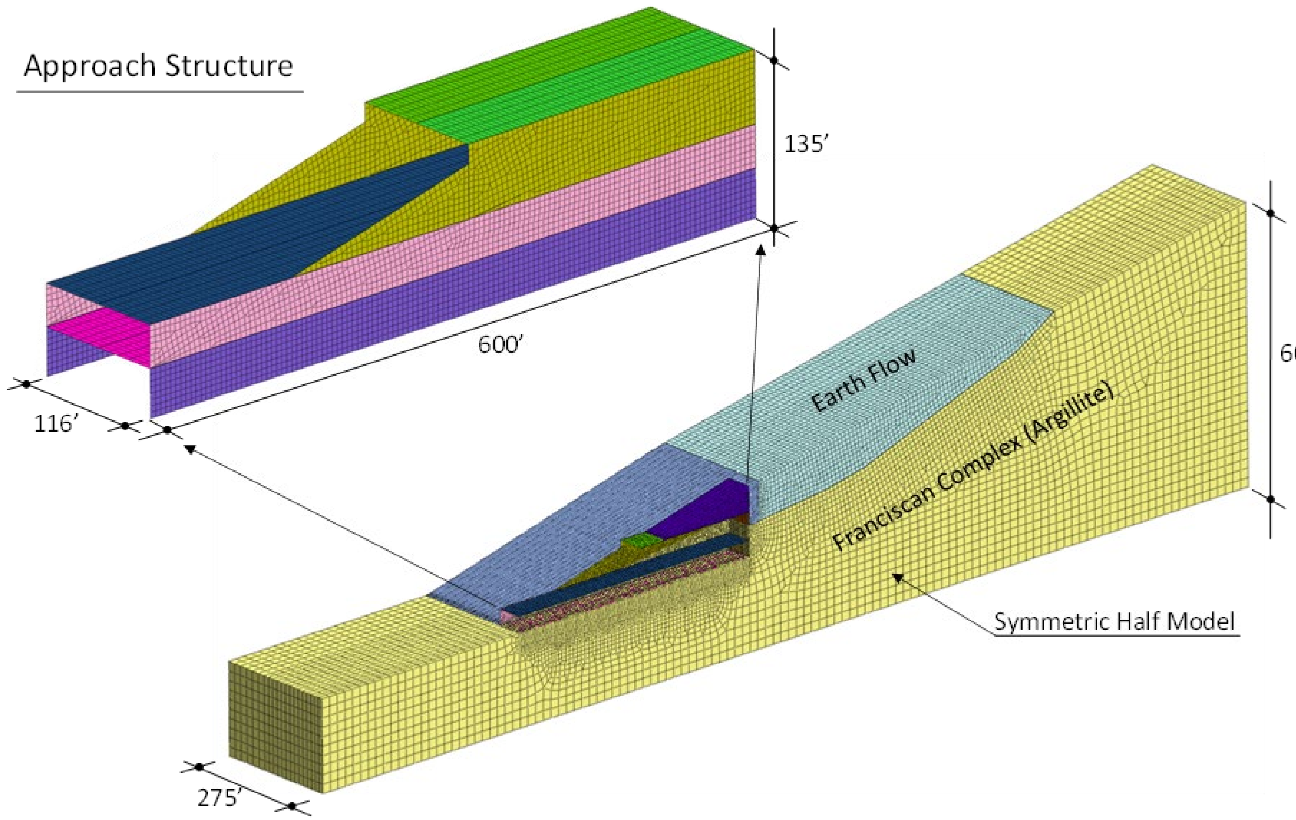


Figure 3-5. MIDAS GTS Model

3.2 Tunnel Stability

In addition to the issue of the earthflow, the stability of a large, two-lane tunnel in the Melange is a concern. A series of finite element analyses was performed to determine what the structural requirements would be needed for the tunnel to survive the design seismic event.

The site is within a seismically active region. The seismic performance of the proposed tunnel structure, where it is situated in the Melange, has been evaluated as fatal flaw check.

The 14 geologic cross sections and the geologic profile developed across and along the proposed Alternative F-Short alignment, described in Section 2, were used to develop interpretations of potential landslide geometries to evaluate landslide scenarios that could impact the proposed tunnel alignment.

Finite element analyses, using MIDAS GTS, were performed to estimate the seismically induced stresses and strains in the tunnel lining. The derived values were then compared to stress and strain levels that have been shown to be acceptable in concrete linings.

These analyses show that the large, two lane sequentially excavated tunnel in the Melange will require a very robust lining system to survive the design earthquake. Where under more normal loading conditions the lining would be on the order of 16 to 18 inches thick, this tunnel will require a lining thickness of 24 inches. Figure 3-6 presents the results for both an 18-inch-thick lining, which is overstressed as demonstrated by the red oval, and a 24-inch lining, which is within acceptable levels. Strains in the 24-inch lining were also found to be acceptable.

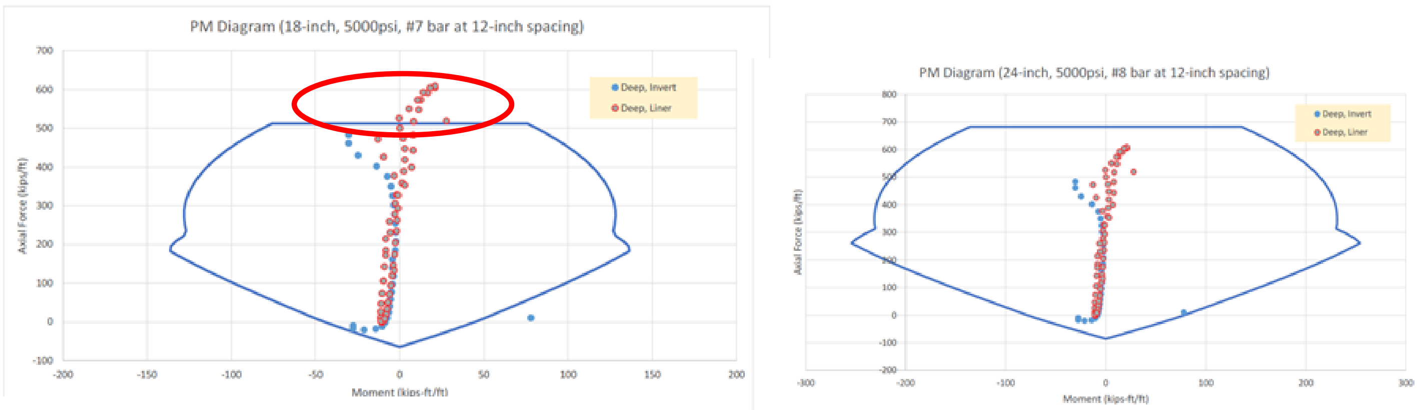


Figure 3-6. Tunnel Lining Stresses in Melange

Another aspect of the large tunnel cross-section is its construction. The Melange is not a favorable material for mining a large opening and would require multiple SEM headings to accomplish the excavation of the full heading. This difficulty is exacerbated by the length of Melange mining required. The current interpretation of the ground conditions suggests that mining in the Melange will exceed 800 feet in length (Plate 5). There are few case histories of SEM tunnels of his size. A project in comparable complexity is a 3 ½ lane highway tunnel in Niayesh, Iran. This tunnel is 59 feet wide and 42 feet high and was constructed in alluvium. It required multiple drifts as can be seen in Figure 3-7.

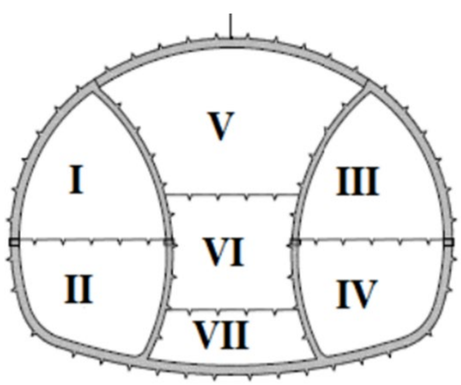


Figure 3-7. Drift Sequence for Large SEM Tunnel

These conditions will require further study to determine if it would be more advantageous to mine two single-lane tunnels from the south portal and merge them at the north end to reduce the exiting footprint. This second option would require that the south portal approach structure width be increased from approximately 80 feet to 120 feet.

3.3 North Portal Area Stability

Another aspect of Alternative F-Short that required evaluation was the stability of the north portal area, which is west of the Alternative F-Long alignment. Slope stability analyses were performed using Slope/W to determine if the proposed cut slopes would be stable.

The current north portal location has been established to be behind the basal failure surface, however the configuration requires the reprofiling of the ridge from the portal to the existing U.S. Highway 101 alignment.

The proposed cut slopes were analyzed to determine their stability under static and seismic conditions. The results indicate that they are stable for the static condition with a Factor of Safety of 2.6, and stable under the design seismic event (Caltrans, 2022a) with a factor of safety of 1.5 (Figure 3-8).

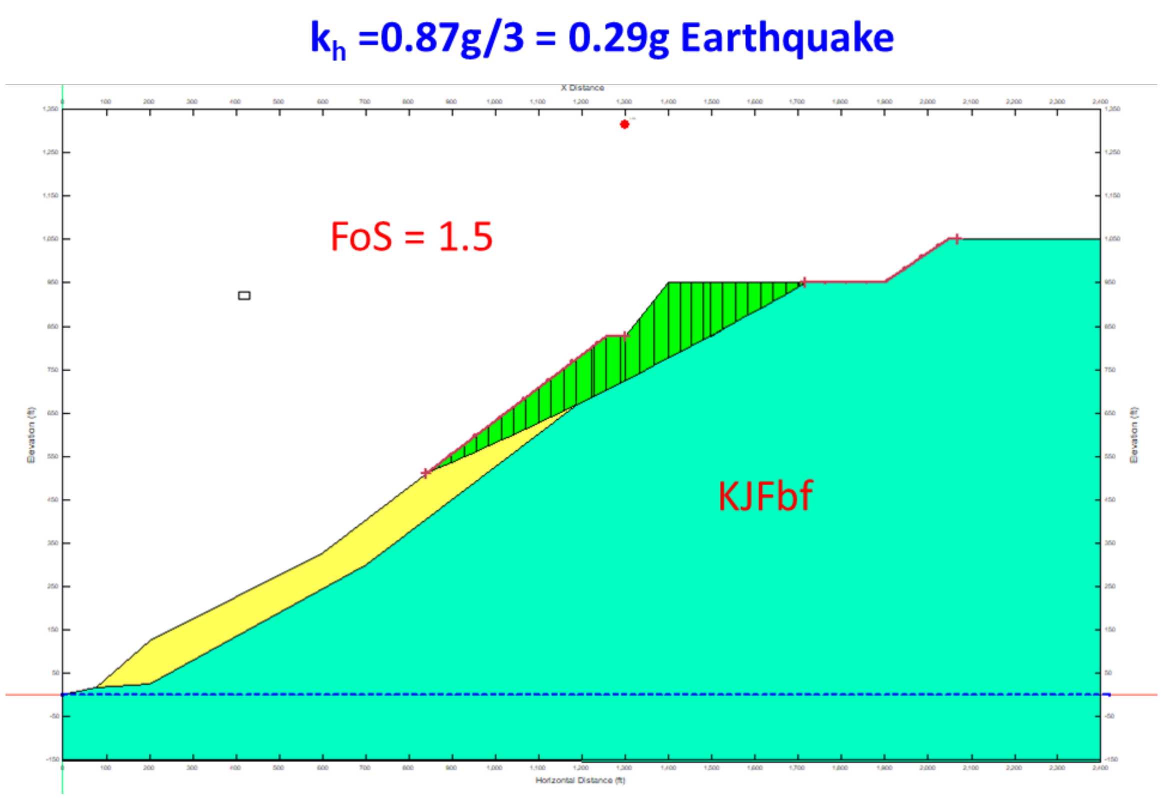


Figure 3-8. North Portal Stability

4 FINDINGS

4.1 Geologic Studies

Geomorphic and geologic interpretation of available data suggests a complex spatial relationship may exist between the south end of the Wilson Creek Complex and the Earthflow Complex. As shown on select cross sections and profile the Earthflow Complex may override the Wilson Creek Complex. There are four key implications to the current F-Short alignment when applying this geologic model:

- The geologic conditions do not present a fatal flaw to the currently proposed F-Short alignment.
- The location and orientation of the bedrock contact between the Franciscan Complex Broken Formation and the Melange and the landslide units derived from these is unclear and can only be postulated from distant data points.
- An understanding of this contact will be a critical path in developing tunnel construction methods and design.
- The southern portal approach will be constructed within the earthflow and will need to be designed to mitigate landslide movement impacting the structures.

4.2 Design Concept and Seismic Stability Studies

Alternative F-Short has been evaluated for three potential fatal flaws and found to be feasible, provided some extraordinary measures are taken. These measures include:

- Use of collapsible columns at the south portal approach structure, and
- A very robust structural system used for the tunnel lining through the Melange.

More work is needed to ascertain the full extent of these design requirements and to establish their costs and construction schedule implications.

5 REFERENCES

Caltrans (2021). Last Chance Grade Permanent Restoration Project, Preliminary Geotechnical Design Report, Submittal SUB-051, December (Draft)

Caltrans (2022a). Last Chance Grade Permanent Restoration Project, Structure Preliminary Geotechnical Report, Alternative F Tunnel and Approach Structures, Submittal SUB-052c, January (Draft).

Caltrans (2022b). Last Chance Grade Permanent Restoration Project, Preliminary Final Geotechnical Data Report, Submittal SUB-032, May (Final).

GeoStudio - SLOPE/W 2021 R2 V11 Seequent, Bentley

MIDAS GTS NX 2021 (v1.1) MIDAS Information Technology

PLATES

LANDSLIDE IDENTIFICATION CHART

STATE OF ACTIVITY

1 = Active or Recently Active

(areas of unstable ground with relatively recent/"fresh" geomorphic features such as ground cracks, hummocky topography, exposed soils, abrupt gradient breaks and/or disrupted vegetation, typically recent to 50 years old)

2 = Dormant

(areas of quasi-stable ground, with eroded and subdued geomorphic features, no exposed soils, somewhat re-vegetated but typically with different type or density, typically >50 to several hundreds of years old)

3 = Ancient

(areas of relatively stable ground, typically characterized by large, broad and deep landslides with highly eroded and subdued geomorphic features, re-vegetated with similar type and density, typically several hundreds to several thousands of years old)

CERTAINTY OF IDENTIFICATION

1 = Definite
2 = Probable
3 = Questionable

DOMINANT TYPE OF MOVEMENT

1 = Slump-Flow Complex
2 = Debris Slide
3 = Debris Flow
4 = Earth Flow
5 = Slump*
6 = Translational*
7 = Rockfall/Topple
8 = Wedge Slide

THICKNESS OF DEPOSIT

1 = Less Than 5 Feet
2 = 5 to 15 Feet
3 = 15 to 50 Feet
4 = Greater Than 50 Feet

1 2 3 4

* Classification includes either soil-like or rock landslides. Classifications modified after Varnes (1978), v.2-2012

GEOLOGIC UNITS

Symbol	Geologic Unit	Description
Qal	Alluvium	Sand and sandy gravel with some fine-grained soil
Qc	Colluvium	Loose, heterogeneous mass of soil and/or rock fragments transported and deposited downslope by sheet flow or slow, continuous creep
Qlsd-m	Earthflow Landslide Deposits, Derived from Melange	Landslide deposits consisting of a mixture of fine-grained soils, deeply weathered rock, and scattered sandstone clasts shich have been transported as a sliding mass with many internal slip surfaces
Qlsd-bf	Rock/Debris Landslide Deposits Derived from Broken Formation	Landslide deposits consisting of blocks of sandstone and argillite rock and/or debris which have been transported by sliding falling
KJFm	Franciscan Complex Melange	Dark gray, pervasively sheared, soil-like argillite with scattered blocks of intact sandstone
KJFbf	Franciscan Complex Broken Formation	Blocks of gray, hard, massive to very thickly bedded sandstone with interbedded argillite separated by weak, sheared zones

EXPLANATION

Qlsd-m (1144)	Geologic Unit and Landslide Identification Number: see Landslide Identification Chart, left
— — —?—?— (red)	Active Landslide Contact: dashed where approximate; queried where uncertain
— — —?—?—	Geologic Contact: dashed where approximate; queried where uncertain
_ Qc _	Colluvial Contact/Older Debris Flow Scar
⊗	Vector point representing view of landslide movement into the page
⊙	Vector point representing view of landslide movement out of the page
▽	Groundwater elevation shown represents highest recorded measurement from monitoring as of May 2022

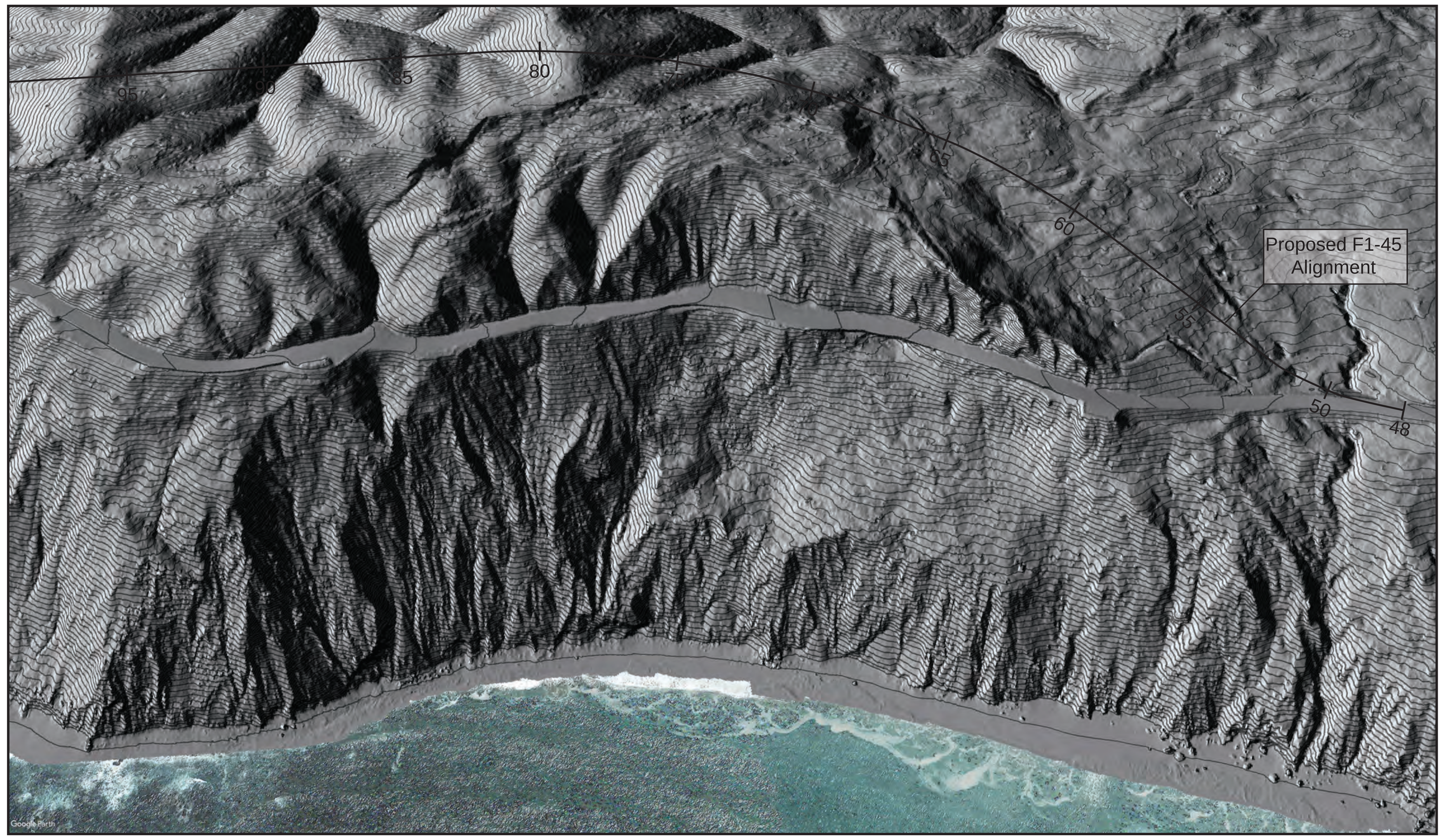
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
ALTERNATIVE F1 FEASIBILITY STUDY

KEY TO GEOLOGIC SYMBOLS

PLATE
1

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	PROJECT LANDSLIDE AND EXPLORATION LOCATIONS MAP	PLATE 2

UNINTERPRETED BARE EARTH DEM: SOUTH PORTAL



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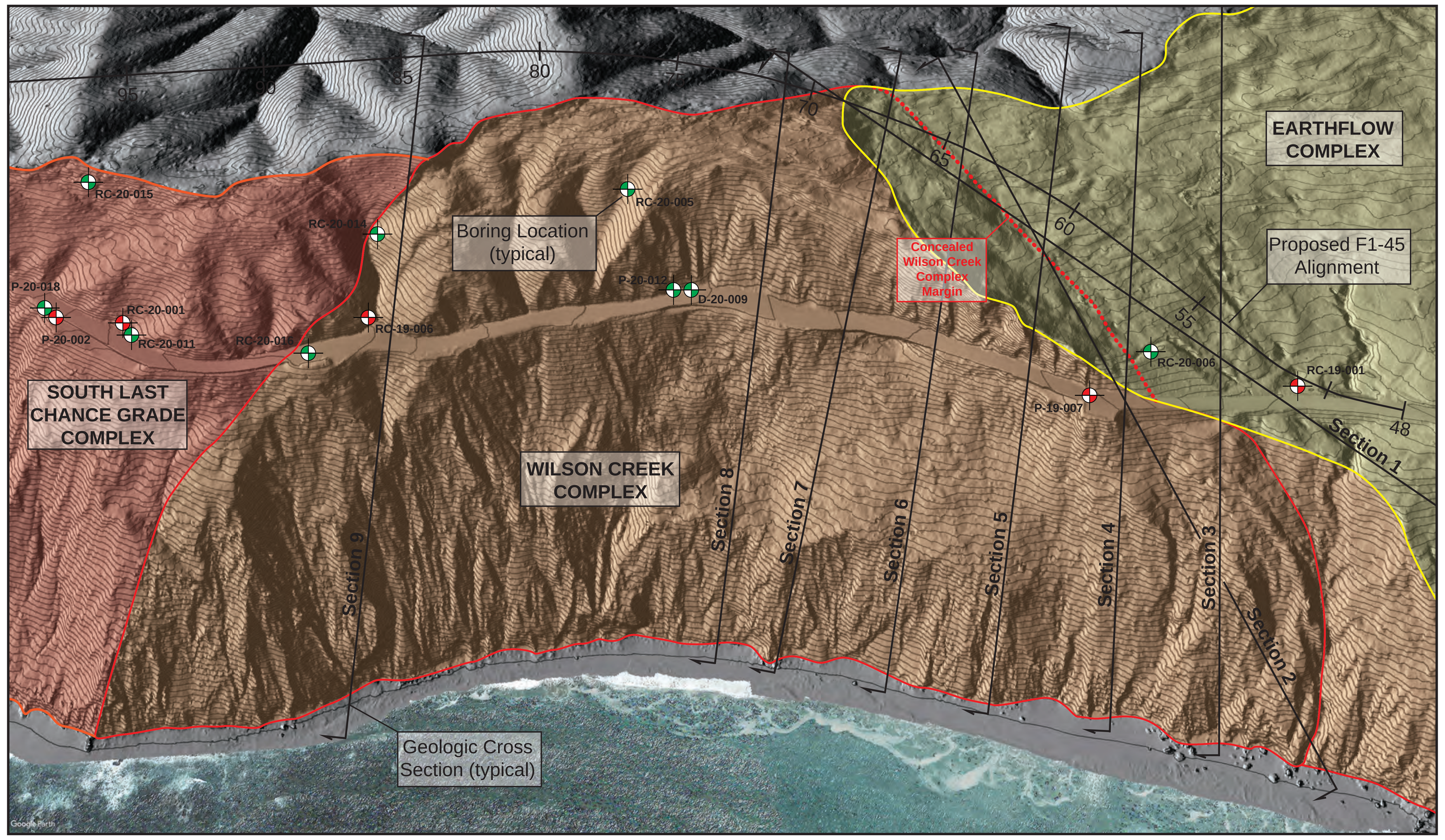
INTERPRETED BARE EARTH DEM: SOUTH PORTAL



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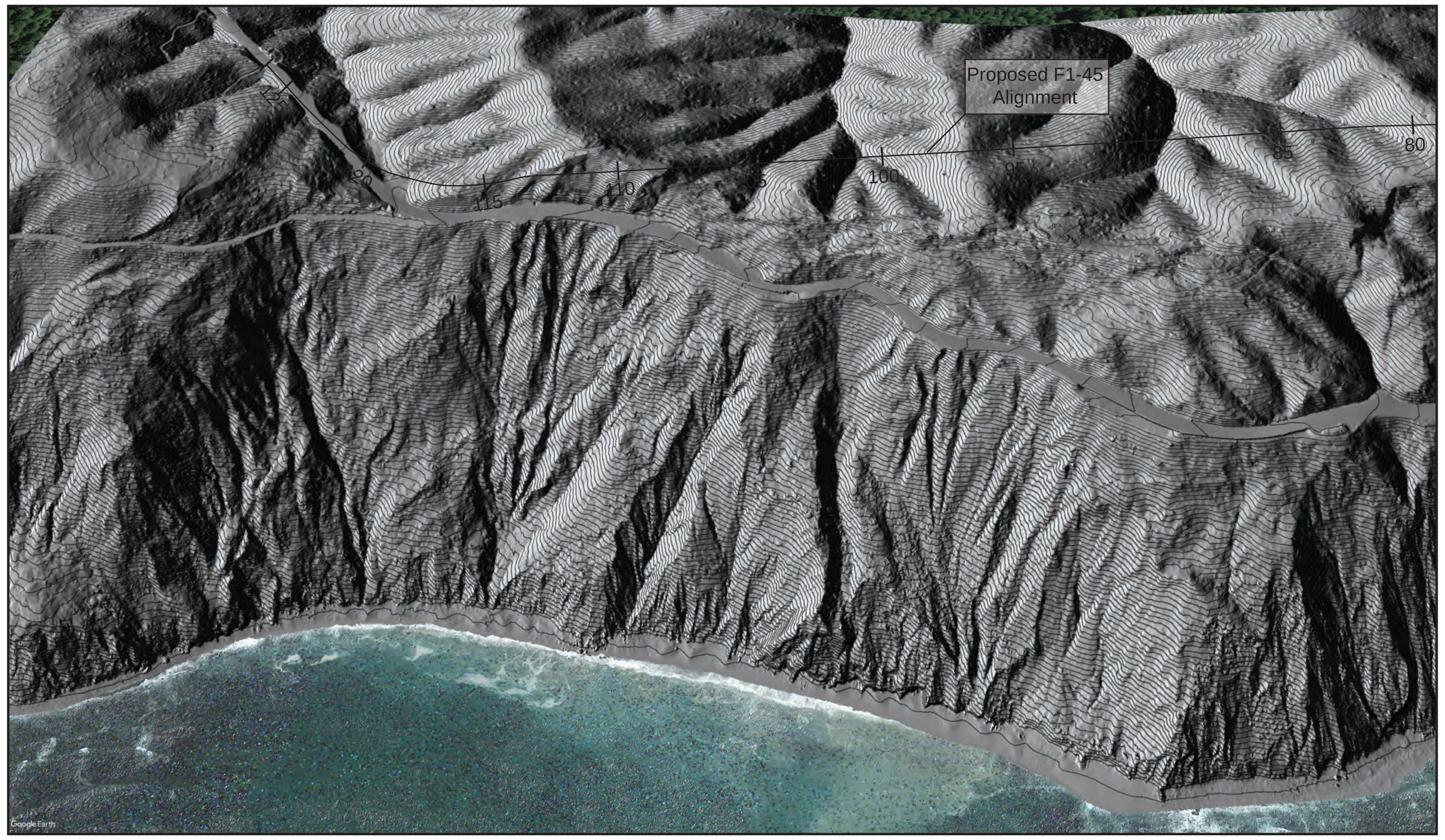
UNINTERPRETED BARE EARTH DEM: NORTH PORTAL



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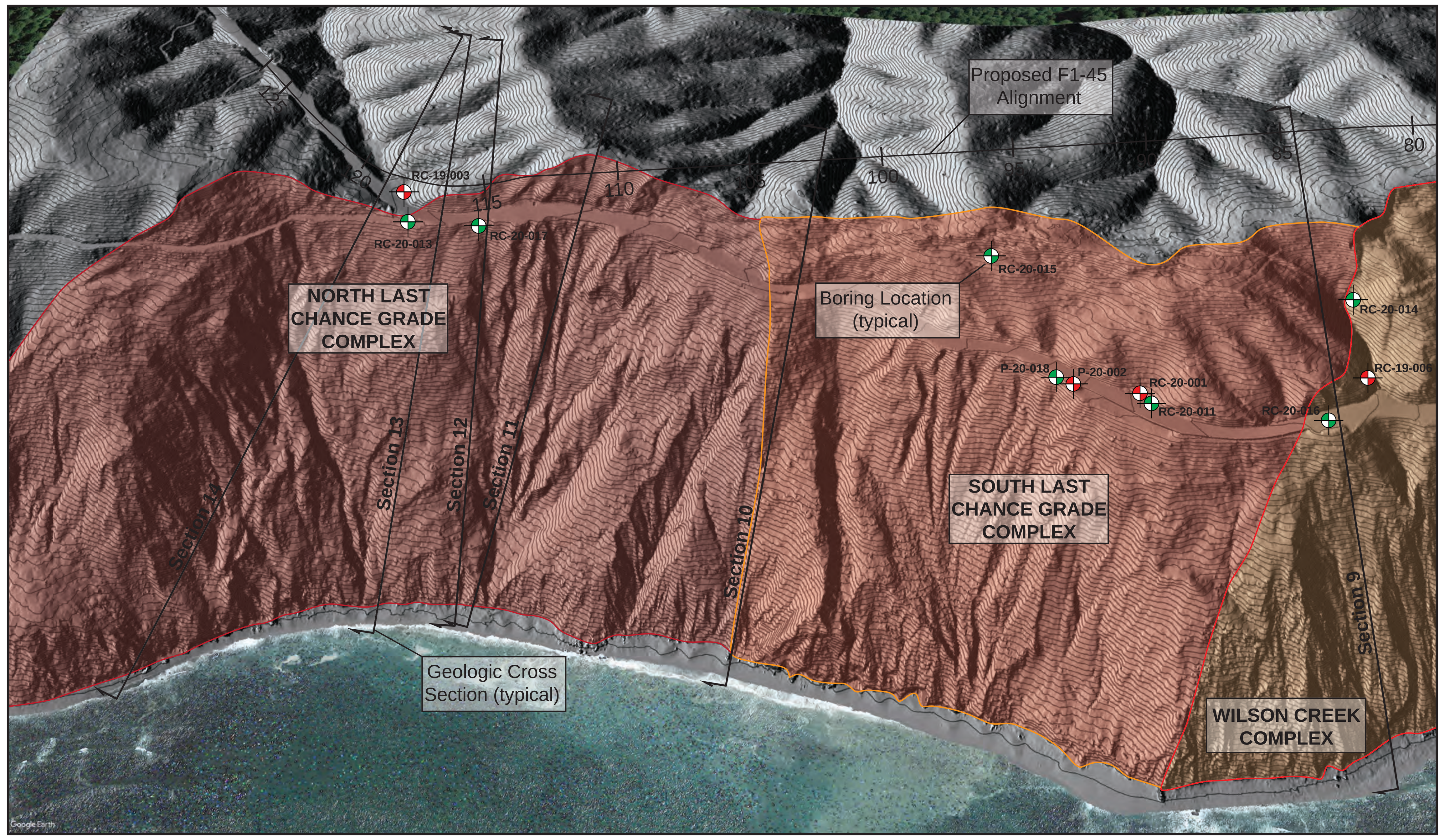
INTERPRETED BARE EARTH DEM: NORTH PORTAL



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LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	OBLIQUE LIDAR INTERPRETATION	PLATE 3

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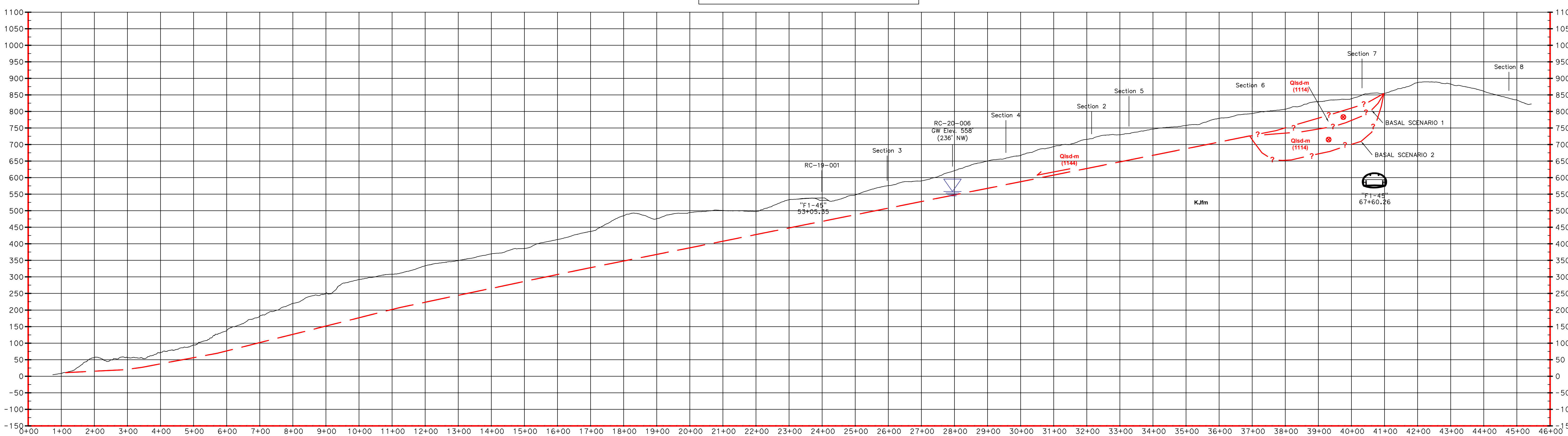
LAYOUT: Layout1

CAD FILE: A:\SACRAMENTO-DATA\DRAFTING\2020 PROJECTS\20208000.001A LAST CHANCE GRADE\Cross Sections and Alignments\Alt F1\

Section 1



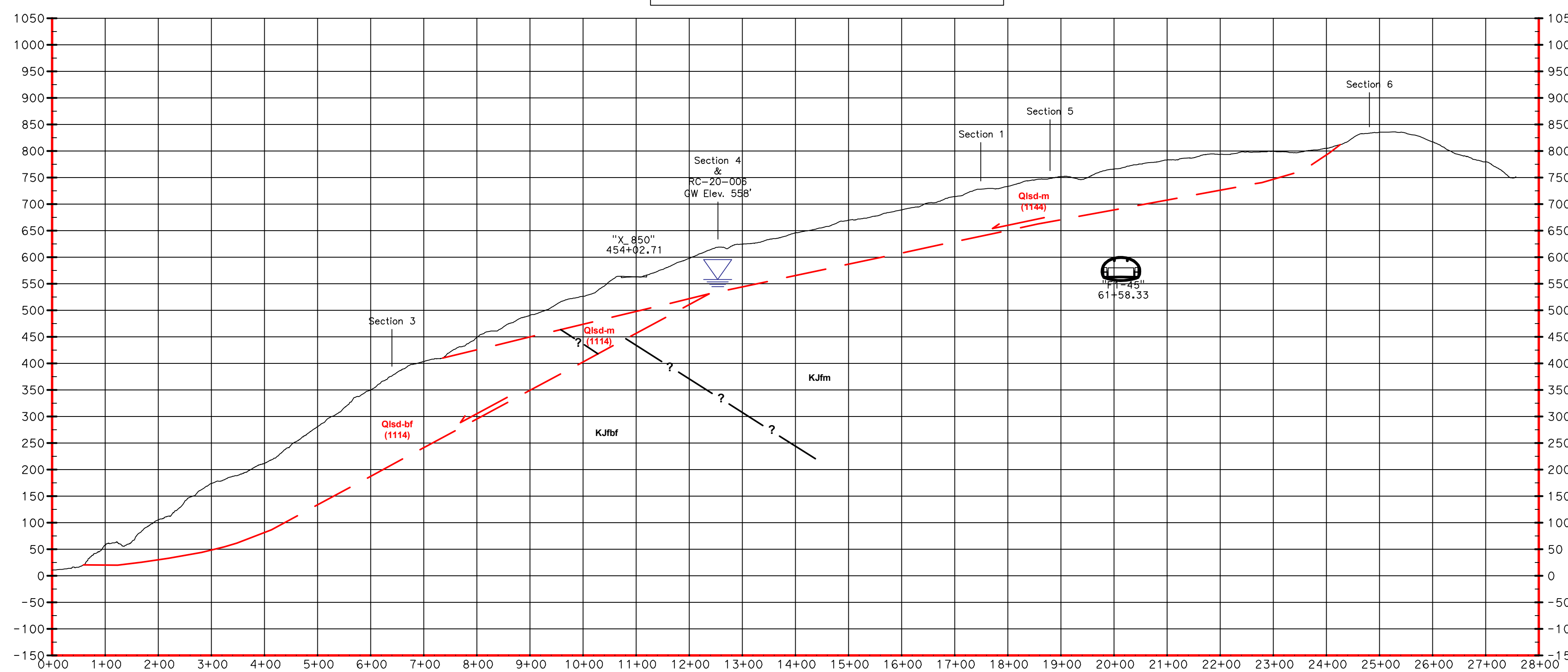
VIEW: NORTH

Notes:

1. Design and alignment shown for Alternative F1 is current as of May 13, 2022.
2. Geology shown is interpreted and based on limited available information. Actual subsurface conditions may differ.
3. Cross section is intended to illustrate geology and is not intended for detailed design or construction.
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 1	PLATE 4a

Section 2



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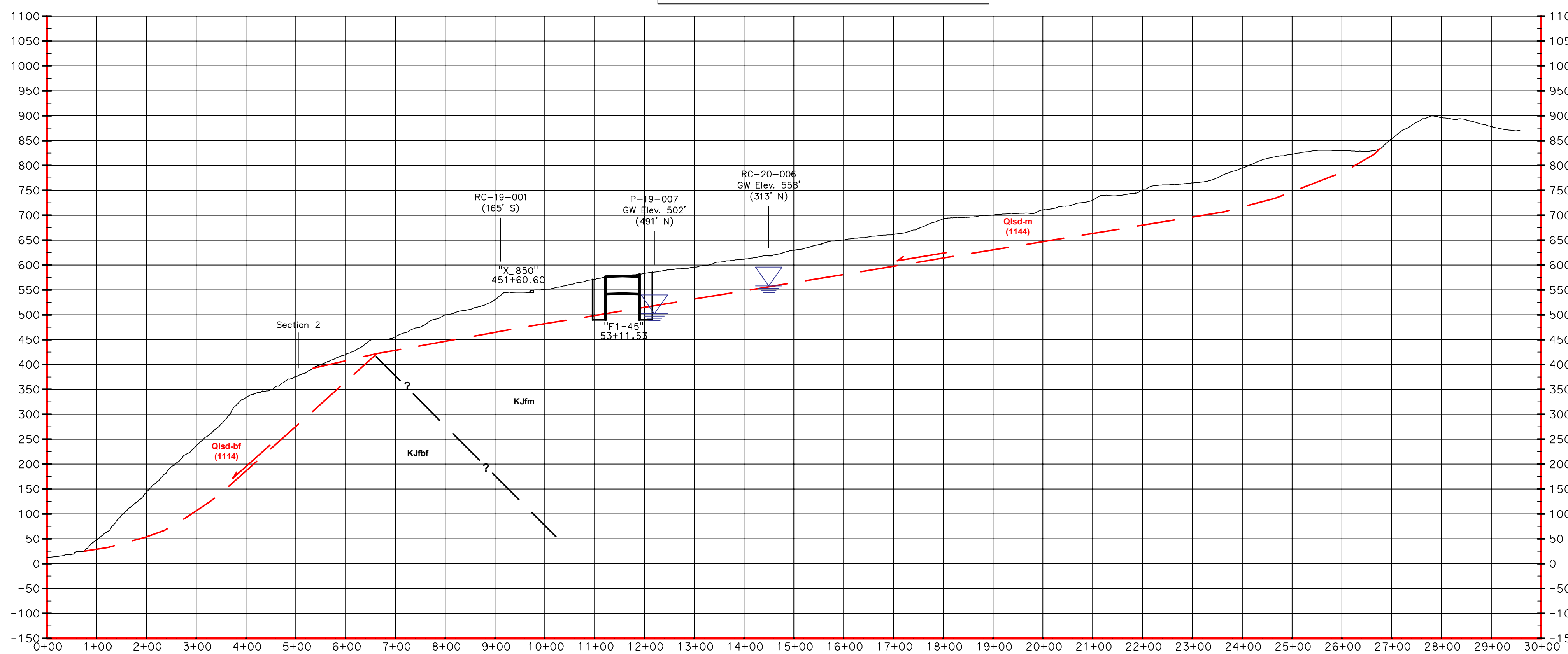
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 2	PLATE 4b

Section 3



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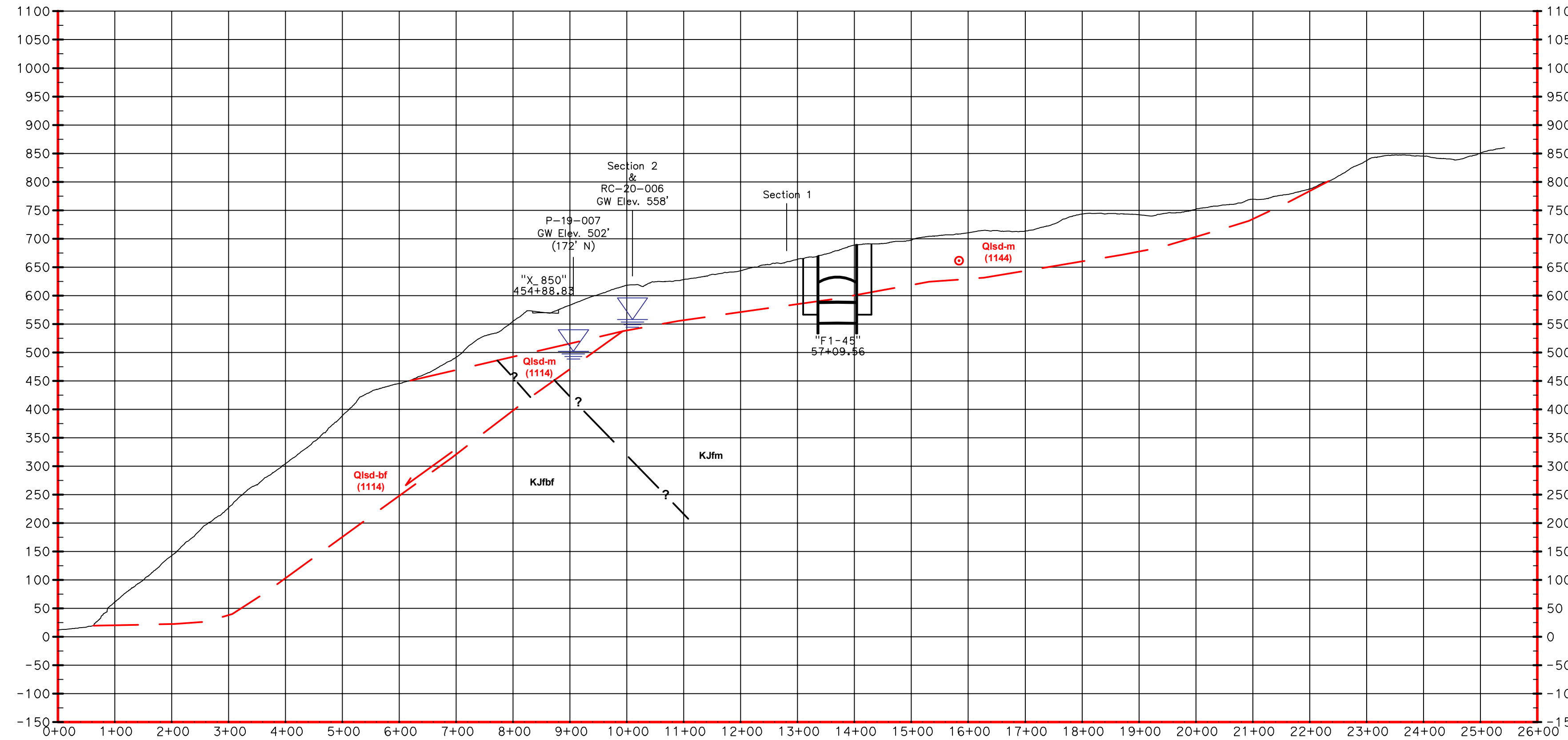
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	**GEOLOGIC CROSS SECTION 3**	PLATE **4c**

Section 4



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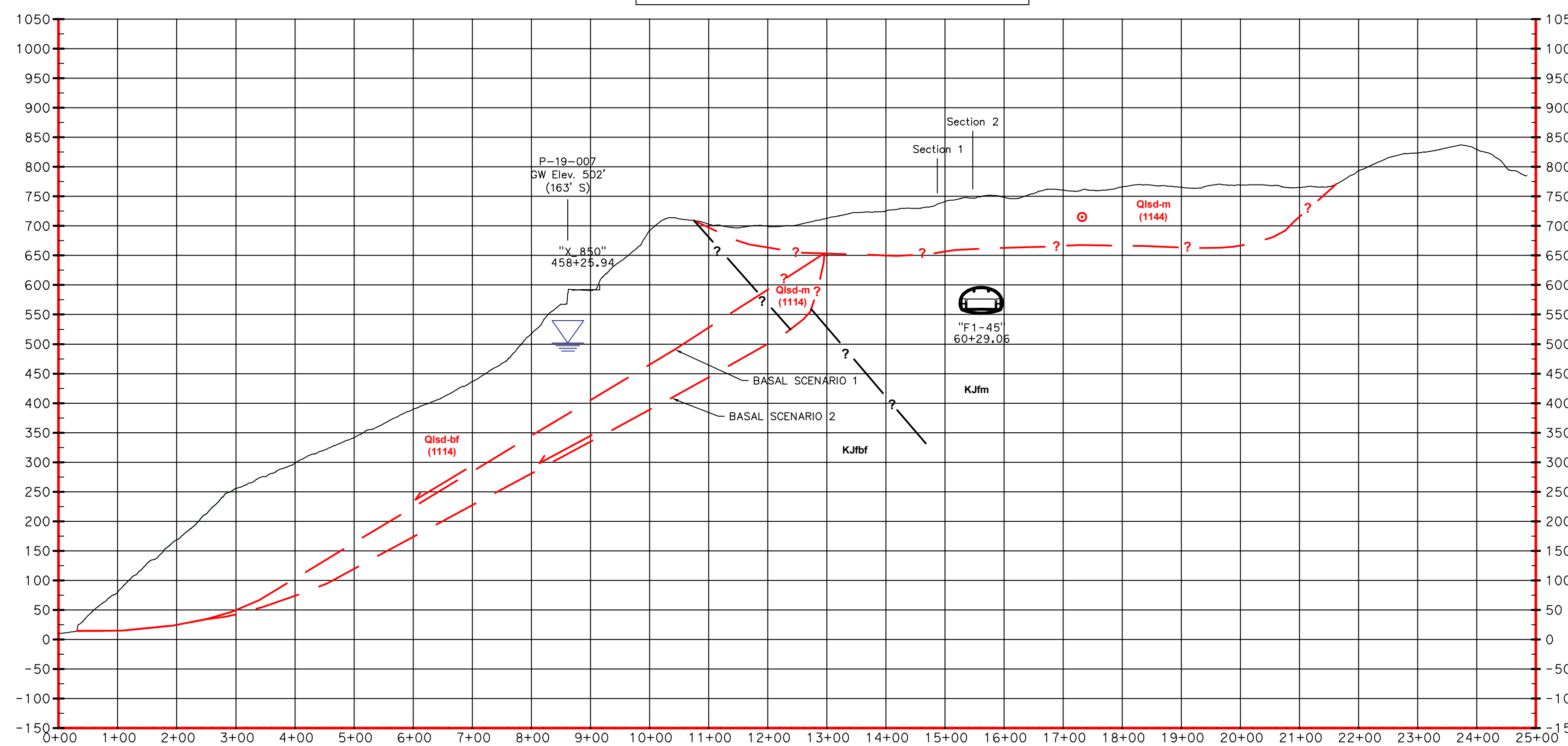
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 4	PLATE 4d

Section 5



VIEW: NORTH

Notes:
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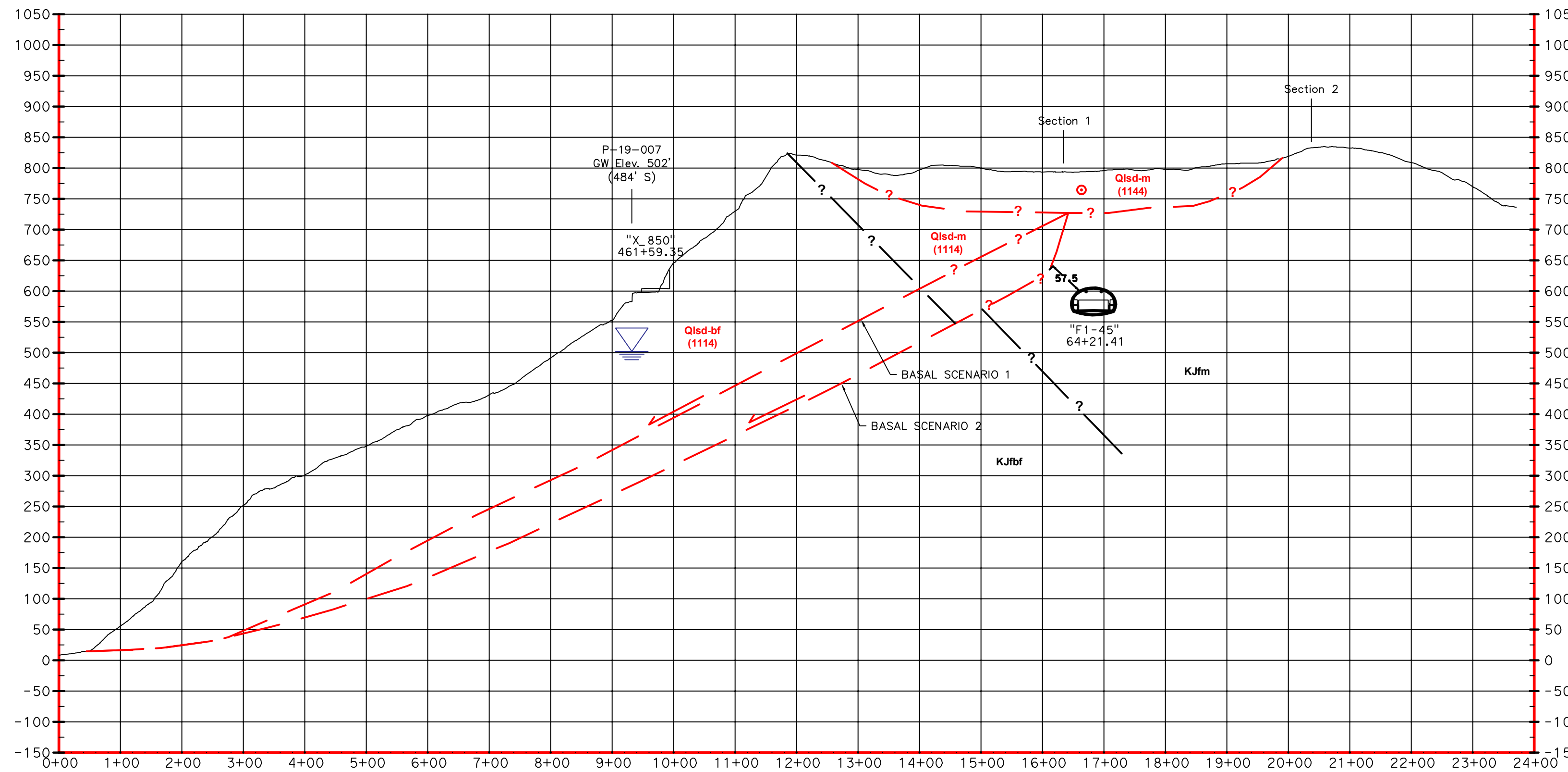
2. Geology shown is interpreted and based on limited available information. Actual subsurface conditions may differ.
3. Cross section is intended to illustrate geology and is not intended for detailed design or construction.
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 5	PLATE 4e

CAD FILE: A:\SACRAMENTO-DATA\DRAFTING\2020 PROJECTS\20208000.001A LAST CHANCE GRADE\Cross Sections and Alignments\Alt F1\ LAYOUT: Layout1 PLOTTED: 23 May 2022, 10:45am, JSala

Section 6



VIEW: NORTH

Notes:
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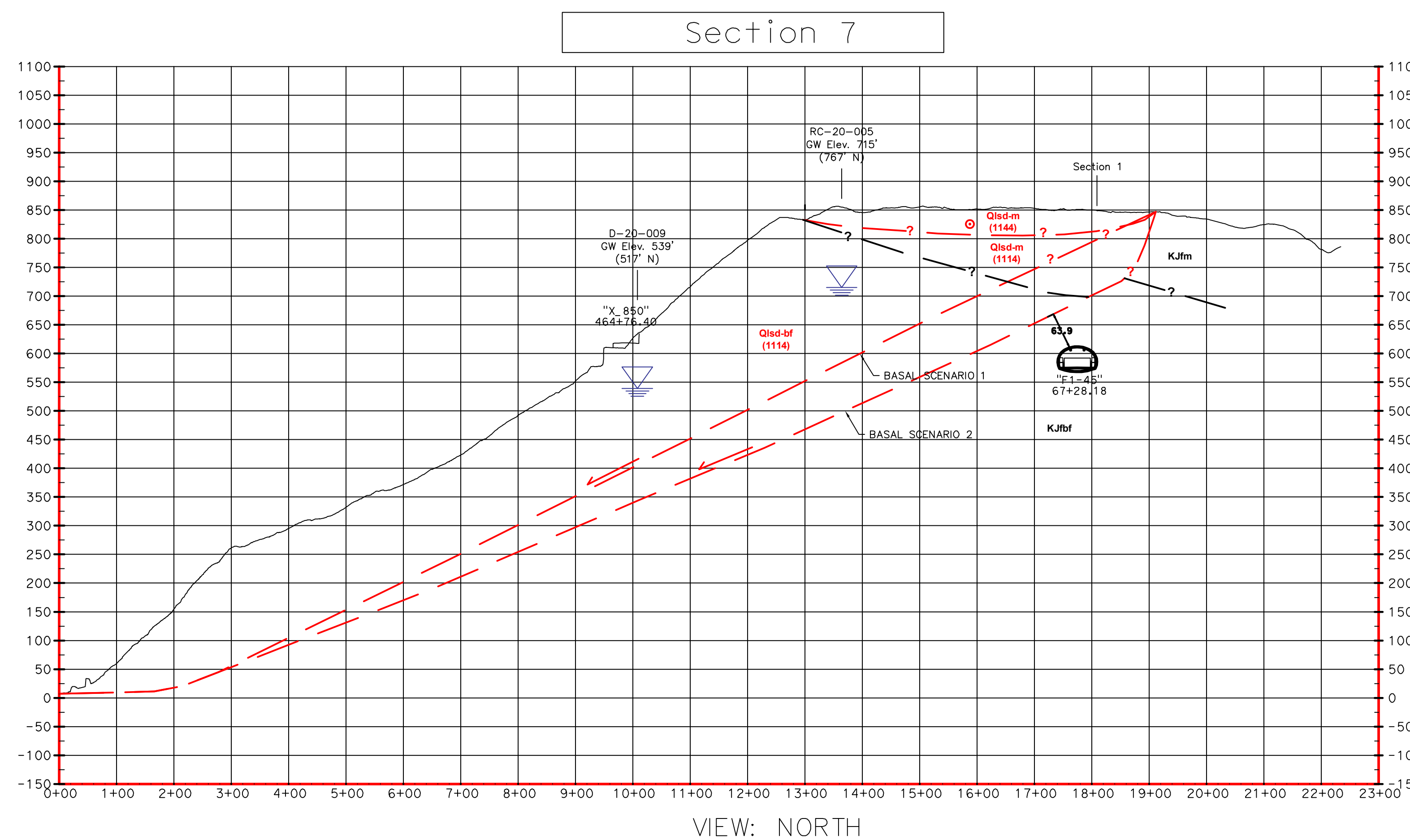
3. Cross section is intended to illustrate geology and is not intended for detailed design or construction.
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 6	PLATE 4f



Notes:

1. Design and alignment shown for Alternative F1 is current as of May 13, 2022.
2. Geology shown is interpreted and based on limited available information. Actual subsurface conditions may differ.
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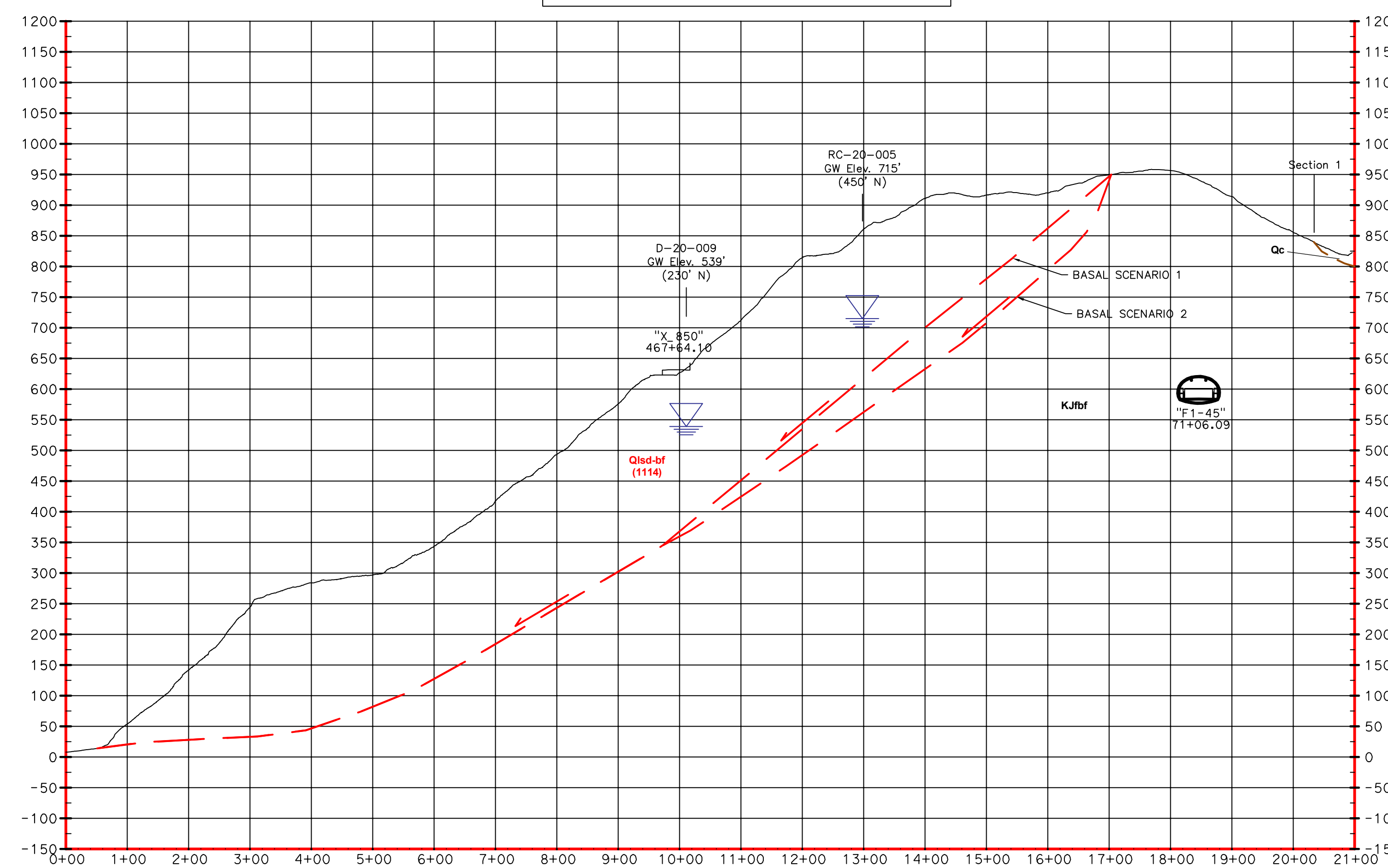
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	**GEOLOGIC CROSS SECTION 7**	PLATE **4g**

CAD FILE: A:\SACRAMENTO-DATA\DRAFTING\2020 PROJECTS\20208000.001A LAST CHANCE GRADE\Cross Sections and Alignments\Alt F1\ LAYOUT: Layout1 PLOTTED: 23 May 2022, 11:32am, JSala

Section 8



VIEW: NORTH

Notes:
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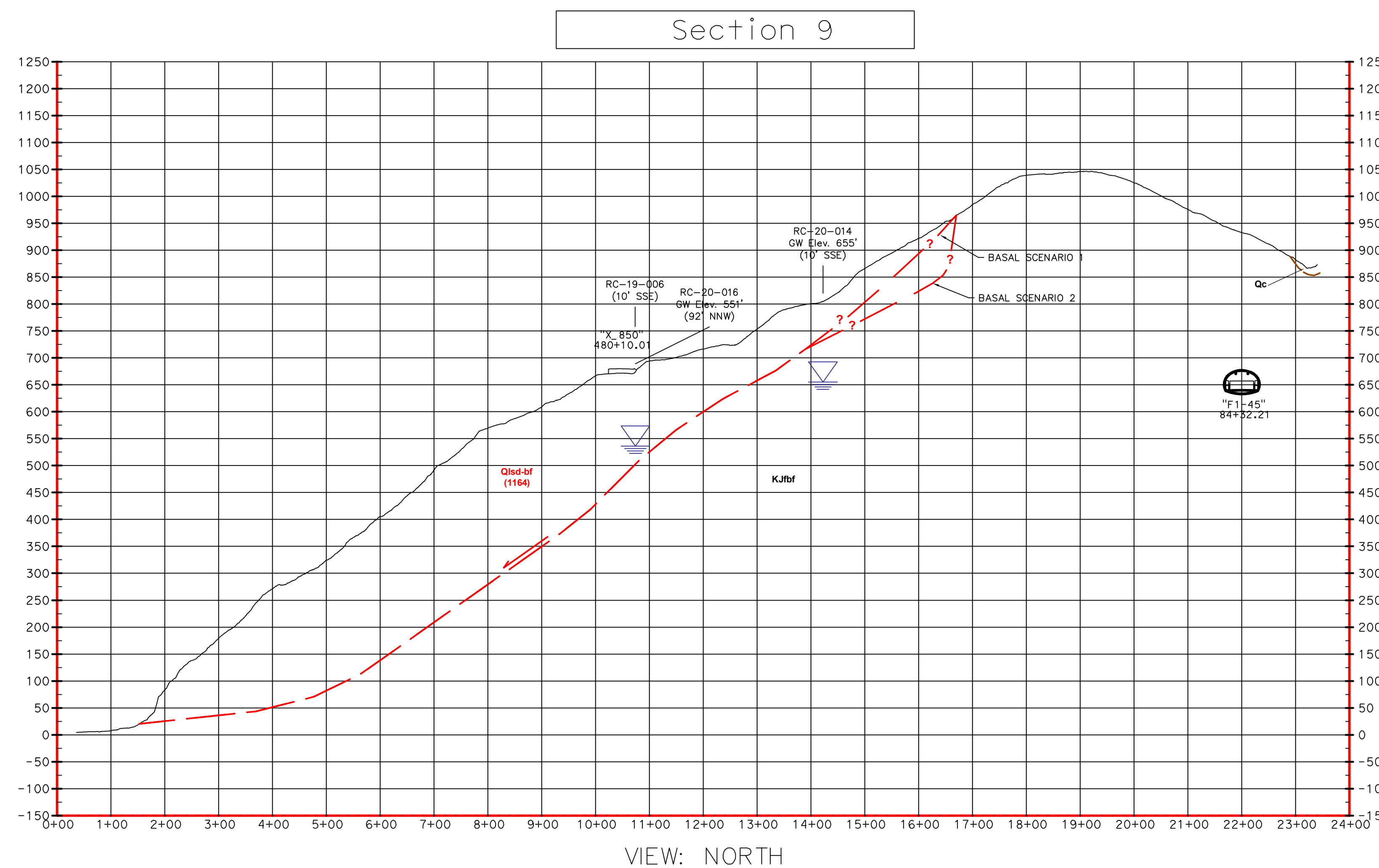
2. Geology shown is interpreted and based on limited available information. Actual subsurface conditions may differ.
3. Cross section is intended to illustrate geology and is not intended for detailed design or construction.
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	**GEOLOGIC CROSS SECTION 8**	PLATE **4h**



Notes:

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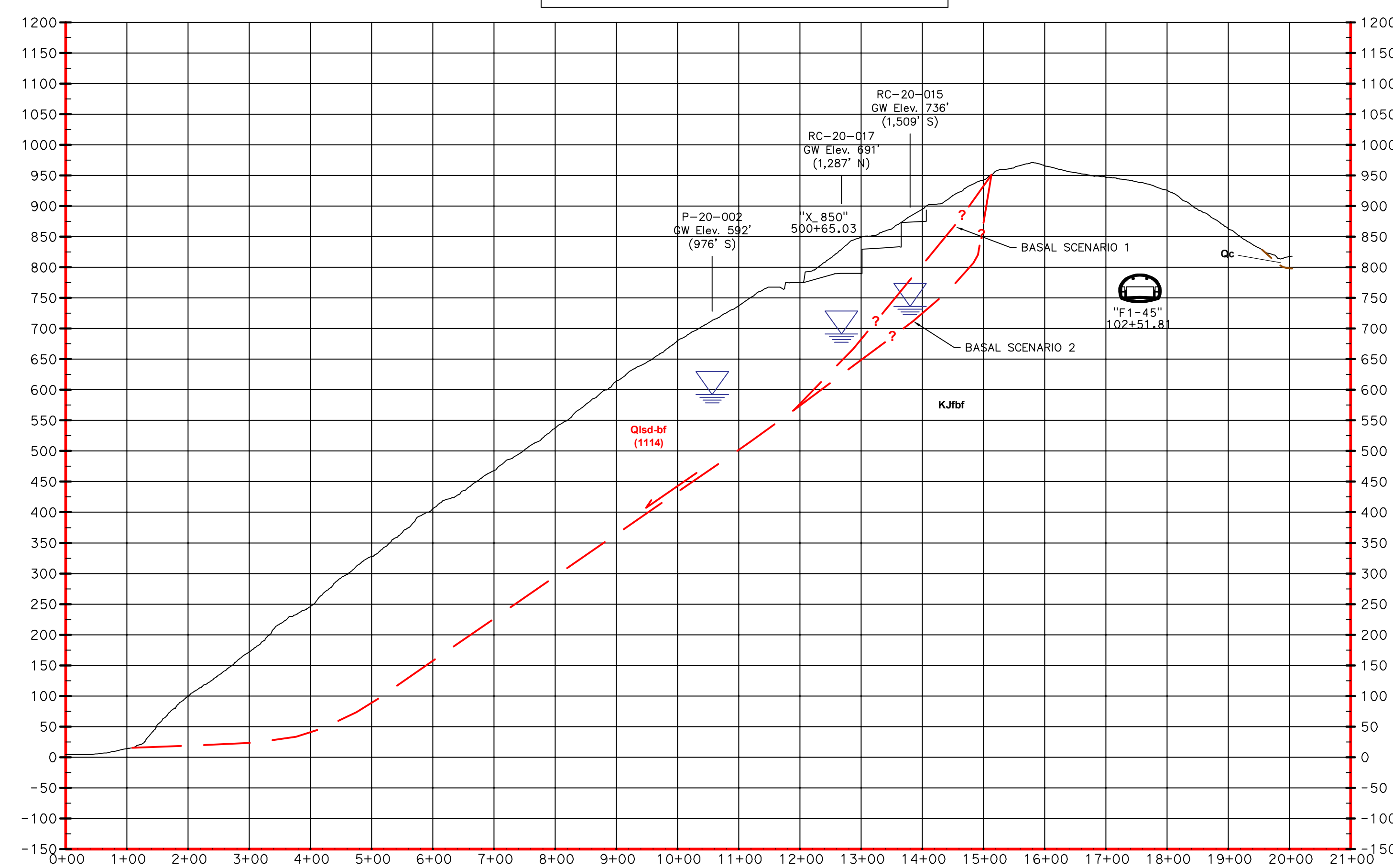
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	**GEOLOGIC CROSS SECTION 9**	PLATE **4i**

Section 10



VIEW: NORTH

Notes:
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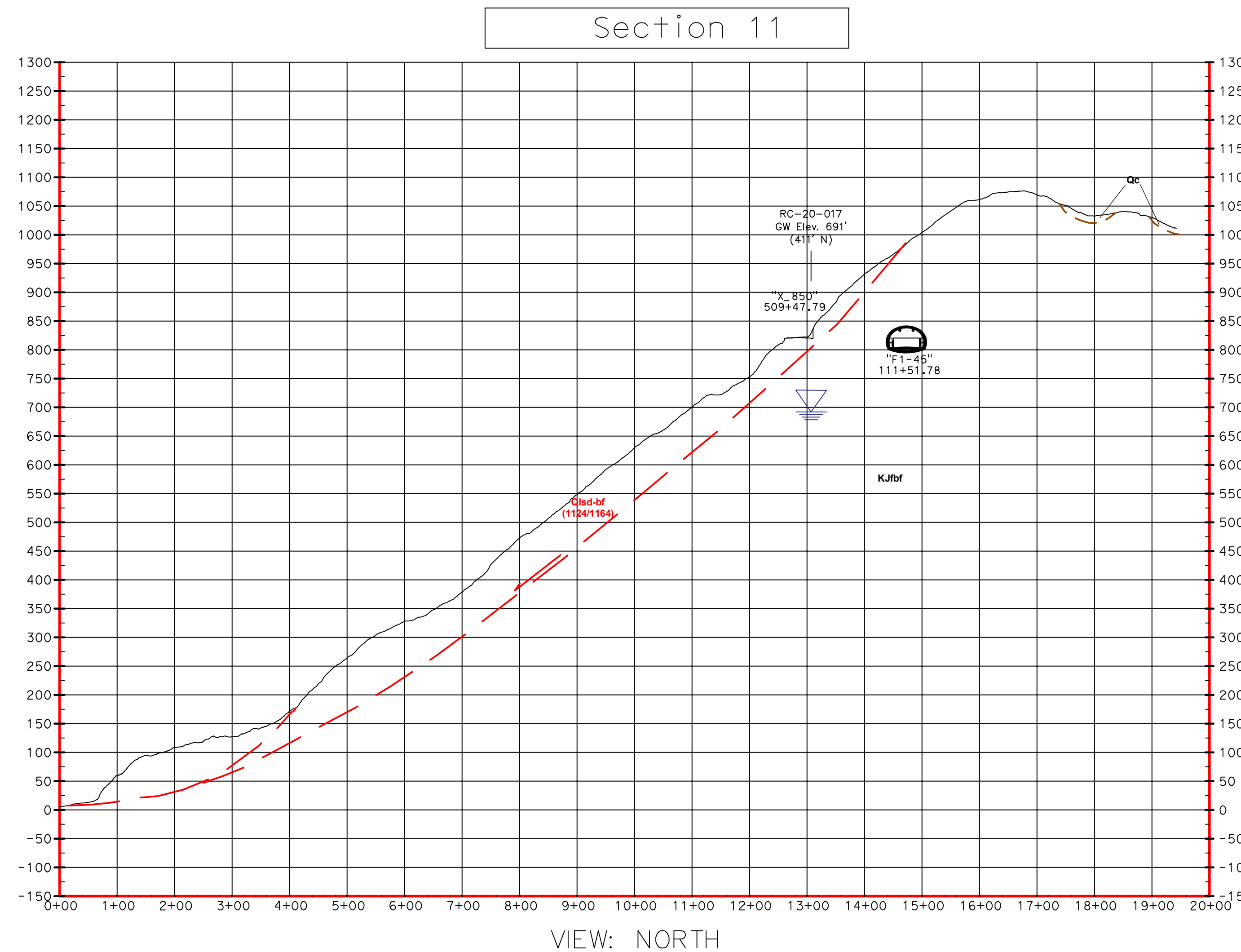
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 10	PLATE 4j



Notes:
1. Design and alignment shown for Alternative F1 is current as of May 13, 2022.
2. Geology shown is interpreted and based on limited available information. Actual subsurface conditions may differ.
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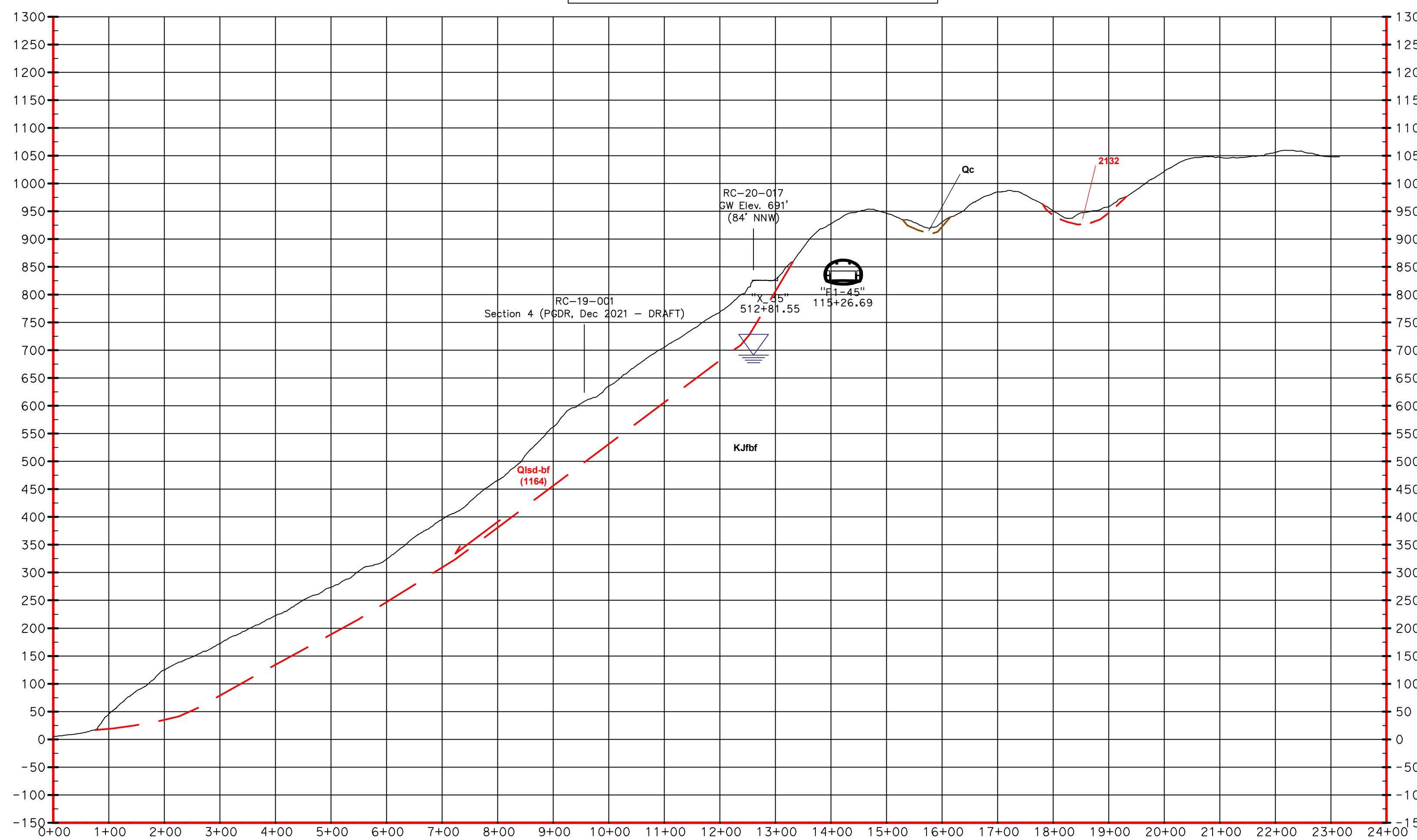
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 11	PLATE 4k

CAD FILE: A:\SACRAMENTO-DATA\DRAFTING\2020 PROJECTS\20208000.001A LAST CHANCE GRADE\Cross Sections and Alignments\Alt F1\ LAYOUT: Layout1 PLOTTED: 23 May 2022, 11:54am, JSala

Section 12



VIEW: NORTH

Notes:
1. Design and alignment shown for Alternative F1 is current as of May 13, 2022.
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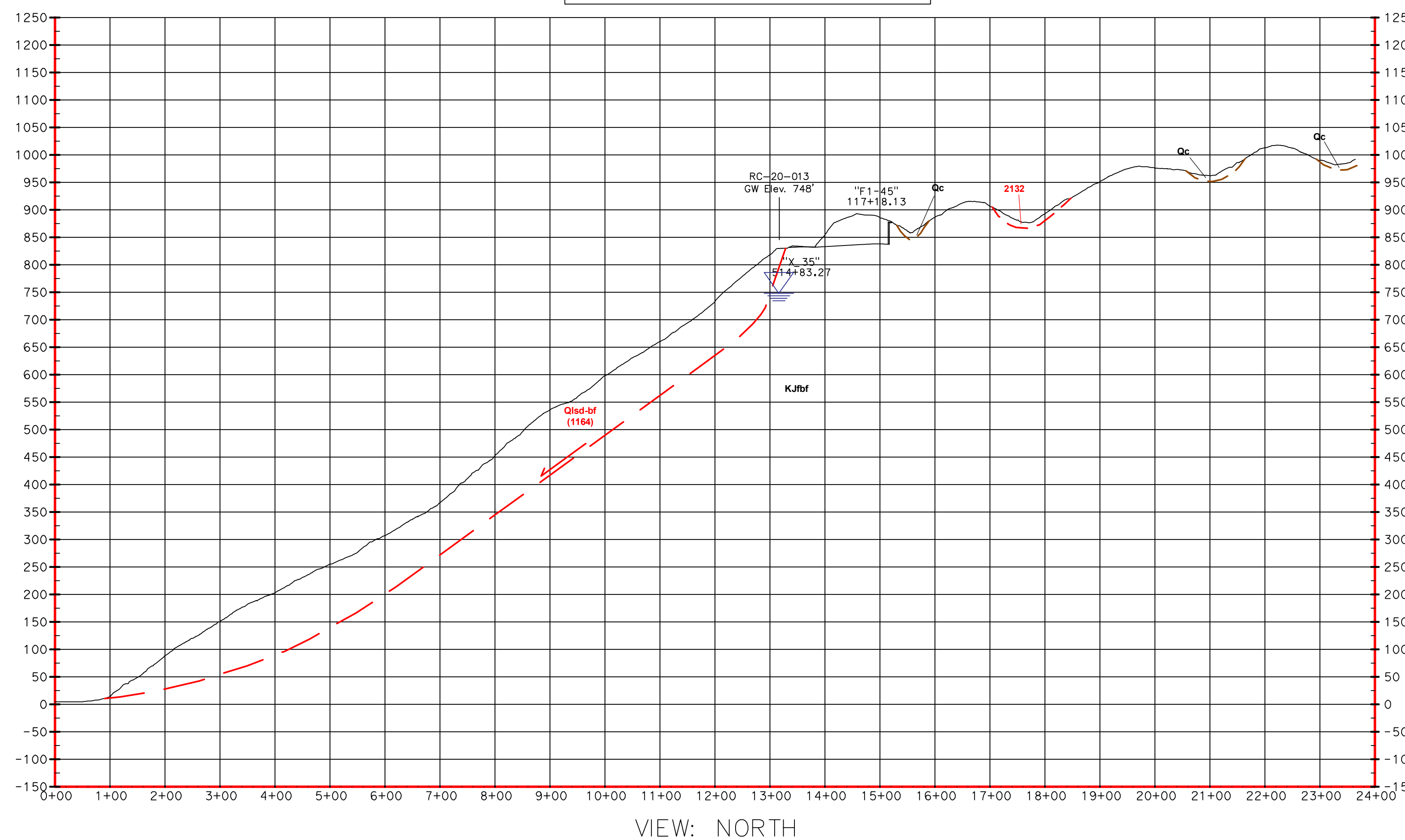
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 12	PLATE 4I

Section 13



Notes:
1. Design and alignment shown for Alternative F1 is current as of May 13, 2022.
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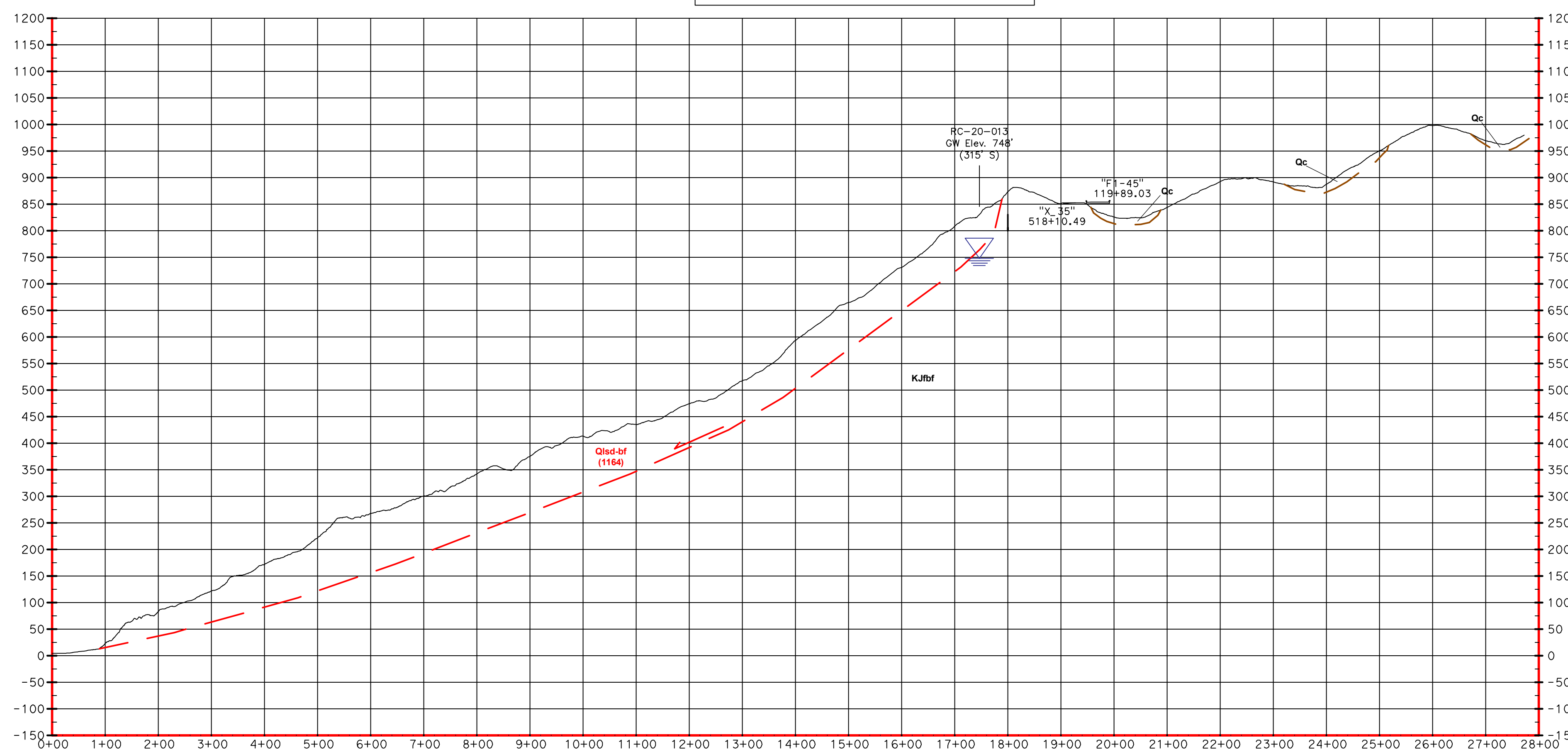
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	**GEOLOGIC CROSS SECTION 13**	PLATE **4m**

Section 14



VIEW: NORTH

Notes:
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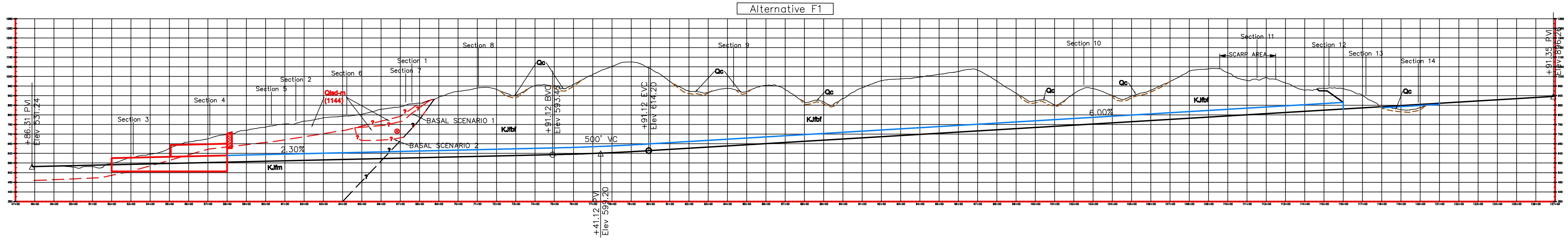
4. See Plate 1 for key to geologic symbols.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT ALTERNATIVE F1 FEASIBILITY STUDY	GEOLOGIC CROSS SECTION 14	PLATE 4n

PLOTTED: 21 May 2022, 8:15pm, RYuen LAYOUT: Layout1

CAD FILE: \\sacramento\SACRAMENTO-DATA\DRAFTING\2020 PROJECTS\20208000.001A LAST CHANCE GRADE\Cross Sections and Alignments\Alt F1\

Alternative F1



Notes:

1. Design and alignment shown for Alternative F1 is current as of May 13, 2022.
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LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
ALTERNATIVE F1 FEASIBILITY STUDY

ALTERNATIVE F1 TUNNEL GEOLOGIC PROFILE

PLATE

5

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
ALTERNATIVE F1 FEASIBILITY STUDY

ALTERNATIVE F1 ALIGNMENT AND CROSS SECTION LOCATIONS

PLATE 6