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Memo To:	Brian Bierwagen, P.E. Parametrix, Inc. Stephen Cruise, P.E. Washington County Department of Land Use and Transportation	3146
From:	Chris Carpenter, P.E. Cornforth Consultants, Inc.	
Date:	September 27, 2023	
Subject:	**Timber Road Landslide – Mitigation Concepts** **Timber, Oregon**	

This memorandum summarizes preliminary results and interim mitigation concepts for landslide mitigation at Timber Road following initial site reconnaissance, geotechnical investigation and engineering analyses.

BACKGROUND

Timber Road has been experiencing ground deformation for many years at a landslide approximately 2 miles south of Timber, Oregon. Washington County routinely blade-patches the asphalt pavement to repair the roadway following episodes of landslide movement. The County has observed that landslide movement generally increases in the wet Winter and Spring seasons. The County estimates that the asphalt thicknesses in the patched areas could be several feet or more due to continual need to repair the road as slide movement occurs. Timber harvest occurred within the vicinity of the project site in recent years. Aerial photography indicates that logging has occurred after 2021. On March 6, 2023 landslide movement and pavement distress reached a point that the County elected to close the roadway. It is our understanding Washington County is methods of funding long-term mitigation of the landslide and preliminary mitigation concepts are provided to provide a basis for developing funding applications and budgeting.

SITE RECONNAISSANCE

Cornforth Consultants performed a site reconnaissance on May 31, 2023. During the site reconnaissance our staff assessed slope conditions to provide data for development of a geologic model, identified boring locations and developed cross section for slope stability analyses. Landslide features, cracks, and extents were mapped.

The landslide cracks were mapped over an approximately 500-foot length of roadway primarily impacting the outboard/northbound lane. The landslide was subdivided into three slide areas based on the amount of deformation and impact on the roadway.

The northern slide area is approximately 120 feet long with cracks extending across (to the west) of roadway centerline. The vertical offset of the northern slide was measured at approximately 6 inches at the time of reconnaissance.

Landslide cracks within the approximately 140-foot-long middle slide area were generally constrained within the outboard (northbound) travel lane. The vertical offset at the headscarp crack in this area was approximately 6 to 8 inches during our site visit.

The southern slide area is approximately 120 feet long with landslide cracks extending to the roadway centerline. Multiple vertical steps/offsets were observed within the northbound travel lane with overall vertical deformation of approximately 16 inches.

Preliminary interpretation of the landslide based on site reconnaissance and review of LiDAR topography indicates that the depth of the landslide is likely between 5 and 25 feet deep. Slide movement is likely within fill materials with slide debris moving along a contact or weak zone near the top of weathered bedrock.

PRELIMINARY GEOTECHNICAL EXPLORATIONS

Geotechnical explorations were conducted between July 21 and July 24, 2023, to investigate subsurface conditions at the landslide site. Preliminary interpretations of subsurface conditions indicate a landslide depth of approximately 8 to 22 feet. Locations of subsurface investigations are shown on Figure 1. Subsurface instrumentation recently installed will allow for monitoring of landslide deformation and groundwater levels.

CAUSATIVE FACTORS

Washington County has observed that landslide movement at Timber Road increases in Winter and Spring during precipitation events and when groundwater levels are generally higher. Based on site reconnaissance and preliminary geotechnical explorations, the factors that likely cause landslide deformation at the Timber Road Slide are weak subsurface residual soils, loading from roadway embankment fill and groundwater level increases during winter months. The landslide is likely marginally stable (FS of approximately 1.0) throughout the year, and increased water pressures increase landslide movement that cause roadway cracking. Precipitation during early 2023 is likely a key contributing factor to increased landslide movement at Timber Road. Recent logging activities have cleared the tree canopy increasing allowing for an increase rate of infiltration.

CONCEPTUAL MITIGATION OPTIONS

The preliminary assessments of mitigation options have been prepared for this landslide. Brief discussions of those considered for this area are described below.

Shear Key at Roadway and Embankment Reconstruction.

This option consists of excavation and replacement of the soft embankment fill and slide debris within the roadway prism with a rockfill embankment keyed into underlying bedrock materials downslope of the roadway. Existing embankment and slide debris materials are very soft and likely contributing to instability of the roadway. Bedrock foundation materials were encountered at depths ranging from 8

to 22 feet in exploratory borings at the outboard edge of the roadway, indicating relatively shallow bedrock or competent material. A typical cross section showing the geometry of this option is shown on Figure 2. The layout of mitigation options in Figure 5 provides a general location and shape of the shear key concept. The purpose of this option would be to intersect the slide failure surface with the shear key to provide increased resistance to slope instability and rebuild the embankment with rockfill to improve strength. This option would require a significant excavation at the toe of the slope and back filling with imported angular rock from a hard rock quarry. Construction would likely extend outside of current County right-of-way (ROW). Exploratory borings indicate that the depth to the slide shear zone is approximately 8 to 22 feet, therefore it is anticipated that the shear key base would be on the order of 15 to 25 feet depth. This option is a slide stabilization measure that would have the goal of significantly reducing or stopping landslide movements.

- *Advantages*
  - Positive landslide treatment.
  - No long-term maintenance.
  - Minor post-construction visual impacts (rockfill surface downslope).
- *Disadvantages*
  - May require additional downslope borings to identify depth of shear key.
  - Temporary excavations within slide would be marginally stable.
  - Material below shear key may continue to deform.
  - Requires disposal of excavated materials.
  - Construction of shear key likely to extend outside of current county ROW.
  - Environmental impacts / tree removal / access road / right-of-way.
- *Engineering Investigation, Analysis, Design Efforts*
  - Site investigations (3 exploratory test pits) would be required to evaluate the depth of slide downslope of the roadway within the slide limits. Continued instrument monitoring to collect relevant data for the engineering analyses would be required and would likely extend the time of the landslide assessments.
  - Engineering analyses would include slope stability analyses of existing conditions and the improvements that would be provided by the shear key option.
  - Design efforts would include preparing a site plan; typical shear key cross sections; estimating quantities for excavation, geotextile filter fabric, and rockfill; and preparing construction technical specifications. Civil and roadway drawings may be needed to repair roadway (i.e. typical pavement section, guardrail, erosion and sediment control, traffic control, etc.).
- *Cost Estimate* (The following cost estimates are based on experience with similar landslide mitigation projects)
  - Construction Costs (assumed mitigation length – 500 feet): $ 3,500,000 - $4,500,000.

Shear Key below the Roadway.

This option consists of excavation and replacement of the slide debris and shear zone material downslope of the roadway where the slide is interpreted to be relatively shallow. The landslide is sliding within soft embankment and slide debris materials with a relatively shallow shear zone. Bedrock foundation materials were encountered at depths ranging from 8 to 22 feet in exploratory borings at the outboard edge of the roadway, indicating relatively shallow bedrock or competent material. A typical cross section showing the geometry of this option is shown in Figure 3. The layout of mitigation options in Figure 5 provides a general location and shape of the shear key concept. The purpose of this option would be to intersect the slide failure surface with the shear key to provide increased resistance to slope instability downslope of the roadway embankment. This option would require a significant excavation at the toe of the slope and back filling with imported angular rock from a hard rock quarry. It is anticipated that most of this mitigation would be outside of County ROW and would require negotiations with adjacent property owners. Exploratory borings at the roadway indicate that the depth to the slide shear zone is approximately 10-20 feet, therefore it is anticipated that the shear key base would be on the order of 15 to 25 feet depth. Two to three additional borings would be helpful to characterize the depth of shear zone downslope of the roadway for final design of this option. This option is a slide stabilization measure that would have the goal of significantly reducing or stopping landslide movements.

- *Advantages*
  - Positive landslide treatment.
  - No long-term maintenance.
  - Minor post-construction visual impacts (rockfill surface downslope).
- *Disadvantages*
  - May require additional downslope borings to identify depth of shear key.
  - Temporary excavations within slide would be marginally stable.
  - Material below shear key may continue to deform.
  - Does not replace soft embankment and slide debris directly below roadway.
  - Requires disposal of excavated materials.
  - Construction outside of current County ROW.
  - Environmental impacts / tree removal / access road / right-of-way.
- *Engineering Investigation, Analysis, Design Efforts*
  - Site investigations (2 to 3 exploratory borings with instrumentation) may be required to evaluate the depth of slide movements and current groundwater levels within the slide limits. Instrument monitoring to collect relevant data for the engineering analyses would be required and would likely extend the time of the landslide assessments.
  - Engineering analyses would include slope stability analyses of existing conditions and the improvements that would be provided by the shear key option.

- Design efforts would include preparing a site plan; typical shear key cross sections; estimating quantities for excavation, geotextile filter fabric, and rockfill; and preparing construction technical specifications. Civil and roadway drawings may be needed to repair roadway (i.e. typical pavement section, guardrail, erosion and sediment control, traffic control, etc.).

- *Cost Estimate* (The following cost estimates are based on experience with similar landslide mitigation projects)
  - Construction Costs (assumed mitigation length – 500 feet): $ 2,500,000 - $3,500,000.

Mechanically Stabilized Earth (MSE) Wall.

This treatment option would involve excavating the embankment slide materials down to a stable base and re-constructing the embankment with a granular fill that has reinforcing elements spaced throughout the fill to support an outer vertical wall. A typical section showing the general configuration and components of this treatment measure is shown in Figure 5. The layout of mitigation options in Figure 4 provides a general location and shape of the shear key concept. This is a semi-rigid structure intended to replace slide materials with more competent embankment fill retained by an outer flexible wall system. The option would be founded on the stable base that could support the wall below the slide. With the vertical face of the wall, it is likely that the structure could be maintained within the current Count ROW. Temporary easements for construction may be necessary depending on contractor means and methods for temporary excavation and shoring.

- *Advantages*
  - Increases landslide stability (assumes the wall can be founded on shallow competent rock).
  - No long-term maintenance.
  - Minimal visual impact after construction.
  - Constructed within County ROW.
- *Disadvantages*
  - More design effort.
  - Longer construction time than shear keys.
  - Disposal of significant excavated materials.
- *Engineering Investigation, Analysis, Design Efforts*
  - Engineering analyses would be required to assess the stability of the wall geometry and the structural and material components.
  - Design efforts would include preparing a site plan, detailed wall cross sections, material quantity estimates, typical detail sections, and technical specifications.
  - Civil and roadway drawings may be needed to repair roadway (i.e. typical pavement section, guardrail, erosion and sediment control, traffic control, etc.).
- *Cost Estimate* (The following cost estimates are based on experience with similar landslide mitigation projects)
  - Construction Costs (assumed mitigation length – 500 feet): $ 3,500,000 - $4,500,000

FIGURES

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A

A'

B

B'

C

C'

B-1

B-2

B-3

B-4

B-5

B-6

B-7, one foot from fog line

Transects

Borings

SCALE: 1 INCH = 800 FEET
CONTOUR INTERVAL: 5 FEET

0 25 50 100 150 200 Feet

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Site Plan

Timber Road Landslide
Timber, Oregon

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FIG. 1

ROCKFILL SHEAR KEY AT ROADWAY

MITIGATION OPTION

B-1
Offset 8 ft

B-2
Offset 3 ft

ROCKFILL SHEAR KEY AT ROADWAY

Asphalt

slightly clayey SILT (FILL)

sandy silty GRAVEL (WEATHERED TUFFECEOUS MUDSTONE)

(R0-R1) TUFFACEOUS MUDSTONE

BOH

Asphalt

sandy silty GRAVEL (FILL)

gravelly CLAY (WEATHERED TUFFECEOUS MUDSTONE)

(R0-R1) TUFFECEOUS MUDSTONE

BOH

OUTLET DRAIN

?

?

ELEVATION (FEET)

920
900
880
860
840
820
800
780
760

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300

HORIZONTAL DISTANCE (FEET)

1 INCH = 20 FEET

Notes:
All measurements are approximated

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Cross Section A

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FIG. 2

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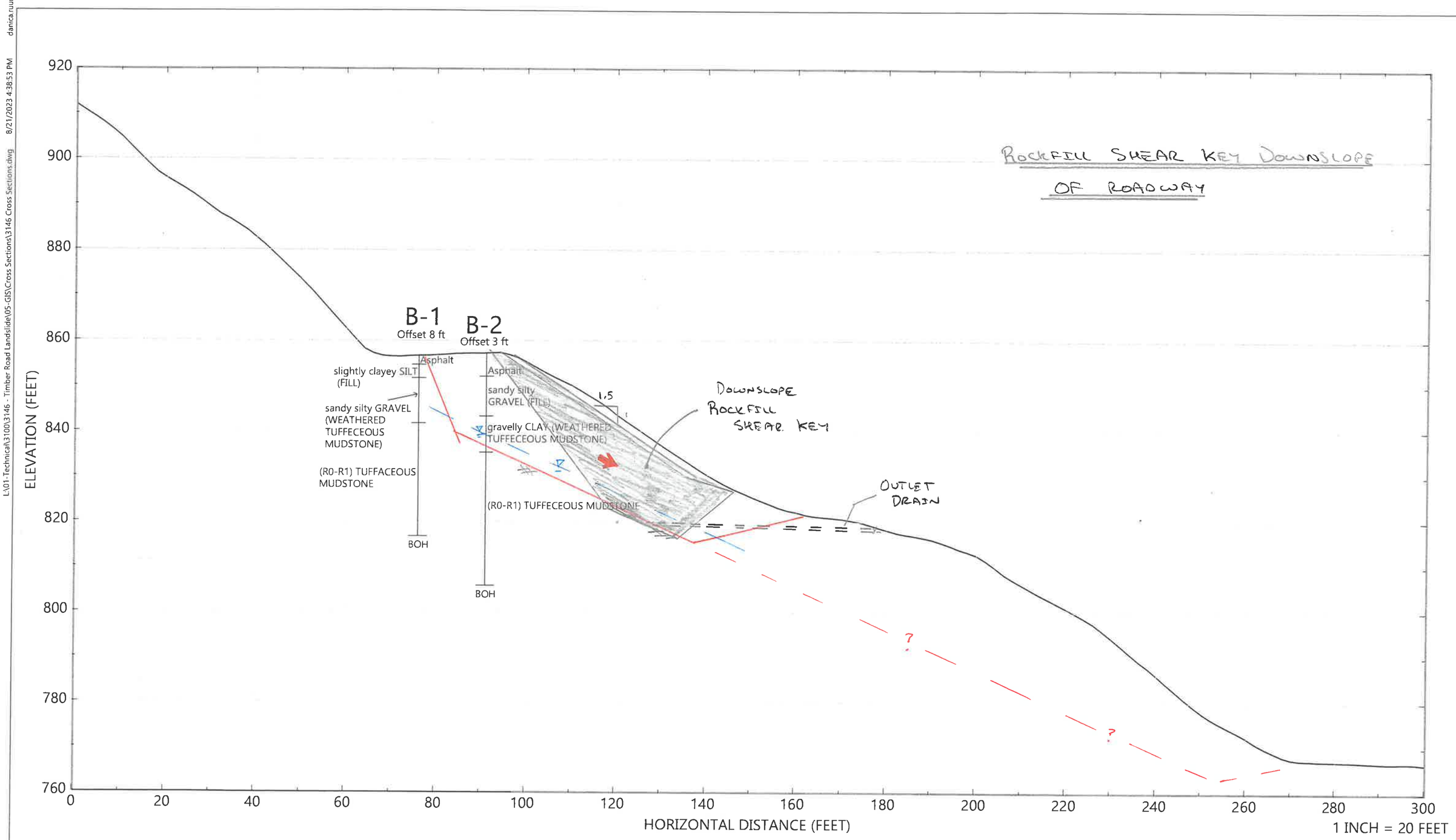

Notes:
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Cross Section A

Timber Road Landslide
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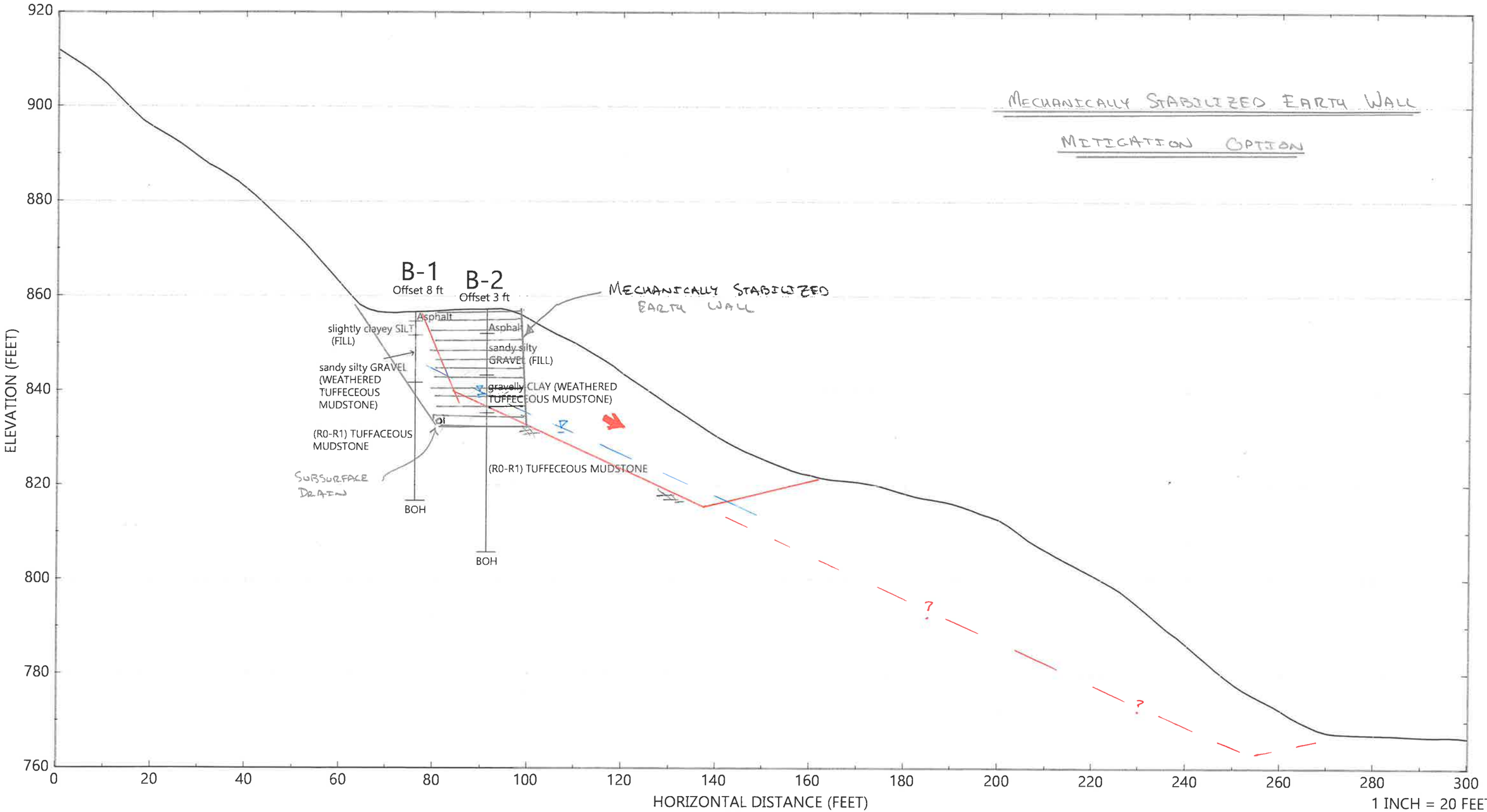
FIG. 3

MECHANICALLY STABILIZED EARTH WALL

MITIGATION OPTION



Notes:
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Cross Section A

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FIG. 4

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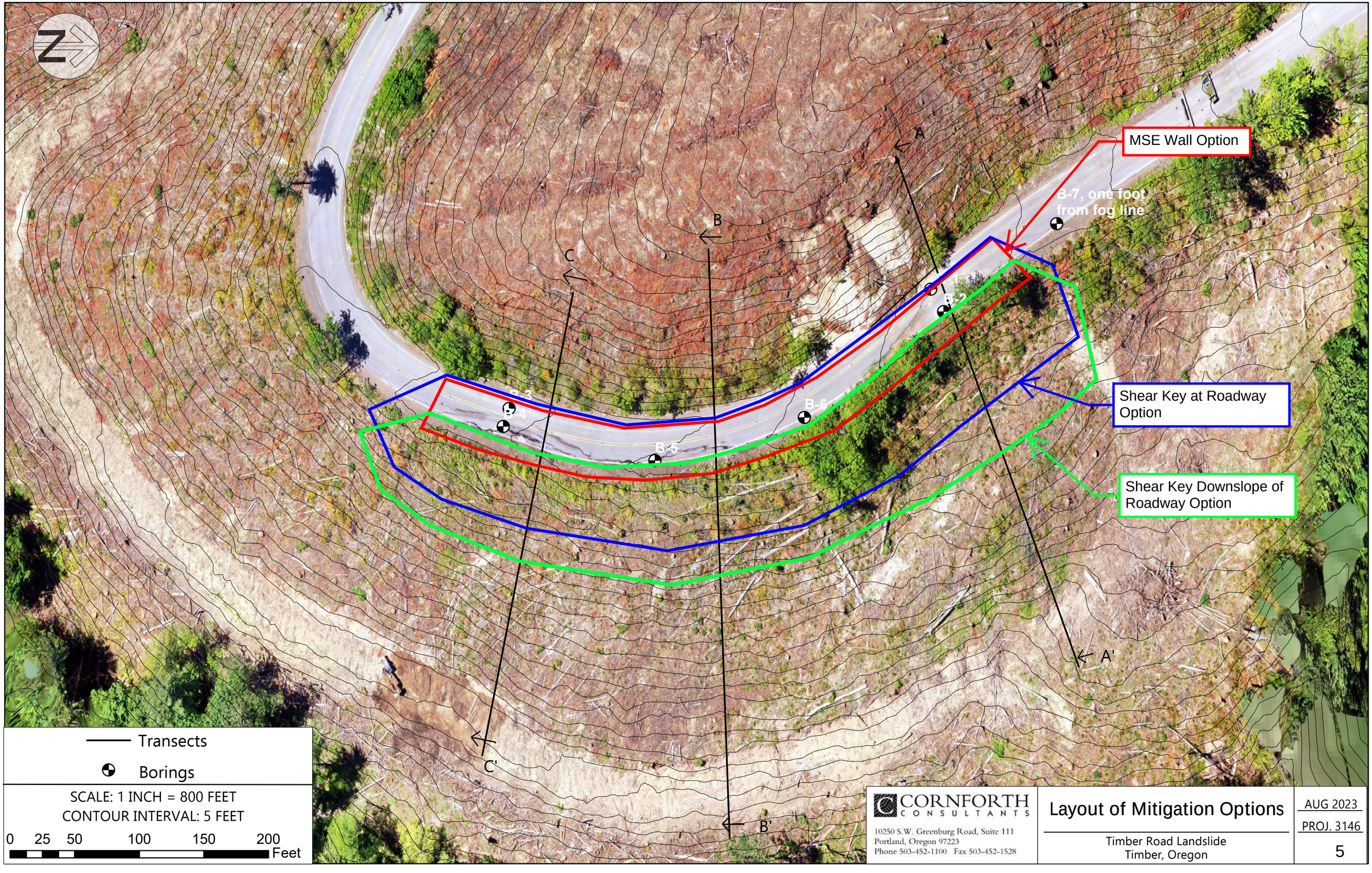

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Layout of Mitigation Options

Timber Road Landslide
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