Middlesex NECR 82.77 Culvert

IM 089-2(49)

PRESENTED BY

VHB and Golder Associates

April 24, 2014

PROJECT LOCATION

NECR 82.77 Culvert

- Culvert General Information
  - 135’ Long
  - 72” Diameter Pipe x 3/8” wall
  - Metal Plate Pipe Material
  - Built in 1950s
- Location
  - 1.2 Miles from Exit 9
  - MP 82.77 on NECR

Project History / Timeline

- 1849 railroad embankment constructed
- 1950s: current 72 in. culvert installed during I-89 construction
- Gene Trombly (ECI) indicated this stretch of rail has required “re-tamping” at much higher frequency than other sections.
- Trombly indicated prior slide in the project area in the late 1970’s
- Trombly indicates tunnel liners of this type commonly leaked at bolted joints – common to line invert with grout or asphalt for average flows.
- Mid-February 2013 – NECR noticed a sinkhole adjacent to the railroad and contacted ECI.

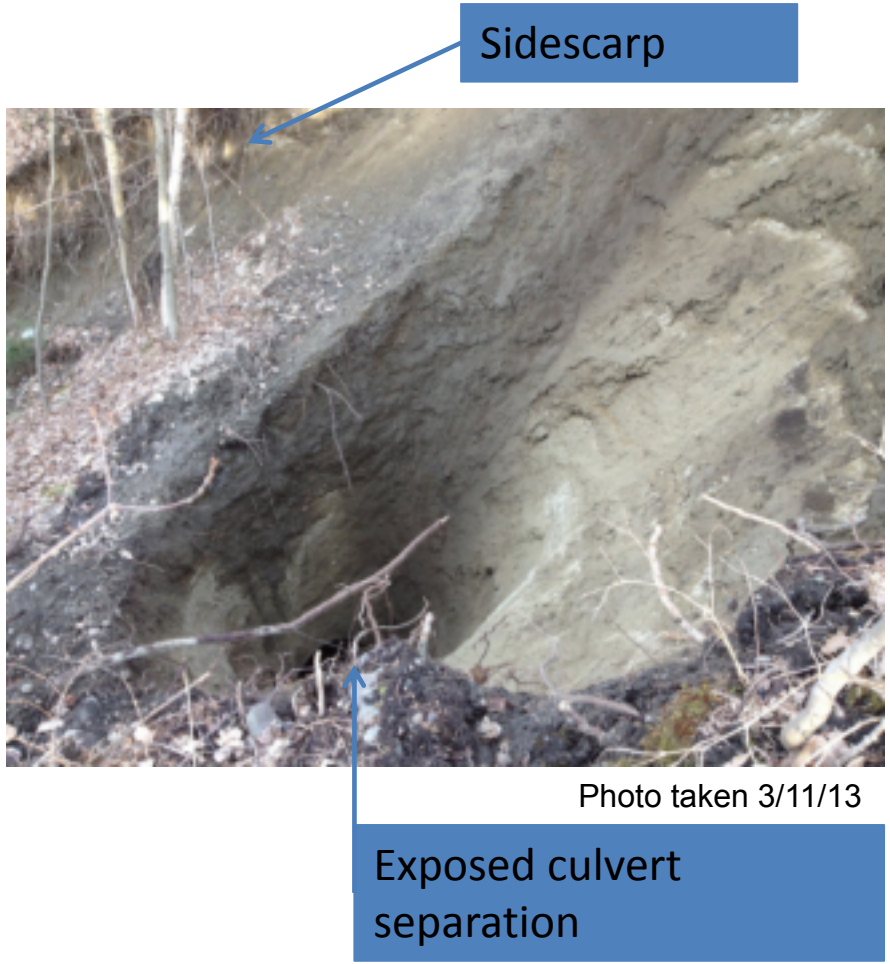

Photo taken 3/11/13

Project History / Timeline

- Late-February 2013 – Sinkhole noticed approximately 24 ft from edge of tracks. ECI inspected and presented findings 2/20/13.
- ECI noted existing cable restraining system at outlet end of culvert presumably to hold culvert from pulling away from embankment.
- Large void below culvert at area of sinkhole. Water containing silt and fine sand observed to be flowing out of slope below culvert.
- March-April 2013 – Slope repair constructed by ECI. Repair was completed approximately 5 weeks after sinkhole was observed. Void below culvert was larger by the time work started. Water flowing out of slope had less silt and sand content.
- Fall 2013 – Head scarp observed at limits of rock fill. Subsidence above approximate location of culvert separation also noticed.

Photo taken 11/12/13

Project History / Timeline

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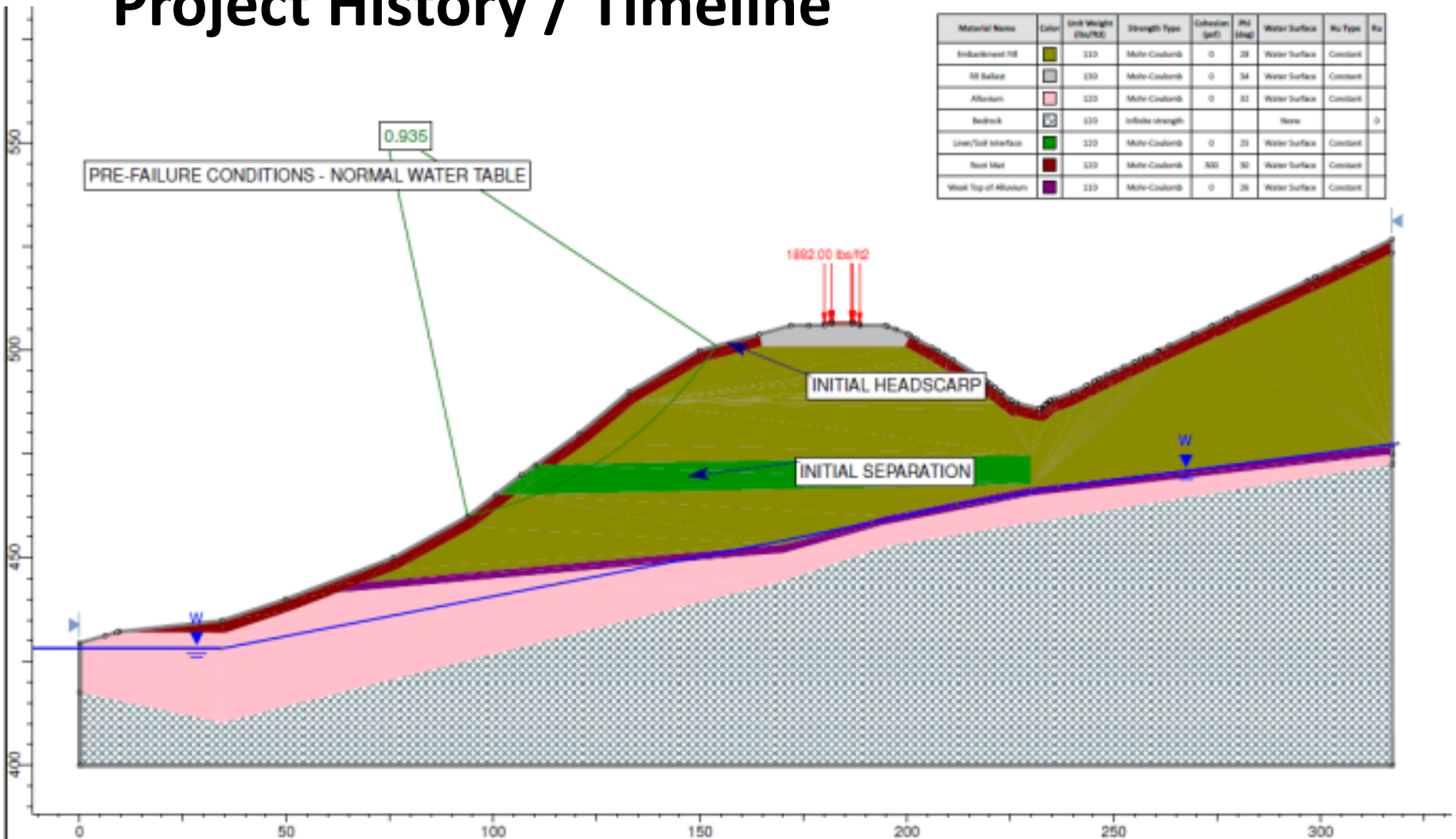

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Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Constant	
Mi Ballast		130	Mohr-Coulomb	0	34	Water Surface	Constant	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Constant	
Bedrock		120	Infinite strength			None		0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Constant	
Root Mat		120	Mohr-Coulomb	500	30	Water Surface	Constant	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Constant	

Project History / Timeline

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Rip Rubble		150	Mohr-Coulomb	0	34	Water Surface	Constant	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Constant	
Bedrock		120	Infinite strength			None		0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Constant	
Root Mat		120	Mohr-Coulomb	500	30	Water Surface	Constant	
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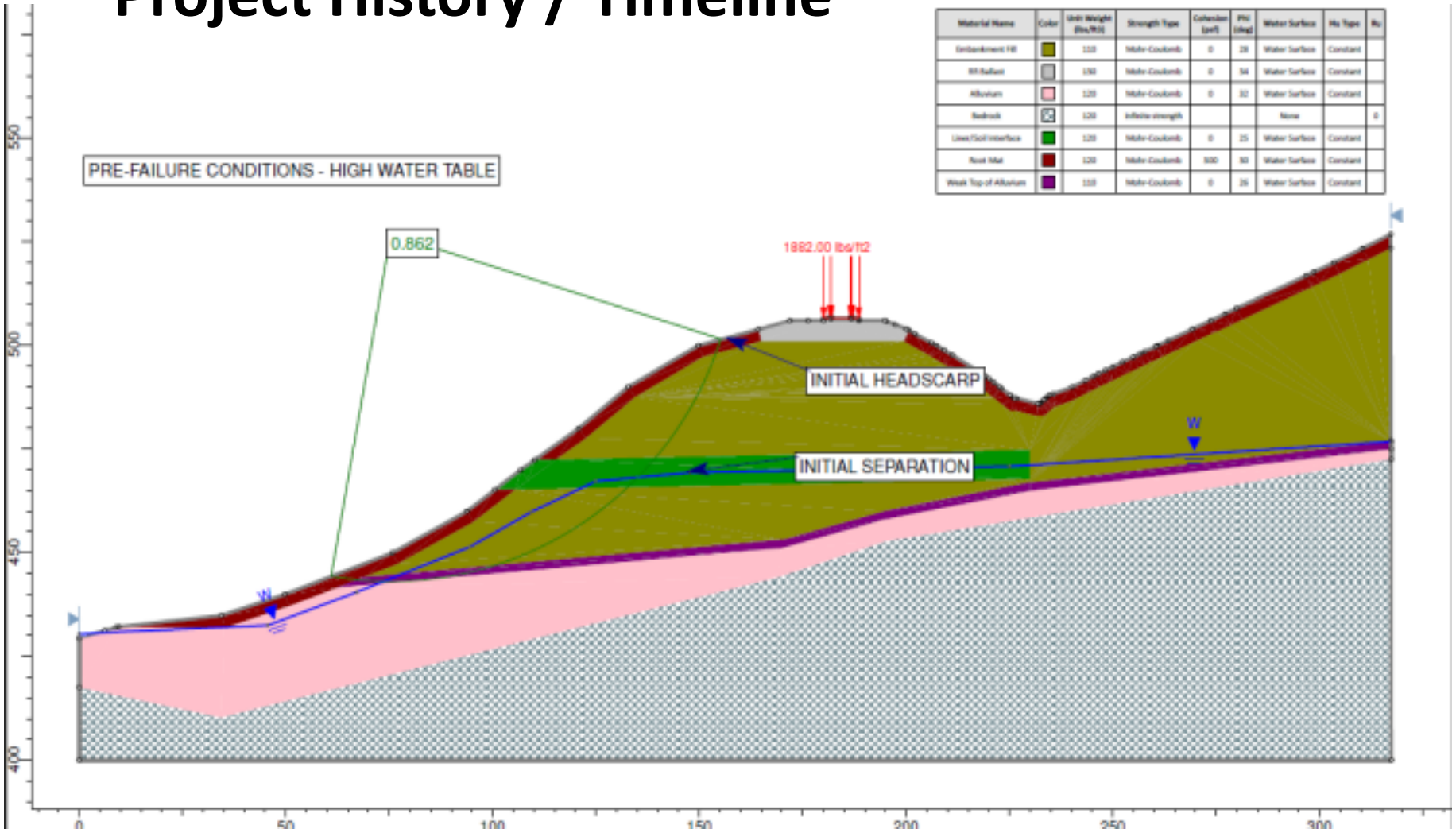

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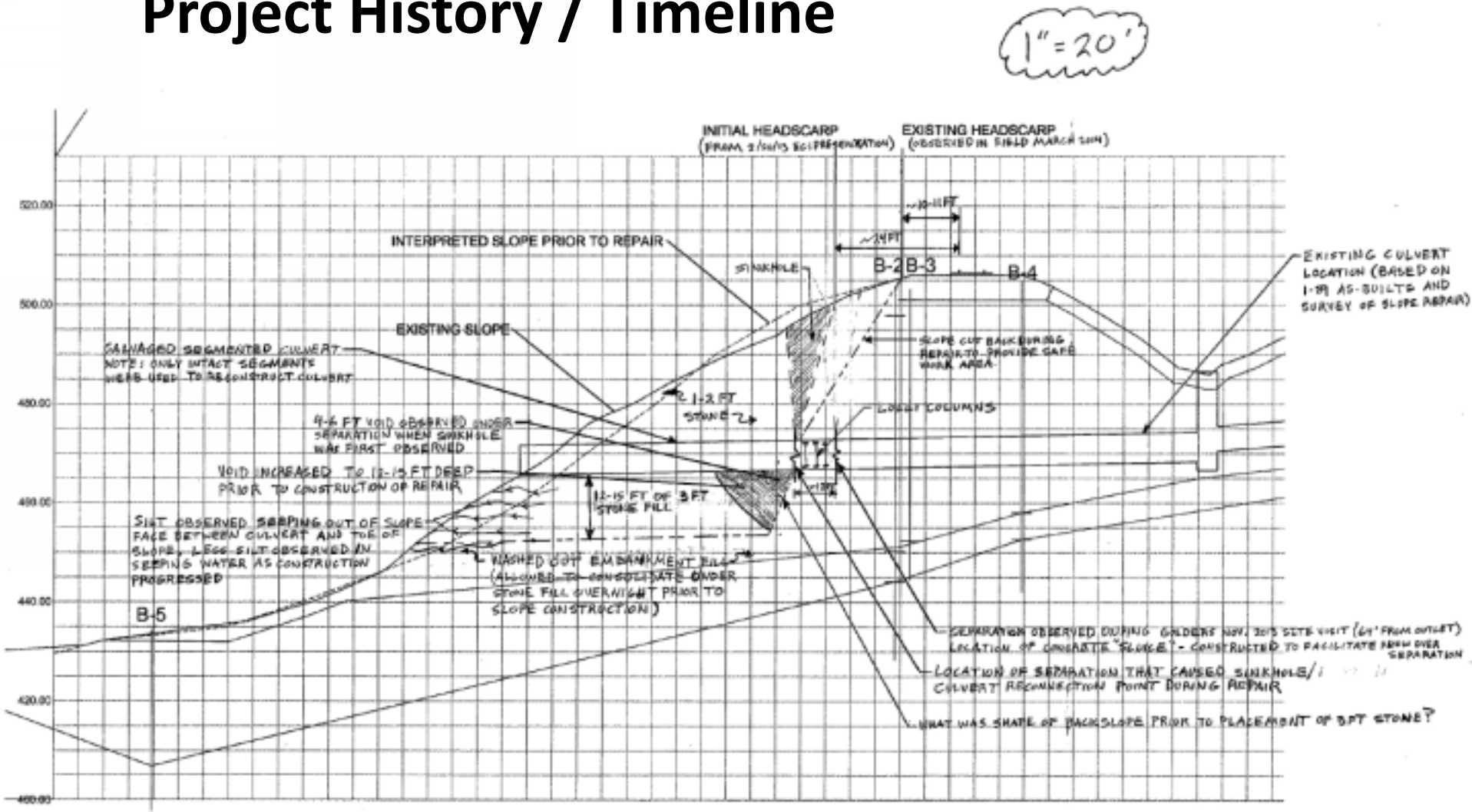

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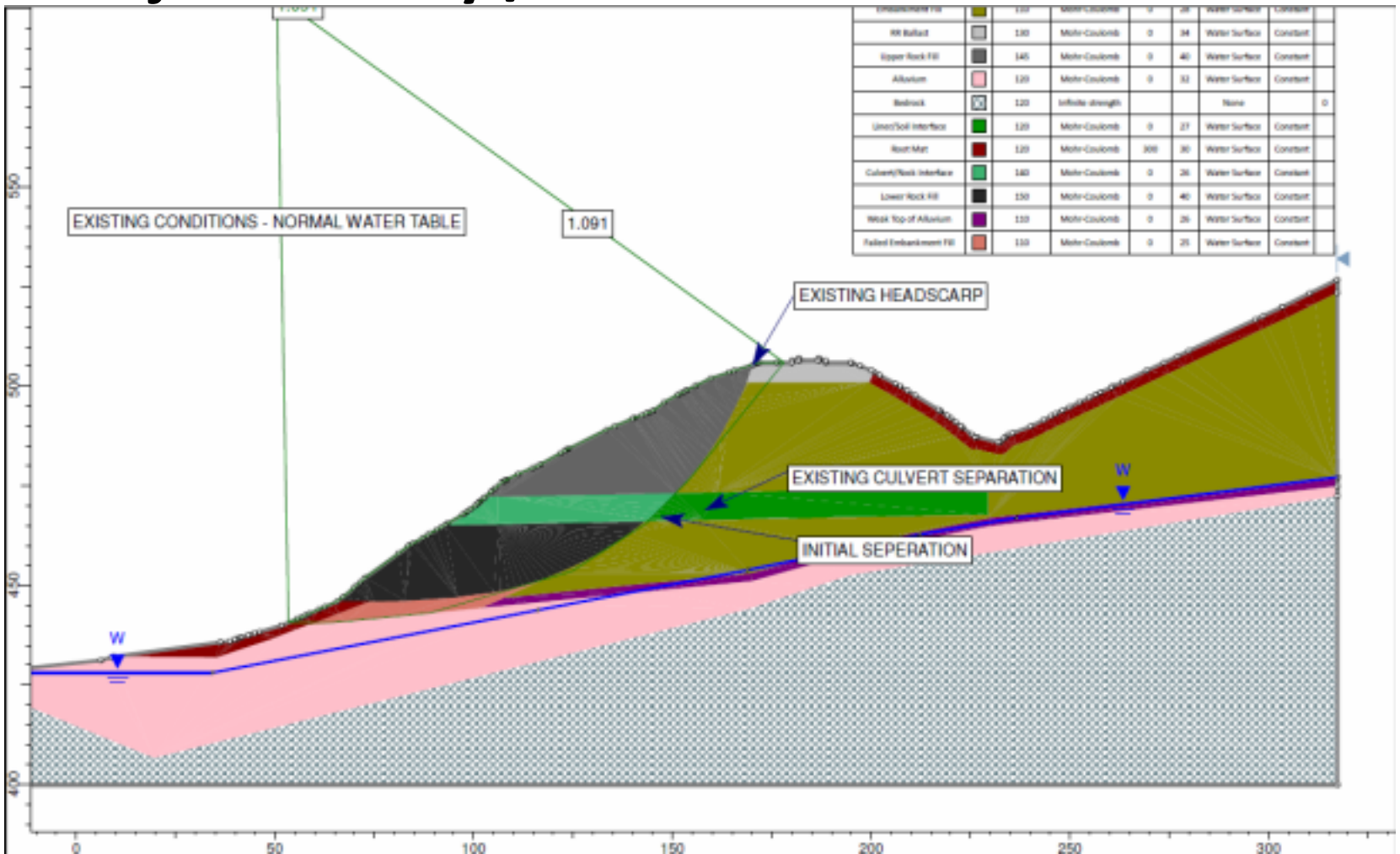


SLOPE CONDITION

SLOPE CONDITION

SLOPE CONDITION - TOE

SLOPE CONDITION

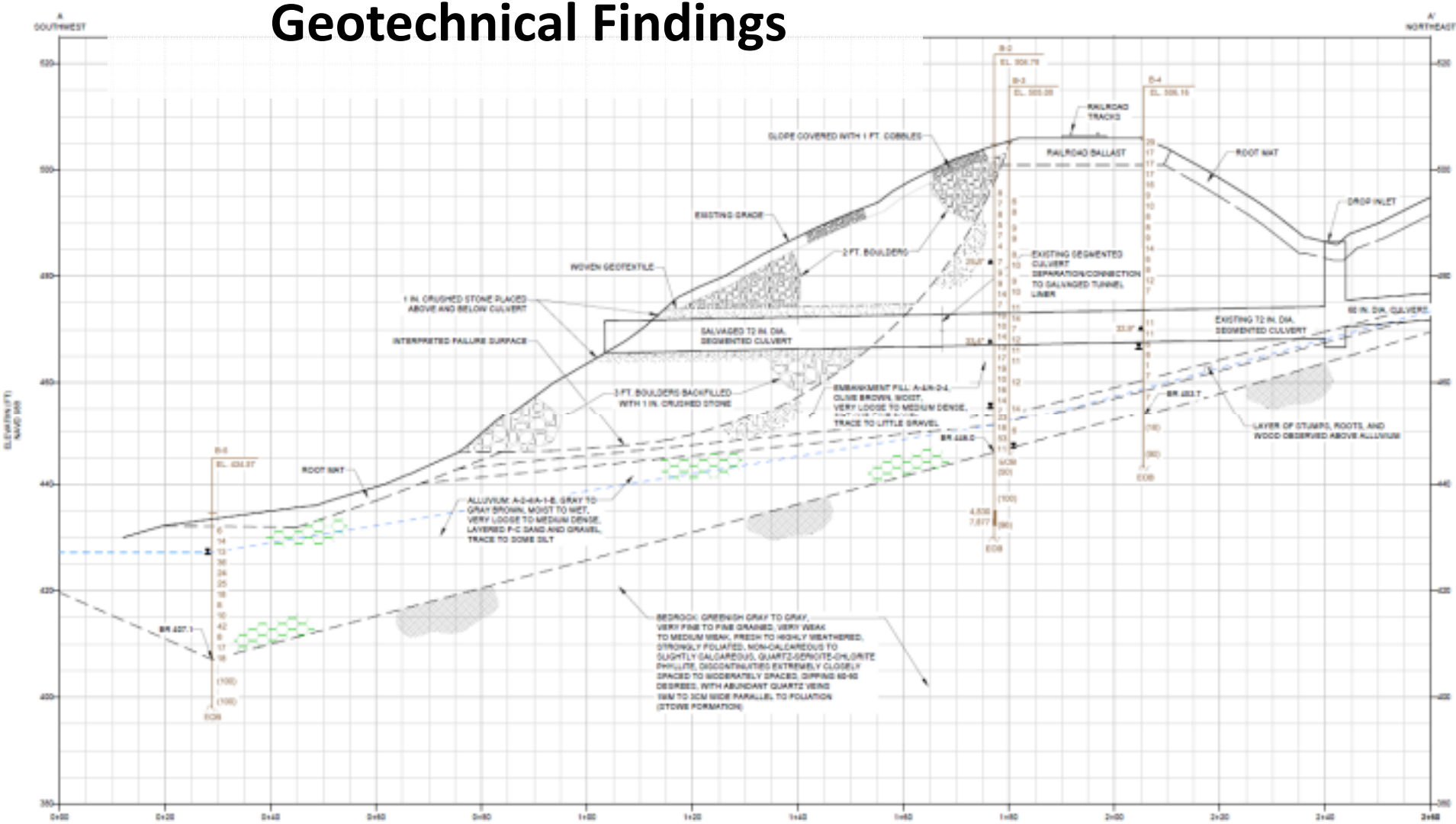
SLOPE CONDITION

SLOPE CONDITION

SLOPE CONDITION

Geotechnical Findings

Geotechnical Findings



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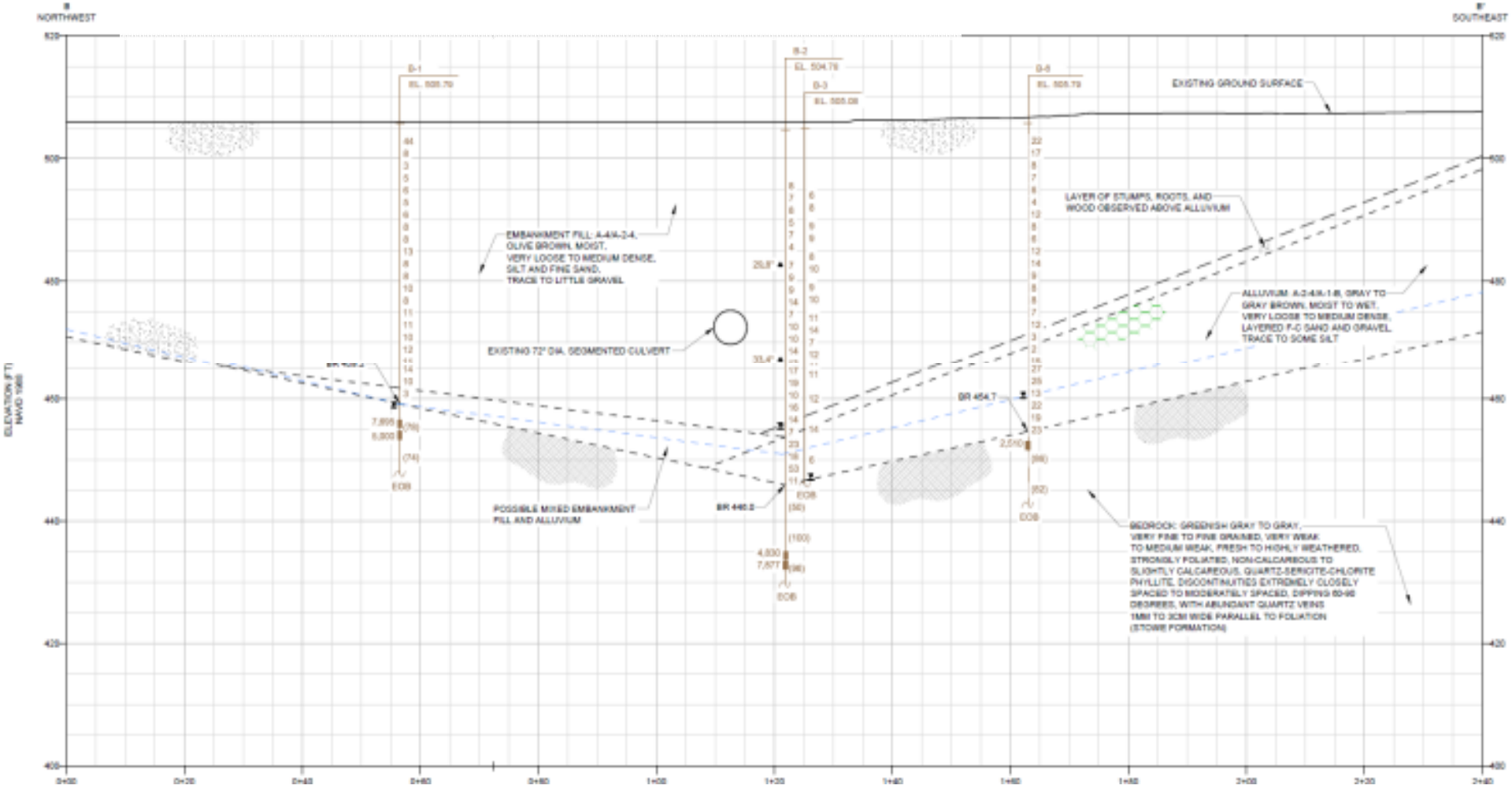
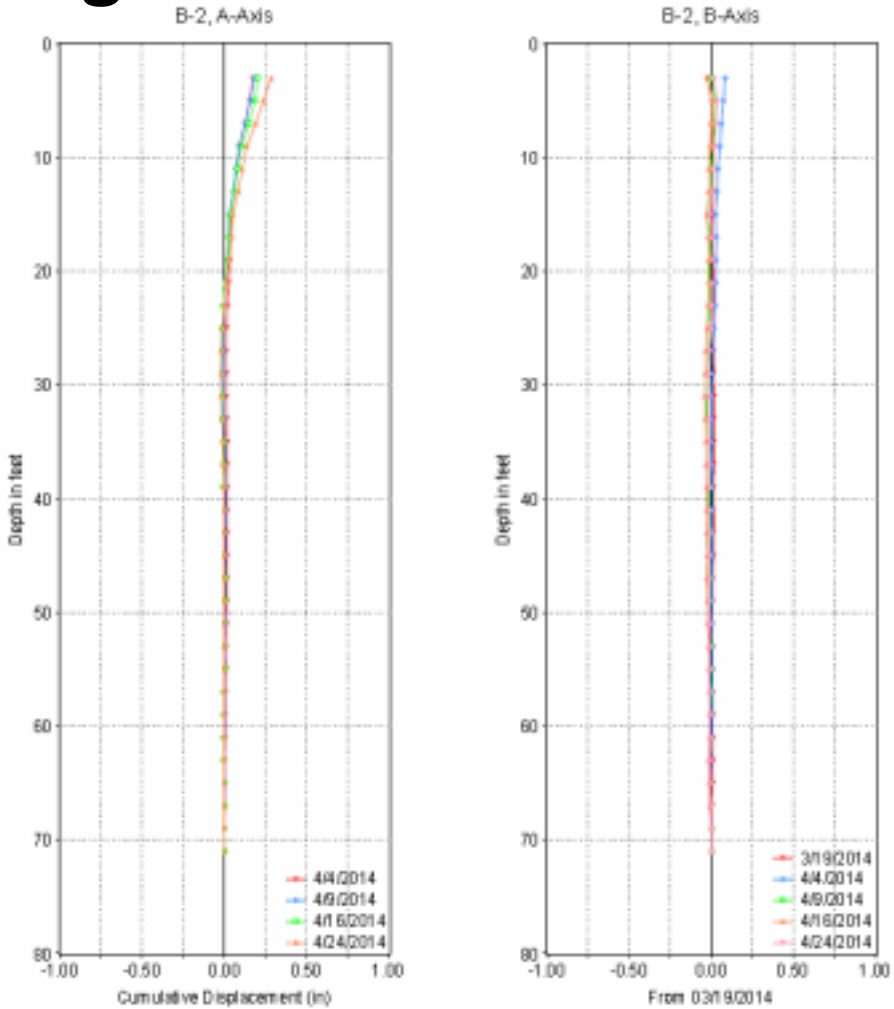


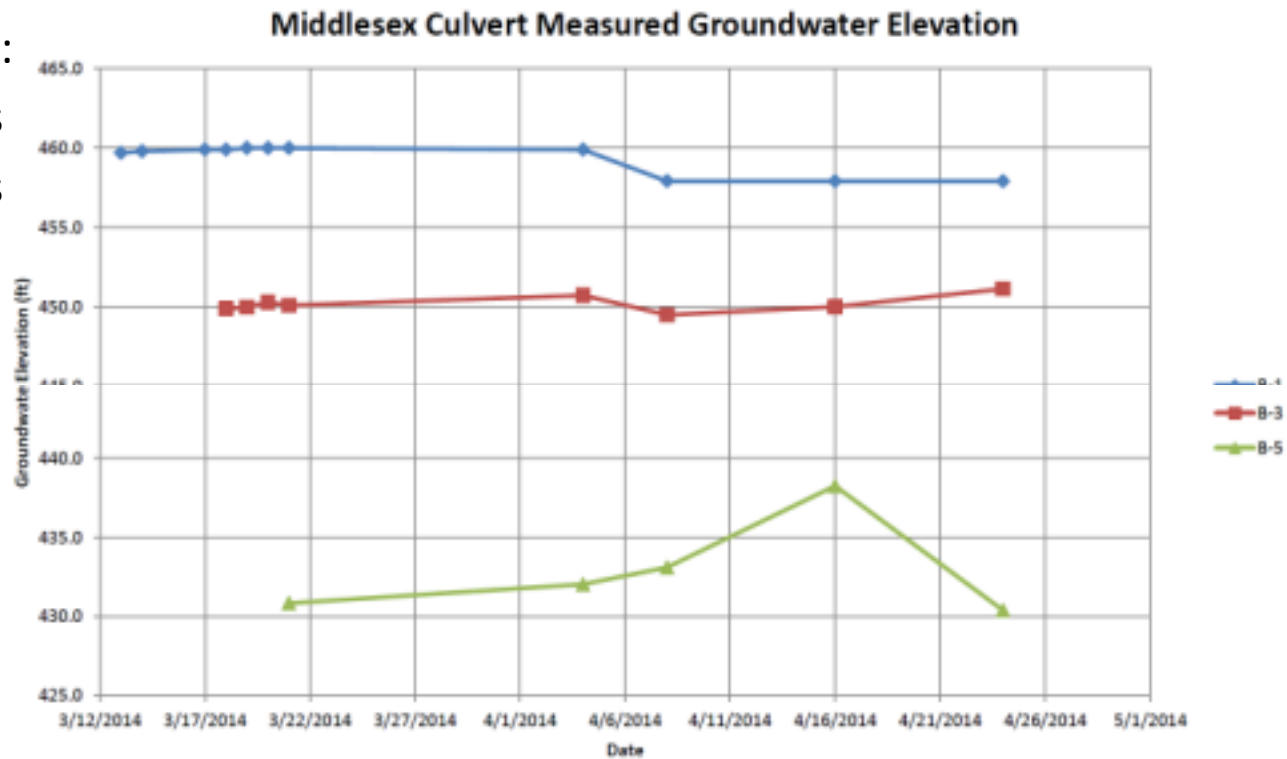
Geotechnical Monitoring – Inclinometers

- 3 readings taken to date
  - ~0.25” of displacement in upper 15 feet
  - Corresponds well with estimated rockfill depth
  - Most movement occurred between baseline and 4/4



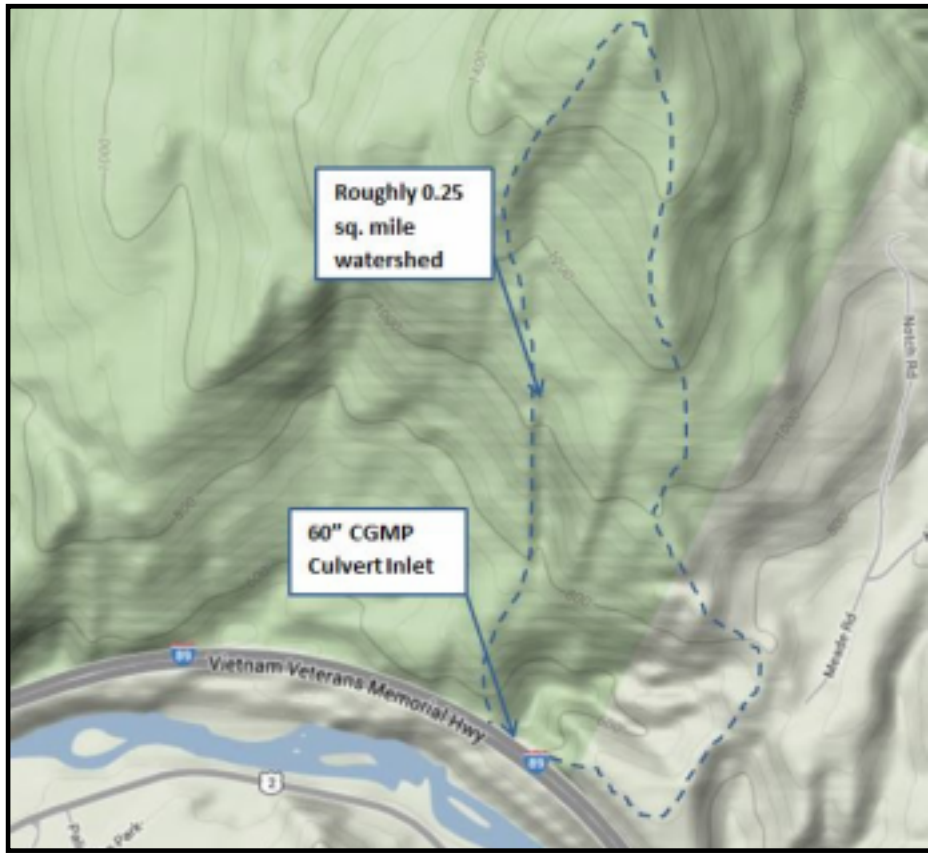
Geotechnical Monitoring – Groundwater

- 3 monitoring wells installed:
  - B-1 screened 18-48 ft bgs
  - B-3 screened 24-59 ft bgs
  - B-5 screened 3-28 ft bgs
- Culvert invert ~El. 470 ft
- Water in B-5 closely related to river elevation



Drainage Network

- Drainage Findings
  - Dimensions of feeder pipes match existing plans
  - 60” Culvert and 5 Drop Inlets feed 72” Culvert
  - Roughly 0.25 square mile watershed area
  - NECR Culvert 82.77 is adequately sized to handle flow



Drainage Network Findings

- 60” Inlet Culvert
  - Light rust along bottom
  - Good condition overall
  - Minor scour at stream inlet

Drainage Network Findings

- 18” Diameter - I-89 Collector Drainage Pipe
  - Good condition overall
  - Collects median drainage

Drainage Network Findings

- 24” Diameter - I-89 Collector Drainage Pipe
  - Good condition overall
  - Collects median and I-89 NB right shoulder drainage

Drainage Network Findings

- Drop Inlet 5
  - Good condition overall
  - Collects I-89 and Brook drainage

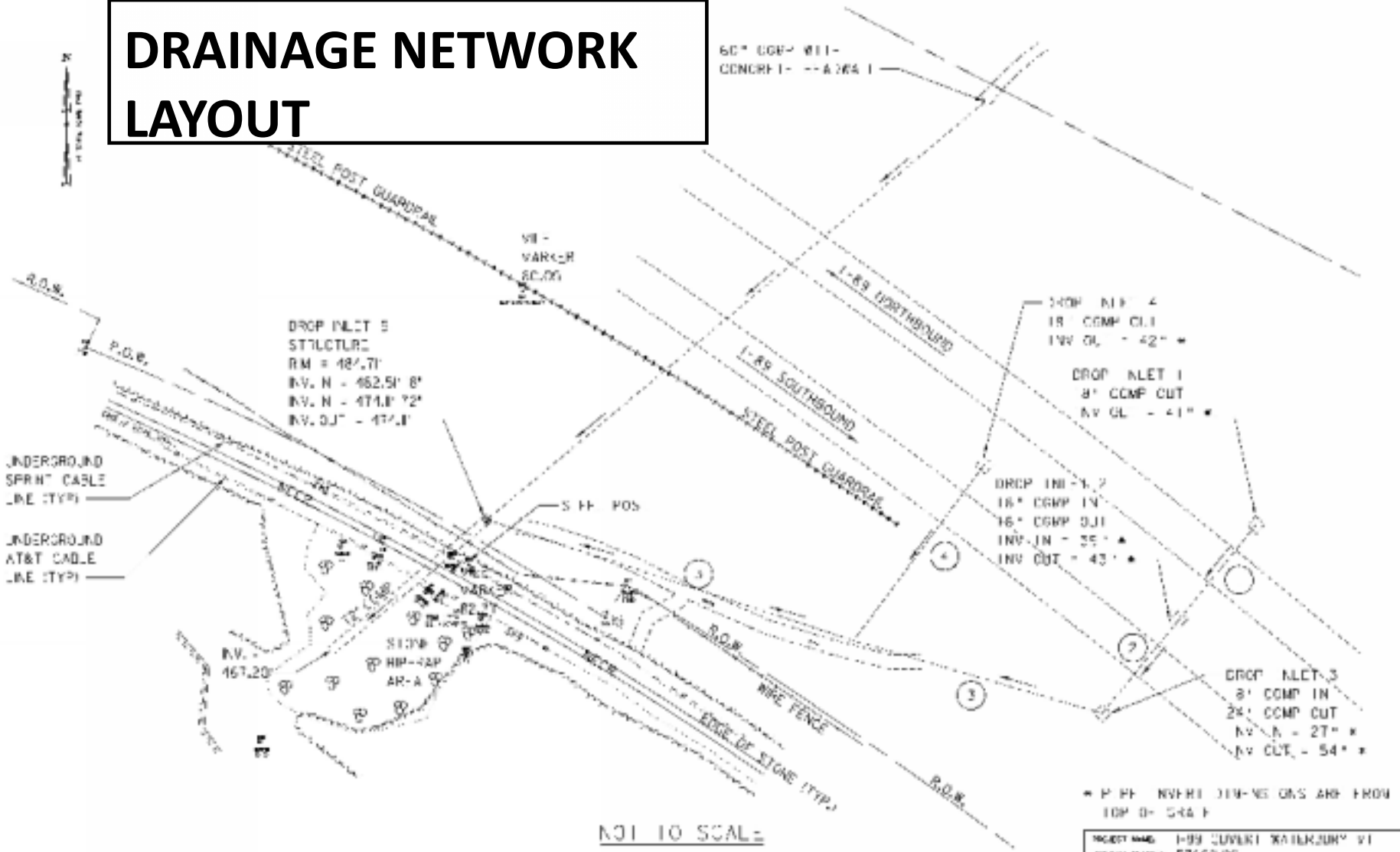
Drainage Network Findings

- 24” Pipe at Drop Inlet 5
  - Good condition overall
  - Collects I-89 drainage
  - Reduction of flow due to ice

Drainage Network Findings

- 60” Pipe at Drop Inlet 5
  - Good condition overall
  - Collects Brook drainage

DRAINAGE NETWORK LAYOUT



NOT TO SCALE

THIS SCHEMATIC IS FOR SHOWING THE DRAINAGE NETWORK OF THE NEW 82.77 CULVERT ONLY. ALL PIPE LENGTHS AND ORIENTATIONS ARE APPROXIMATE.

Drainage Findings Conclusion

- Existing Condition
  - Culvert is sized adequately
  - Existing drainage network is in good condition
  - Minor improvements could be considered i.e. minor scour & vegetation

Structural Inspection Findings

- Bolts
  - Diameter of bolts are too small for bolt holes
  - Allows for misalignment between panels
  - No washers present
  - Light rust

Structural Inspection Findings

- Misalignment
  - Typical ½” misalignment throughout
- Reduction of flow
  - Large sections of ice in bottom

Structural Inspection Findings

- Channel Floor
  - Deteriorated Concrete
  - Exposed rebar
  - Light accumulation of leaves and debris
  - Ponding water

Structural Inspection Findings

- Separated Section
  - At 25.6’ from outlet
  - Geotextile fabric is exposed

Structural Inspection Findings

- Misaligned Section
  - Between 31’ and 43’ from outlet
  - Isolate cracks below bolts
  - Misalignment up to ¾”

Structural Inspection Findings

- Cracks
  - Between 31’-43’ and 46’-64’ from outlet
  - At locations of misalignment along the top of the structure

Structural Inspection Findings

- Collapsed Section
  - Between 46’ and 64’ from outlet
  - 5 lally columns supporting collapsed sections
  - Up to 1-½” misalignment

Structural Inspection Findings

- Separation
  - At 64’ from outlet
  - 15” misalignment/sagging
  - 12 bolts missing of +/- 24

Structural Inspection Findings

- Drop Inlet Structure
  - Collects drainage from I-89 North and South, as well as a brook through a 60” culvert

Structural Inspection Conclusion

- Existing Condition
  - Moderate to Heavy deterioration throughout
  - Temporary supports installed to arrest further deterioration
  - Rating of 2 “Imminent” Failure Condition
  - At end of service life >50 years old

STRUCTURAL ALTERNATIVES

Structural Alternatives

- Do Nothing, not an option
- Partial Replacement and Interior Lining
- Open Cut Construction
- Pipe Ramming - Shell
- Pipe Ramming - New
- Slip Lining and Grouting

Structural Alternatives: Do Nothing

- Not a viable option given deterioration
  - Probable failure
  - Railway impact
  - Probable impacts to Winooski River

Structural Alternatives: Partial Replacement

- Partial Replacement
  - Replace first 64’ of culvert with new culvert
  - Line full length of structure to make it water tight
- Key Considerations:
  - Possible future failure of non-replaced section of culvert
  - Rail closures
  - Temporary fix

Structural Alternatives: Open Cut

- Open Cut
  - Removal of all fill above culvert
- Key Considerations:
  - Large Cost
  - Closure of railroad
  - Increased Service life
  - Full replacement of structure
  - Large amount of earthwork
  - Restructure of existing slopes

Structural Alternatives: Pipe Ramming Shell

- Pipe Ramming Shell
  - New shell around existing structure
- Key Considerations:
  - Medium Cost
  - Maintain rail traffic
  - Soil characteristics limits, need to remove large stones
  - Requires medium construction work area at outlet

Structural Alternatives: Pipe Ramming New

- Pipe Ramming New
  - New pipe adjacent to existing culvert
- Key Considerations:
  - Medium Cost
  - Maintain rail traffic
  - Soil characteristics limits, need to remove large stones
  - Requires medium construction work area at outlet
  - Cost to fill existing culvert

Structural Alternatives: Slip Line and Grout

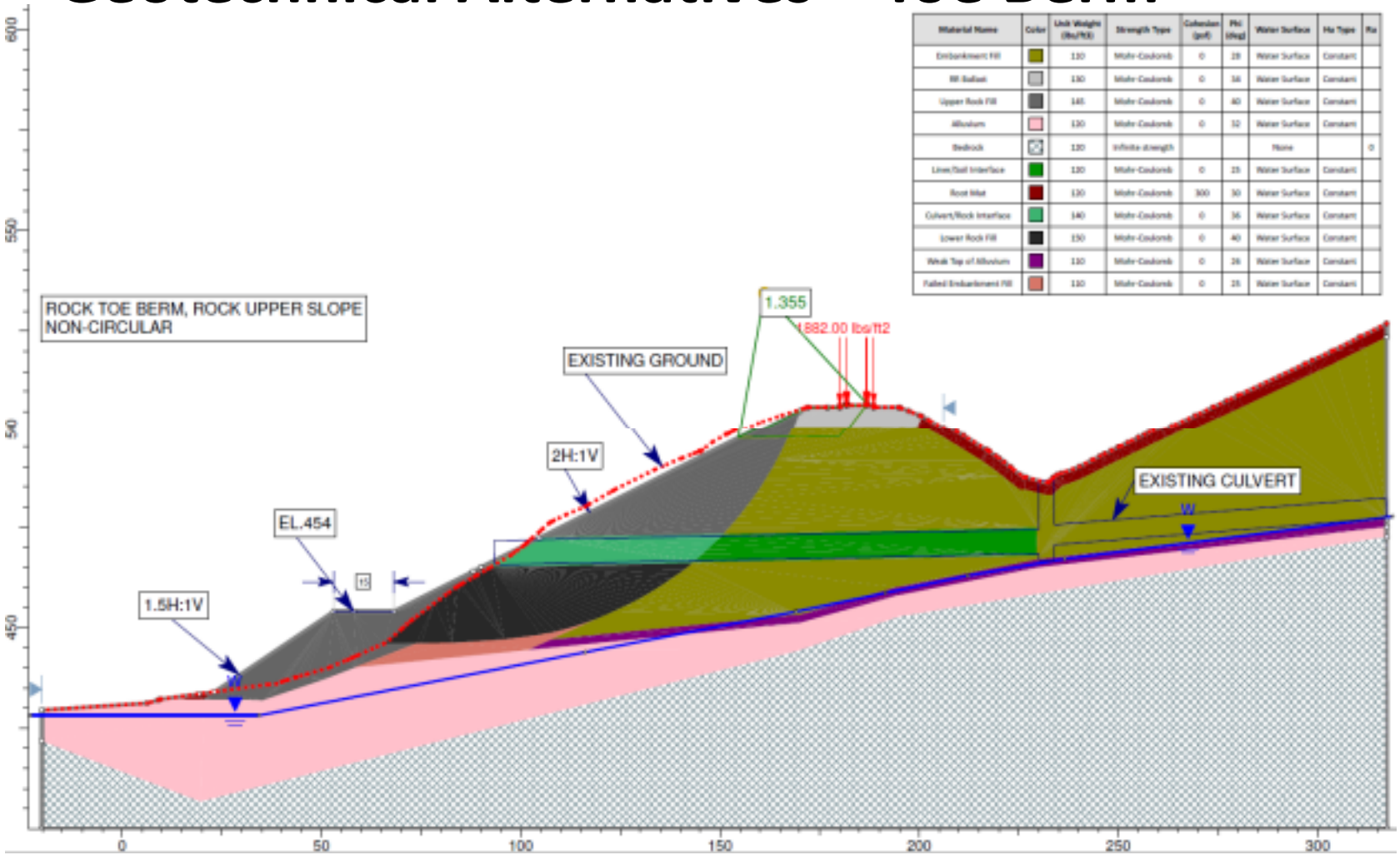
- Slip Line and Grout
  - Smaller diameter pipe placed inside existing than grout space in between
- Key Considerations:
  - Medium Cost
  - Maintains rail traffic
  - Requires smaller construction work area at outlet
  - Reduces hydraulics capacity
  - Cost to fill voids

GEOTECHNICAL ALTERNATIVES

Geotechnical Alternatives

- Do Nothing
- Toe Berm
- Grouting Toe/Crest
- Soil Reinforcing

Geotechnical Alternatives – Toe Berm



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Upper Rock Fill		145	Mohr-Coulomb	0	40	Water Surface	Constant	
Alluvium		130	Mohr-Coulomb	0	32	Water Surface	Constant	
Bedrock		120	Infinite strength			None		0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Constant	
Root Mat		130	Mohr-Coulomb	300	30	Water Surface	Constant	
Culvert/Rock Interface		140	Mohr-Coulomb	0	36	Water Surface	Constant	
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface	Constant	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Constant	
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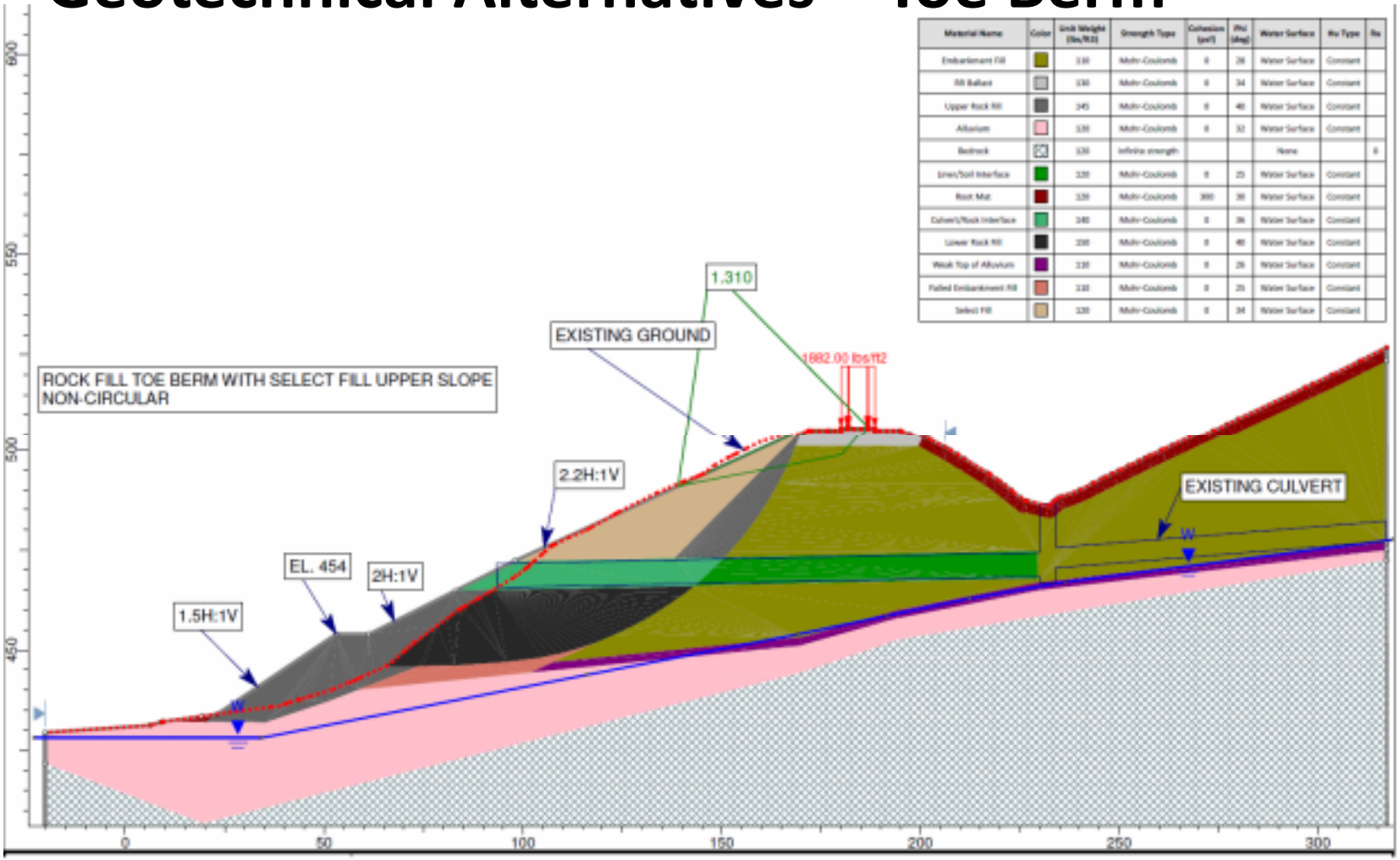
Geotechnical Alternatives – Toe Berm



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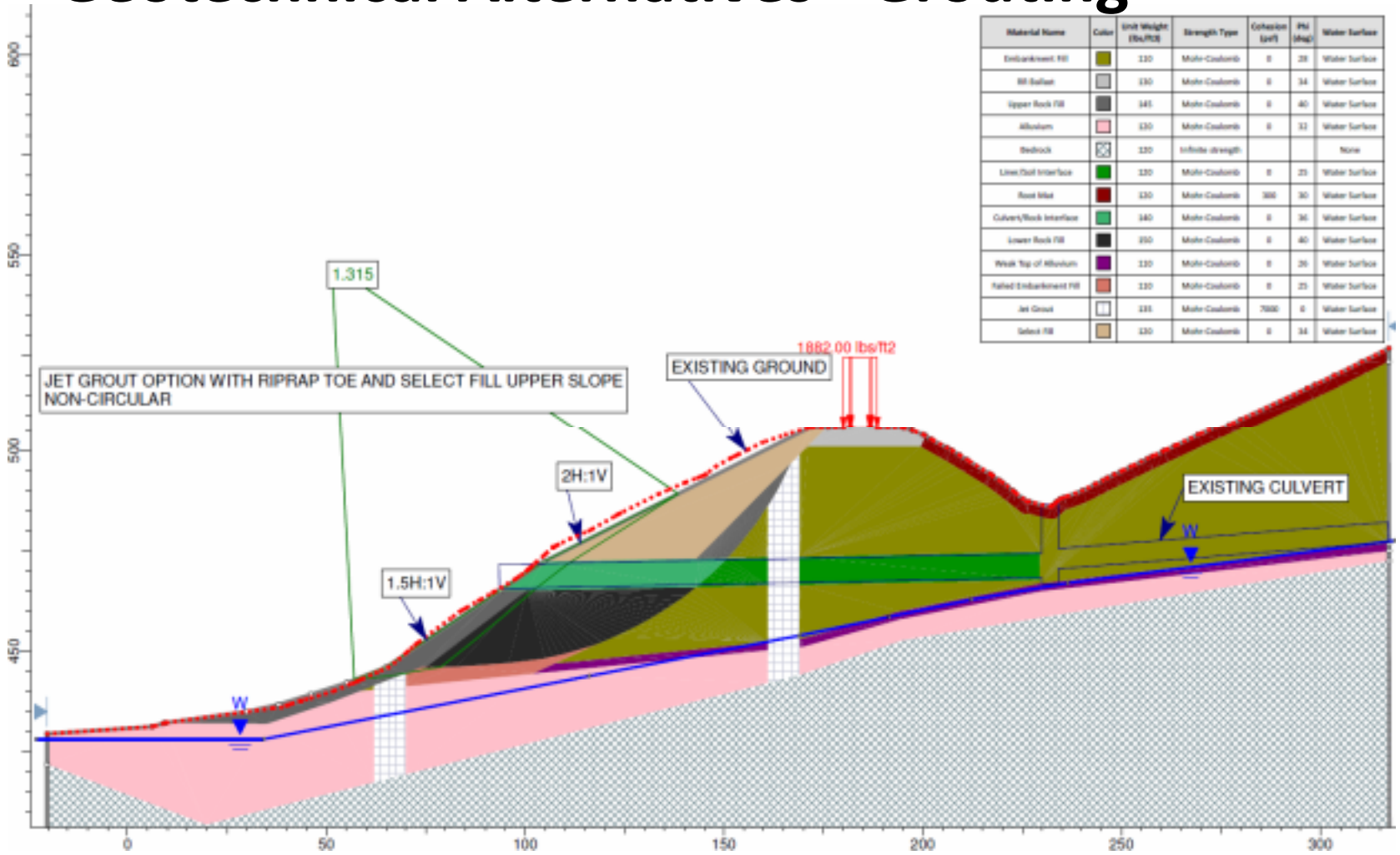
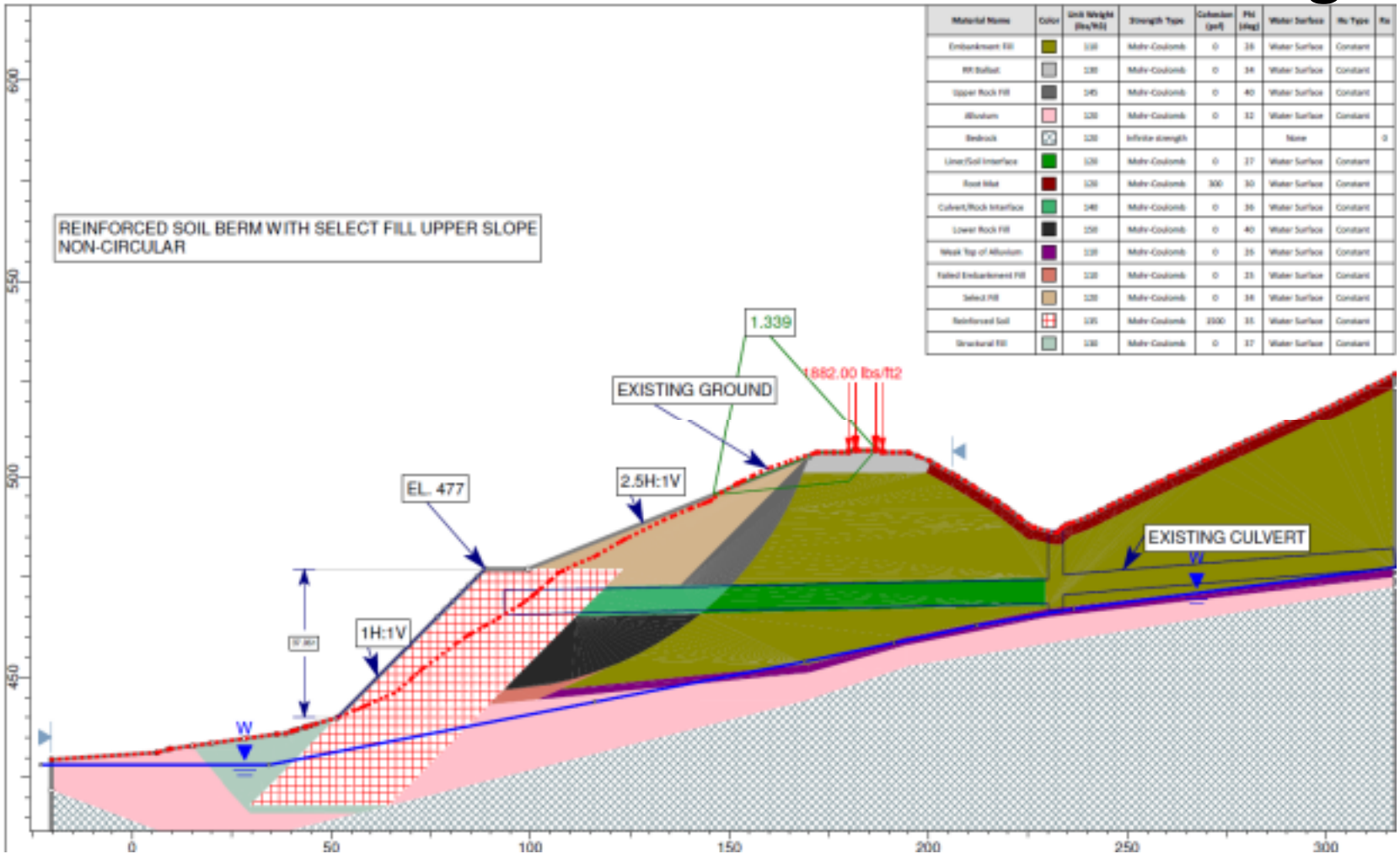
Failed Embankment Fill		130	Mohr-Coulomb	0	25	Water Surface	Constant	
Select Fill		130	Mohr-Coulomb	0	34	Water Surface	Constant	

Geotechnical Alternatives - Grouting



Geotechnical Alternatives – Soil Reinforcing



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Failed Embankment Fill		110	Mohr-Coulomb	0	23	Water Surface	Constant	
Select Fill		120	Mohr-Coulomb	0	34	Water Surface	Constant	
Reinforced Soil		135	Mohr-Coulomb	1500	35	Water Surface	Constant	
Structural Fill		130	Mohr-Coulomb	0	37	Water Surface	Constant	

Construction Considerations

- Partial open cut replacement of culvert
  - Deep excavation - ~35 ft at edge of trackbed
  - Potential need for tie-back anchor support
  - Bedrock ~90-100 ft from potential anchor heads
- Fully-braced partial culvert replacement
  - Only culvert daylighted
  - Limited slope material replacement
- Access to toe of slope
  - Constructing road east of slide area
  - Very steep existing slope
- General
  - Presence of rock fill around culvert impacting trenchless-technology based replacement
  - Very steep slopes: limited access to culvert on river side
  - Limited space along trackbed for material and equipment
  - Grouting around existing culvert to close potential voids

Questions/Discussion

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