Draft Scoping Summary

Middlesex IM 089-2(49)

New England Central Railroad (NECR) Culvert at MP 82.77 Middlesex, VT

Prepared for: VTrans / Vermont Agency of Transportation
Prepared by: VHB and Golder Associates
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EXECUTIVE SUMMARY

The Vermont Agency of Transportation (VTrans) retained Vanasse Hangen Brustlin, Inc. (VHB) and Golder Associates Inc. (Golder) to provide Engineering Evaluation Services for the rehabilitation of New England Central Railroad (NECR) Culvert 82.77 in Middlesex at milepost 82.77.

VHB and Golder have completed an evaluation of the existing culvert condition and geotechnical condition of the embankment. This report summarizes the findings from the studies and provides a detailed discussion of the existing conditions and rehabilitation alternatives.

NECR is carried by culvert 82.77. Culvert 82.77 directs drainage from an unnamed brook and Interstate 89 to the Winooski River. The culvert is a steel panel pipe with a 72 inches diameter. The embankment has partially failed several times throughout the railroad history. The embankment failures have caused the culvert to collapse at several locations. Several emergency improvements have been made by contractors to try and arrest the deteriorating slope and culvert.

VHB and Golder have completed the following studies and investigations including culvert inspection, drainage network assessment, data collection and survey, a geotechnical investigation, and feasibility analysis.

The primary recommendation is based on several alternatives that were examined. The most reliable and cost effective solution to the rehabilitation of this structure includes the following work:

- Excavation of slope and placement of permanent wall parallel to the track
- Slip lining and grouting soil around the culvert
- Backfill slope with suitable fill and re-grade accordingly

The preferred alternative was discussed in a project meeting with VTrans and the Railroad on May 30, 2014 and VTrans agreed with the alternative. Due to the urgent nature of the project, VTrans instructed VHB to forgo edits to this report, and begin the final design stage of the project. VTrans' comments will be included in the appendices, and comments pertinent to Alternative 2A will be addressed in the final design.

GENERAL INFORMATION

CULVERT DESCRIPTION

New England Central Railroad (NECR) 82.77 Culvert conveys drainage from a brook at the north of Interstate 89 to the Winooski River at milepost 82.77 on the NECR in Middlesex, VT. In addition, the culvert conveys drainage from the north and southbound lanes as well as the median and shoulders of I-89. See Page 3 for a Project Location Map. The existing culvert is a 136′ segmented steel plate (four-flange tunnel liner plate) culvert approximately 35′ beneath the railroad. The bottom of the culvert has a concrete liner. The slope surrounding the culvert is armored with stone fill placed during the 2013 temporary repair. The railroad Right-of-Way extends 100 ft from the track centerline south toward the Winooski River. The Right-of-Way does not extend all the way to the river. See Appendix B for a layout plan showing Right-of-Way as well as flood plain elevation.

Based on existing Interstate Project plans, the culvert was originally constructed in the late 1950's. The culvert had emergency rehabilitation in 2013.

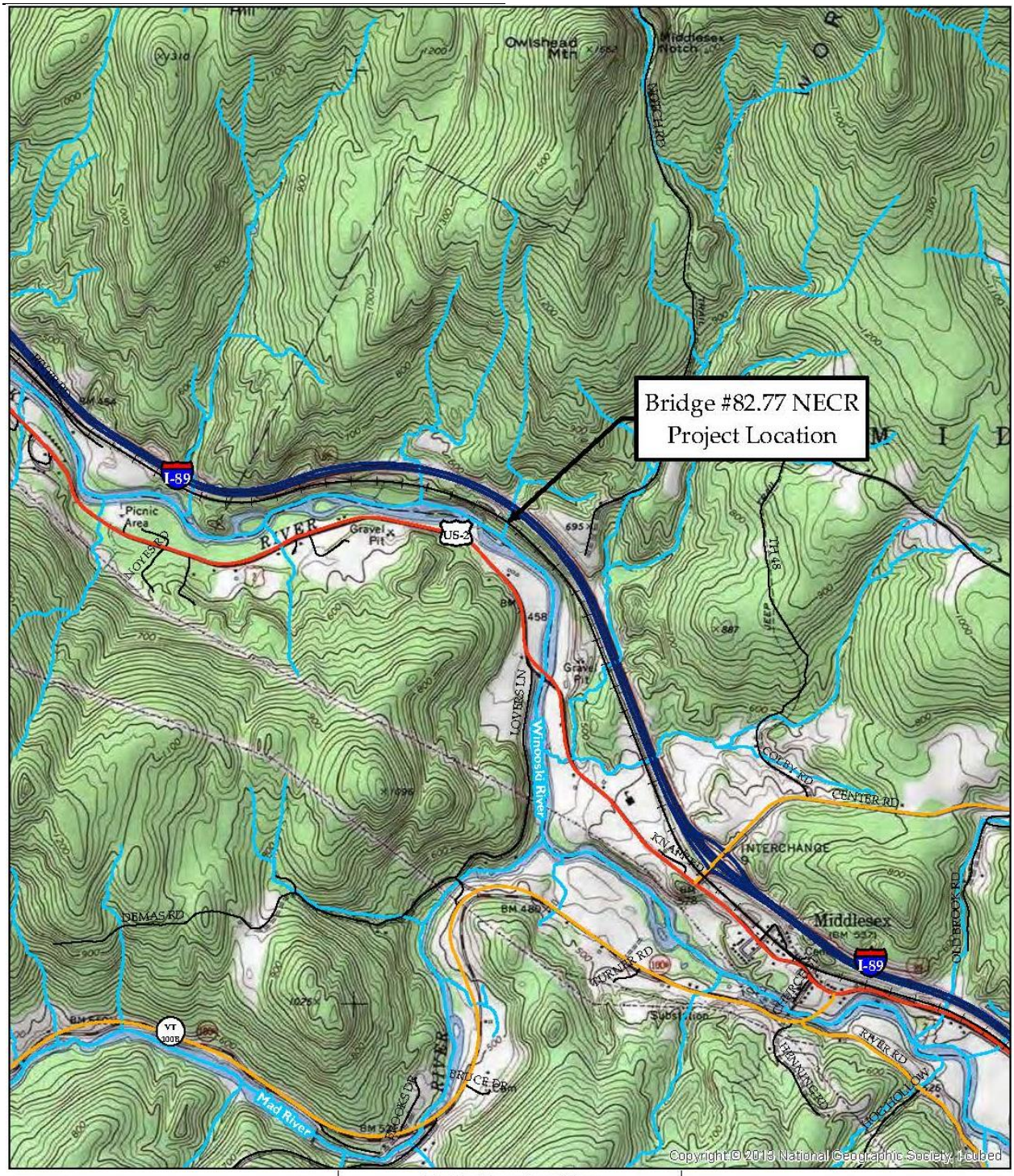
For the purposes of this report, the track runs south to north and is orientation east to west within the project site.

AVAILABLE DOCUMENTS

The following is a list of documents made available to VHB and Golder that have been utilized during the field inspection and report preparation:

- Right-of-Way and Track Map Valuation Plans, June 30, 1917.
- Interstate Project Plans, State of Vermont, unknown date.
- Observations and Recommendations by Engineers Construction, Inc. (ECI) February, 20 2013.

PROJECT LOCATION MAP



Legend
- Railroad
- Interstate
- US Highway
- State Named Highway
- Town Road
- Stream (VHD)

Prepared by: ltherrien

Project Location Map
Bridge #82.77
Middlesex, VT

May 5, 2014

2,000 1,000 0 2,000 Feet

Sources: Background - USGS Topo Quads (2013); Roads downloaded from VCGI (2013); VHD streams downloaded from VCGI (2009).

Vanasse Hangen Brustlin, Inc.

F:\57669.00\GIS\Project\Bridge 82.77_Location Map.mxd

CULVERT HISTORY

The railroad embankment was originally constructed in 1849 with a 3 feet by 3 feet stone box culvert. As part of the interstate construction in the late 1950s, the existing box culvert was replaced with a 136 feet long 72 inches diameter segmented culvert with a tunnel liner. The new culvert extended from a drop inlet on the upstream side of the culvert to discharge above the Winooski River mid embankment slope. Segmented culverts of this type commonly leak at the bolted joints, and it is common to line the invert with grout or asphalt.

Engineers Construction Inc. (ECI) reported that the track within the project area has had a higher frequency of re-tamping compared to other sections of track which suggests embankment deformation issues have been occurring at this location for some time. Additionally, ECI indicated that there was a prior slide in the project area in the late 1970's. This may have been when the culvert was lengthened by attaching a 45 degree bend at the outlet end and a new portion of culvert running down on the surface of the slope towards the toe, where another 45 degree bend directed flow out to the river.

In mid-February 2013, NECR noticed a sinkhole approximately 24 feet from edge of tracks and approximately 34 feet deep, and contacted ECI. ECI inspected the site and presented their findings. A large lateral separation was visible in the crown of the culvert at the bottom of the sinkhole, and ECI noted existing cable restraining system at the location of the 45 degree bend, presumably to hold culvert from pulling away from the embankment. Additionally, ECI indicated there was a large void below the culvert at the sinkhole location and water containing silt and fine sand was observed to be flowing out of slope below culvert. A significant amount of material above the culvert between the sinkhole and the outlet was also vertically displaced (based on side scarp heights visible in photographs), presumably due to erosion from water flowing outside of the culvert.

Due to concerns with losing the track, ECI constructed a temporary slope repair in March 2013 and completed the work in April 2013, approximately five weeks from when the sinkhole was first discovered. The temporary repair involved resetting portions of the culvert, removing the 45 degree bends, and placing rock fill to reconstruct the slope. Rock fill consisted of 3 foot diameter boulders placed from the toe of the slope and up to the bottom of the existing culvert elevation, a blanket of woven geotextile, one inch crushed stone below and above the culvert, two foot diameter boulders to reconstruct the slope above the culvert, and a cover of one foot diameter

boulders over the entire repair area. Based on discussions with ECI and NECR, approximately 90 side dump rail cars of rock fill were used in the construction of the slope repair. Each rail car has an approximate capacity of 50 cubic yards; therefore approximately 4,500 cubic yards of rock fill were used in the temporary slope repair.

In the Fall of 2013, a shallow head scarp, approximately 8-12 inches high, developed around 10 feet from the edge of the tracks along the crest of the slope in the location of the rock fill repair. Observations made inside the culvert in November 2013 indicated a new vertical displacement of the culvert had occurred approximately 64 feet from the present day southern outlet of the culvert. The displacement measured about 15 inches at the crown of the culvert and embankment fill was exposed at the open crown section. Additionally, crushing of the culvert was observed just south of the displacement which indicates loss of sidewall support, possibly due to erosion of material from around the outside of the culvert. Steel lally column supports were installed to prevent further collapse and culvert failure.

APPROACH

The scope of services related to the evaluation of the NECR Culvert at MP 82.77 included culvert inspection, drainage network assessment, data collection and survey, a geotechnical investigation, and feasibility analysis. The data collection included obtaining Right-of-Way and utility information, performing a topographic survey of the project area, and performing a culvert inspection.

The culvert inspection included the identification of damage to the existing culvert. Measurements were taken of the partially collapsed sections as well as documentation of all additional deteriorations. A drainage network assessment included the verification of the existing layout and size of the drainage network.

The geotechnical investigation included six test borings to identify subsurface conditions, laboratory testing of soil and rock samples, inclinometer and open standpipe piezometer installation and readings, and slope stability modeling of conditions prior to the 2013 failure and current conditions with the temporary rock fill repair.

The feasibility analysis included the evaluation, analysis and preliminary opinions of construction costs for several alternatives to repair the culvert and stabilize the embankment.

EXISTING CONDITIONS

In an effort to determine the most feasible, cost effective and viable alternatives additional information was gathered in the form of a field survey, culvert inspection, drainage network assessment, borings, and inclinometer readings.

CULVERT INSPECTION

The culvert was inspected to identify all structurally deficient areas that would need some rehabilitation work.

The culvert carries drainage north to south where it drains into the Winooski River. The south outlet was used as a point of reference throughout the inspection.

The culvert channel bottom liner has failed at random locations throughout the culvert with exposed reinforcing. The failed channel bottom has led to ponding of water and accumulation of light debris as well as gradual build-up of ice during the winter months.

The culvert panels have random backed off bolts less than a 1/8 inch. The bolts connecting the panels are 1/2 inch in diameter and the bolt holes are approximately 7/8 inch in diameter. The bolts have light to moderate rust.

The culvert wall panels have leaks and moderate efflorescence between the flanges. The panels have misalignment between flanges up to 1/2 inch possibly due to the bolt diameter size being much smaller than the bolt hole size.

At 25.6 feet from the southern outlet there is a 28 inches long section that has settled up to 3/4 inch. At this location there are 16 bolts missing at the north flange edge and 5 bolts missing at the south flange edge of the panels. The flange has horizontal separation up 3 inches.

Between 31 and 43 feet from the southern outlet there are two sections with 3/4 inch misalignment. This section has random missing bolts and isolated cracks in the panel flanges below the bolts along the top of the culvert.

Between 46 and 64 feet from the southern outlet five lally columns have been place to prevent any further collapse of this culvert segment. The culvert panels at this section have up to a 4 inch horizontal gap, up to 1-1/2 inches of flange misalignment/settlement, and cracks in the panel flanges. At 64 feet from the southern outlet the culvert has experienced a separation of 15 inches vertically. The collapsed dimensions at 51 feet are 45 inches vertical and 85 inches horizontal. The culvert dimensions at 64 feet are 52 inches vertical and 68 inches horizontal.

GEOTECHNICAL EVALUATION

Between March 4 and March 21, 2014, Golder conducted a subsurface exploration program. Six test borings ranging from 36.5 to 75 feet below ground surface (bgs) were advanced to bedrock at the locations shown in Appendix F with a 4 inch diameter casing fitted with a diamond-impregnated spinning shoe. Continuous Standard Penetration Test (SPT) sampling was conducted in each borehole with the exception of B-3, which was sampled at reduced intervals due to its proximity to B-2. Samples were collected using a 2 inch diameter split spoon sampler with an automatic hammer driving system in accordance with ASTM D1586. Blow counts and field soil classification were recorded for each sample by the Golder field engineer. With the exception of B-3, a NX-sized (2-inch inside diameter) diamond tipped double tubed core barrel was used to collect between 7.5 and 15 ft of rock core in each test boring. Representative samples of soil and rock were tested by the VTrans Materials and Research Section for particle size analysis, water content, and compressive strength of rock, and by GeoTesting Express of Acton, MA for direct shear of soil and elastic moduli of rock.

To monitor groundwater levels, 2 inch diameter monitoring wells were installed in three of the borings. To evaluate the depth of the slope failure and current slope movements, a standard 2.75 inch inclinometer casing was installed in boring B-3, which is located at the center of the slope failure along the crest and downslope of the head scarp. Monitoring of the inclinometer and the monitoring wells is performed by VTrans personnel and the data is transmitted to the design team. The groundwater level at the center of the slope failure (boring B-3) has steadily increased since the beginning of the spring thaw (about mid-April) at the rate of 6-12”, although it has remained

constant at the perimeter of the project site (boring B-1). Groundwater at the toe of the embankment slope appears to be directly related to the river elevation. Inclinometer data at the boring B-3 location indicates the slope surface has moved a total of 0.4 inches from 3/19/14 to 5/14/14 at a rate of approximately 0.05" per week. See Appendix G for a summary of inclinometer data.

Soils encountered in the borings generally include railroad ballast and fill materials placed during construction of the railroad overlying alluvial sediments and bedrock. Roadbed fill approximately 4 thick was encountered beneath the ground surface in borings B-1, B-4, and B-6. The roadbed fill materials consisted of medium brown to gray, compact to very dense, fine to coarse sand and gravel. Embankment fill was encountered directly beneath the roadbed fill in all borings (except boring B-5 drilled at the toe of the slope), to depths ranging from 34 to 53 ft bgs. The embankment fill consists of olive brown, very loose to medium dense, fine to medium sand with some silt, and trace to little gravel. Isolated pockets of silt and silty clay were encountered. Alluvial sediments were encountered for the full depth of boring B-5 and between the base of the embankment fill and the bedrock surface at most of the other borings. The alluvium consists of brown, gray, and dark brown, very loose to very dense, layered fine to coarse sands and gravels. Wood in the form of wood fragments (possibly from stumps), roots, and twigs was encountered at the top of the alluvium layer. Bedrock was encountered at depths ranging from about 27 to 59 ft bgs and consisted of medium light gray, dark gray, and greenish gray, very fine to fine grained, weak to extremely weak, fresh to highly weathered, strongly foliated, non-calcareous to slightly calcareous, quartz-sericite-chlorite phyllite, with discontinuities parallel to the foliation, dipping 60-90 degrees, extremely closely spaced to widely spaced.

Slope stability modeling of the interpreted culvert/embankment conditions in 2013 prior to the sink hole development and culvert separation indicate a factor of safety of about 1.0 depending on the assumed strength of the embankment fill and groundwater levels. Seepage pressures and culvert subgrade erosion leading to sinkhole development were not modeled in the analysis; however, incorporation of these mechanisms would likely demonstrate a factor of safety less than 1.0 consistent with the behavior observed in early 2013. The results of this analysis are presented in Appendix H. Stability analyses were also performed for the interpreted existing culvert/embankment conditions after the ECI repair in April 2013. The results of this analysis are shown in Appendix H and indicate the current embankment slope has a factor of safety of about 1.1. This is close to unity and is consistent with the continued creeping failure of the slope observed in the inclinometer.

DRAINAGE ASSESSMENT

A field visit confirmed as built drainage in the Interstate Project Plans. There are a total of five drop inlets and a 60 inch culvert that feed into the existing 72 inch culvert. The first drop inlet collects the northbound shoulder and flows to the second in the median via an 18 inch corrugated metal pipe. The second collects the median and flows to the third on the southbound shoulder via an 18 inch corrugated metal pipe. The third collects the southbound shoulder and flows to the fifth via a 24 inch corrugated metal pipe. The fourth drop inlet collects water in the interstate median further to the west and flows south via an 18 inch corrugated pipe until it intersects the 24 inch corrugated metal pipe. The fifth drop inlet collects flow from the four other drop inlets as well as a swale and a 60 inch corrugated metal culvert. It conveys this drainage to the Winooski River via the 72 inch culvert of interest. See Appendix B for a diagram of the drainage network.

The 72″ culvert is oversized and has potential to be slip lined. Based on simplified inlet control hydraulics performed by VTrans Hydraulics, a 54″ liner is the smallest allowable liner for this culvert. See Appendix J for hydraulics information.

SURVEY

A topographic survey was completed of the project limits to identify features and resources potentially impacted. The survey extends from the Winooski River to the steel post guardrail of Interstate 89 Southbound. It includes the Winooski's ordinary high water and a wetland to the southeast of the project area. Utility locations and monuments were noted. In addition, was conducted to determine the Right-of-Way and property boundaries.

CONCLUSION

The culvert failure is likely due to stresses imposed on the culvert from a marginally stable embankment, and undersized culvert bolts and bolt corrosion. One possibility is that the bolts are too small for the holes allowing the panels to shift. Additionally, the bolts do not have washers. Per VTrans Specifications an oversized hole should have washers on both the bolt head and nut. The shift in panels, combined with the deterioration of the original lining, would allow water to escape through the panel seams and erode the culvert's bedding and backfill materials. This would weaken the culvert

structurally and allow the weight of overburden soils to overstress and deform the culvert. Another possibility is that the bolts were sized with a small factor of safety. In this case the corrosion would cause the bolts to become overstressed and fail. Without a tight connection between the flanges of panels, the culvert loses its structural stability.

The initial slope failure in early 2013 (sinkhole and vertical displacement) is likely due to a sequence of events: the culvert failure (lateral separation) allowing water flowing in the culvert to seep out through bedding and backfill materials, causing erosion (piping through seepage pressures) of these materials and eventually leading to piping of overlying embankment fill through the culvert opening at the separation point. The development of the head scarp near the crest of the embankment slope (and parallel to the railroad track) after the ECI 2013 slope repair indicates the existing slope and culvert are marginally stable. The current condition is believed to be the result of continued culvert leakage, continued subgrade erosion from the culvert seepage, and marginal global stability conditions for the embankment. The embankment slope in this area currently has a calculated factor of safety of about 1.1.

Given the extent of collapse, misalignment between panels, and service life of the structure, the culvert should be replaced with a watertight structure. In addition, the embankment slope supporting and overlying the culvert should be reinforced and/or otherwise improved to provide a long term factor of safety of at least 1.3.

REHABILITATION RECOMMENDATIONS

INTRODUCTION

The following evaluation and rehabilitation recommendations are in accordance with the current provisions of the following design criteria:

- American Railway Engineering and Maintenance-of-Way Association (AREMA), 2013 Manual for Railway Engineering
- Unless otherwise noted the design live load is a Cooper E80 in accordance with AREMA
- Vermont Agency of Transportation Structures Manual

ALTERNATIVES

Considerations

Per conversation with VTrans and NECR certain parameters for alternatives were determined.

- The railroad cannot be closed due to the presence of passenger and freight rail traffic seven days a week
- No permanent disturbances can occur within the limits of the flood plain (i.e. no rock fill toe berm)
- The minimum replacement culvert diameter is 54 inches

Below are feasible stabilization and repair alternatives that have been considered due to existing conditions and per the criteria listed above.

Alternative 1A: Grouting with Trenchless Technology

This alternative would stabilize the existing rock filled slope using soil improvement (either jet grouting or soil mixing) at the toe of the slope and at the crest of the slope as shown in Appendix A Figure 1A. Soil improvement increases the strength of the existing soils to provide a post construction embankment global stability factor of safety greater than **1.3**. The proposed zone of improvement at the toe of the slope is approximately 8 feet wide (north-south dimension), 25 feet deep, and 85 feet long. The improvement zone at the crest of the slope is approximately 8 feet wide, starting at the back edge of the rock fill and extending towards the railroad tracks, 35 feet deep (to the elevation of the culvert), and 170 feet long, centered on the culvert.

Due to the difficulties in drilling though the rock fill, ground improvement is limited to areas outside of the rock fill. Horizontal drains would be provided at the toe of the slope to relieve excess pore water pressure behind the grouted soil and to reduce the chances of erosion of material below the rock fill.

The failed portion of the existing culvert would be replaced by trenchless technology micro-tunneling using manned entry, along the current alignment. The new tunneled culvert will match into existing culvert with a designed splice. Any voids outside the existing culvert will be pressure grouted prior to being slip lined.

Potential difficulties with this alternative include the unknown quality of the rock fill placement, specifically in regards to the placement of the large (3 feet minus) material below the elevation of the existing culvert. It our understanding that no filter was provided between the rock fill and the existing embankment fill material behind (north) and below the rock fill. Accordingly, a concern and risk exists for future erosion of fine grained materials through the open work voids of the 3 feet stone fill and related loss of support for the new culvert. Grouting annular zones around the culvert can potentially seal the culvert against leakage and related support problems due to seepage, but uncertainties will be present with grouting efficiencies in open graded large stone fill. In addition, if loose fine grained sediments are present at the base of the rock fill, these materials will still be susceptible to erosion, void development and detrimental impacts on global stability of the embankment. Access to the toe of the slope will be required, both during construction and for maintenance of the horizontal drains, and construction of an access road will be difficult. The slope to the east of the project site is steep and the current slope stability factor of safety is unknown but presumed to be low, making installation of an access road difficult. Another potential difficulty is advancing a new culvert using trenchless technology through the rock fill; a specialty contractor will need to be consulted during final design.

Proposed Construction Schedule

2 Week Mobilization

2 Weeks Access Road & Working Pad

7 Weeks Trenchless Technology & Grouting

2 Week Demobilization

Total 13 weeks

Alternative 1B: Grouting with Trench Cut

This alternative uses the same soil improvement configuration as Alternative 1A to stabilize the existing slope. The difference is that this alternative uses a shored trench excavation instead of the trenchless technology to replace the failed portion of existing culvert and slip lines the remainder of the existing

culvert. This results in essentially a new and sealed culvert from inlet to outlet. Since the portion of the existing culvert will still be used, the existing drop inlet structure only needs limited rehabilitation to function with this alternative. Pressure grouting outside of the existing culvert from the inlet to the replaced section would occur to seal any existing erosion channels prior to installing the slip line. The slip lined 71 feet and replaced 65 feet portion of the culvert is envisioned to have a continuous HDPE culvert designed for both the soil and railroad loads extend beyond the 71 feet remaining slip lined section and act as a replacement for the removed 65 feet section.

Potential difficulties with this alternative are the same as Alternative 1A with regard to the soil improvement and slope stabilization. Additional difficulties are performing a limited trench excavation through the rock fill. It is assumed that a fully-shored excavation could be completed without the need for tieback anchors; however a shoring contractor should be contacted during final design to evaluate the assumptions. Difficulties in drilling and installing excavation supports, if they need to be predrilled or extend below the bottom elevation of the culvert excavation, should be expected due to the presence of the rock fill.

Proposed Construction Schedule

1 Week Mobilization

2 Weeks Access Road & Working Pad

8 Weeks Trench Cut and Slip Lining & Grouting

1 Week Demobilization

Total 12 weeks

Alternative 2A: Permanent wall with Slip Lining

Alternative 2A is a permanent tied back soldier pile and lagging wall as shown in Appendix A Figure 2A. This alternative would involve installing an approximately 170 feet long retaining wall along the crest of the slope, installing the lagging boards and two or three rows of tie back anchors as the excavation continued down to the elevation of the culvert. All of the rock fill placed by ECI would be removed down to undisturbed existing material, and a proper filter material installed before replacing rock fill back to the culvert elevation. At the culvert, horizontal drains would be placed. Above the culvert elevation, the slope would be reconstructed using compacted sand and gravel with a final grade of 2H:1V, intercepting the retaining wall approximately 10 feet below the top of the wall. Above this elevation the wall would have permanent lagging boards installed; below this elevation only temporary lagging boards will be required. As with Alternative 1B, the replacement culvert would be a continuous HDPE culvert slip lined into the portion of the existing culvert to remain. Pressure grouting of the area around the outside of the existing culvert will be completed prior to installing the slip lined culvert. This alternative improves the slope stability factor of safety to above **1.3** through unloading the crest of the slope (lowering the

grade downhill of the wall) and improvements to the unknown quality of material beneath the rock fill. Additionally, this alternative uses a known technology and many contractors are available for construction.

Potential difficulties with this alternative include the large amount of rock fill that needs to be removed, stockpiled, and replaced into the slope, with the balance removed from site. Additionally, the existing loose embankment fills behind this wall could make tensioning of the tieback anchors to withstand the full Cooper E80 railroad loading difficult in the temporary full-depth excavation condition; a temporary reduction in rail loading to 286k during construction only may need to be considered.

Proposed Construction Schedule

1 Week Mobilization

2 Weeks Access Road & Working Pad

10 Weeks Permanent Wall and Slip Lining

1 Week Demobilization

Total 14 weeks

Alternative 2B: Soil Mix wall with Slip Lining

Alternative 2B utilizes soil mixing to incorporate cement into the existing soils and create vertical panels along the crest of the slope, extending down to or near the bedrock surface as shown in Appendix A Figure 2B. The vertical panels, orientated perpendicular to the track, form shear walls able to withstand the earth pressures and railroad loading, due to the soil arching between the panels, while allowing groundwater to flow through the wall. The upper portion of the wall, extending to the bottom of the excavation, will have panels orientated parallel to the track to form a continuous wall to withstand the surface soils and for the permanent precast concrete wall panels to mount to for the upper 10 feet of exposed wall after slope regrading. The slope excavation and replacement construction, and the culvert replacement operations, are similar to those discussed for Alternative 2A. Potential difficulties with Alternative 2B are the limited number of contractors available who can perform deep soil mixing, and the size and location of the required working platform for the soil mix rig. Cribbing and ballast will most likely need to be added to bring the work platform up to the rail grade, allowing the equipment to work on top of the tracks during windows with no train traffic. Additional difficulties are addressing any spoils from the mixing process, and a staging area for the soil mix rig while train traffic is present and for the consumable materials. Difficulties from the slope excavation and replacement and for the culvert replacement are similar to those discussed for Alternative 2A.

Proposed Construction Schedule

2 Week Mobilization

2 Weeks Access Road & Working Pad

5 Weeks Soil Mix Wall and Slip Lining

2 Week Demobilization

Total 11 weeks

Alternative 3A: Grade Beam with Tiebacks and Trenchless Technology

Alternative 3A would stabilize the existing rock fill slope with active (tensioned) tieback anchors located at the toe of the slope to provide lateral restraint and increase the embankment global stability factor of safety. As shown in Appendix A Figure 3, the tieback anchors would be restrained on the surface through the use of a reinforced concrete grade beam running continuous between the anchors, or though individual reinforced concrete reaction pads at each anchor location. Each anchor would be terminated in bedrock. Preliminary anchor sizing is 15 anchors with a design load of 175 kips installed every 5 feet at elevation 450 feet, and inclined downward 30 degrees from horizontal. Horizontal drains would be provided at the toe of the slope to relieve excess pore water pressure and reduce the chances of erosion of material below the rock fill. Replacement of the culvert would be the same as discussed for Alternative 1A.

Potential difficulties and concerns with this alternative are many. With the large anchor loads applied at discrete points along the toe of the slope, load transfer via arching between dissimilar soil materials is assumed but difficult to predict. Settlement of the rock fill below the anchor heads is a concern, which would reduce the tension in the tieback anchors and consequently reduce the resisting force on the slope. With the unknown depth of the rock fill immediately below the anchor heads, and the susceptibility of the underlying foundation soils to consolidate beneath the fill, estimating the amount of settlement would be difficult. Any continued erosion of subgrade materials below the 3 feet stone layer could result in a reduction in anchor tension. Additionally, stability of the slope below the anchor head elevation is critical to protecting and keeping the tension in the anchors. Since the toe is adjacent to a river and flood plain, scour protection of the rock fill below at least the 100-year flood level would be warranted. Additional difficulties associated with the culvert replacement are the same as for Alternative 1A.

Proposed Construction Schedule

2 Week Mobilization

2 Weeks Access Road & Working Pad

7 Weeks Trenchless Technology and Slip Lining & Toe Beam

2 Week Demobilization

Total 13 weeks

Alternative 3B: Grade Beam with Tiebacks and Trench Cut

This alternative uses the same slope stability improvement configuration as Alternative 3A to stabilize the existing slope, but replaces the trenchless technology culvert replacement with a shored trench excavation as outlined in Alternative 1B.

Potential difficulties with this alternative are the same as Alternative 3A with regard to the slope stability and as Alternative 1B with regard to the culvert replacement.

Proposed Construction Schedule

1 Week Mobilization

2 Weeks Access Road & Working Pad

8 Weeks Trench Cut and Slip Lining & Toe Beam

1 Week Demobilization

Total 12 weeks

CONCLUSION AND RECOMMENDATIONS

Alternatives 1 and 3 stabilize the existing slope and replace the culvert. Alternative 1 would still involve significant work next to the track; however the majority of the work for Alternatives 1 and 3 would be away from the foul zone, reducing the impact on train traffic. Both alternatives do not address the uncertainties with the way the rock fill was placed onto the existing soils and the potential for erosion due to the lack of a proper filter beneath the rock fill. Although the alternatives include provisions to minimize the potential for erosion leading to future slope failures through the inclusion of horizontal drains, these drains will need periodic maintenance to continue to function correctly. Additionally, a road to the toe of the slope will need to be constructed to provide construction and future maintenance access, and the existing slopes to the east are steep and have a low factor of safety currently.

Alternatives 2A and 2B correct concerns with the lack of a filter element beneath the rock fill, limit impacts beyond the toe of the slope both during and after construction, and allow the most access to the culvert for its replacement. Both alternatives do involve a significant amount of work at the crest of the slope, and in the case of Alternative 2B, may require a work pad on top of the rails for the soil mixing rig to work from. Additionally, a significant amount of rock fill will need to be removed from the slope and partially stockpiled for eventual replacement into the slope, or removed from site and replaced by sand and gravel.

Alternative 3 has the least amount of work along the crest of the slope, however its success in improving the slope stability rely on applying high

anchor loads to rock fill and underlying soils of unknown quality and preventing future scour of the toe of the slope. Long term maintenance of the horizontal drains and inspection of the anchors will be important.

The preferred alternative is Alternative 2A: Permanent wall with Slip lining. Alternative 2A provides for the most reliable and cost effective rehabilitation of this structure. It includes the following work:

- Excavation of slope and placement of permanent wall parallel to the track
- Slip lining and grouting soil around the culvert
- Backfill slope with suitable fill and re-grade accordingly

The preferred alternative was discussed in a project meeting with VTrans and the Railroad on May 30, 2014 and VTrans agreed with the alternative. Due to the urgent nature of the project, VTrans instructed VHB to forgo edits to this report, and begin the final design stage of the project. VTrans' comments will be included in the appendices, and comments pertinent to Alternative 2A will be addressed in the final design.

The following section provides an estimate for Construction costs.

ORDER-OF MAGNITUDE CONSTRUCTION COST ESTIMATES

Below is a list of overall construction cost for the separate alternatives. A 15% construction contingency was incorporated into the each cost. A detailed breakdown of each cost estimate is located in Appendix I.

Alternative 1A Grouting and Trenchless	**$2,625,000.00**
Alternative 1B Grouting and Trench Cut	**$2,650,000.00**
Alternative 2A Permanent Wall and Slip Lining	**$2,325,000.00**
Alternative 2B Soil Mix Wall and Slip Lining	**$2,525,000.00**
Alternative 3A Tieback Anchors with Grade Beam and Trenchless	**$2,050,000.00**
Alternative 3B Tie Back Anchors with Grade Beam and Trench Cut	**$2,075,000.00**

Alternative 1A, 1B, and 2B are all viable solutions to the embankment stabilization and culvert repair, but have significantly more cost associated and contingencies involved in the construction.

Alternative 2A has a theoretical solution to the repair to the embankment stabilization and culvert damage and most comparable cost.

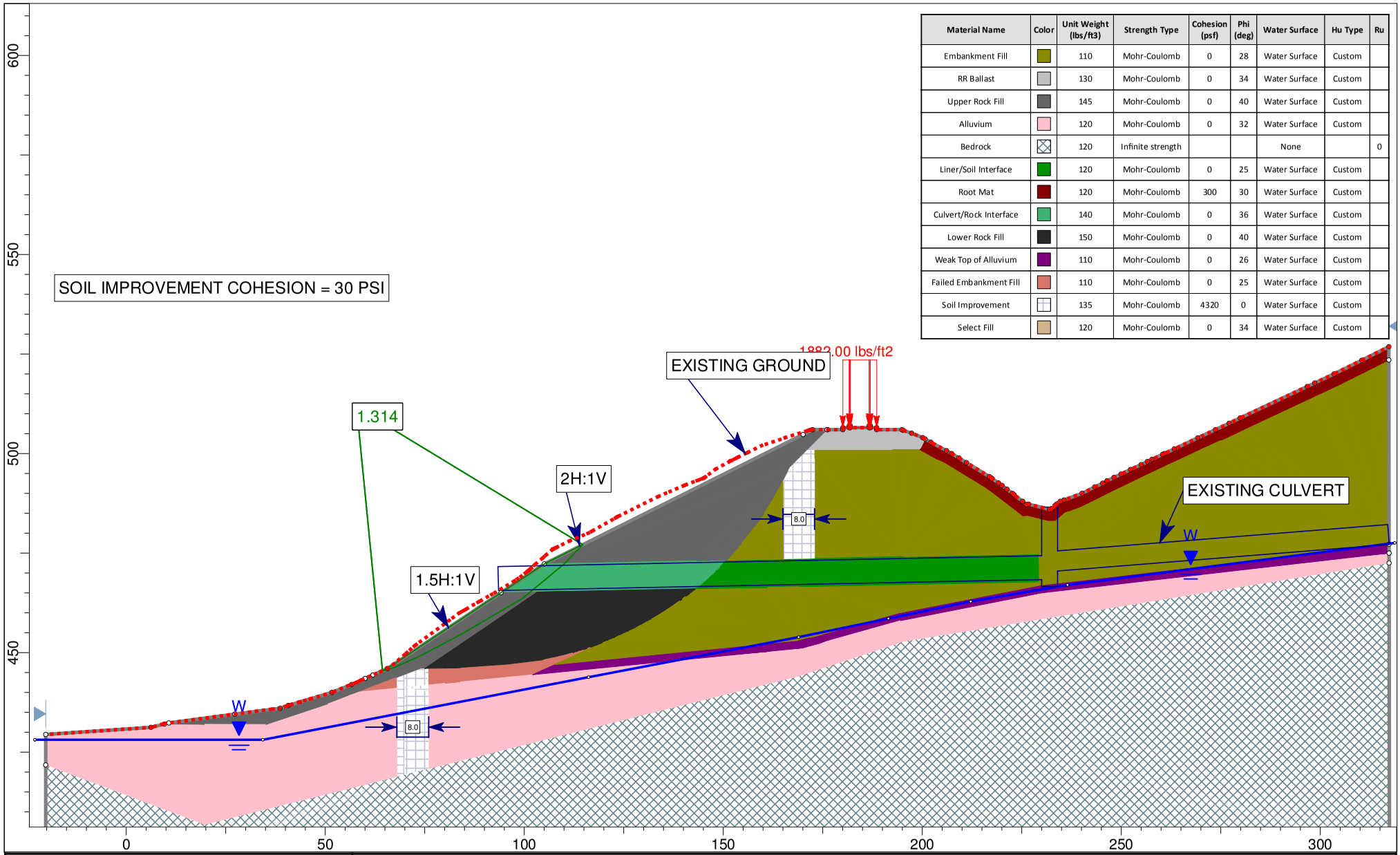
There is a significant of imposed risk associated with the embankment stabilization for the lower costing Alternatives 3A and 3B.

See section above "Conclusion and Recommendation" for a more in depth discussion pertaining to the most viable solution for embankment stabilization and culvert replacement.

APPENDICES

APPENDIX A: ALTERNATIVES DIAGRAMS

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Ru
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Custom	
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface	Custom	
Upper Rock Fill		145	Mohr-Coulomb	0	40	Water Surface	Custom	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Custom	
Bedrock		120	Infinite strength			None		0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Custom	
Root Mat		120	Mohr-Coulomb	300	30	Water Surface	Custom	
Culvert/Rock Interface		140	Mohr-Coulomb	0	36	Water Surface	Custom	
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface	Custom	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Custom	
Failed Embankment Fill		110	Mohr-Coulomb	0	25	Water Surface	Custom	
Soil Improvement		135	Mohr-Coulomb	4320	0	Water Surface	Custom	
Select Fill		120	Mohr-Coulomb	0	34	Water Surface	Custom	

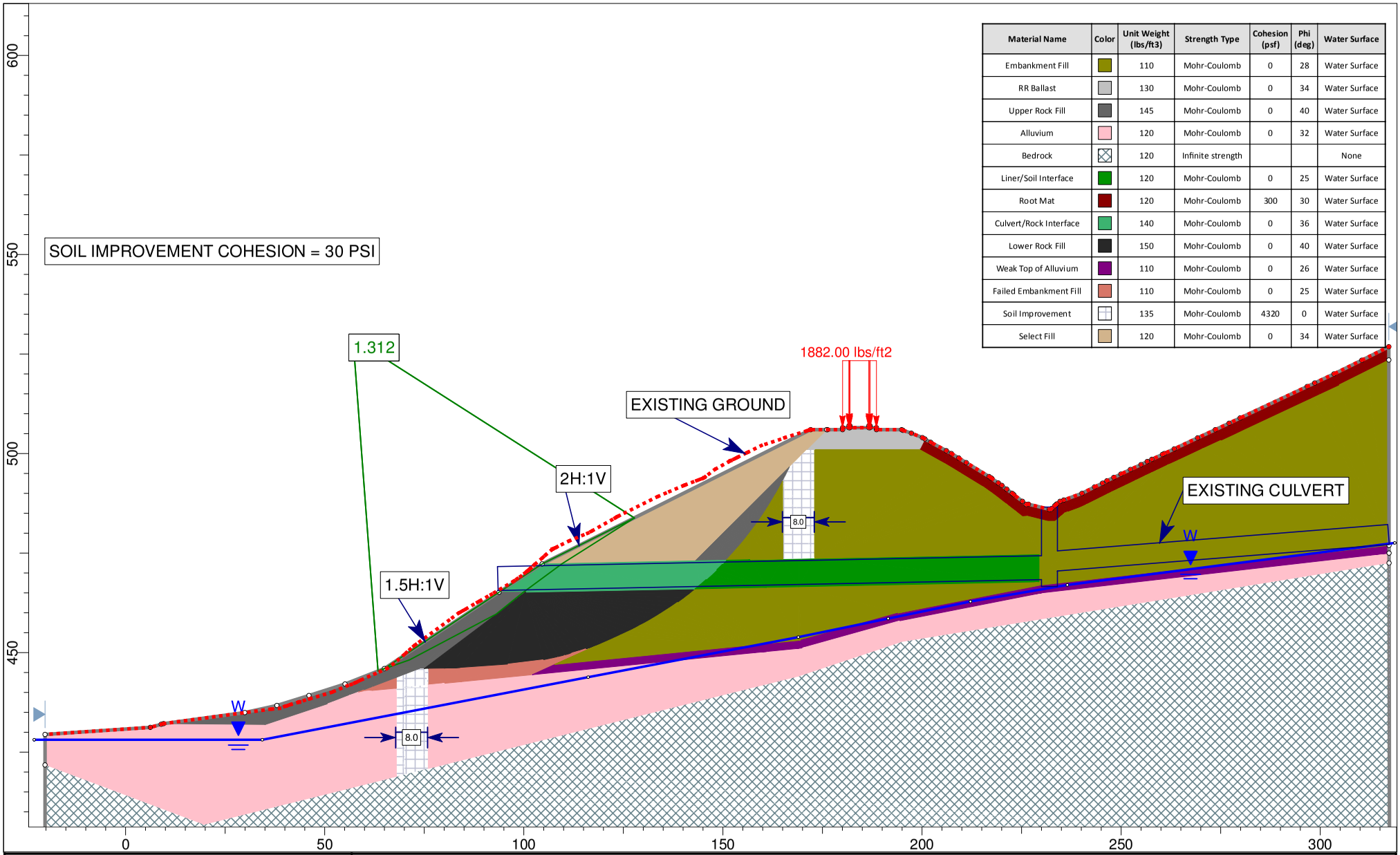


Golder Associates

SLIDEINTERPRET 6.029

Project	Alternative 1A: Grouting with Trenchless Technology		
Analysis Description	Non-Circular		
Drawn By	*Checked by:*	*Reviewed by:*	*Scale* 1:400
Date	5/19/2014		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface
Upper Rock Fill		145	Mohr-Coulomb	0	40	Water Surface
Alluvium		120	Mohr-Coulomb	0	32	Water Surface
Bedrock		120	Infinite strength			None
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface
Root Mat		120	Mohr-Coulomb	300	30	Water Surface
Culvert/Rock Interface		140	Mohr-Coulomb	0	36	Water Surface
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface
Failed Embankment Fill		110	Mohr-Coulomb	0	25	Water Surface
Soil Improvement		135	Mohr-Coulomb	4320	0	Water Surface
Select Fill		120	Mohr-Coulomb	0	34	Water Surface

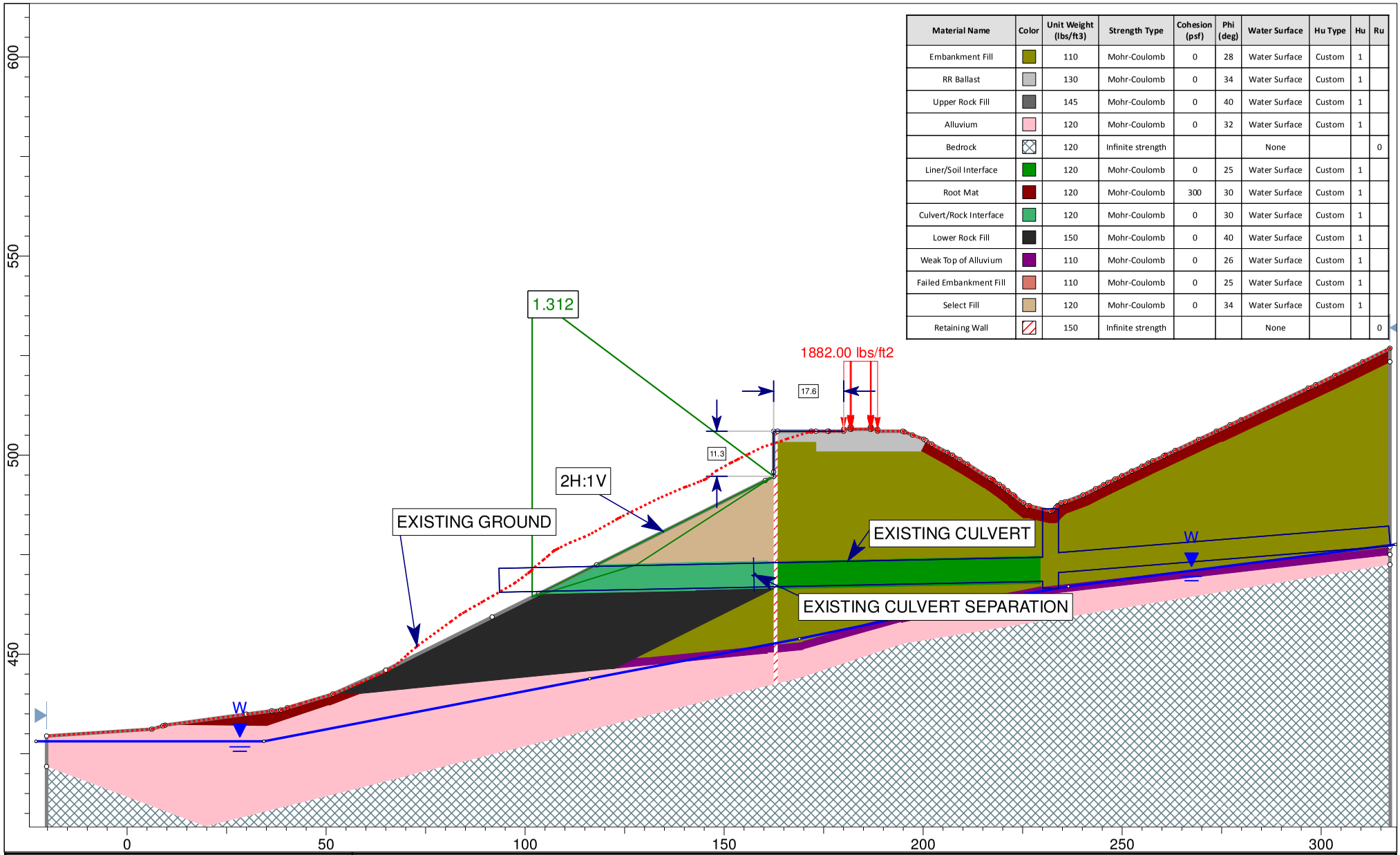


Golder Associates

SLIDEINTERPRET 6.029

Project	Alternative 1B: Grouting with Trench Cut		
Analysis Description	Non-Circular		
Drawn By	*Checked by:*	*Reviewed by:*	*Scale* 1:400
Date	5/19/2014		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Custom	1	
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface	Custom	1	
Upper Rock Fill		145	Mohr-Coulomb	0	40	Water Surface	Custom	1	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Bedrock		120	Infinite strength			None			0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Root Mat		120	Mohr-Coulomb	300	30	Water Surface	Custom	1	
Culvert/Rock Interface		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface	Custom	1	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Failed Embankment Fill		110	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Select Fill		120	Mohr-Coulomb	0	34	Water Surface	Custom	1	
Retaining Wall		150	Infinite strength			None			0

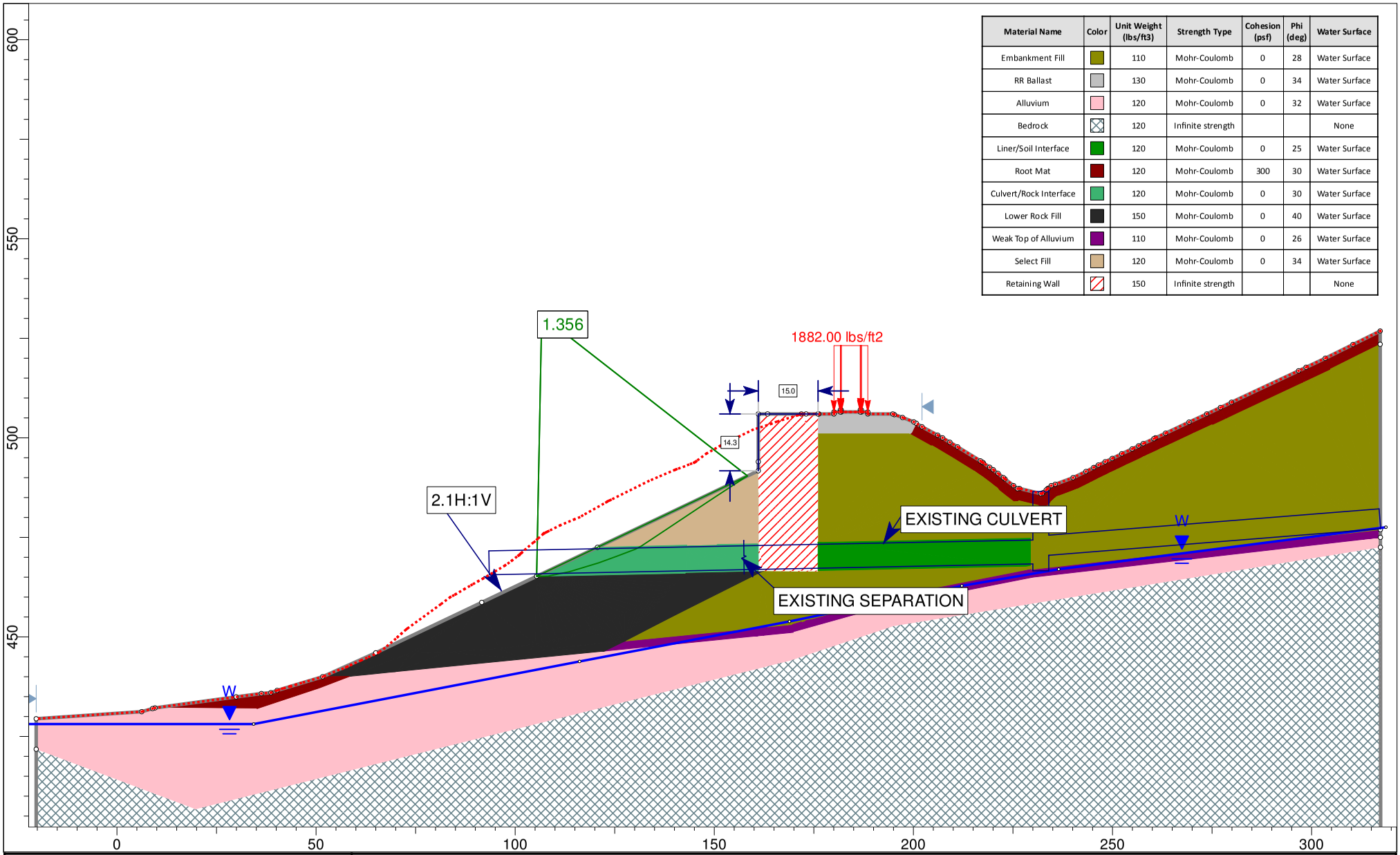


Golder Associates

SLIDEINTERPRET 6.029

Project	Alternative 2A: Soldier Pile with Lagging Wall
Analysis Description	Non-Circular
Drawn By	
Checked by:	
Reviewed by:	
Scale	1:400
Date	5/13/2014

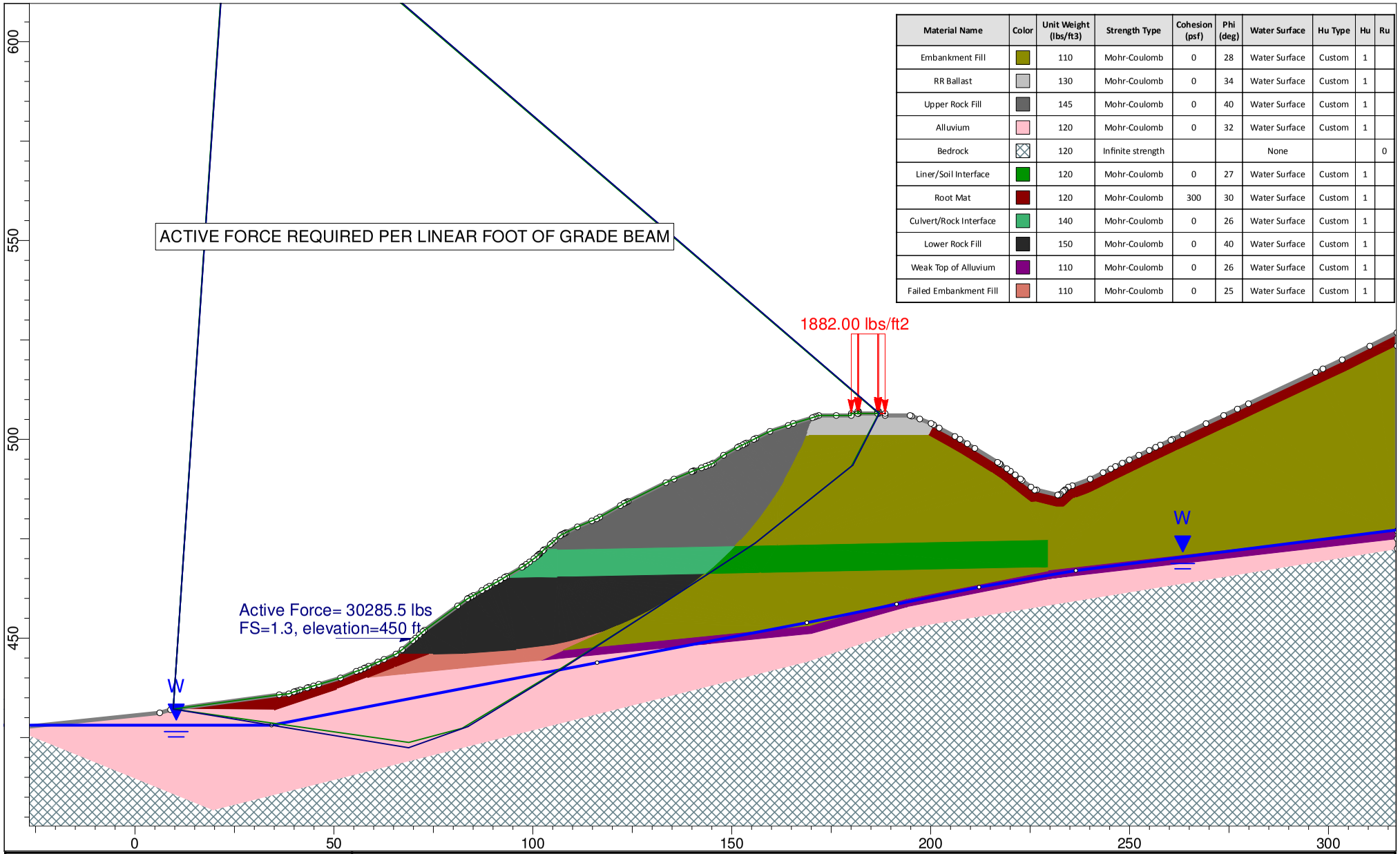
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface
Alluvium		120	Mohr-Coulomb	0	32	Water Surface
Bedrock		120	Infinite strength			None
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface
Root Mat		120	Mohr-Coulomb	300	30	Water Surface
Culvert/Rock Interface		120	Mohr-Coulomb	0	30	Water Surface
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface
Select Fill		120	Mohr-Coulomb	0	34	Water Surface
Retaining Wall		150	Infinite strength			None



Golder Associates

SLIDEINTERPRET 6.029

Project	Alternative 2B: Soil Mix Wall		
Analysis Description	Non-Circular		
Drawn By	*Checked by:*	*Reviewed by:*	*Scale* 1:400
Date	5/13/2014		



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Custom	1	
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface	Custom	1	
Upper Rock Fill		145	Mohr-Coulomb	0	40	Water Surface	Custom	1	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Bedrock		120	Infinite strength			None			0
Liner/Soil Interface		120	Mohr-Coulomb	0	27	Water Surface	Custom	1	
Root Mat		120	Mohr-Coulomb	300	30	Water Surface	Custom	1	
Culvert/Rock Interface		140	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface	Custom	1	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Failed Embankment Fill		110	Mohr-Coulomb	0	25	Water Surface	Custom	1	

Golder Associates

SLIDEINTERPRET 6.029

Project

Alternative 3: Grade Beam

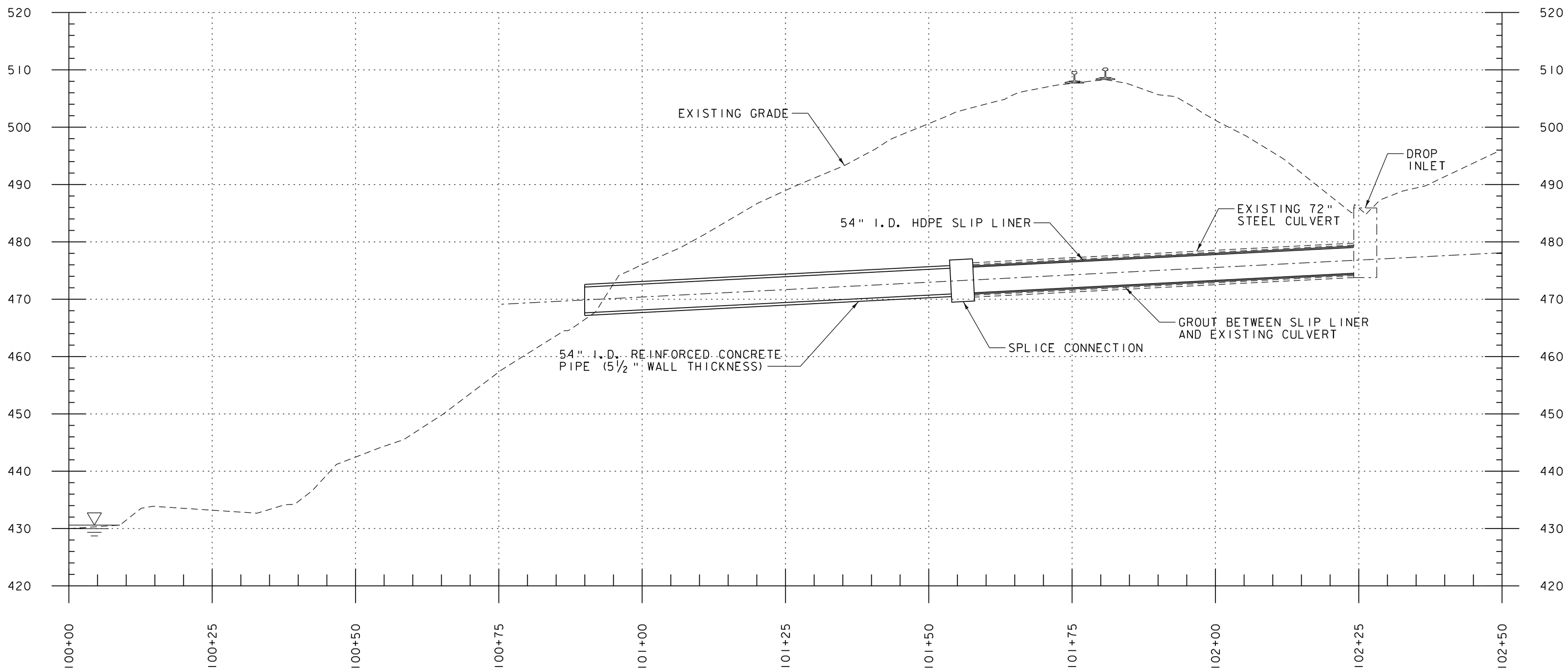
Analysis Description

Non-Circular Beam Load Back Analysis

Drawn By | *Checked by:* | *Reviewed by:* | *Scale* 1:400

Date 5/13/2014

ALTERNATIVES 1A & 3A



DRAFT

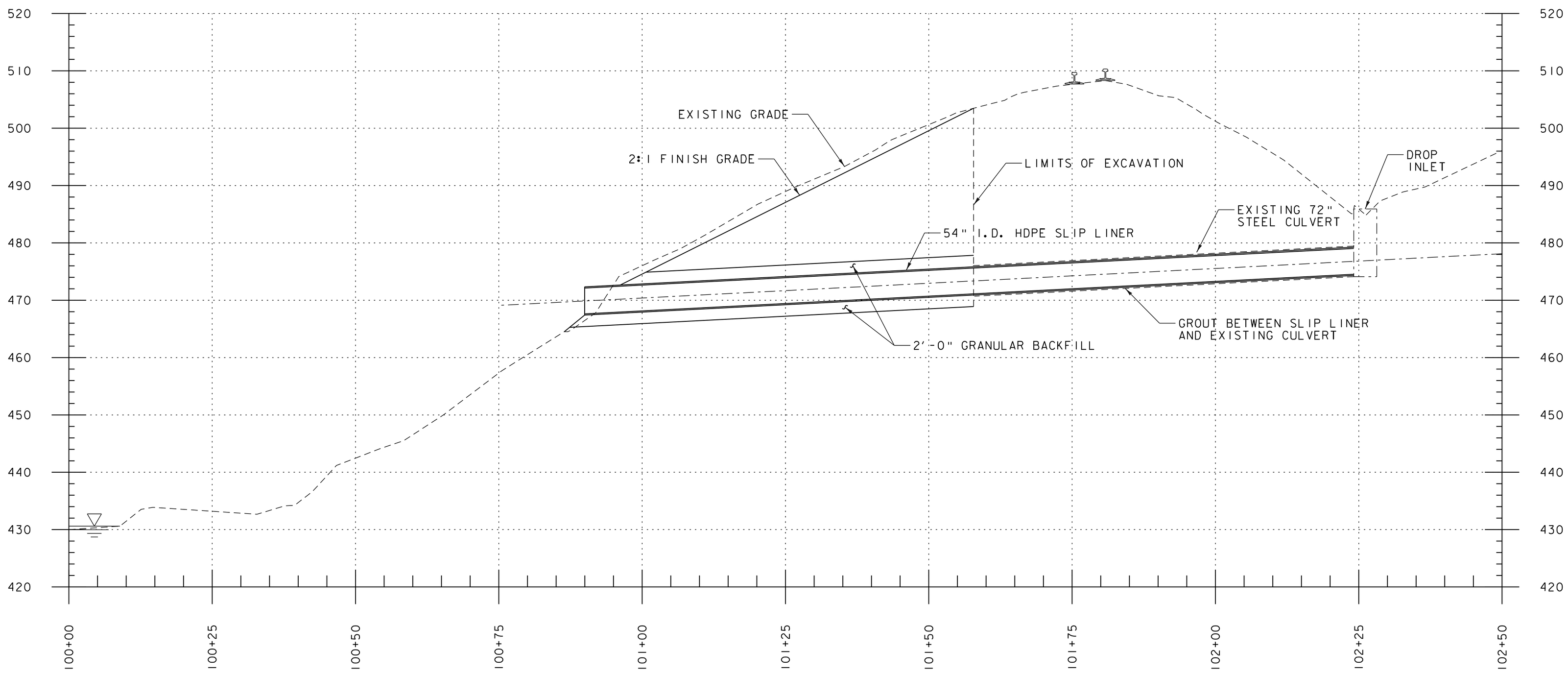
NOT FOR CONSTRUCTION

SCALE 1" = 10'-0"
10 0 10

VHB Vanasse Hangen Brustlin, Inc.

PROJECT NAME: MIDDLESEX	
PROJECT NUMBER: IM 089-2(49)	
FILE NAME: 57669wrk_profiles.dgn	PLOT DATE: 5/22/2014
PROJECT LEADER: M.A. COLGAN	DRAWN BY: A.J. GOUDREAU
DESIGNED BY: J.J. WESTCOTT	CHECKED BY: A.J. GOUDREAU
ALTERNATIVES 1A & 3A	SHEET 1 OF 4

ALTERNATIVES 1B & 3B



DRAFT

NOT FOR CONSTRUCTION

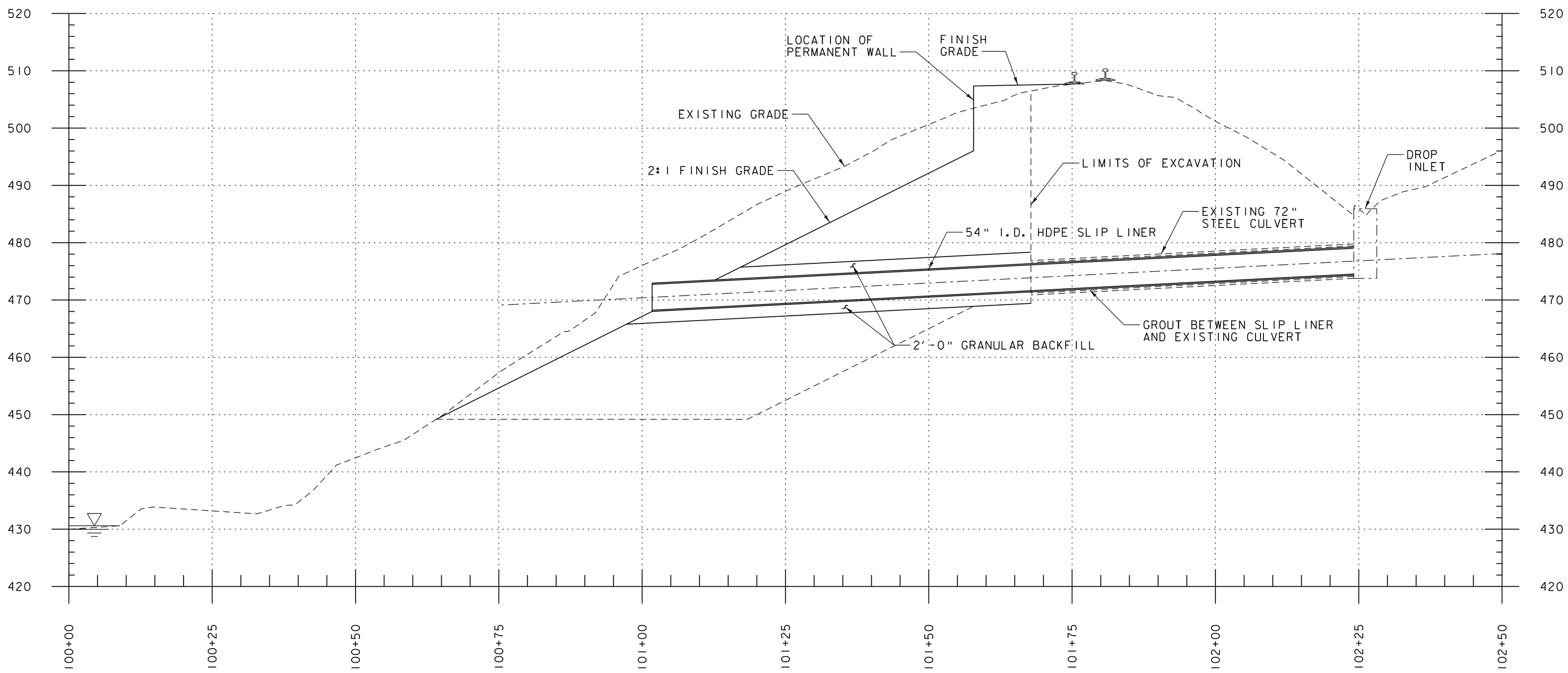
SCALE 1" = 10'-0"

10 0 10

VHB Vanasse Hangen Brustlin, Inc.

PROJECT NAME: MIDDLESEX	
PROJECT NUMBER: IM 089-2(49)	
FILE NAME: 57669wrk_profiles.dgn	PLOT DATE: 5/22/2014
PROJECT LEADER: M.A. COLGAN	DRAWN BY: A.J. GOUDREAU
DESIGNED BY: J.J. WESTCOTT	CHECKED BY: A.J. GOUDREAU
ALTERNATIVES 1B & 3B	SHEET 2 OF 4

ALTERNATIVES 2A & 2B



DRAFT

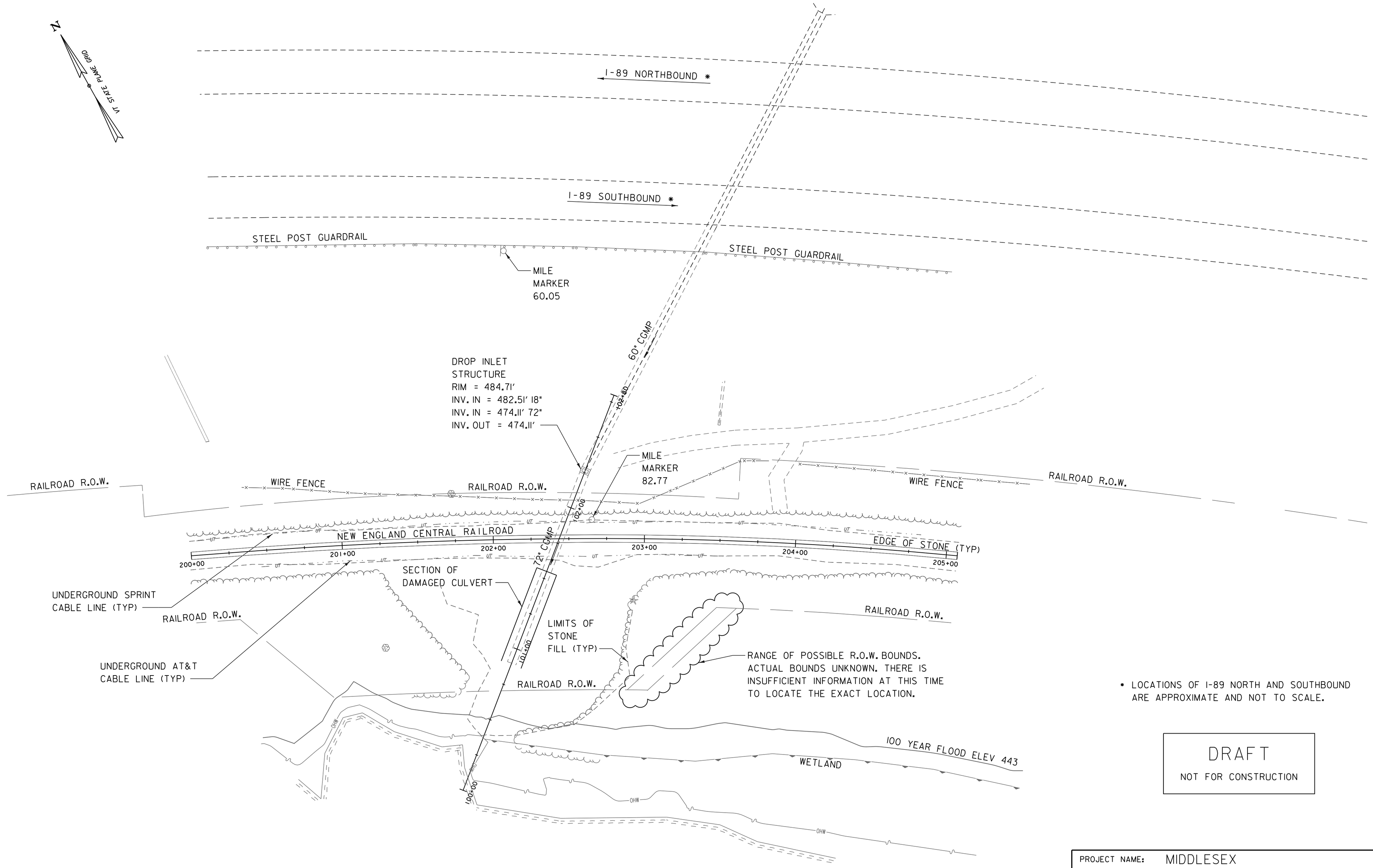
NOT FOR CONSTRUCTION

SCALE 1" = 10'-0"

10 0 10

VHB Vanasse Hangen Brustlin, Inc.

PROJECT NAME: MIDDLESEX	
PROJECT NUMBER: IM 089-2(49)	
FILE NAME: 57669wrk_profiles.dgn	PLOT DATE: 5/23/2014
PROJECT LEADER: M.A. COLGAN	DRAWN BY: A.J. GOUDREAU
DESIGNED BY: J.J. WESTCOTT	CHECKED BY: A.J. GOUDREAU
ALTERNATIVE 2A & 2B	SHEET 3 OF 4



• LOCATIONS OF I-89 NORTH AND SOUTHBOUND ARE APPROXIMATE AND NOT TO SCALE.

DRAFT

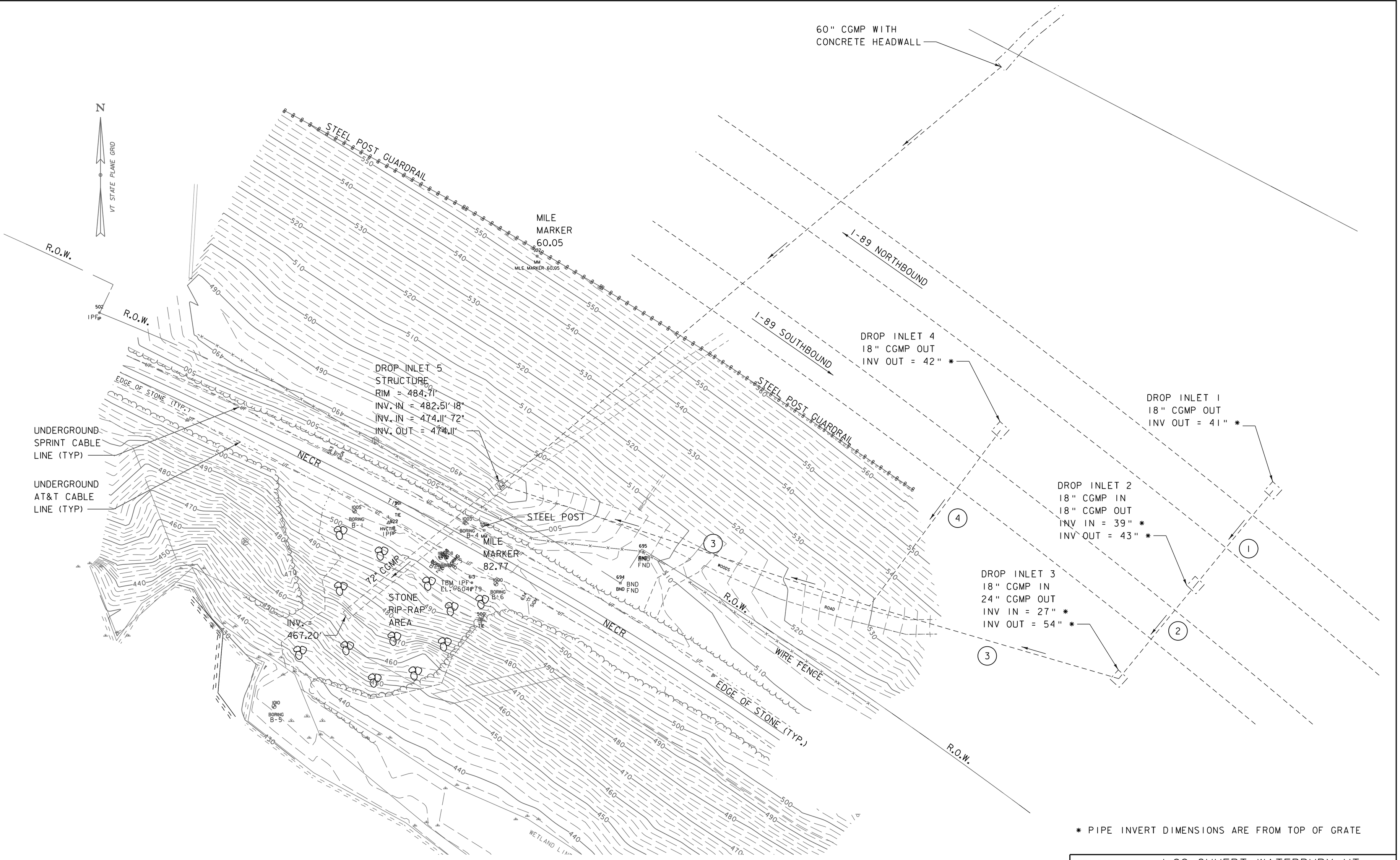
NOT FOR CONSTRUCTION

NAD 83 (2011)
NAVD 88 (GEOID 12A)
FB 73

VHB Vanasse Hangen Brustlin, Inc.

PROJECT NAME: MIDDLESEX	
PROJECT NUMBER: IM 089-2(49)	
FILE NAME: 57669bdr_nul.dgn	PLOT DATE: 5/22/2014
PROJECT LEADER: M.A. COLGAN	DRAWN BY: A.J. GOUDREAU
DESIGNED BY: A.J. GOUDREAU	CHECKED BY: J.J. WESTCOTT
SURVEY BASE PLAN	SHEET 4 OF 4

APPENDIX B: LAYOUT SHEET WITH SURVEY AND DRAINAGE



* PIPE INVERT DIMENSIONS ARE FROM TOP OF GRATE

NAD 83 (2011)
NAVD 88 (GEOID 12A)
FB 73

NOT TO SCALE

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

PROJECT NAME: I-89 CUVERT WATERBURY VT	
PROJECT NUMBER: 57669.00	
FILE NAME: z57669_DRAINAGE_NETWORK.DGN	PLOT DATE: APRIL 24, 2014
PROJECT LEADER: M.A. COLGAN	DRAWN BY: A.J. GOUDREAU
DESIGNED BY: A.J. GOUDREAU	CHECKED BY: J.J. WESTCOTT
DRAINAGE NETWORK	SHEET 1 OF 1

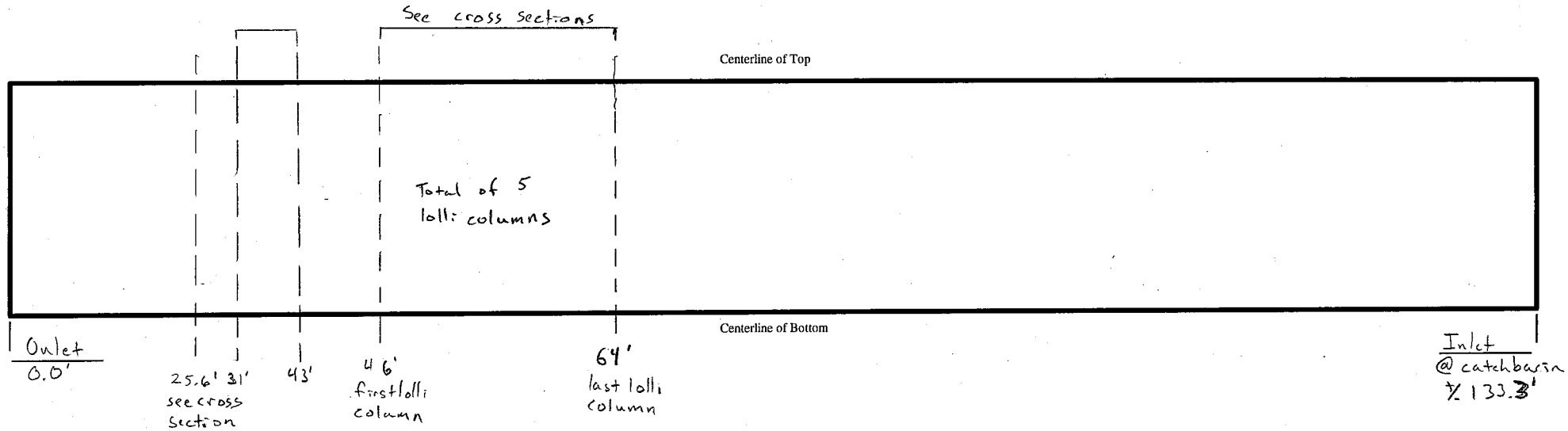
APPENDIX C: INSPECTION NOTES AND SKETCHES

Project: Middlesex IM 089-2(49) **Project Number:** 57669

TEAM LEADER: James Westcott **ASST. TEAM LEADER:** Matthew Baker **DATE:** 4/4/2014

Structure: NECR 82.77 **Type:** Corrugated Segmental Culvert

Sidewall Deteriorations



Wall Elevation

Typical Dimensions

- bolts ± ½" OD
- bolt holes ± ⅞" OD
- Culvert panel dimensions
  3'L x 16"w x 1½" w flange

Typical Notes

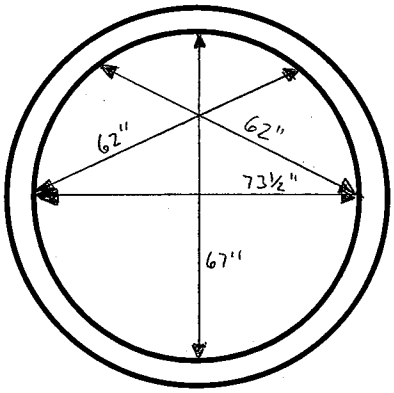
- Concrete/Bituminous channel bottom in culvert has failed w/exposed reinforcing
- 2' High x 2' wide ice layer along culvert edges, could not be inspect parts of bottom + walls of culvert
- There are random backed off bolts < ⅛" gap
- Moderate efflorescence along walls
- leakage along top of culvert
- light - moderate rust on bolts + nuts
- Embankment stones have settle at south side approximate size of area 36" x 36" x 28" DP

Project: Middlesex IM 089-2(49) **Project Number:** 57669

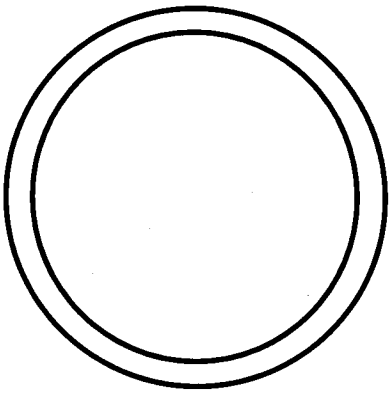
TEAM LEADER: James Westcott **ASST. TEAM LEADER:** Matthew Baker **DATE:** 4/4/2014

Structure: NEtR 82.77 **Type:** culvert

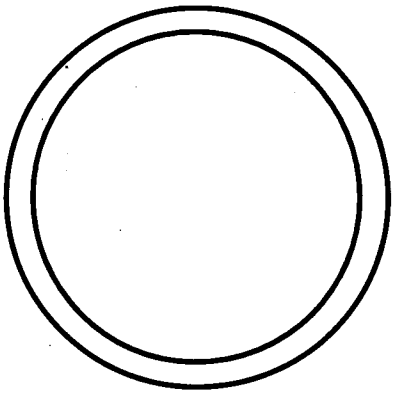
Typical Cross Sections



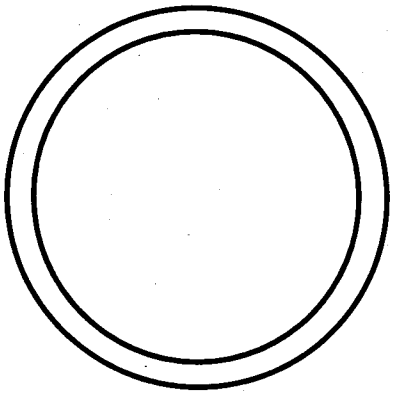
Cross Section at
18 feet from outlet



Cross Section at
feet from outlet



Cross Section at
feet from outlet



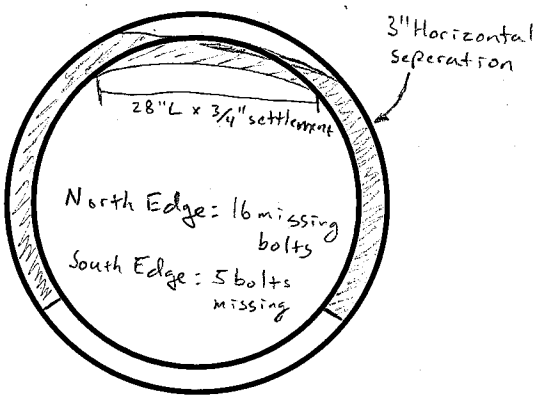
Cross Section at
feet from outlet

Project: Middlesex IM 089-2(49) **Project Number:** 57669

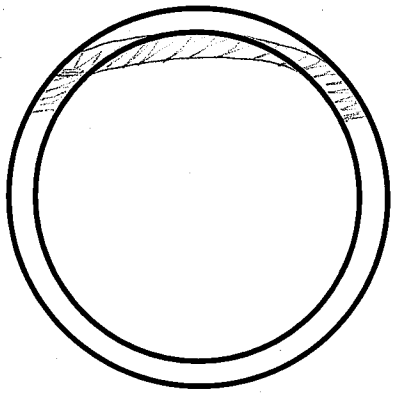
TEAM LEADER: James Westcott **ASST. TEAM LEADER:** Matthew Baker **DATE:** 4/4/2014

Structure: NECR 82.77 **Type:** Culvert

Typical Cross Sections

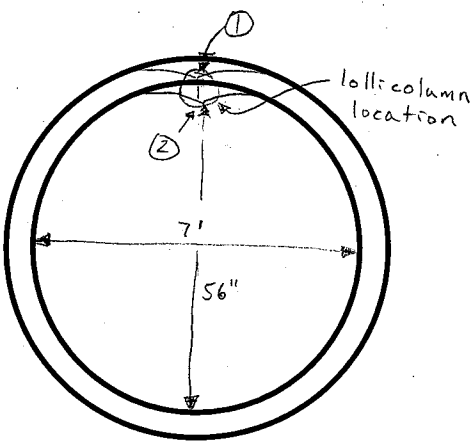


Cross Section at
25.6 feet from outlet



Cross Section at
31-43 feet from outlet

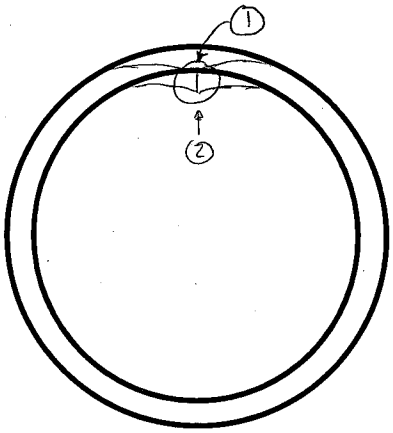
- 2 sections settled up to 3/4"
- 1 bolt missing
- Isolated cracked flange at top



Cross Section at
46 feet from outlet

1 1½" settlement & cracked flange..

2 up to ½" seperation gap @ underside



Cross Section at
49-51.7 feet from outlet

1 1⅛" settlement & cracked flange

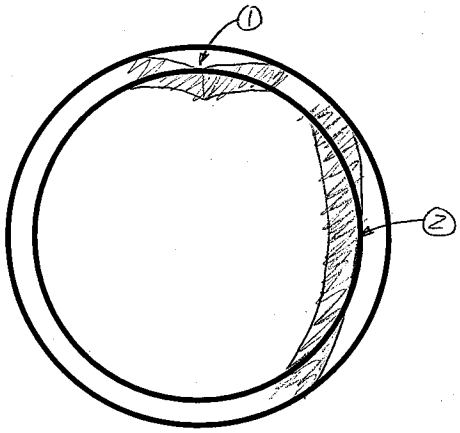
2 up to ½" seperation gap @ underside

Project: Middlesex IM 089-2(49) **Project Number:** 57669

TEAM LEADER: James Westcott **ASST. TEAM LEADER:** Matthew Baker **DATE:** 4/4/2014

Structure: NECR 82.77 **Type:** Culvert

Typical Cross Sections

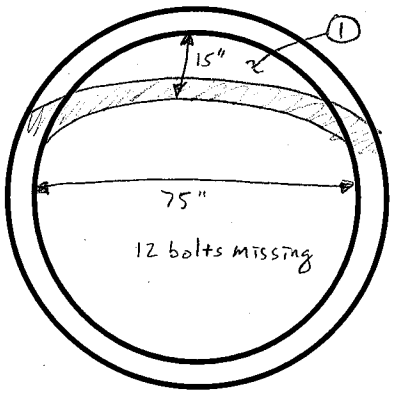


Cross Section at
52.4 feet from outlet

1 1½" settlement

2 4" Horizontal movement

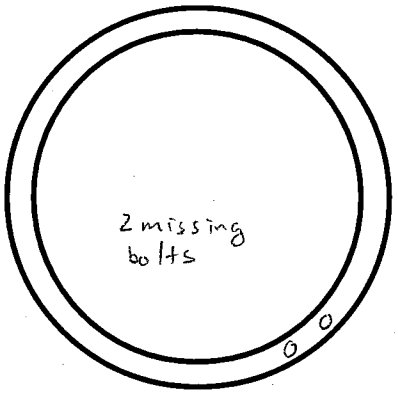
• cracked flange at top



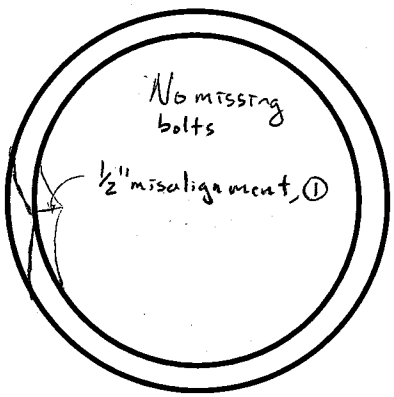
Cross Section at
64' feet from outlet

1 Exposed fill, temporarily stable

• Could not measure top to bottom due to ice



Cross Section at
84 feet from outlet



Cross Section
Typical Condition throughout, unless otherwise noted.

1 misaligment due to bolt OD + hole ID.

VHB	[ ] Field Original [X] Transcribed JJW	Structure: Culvert 82.77	Date: 4/4/14
		Crew: JJW, MAB MM	Sheet:

Photo No.	Image Description
1	ID Br # 82.77 4/4/14 JJW, MAB
2-3 S.	Outlet
4-5. E	Typ. Top of Track
6-7. N	catch basin
8. N	Outlet
9. N	Inside of barrel
10-14	At 25.6' from outlet
15-16 S	From 31'-43' from outlet
17-18 S	At 56' from outlet
19. N	At +/- 130' from outlet
20 S	Typ. barrel from 128' from outlet
21	Typ. barrel floor
22-23	At 130' from outlet, backed off bolts
24-28 S	At 116' from outlet, typ ½" misalignment/settlement
29	Typical bolt hole
30-32	At 97', typ. bolt smaller than hole
33-35	At 56' from outlet
36-42	Lolli columns
43-44 N	Set of lolli columns
45-47 N+S	At 47' from outlet
48-50	At 51' from outlet
51-53	At 49' from outlet
54 N	S. Embankment settlement
55-56 W	Typical Top of track

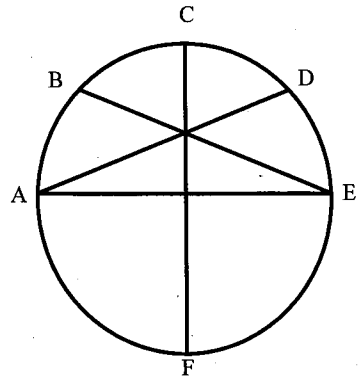
Project: Middlesex IM 089-2(49) **Project Number:** 57669

TEAM LEADER: A. GOUDREAU **ASST. TEAM LEADER:** C. HAKEY **DATE:** 5/02/2014

Structure: CULVERT **Type:** Structural Plate Steel pipe

NECR 82.77

SPAN # _____ **DOCUMENTATION**



Original Dimensions

Span	Rise	Corrugation	Gauge/Thick
136'			

Dimensions given in standard units (feet)

Location		Location 1 - 51 feet						Location 2 - 64 feet					
Date	By	A-D	B-E	C-F	A-E	Lean	change	A-D	B-E	C-F	A-E	Lean	change
5/2	ASG	/	/	45"	85"	/	/	/	/	52"	68"	/	/

Location		Location 3 - _____ feet						Location 4 - _____ feet					
Date	By	A-D	B-E	C-F	A-E	Lean	change	A-D	B-E	C-F	A-E	Lean	change

Location		Location 5 - _____ feet						Location 6 - _____ feet					
Date	By	A-D	B-E	C-F	A-E	Lean	change	A-D	B-E	C-F	A-E	Lean	change

Location		Location 7 - _____ feet						Location 8 - _____ feet					
Date	By	A-D	B-E	C-F	A-E	Lean	change	A-D	B-E	C-F	A-E	Lean	change

Location		Location 9 - _____ feet						Location 10 - _____ feet					
Date	By	A-D	B-E	C-F	A-E	Lean	change	A-D	B-E	C-F	A-E	Lean	change

APPENDIX D: SITE PHOTOGRAPHS

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Typical bolt hole to bolt diameter relationship

Partial collapse of section of culvert 64 feet from south outlet

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Typical steel panel misalignment due to bolt relationship

Typical culvert liner deterioration

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Separated section of culvert near south outlet

Misaligned panels, missing bolts, and cracked steel panel flange

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Section of culvert that has partially collapsed/squatted

Section of culvert that has partially collapsed/squatted

Middlesex IM 089-2(49) – Middlesex, VT

Site Photographs

May 2014

Lally column no longer in place

Separated section of culvert, missing bolts and cracked panel flange

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Typical view of culvert

Southern embankment of culvert

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Southern embankment looking south at Winooski River

Southern embankment looking west

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Adjacent embankment to the west of the southern outlet

Adjacent embankment to the west of the southern outlet

Middlesex IM 089-2(49) – Middlesex, VT

Site Photographs

May 2014

Drop inlet to inlet of 72” culvert

Existing I-89 drainage pipe outlet at drop inlet of 72” culvert

Middlesex IM 089-2(49) – Middlesex, VT
Site Photographs
May 2014

Drop inlet view of stream drain outlet

Temporary access road to Interstate 89

APPENDIX E: EXISTING PLANS AND VALUATION PLANS

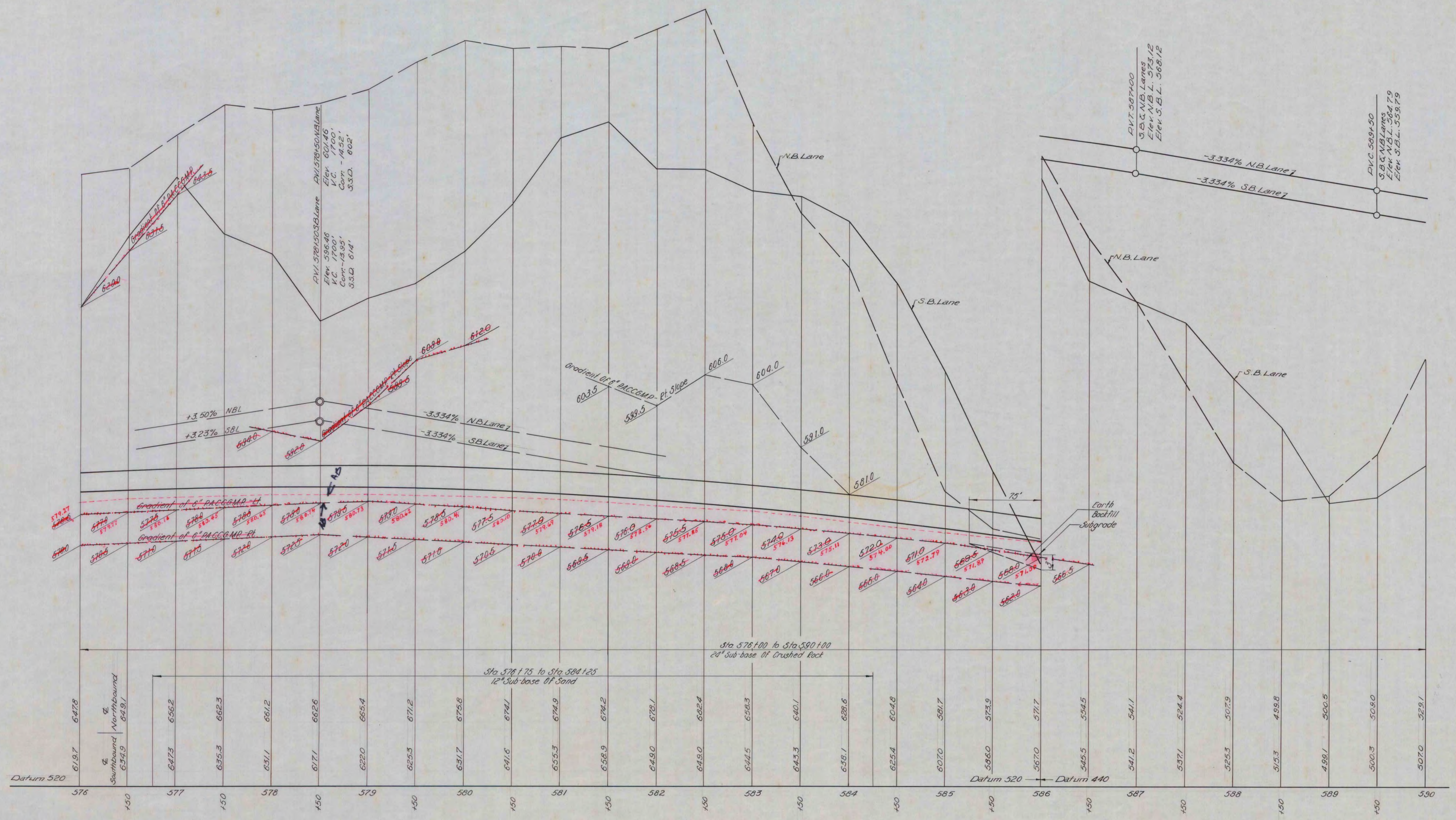
STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

INTERSTATE PROJECT IN THE TOWNS OF
MIDDLESEX – WATERBURY

PLAN

WILLIAM H. McFARLAND
ENGINEER
BINGHAMTON, N.Y.

SURVEYED BY	CHECKED BY	SCALE 1" = 50'
DRAWN BY	IN CHARGE	DATE
PROJECT NO. I 89-2(5) CONTRACT NO. I	SHEET 32	OF 315



B.M. #94 D Sta. 581+35 ℄
S.I.T. 6" White Birch
Elev. 673.56 - 7' Lt.

B.M. #94 E Sta. 584+55 ℄
Spike in Root 10" White Birch
Elev. 611.32 2' Lt.

B.M. #94 F Sta. 587+00 ℄
Spike in Root 15" Yellow Birch
Elev. 548.80 - 5' Lt.

B.M. #96 Sta. 580+20 (Traverse Line)
Top Of Mile Post #82/80
Elev. 513.87 - 14' Rt.

B.M. #97 (Traverse Line)
Mile Post #82/77
Elev. 509.08 - 24' Rt.

STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

INTERSTATE PROJECT IN THE TOWNS OF
MIDDLESEX – WATERBURY

PROFILE

WILLIAM H. McFARLAND
ENGINEER
BINGHAMTON, N.Y.

SURVEYED BY	CHECKED BY	SCALE 1"=50 HOR. 1"=10 VERT.
DRAWN BY	IN CHARGE	DATE
PROJECT NO. I 89-2(5) CONTRACT NO.	SHEET 33	OF 315

LANDSCAPE MATERIAL
TREES
598+85 RT. 130' W. BIRCH (1)
599+00 RT. 115' W. BIRCH (1)
599+10 RT 110' W. BIRCH (1)

THREE CABLE GUARD RAIL w/ STEEL POSTS
Left: 590+00 to 595+50; 601+00 to 604+00
Right: 590+50 to 602+30; 602+50 to 604+00

PROPERTY LINE FENCE W/STEEL POSTS
Left: 590+00 to 604+00; 599+00 to 604+00
Right: 590+00 to 604+00

Sta. 590+00 to Sta. 592+50 Special Ditch - Item 103 Stone Fill Item 522

#51 F CENTRAL VERMONT RAILWAY, INC.
(A 0.6±) STA 588+80 - 593+00±
CULVERT RIGHTS STA 582+80 - 586+00 - 587+50 - 588+70 - 593+06 - 593+55
598+28
COND. 1/2/59
RECORDED: MIDDLESEX - BK 27 - PG 436 1/5/59

℄ CURVE DATA
ARC. DEF.
P.I. 601+33.06 = 506+58.30
Δ - 81°05' LT
D - 1°30'
R - 3819.72
L - 5827.79
T - 3651.27
E - 1464.40
S.E. - 1/2'/ft.

B.M. #90 El. 507.14

B.M. #99 El. 500.11

To be Constructed by Others
Sta 602+40 LT. Tunnel Liner
New 60" x 48' Tunnel Liner
Cradle Headwall - 212' Lt.
Cradle Headwall - 300' Lt.
Remove Existing 3'x3' Stone Box Culvert

#51 G - CENTRAL VERMONT RAILWAY, INC.
(A 1.30±) STA. 601+10 - 612+70±
CULVERT RIGHTS: STA. 602+40; 611+04; 607+00
COND. 1/2/59
RECORDED: MIDDLESEX - BK 27 - PG 436 1/5/59

Inv. El. 451.4
3'x3' Stone Box w/ Stone Wingwalls

Sta. 602+35 to Sta. 602+45 Stone Fill for Slope Protection - Item 522

Traverse Line
Mile Post 83
Central Vermont Railroad
Limit of Slopes
P.I. 592+20.3 Δ - 12°12' LT.
Boundary Markers (2)
P.I. 599+74.6 Δ - 9°07'43" LT.
Boundary Marker
Spot on Ledge
1/3" CMP
R.O.W. FENCE
P.P. R/W Line
Inv. El. 457.7
Inv. El. 458.3
Woods
Sta. 598+00 Rt - Lt
6" x 166' Perf. A.C.C.G.M. Underdrain S.H. at Outlet
Boundary Marker 70.5' from D.I. 01+58.28
B.M. #99-C El. 527.00
42" Oak
Sta. 603+43 - Skew Rt. 63°
New 54" x 362' #8 Gage A.C.C.G.M.P. (Unstrutted) 33.6'
Cradle Headwall - 227' Lt. on Skew
Cradle Headwall - 139' Rt. on Skew
1-54" x 20' #8 Gage A.C.C.G.M.P. Elbow
1-54" x 20' #8 Gage A.C.C.G.M.P. Elbow
Wire Collars on all Joints
2 Steel Marker Posts
#54 CENTMONT CORPORATION
Inv. El. 435.8
Inv. El. 331.0
Inv. El. 499.0
Inv. El. 329.9
Inv. El. 445.7
10" Oak
8" W. Birch
15" Birch Stump
F.O.C. 593+00.00
Survey Base Line ℄ of Construction
Inv. El. 336.4
8" Oak
Spot on Ledge
Inv. El. 337.5
18" Oak
WHITE BIRCH (3)
12" Oak
B.M. #97-A El. 572.38
B.M. #96-A El. 526.55
Inv. El. 512.0
WHITE BIRCHES (3)
B.M. #94-G El. 511.80
B.M. #94-H El. 563.13
B.M. #94-I El. 594.78
B.M. #95-A El. 557.49
B.M. #94-H-1 El. 570.86
12" Pop.
B.M. #99-B El. 534.51
#3 TOWN OF MIDDLESEX
R.O.W. FENCE
Boundary Marker
Note: for Summary of Landscape Materials Project I-89-2(5) Sheet #28 Contract #1 Sheet #26

Sta. 593+05 - Skew Rt. 75° New 30" x 316' E.S.B.C.P. Straight Headwall - 126' Rt. on Skew Cradle Headwall - 105' Lt. on Skew 12 Concrete Pipe Anchors 2 Steel Marker Posts

Sta. 593+58 Lt After 62° 30' Lt New 18" x 74' A.C.C.G.M.P. Cradle Headwall - 83' Lt. Standard R.C. Drop Inlet - 5' Lt. Steel Marker Post Paved Median Inlet

Sta. 594+75 - 598+00 Rt. 6" x 328' Perf. A.C.C.G.M. Underdrain C.I. Flushing Basin at Inlet

Sta. 598+26 Rt New 18" x 84' R.C.P. Cradle Headwall - 89' Lt. Standard R.C. Drop Inlet - 5' Lt. Steel Marker Post Paved Median Inlet

Sta. 598+28 to Sta. 604+10 Bituminous Grouted Stone Gutter Item 533

Sta. 598+28 to Sta. 604+00 Special Ditch - Item 103

Sta. 603 Rt New 18" x 60' A.C.C.G.M.P. Cradle Headwall - 89' Lt. Standard R.C. Drop Inlet - 5' Lt. 1 Concrete Pipe Connection Paved Median Inlet Anchor Outlet

B.M. #94-G Sta. 592+70 Rt. S.I.R. - 8" W. Birch Elev. 511.80 - 1' Lt.

B.M. #94-H Sta. 593+97 Rt S.I.R. - 10" Oak Elev. 563.13 - 9' Lt.

B.M. #94-I Sta. 596+65 Rt Spot on Ledge Elev. 594.78 - 12' Lt.

B.M. #95-A Sta. 598+74 Rt S.I.R. - 8" Oak Elev. 557.49 - 6' Lt.

B.M. #96-A Sta. 601+90 Rt S.I.T. 15" Birch Stump Elev. 526.55 - 23' Lt.

B.M. #98 Sta. 596+13 (Trav. Line) Spot on Ledge Elev. 507.14 - 17' Rt. of Rail 205' Lt. ℄

B.M. #99 Sta. 601+00 (Trav. Line) Mile Post 83 Elev. 500.11 - 9' Rt. of Rail 245' Lt. ℄

B.M. #94-H-1 S.I.R. 18" Oak 125' Rt. Sta. 593+85 Elev. 570.86'

B.M. #97-A S.I.R. 12" Oak 120' Rt. Sta. 590+38 Elev. 572.38'

B.M. #99-B S.I.R. 12" Pop. 158' Rt. Sta. 602+53 Elev. 534.51'

B.M. #99-C S.I.T. 42" Oak 106' Lt. Sta. 600+00 Elev. 527.00'

STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

INTERSTATE PROJECT IN THE TOWNS OF
MIDDLESEX — WATERBURY

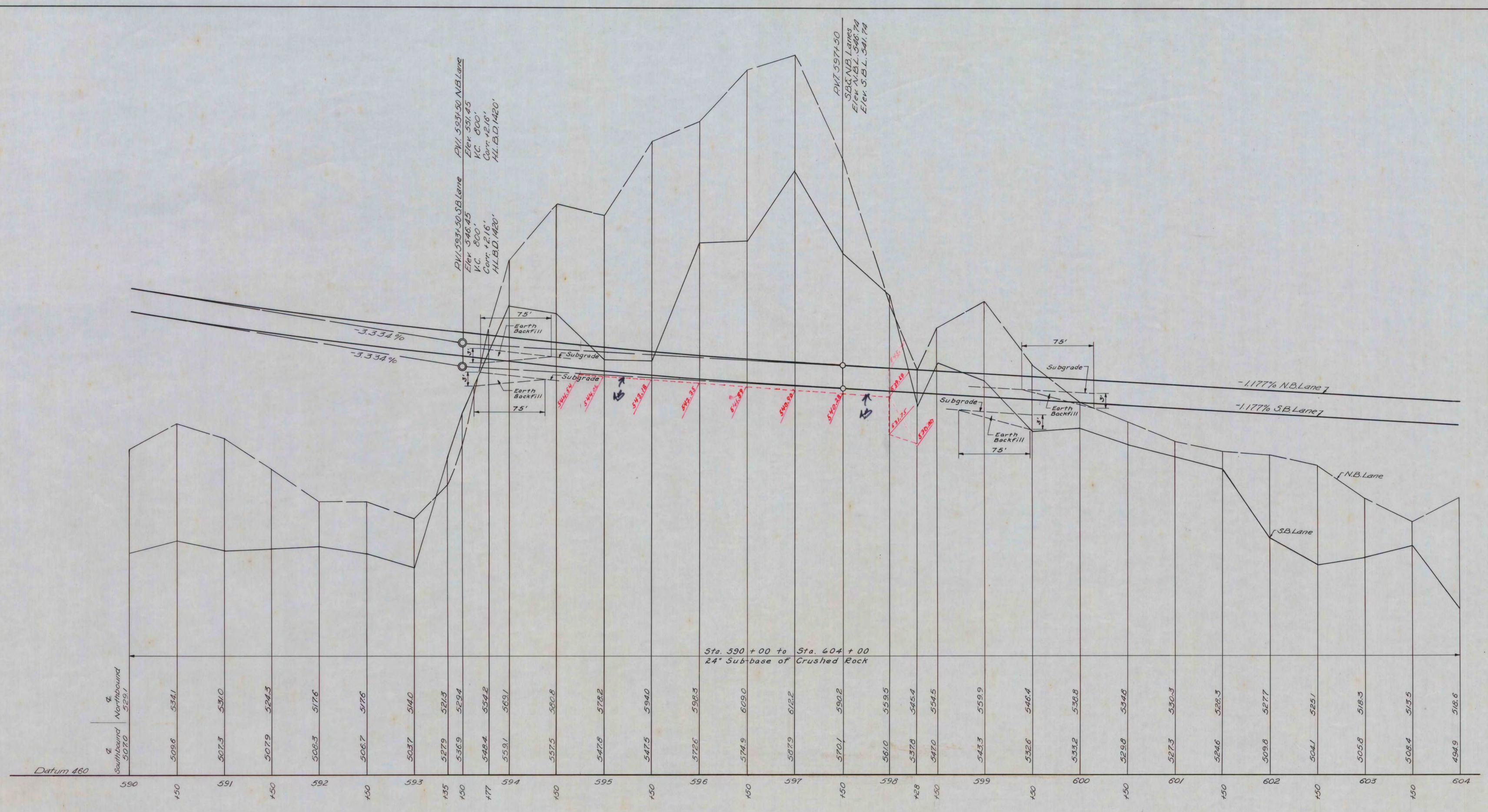
PLAN

WILLIAM H. McFARLAND
ENGINEER
BINGHAMTON, N.Y.

SURVEYED BY | CHECKED BY | SCALE 1" = 50'
DRAWN BY | IN CHARGE | DATE

PROJECT NO. I-89-2(5)
CONTRACT NO. 1

SHEET 34 OF 315



B.M. #94-G Sta. 592 + 70 ℄
S.I.R. - 8" W. Birch
Elev. 511.80 - 1' Lt.

B.M. #94-H Sta. 593 + 97 ℄
S.I.R. - 10" Oak
Elev. 563.13 - 9' Lt.

B.M. #94-I Sta. 596 + 65 ℄
Spot on Ledge
Elev. 594.78 - 12' Lt.

B.M. #95-A Sta. 598 + 74 ℄
S.I.R. - 8" Oak
Elev. 557.49 - 6' Lt.

B.M. #96-A Sta. 601 + 90 ℄
S.I.T. 15" Birch Stump
Elev. 526.35 - 23' Lt.

B.M. #98 Sta. 596 + 13 (Trav. Line)
Spot on Ledge
Elev. 507.14 - 17' Rt. of Rail

B.M. #99 Sta. 601 + 00 (Trav. Line)
Mile Post 83
Elev. 500.11 - 9' Rt. of Rail

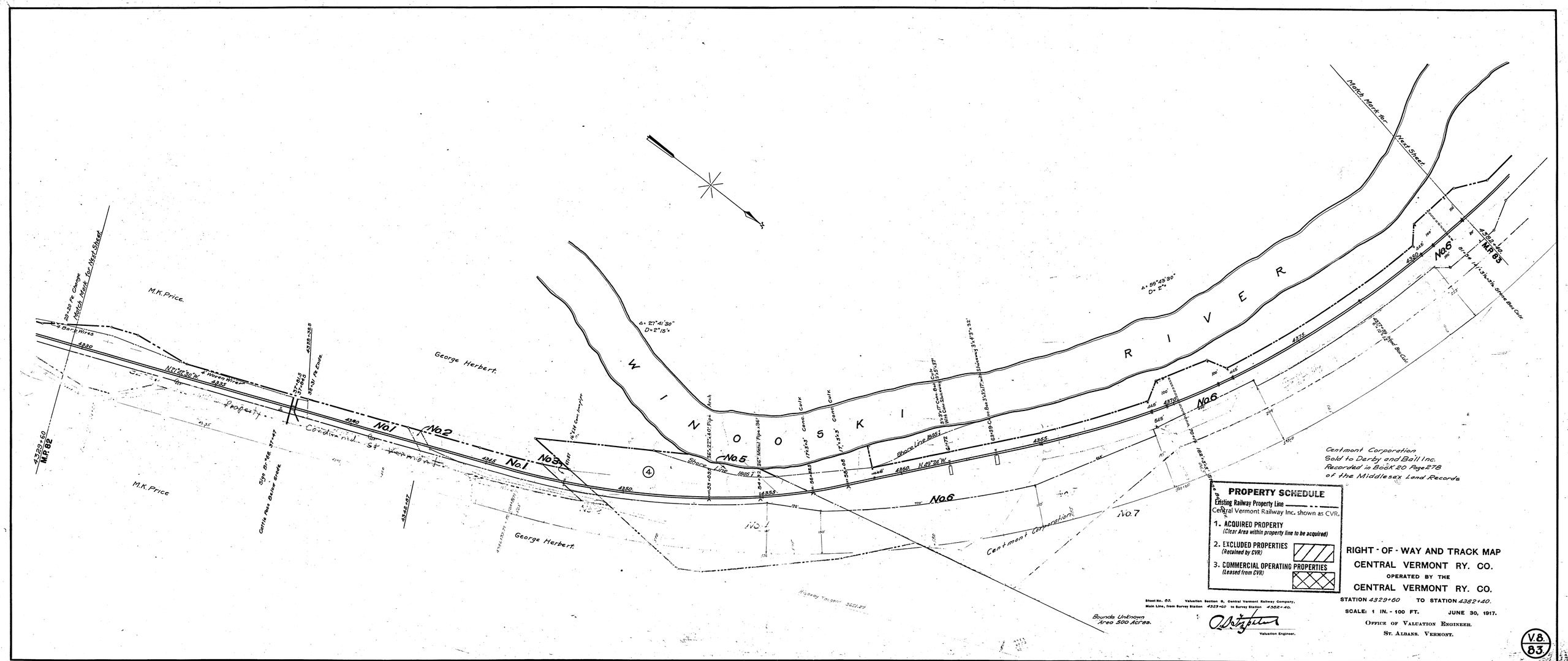
STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

INTERSTATE PROJECT IN THE TOWNS OF
MIDDLESEX – WATERBURY

PROFILE

WILLIAM H. McFARLAND
ENGINEER
BINGHAMTON, N.Y.

SURVEYED BY _____	CHECKED BY _____	SCALE 1" = 50 HOR. 1" = 10 VERT.
DRAWN BY _____	IN CHARGE _____	DATE _____
PROJECT NO. I 89-2(5) CONTRACT NO.	SHEET 35	OF 315


Match Mark for Next Sheet
M.K. Price
George Herbert
W I N O O S K I
R I V E R
Property
Cordwainer St
Vermont
No.1
No.2
No.3
No.4
No.5
No.6
No.7
Centmont Corporation
Sold to Derby and Ball Inc.
Recorded in Book 20 Page 278
of the Middlesex Land Records
Bounds Unknown
Area 500 Acres.
PROPERTY SCHEDULE
Existing Railway Property Line
Central Vermont Railway Inc. shown as CVR.
1. ACQUIRED PROPERTY
(Clear Area within property line to be acquired)
2. EXCLUDED PROPERTIES
(Retained by CVR)
3. COMMERCIAL OPERATING PROPERTIES
(Leased from CVR)
RIGHT - OF - WAY AND TRACK MAP
CENTRAL VERMONT RY. CO.
OPERATED BY THE
CENTRAL VERMONT RY. CO.
STATION 4329+60 TO STATION 4382+40.
SCALE: 1 IN. - 100 FT. JUNE 30, 1917.
OFFICE OF VALUATION ENGINEER.
ST. ALBANS. VERMONT.
Valuation Engineer.
V.8
83.

APPENDIX F: BORING LOGS AND SUBSURFACE PROFILES

60" CGMP

NEW ENGLAND CENTRAL RAILROAD

UT

B-4

B-3

72" CGMP

B-1

B-2

B-6

RANGE OF POSSIBLE R.O.W. BOUNDS.
ACTUAL BOUNDS UNKNOWN. THERE IS
INSUFFICIENT INFORMATION AT THIS TIME
TO LOCATE THE EXACT LOCATION.

OHW

B-5

WINOOSKI RIVER

• LOCATIONS OF I-89 NORTH AND SOUTHBOUND
ARE APPROXIMATE AND NOT TO SCALE.

DRAFT

NOT FOR CONSTRUCTION

SCALE 1" = 20'-0"

20 0 20

NAD 83 (2011)
NAVD 88 (GEOID 12A)
FB 73

Vanasse Hangen Brustlin, Inc.

PROJECT NAME: MIDDLESEX	
PROJECT NUMBER: IM 089-2(49)	
FILE NAME: 57669bor.dgn	PLOT DATE: 5/23/2014
PROJECT LEADER: M.A. COLGAN	DRAWN BY: A.J. GOUDREAU
DESIGNED BY: A.J. GOUDREAU	CHECKED BY: J.J. WESTCOTT
BORING LAYOUT	SHEET 1 OF 1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-1
SHEET 1 of 3
DATE STARTED: 3/12/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661129.99 ft E 1588175.50 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 46.5 ft 3/13/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

Top of Well Elevation: 506.3 ft

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S1: 0.0 ft - 2.0 ft, A-1-b, Medium brown, moist, very dense (frozen), fine to coarse SAND and GRAVEL, some silt, trace organics and pieces of rock fill, (GM), (FILL), Rec. = 1.3 ft		32-51-30-9 (81)				
2.5		S2: 2.0 ft - 4.0 ft, A-1-b, Gray and red brown, dry, medium dense, fine to coarse SAND and GRAVEL, (GM), (FILL), Rec. = 0.5 ft		7-17-11-5 (28)				
5.0		S3: 4.0 ft - 6.0 ft, Loose, no recovery - broken gravel in spoon tip, Rec. = 0.0 ft		1-2-4-1 (6)				
7.5		S4: 6.0 ft - 8.0 ft, Very loose, no recovery - broken gravel in spoon tip, Rec. = 0.0 ft		2-1-1-1 (2)				
		S5: 8.0 ft - 10.0 ft, A-2-4, Olive brown, moist, very loose, fine to coarse SAND, some silt, little gravel, trace clay, (SM), (FILL), Rec. = 0.6 ft		3-2-2-2 (4)	16.5	23.2	49.4	27.4
10.0		S6: 10.0 ft - 12.0 ft, Loose, no recovery - gravel in spoon tip, Rec. = 0.0 ft		4-3-2-3 (5)				
12.5		S7: 12.0 ft - 14.0 ft, A-2-4, Olive brown, moist, loose, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.3 ft		4-3-2-2 (5)				
15.0		S8: 14.0 ft - 16.0 ft, A-2-4, Olive brown, moist, loose, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.5 ft		5-3-2-3 (5)				
17.5		S9: 16.0 ft - 18.0 ft, Loose, no recovery, Rec. = 0.0 ft		5-3-4-3 (7)				
		S10: 18.0 ft - 20.0 ft, Loose, no recovery, redrove spoon with new catcher, no recovery, Rec. = 0.0 ft		7-4-3-4 (7)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-1
SHEET 2 of 3
DATE STARTED: 3/12/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661129.99 ft E 1588175.50 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 46.5 ft 3/13/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S11: 20.0 ft - 22.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), no recovery, redrove spoon, Rec. = 0.9 ft		7-6-5-5 (11)	14.2	31.9	39.8	28.3
22.5		S12: 22.0 ft - 24.0 ft, A-2-4, Olive brown, moist, loose, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), Rec. = 0.5 ft		5-3-4-3 (7)				
25.0		S13: 24.0 ft - 26.0 ft, A-2-4, Olive brown, moist, loose, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.7 ft		8-4-3-3 (7)				
27.5		S14: 26.0 ft - 28.0 ft, A-2-4, Olive brown, moist, loose, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.8 ft		7-4-5-6 (9)	13.5	32.6	37.8	29.6
		S15: 28.0 ft - 30.0 ft, A-2-4, Olive brown, moist, loose, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.3 ft		6-4-4-5 (8)				
30.0		S16: 30.0 ft - 32.0 ft, A-2-4, Olive brown, moist, medium dense, silty fine to medium SAND, trace coarse sand, trace gravel, (SM), (FILL), Rec. = 0.6 ft		8-5-6-7 (11)				
32.5		S17: 32.0 ft - 34.0 ft, A-2-4, Olive brown, moist, medium dense, silty fine to medium SAND, trace coarse sand, trace gravel, (SM), (FILL), Rec. = 0.2 ft		7-5-6-8 (11)				
35.0		S18: 34.0 ft - 36.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little gravel, trace coarse sand, trace clay, (SM), (FILL), Rec. = 0.6 ft		9-5-5-6 (10)	15.4	21.5	45.7	32.8
37.5		S19: 36.0 ft - 38.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little gravel, trace coarse sand, trace clay, (SM), (FILL), Rec. = 0.8 ft		9-6-6-9 (12)				
		S20: 38.0 ft - 40.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little gravel, trace clay, trace coarse sand, (SM), (FILL), Rec. = 1.0 ft		6-6-6-6 (12)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-1
SHEET 3 of 3
DATE STARTED: 3/12/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661129.99 ft E 1588175.50 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 46.5 ft 3/13/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE) / RUN	M.C. (%) / REC (%)	AASHTO GRAVEL (%) / RQD (%)	AASHTO SAND (%) / Drill Rate (min/ft)	AASHTO FINES (%) / UCS (psi)
		S21: 40.0 ft - 42.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little gravel, little coarse sand, trace clay, (SM), (FILL), Rec. = 0.9 ft		10-7-8-10 (15)				
42.5		S22: 42.0 ft - 44.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little gravel, little coarse sand, trace clay, (SM), (FILL), Rec. = 0.5 ft		8-6-5-5 (11)				
45.0		S23: 44.0 ft - 46.0 ft, A-1-b, Olive brown, moist, very loose, mixed chunks of medium plastic clay and gravel - suspected wash, (GM), (FILL), Rec. = 0.2 ft		5-1-2-4 (3)				
		S24: 46.0 ft - 47.2 ft, A-1-b, Top 0.6': Olive brown and gray brown, moist, mixed medium plastic clay, fine to medium sand, and gravel, (GM), (FILL). Bottom 0.4': Weathered bedrock., Rec. = 1.0 ft		6-10-50/0.2 (R)	Top of Bedrock @ 46.6 ft 14.4	55.7	19.3	25.0
47.5		47.2 ft - 58.0 ft, Medium dark gray (N4), medium gray (N5), dark greenish gray (5GY 4/1 and 5G 4/1), white (N9), and light brown (5YR 5/6) to dark yellowish orange (10YR 6/6) (weathered), very fine to fine grained, fresh to slightly weathered, weak (R2) to medium weak (R3), strongly foliated, non-calcareous to slightly calcareous, quartz-serecite-chlorite PHYLLITE, with abundant quartz veins 0.1 to 3 cm wide, parallel to foliation. [STOWE FORMATION] R1: NX, Rec. = 4.5 ft		R1	90	78		
50.0								
52.5		R2: NX, Rec. = 5.0 ft		R2	100	74		
55.0								
57.5								

Hole stopped @ 58.0 ft

Notes:
- A temporary observation well was installed to a depth of 48.0 feet.
- Reported groundwater depth measured the day after well installation.

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-2
SHEET 1 of 4
DATE STARTED: 3/07/14
DATE COMPLETED: 3/12/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.11 ft E 1588233.14 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 504.78 ft
GROUNDWATER DEPTH: 49.4 ft 3/11/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

Top of Well Elevation: 507.38 ft

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		0.0 ft - 5.5 ft, Advanced to 8' with air hammer. Rock fill encountered to 5.5'.						
2.5								
5.0								
7.5								
		S1: 8.0 ft - 10.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, little gravel, trace clay, (SM), (FILL), Rec. = 0.6 ft		3-4-3-3 (7)	21.1	25.3	25.2	49.5
10.0		S2: 10.0 ft - 12.0 ft, A-4, Olive brown, wet, loose, SILT, some sand, trace gravel, trace clay, (SM), (FILL), Rec. = 0.5 ft		4-3-3-4 (6)				
12.5		S3: 12.0 ft - 14.0 ft, A-4, Olive brown, moist, loose, sandy SILT, trace gravel, (ML), (FILL), Rec. = 0.6 ft		3-4-3-3 (7)	22.6	12.6	26.6	60.8
15.0		S4: 14.0 ft - 16.0 ft, A-4, Olive brown, wet, very loose, sandy SILT, trace clay, (ML), (FILL). PP = 0.0, 0.0, 0.0 tsf, Rec. = 0.9 ft		3-2-2-2 (4)				
17.5		S5: 16.0 ft - 18.0 ft, A-4, Olive brown, moist, loose, sandy SILT with layers of medium plasticity clayey silt, (ML), (FILL). PP = 0.0, 0.3, 0.5 tsf, Tv = 1.0 tsf, Rec. = 0.8 ft		2-3-3-4 (6)	21.3	15.0	29.8	55.2
		S6: 18.0 ft - 20.0 ft, A-4, Olive brown, moist, very loose, SILT, little sand, trace gravel, trace clay, (ML), (FILL). PP = 0.4, 0.4, 0.3 tsf, Rec. = 1.1 ft		2-2-2-3 (4)	26.0	7.2	12.4	80.4

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-2
SHEET 2 of 4
DATE STARTED: 3/07/14
DATE COMPLETED: 3/12/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.11 ft E 1588233.14 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 504.78 ft
GROUNDWATER DEPTH: 49.4 ft 3/11/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		20.0 ft - 21.0 ft, V1 at 21.0 ft = 24 in-lb (3772 psf) V2 at 22.0 ft = 42, 24 in-lb (6602, 3772 psf)						
		S7: 21.0 ft - 23.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace clay, (ML), (FILL). PP = 0.0, 0.0 tsf , Tv = 0.5, 0.6 tsf, Rec. = 1.1 ft		2-3-3-4 (6)				
22.5		S8: 23.0 ft - 25.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, trace clay, (ML), (FILL), Rec. = 1.6 ft		4-3-5-5 (8)				
25.0		S9: 25.0 ft - 27.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, trace clay, (ML), (FILL), Rec. = 0.7 ft		4-4-4-4 (8)				
27.5		S10: 27.0 ft - 29.0 ft, A-4, Olive brown, wet, medium dense, sandy SILT, suspected wash, (ML), (FILL), Rec. = 0.1 ft		6-7-6-6 (13)				
30.0		S11: 29.0 ft - 31.0 ft, A-4, Olive brown with layers of rust brown, moist, loose, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 0.9 ft		1-3-4-5 (7)				
32.5		S12: 31.0 ft - 33.0 ft, A-4, Olive brown with layers of rust brown, moist, loose, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 1.0 ft		6-5-5-7 (10)				
		S13: 33.0 ft - 35.0 ft, A-4, Olive brown mixed with rust brown, wet, loose, SILT, little sand, trace gravel, suspected wash, (ML), (FILL), Rec. = 0.7 ft		4-4-6-7 (10)	23.1	12.5	18.1	69.4
35.0		S14: 35.0 ft - 37.0 ft, A-4, Olive brown mixed with rust brown, moist, medium dense, SILT, little sand, little gravel, (ML), (FILL), Rec. = 1.1 ft		8-8-6-5 (14)				
37.5		S15: 37.0 ft - 39.0 ft, A-4, Olive brown mixed with rust brown, moist, medium dense, SILT, little sand, little gravel, trace organics (twig), (ML), (FILL), Rec. = 0.9 ft		6-6-7-7 (13)				
		S16: 39.0 ft - 41.0 ft, Medium dense, no recovery, Rec. = 0.0 ft		8-9-9-10 (18)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-2
SHEET 3 of 4
DATE STARTED: 3/07/14
DATE COMPLETED: 3/12/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.11 ft E 1588233.14 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 504.78 ft
GROUNDWATER DEPTH: 49.4 ft 3/11/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE) / RUN	M.C. (%) / REC (%)	AASHTO GRAVEL (%) / RQD (%)	AASHTO SAND (%) / Drill Rate (min/ft)	AASHTO FINES (%) / UCS (psi)
		S17: 41.0 ft - 43.0 ft, Medium dense, no recovery, possibly pushing cobble (FILL), Rec. = 0.0 ft		15-12-9-10 (21)				
42.5		S18: 43.0 ft - 45.0 ft, A-2-4, Olive brown with rust brown staining, moist, medium dense, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.9 ft		5-5-6-5 (11)				
45.0		S19: 45.0 ft - 47.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.7 ft		9-7-11-12 (18)	11.2	23.3	46.4	30.3
47.5		S20: 47.0 ft - 49.0 ft, A-2-4, Olive brown, moist, wet, medium dense, fine to medium SAND, some silt, little coarse sand, some gravel, (SM), (FILL), Rec. = 0.2 ft		9-9-7-9 (16)				
50.0		S21: 49.0 ft - 51.0 ft, Loose, no recovery, Rec. = 0.0 ft		6-5-3-8 (8)				
52.5		S22: 51.0 ft - 53.0 ft, Medium dense, no recovery, possibly pushing cobble, (FILL), Rec. = 0.0 ft		29-17-10-8 (27)				
		S23: 53.0 ft - 55.0 ft, Wood, Rec. = 0.6 ft		9-11-11-17 (22)				
55.0		S24: 55.0 ft - 57.0 ft, Top 0.2': Wood Middle 0.6': Weathered phyllite cobble. Bottom 0.2': Brown, moist, medium SAND (ALLUVIUM), Rec. = 1.0 ft		13-33-31-19 (64)				
57.5		S25: 57.0 ft - 59.0 ft, A-2-4, Layered brown and gray with dark brown staining, moist, medium dense, fine to medium SAND, little silt, (SP-SM), (ALLUVIUM), Rec. = 1.0 ft		5-5-9-7 (14)	22.3	0.8	87.5	11.7
		S26: 59.0 ft - 59.2 ft, Weathered bedrock in spoon tip, Rec. = 0.0 ft		50/0.2 (R)	Top of Bedrock @ 59.2 ft			

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-2
SHEET 4 of 4
DATE STARTED: 3/07/14
DATE COMPLETED: 3/12/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.11 ft E 1588233.14 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 504.78 ft
GROUNDWATER DEPTH: 49.4 ft 3/11/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	RUN	REC (%)	RQD (%)	Drill Rate (min/ft)	UCS (psi)
62.5		59.2 ft - 75.0 ft, Dark gray (N3), medium dark gray (N4), and white (N9), very fine to fine grained, fresh to slightly weathered, weak (R2) to medium weak (R3), strongly foliated, non-calcareous to slightly calcareous, quartz-sericite-chlorite PHYLLITE, discontinuities close to very widely spaced, parallel with foliation, dipping 75-90 degrees, with quartz veins parallel with foliation 0.1 to 4 cm wide. [STOWE FORMATION] R1: NX, Rec. = 4.8 ft		R1	96	50		
65.0		R2: NX, Rec. = 5.1 ft		R2	102	100		
70.0		R3: NX, Rec. = 4.8 ft		R3	96	96		
75.0		Hole stopped @ 75.0 ft						
77.5								

Notes:
- Inclinometer installed to 65.5 ft upon completion of boring.
- Reported groundwater depth measured with bottom of casing at 53 ft after stabilizing overnight.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-3
SHEET 1 of 4
DATE STARTED: 3/14/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.20 ft E 1588237.05 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.08 ft
GROUNDWATER DEPTH: 58.0 ft 3/18/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description) Top of Well Elevation: 507.89 ft	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		0.0 ft - 5.5 ft, Rock fill encountered to 5.5'.						
2.5								
5.0								
7.5								
10.0		S1: 10.0 ft - 12.0 ft, Loose, no recovery, Rec. = 0.0 ft		4-2-3-3 (5)				
12.5		S2: 12.0 ft - 14.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 0.4 ft		6-3-4-6 (7)				
15.0		S3: 15.0 ft - 17.0 ft, Loose, no recovery, Rec. = 0.0 ft		3-4-4-4 (8)				
17.5		S4: 17.0 ft - 19.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 0.6 ft		3-4-4-3 (8)				

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-3
SHEET 2 of 4
DATE STARTED: 3/14/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.20 ft E 1588237.05 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.08 ft
GROUNDWATER DEPTH: 58.0 ft 3/18/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S5: 20.0 ft - 22.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 0.1 ft		4-3-4-4 (7)				
22.5		S6: 22.0 ft - 24.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 0.5 ft		3-4-5-3 (9)	20.5	22.7	11.7	65.6
25.0		S7: 25.0 ft - 27.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, trace gravel, trace organics (root), (ML), (FILL), Rec. = 0.8 ft		3-4-4-4 (8)				
27.5		S8: 27.0 ft - 29.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, (ML), (FILL), Rec. = 0.6 ft		3-5-5-5 (10)				
30.0		S9: 30.0 ft - 32.0 ft, Medium dense, no recovery, Rec. = 0.0 ft		8-5-6-7 (11)				
32.5		S10: 32.0 ft - 34.0 ft, Medium dense, no recovery, gravel in spoon tip, Rec. = 0.0 ft		11-7-7-8 (14)				
35.0		S11: 34.0 ft - 36.0 ft, A-4, Olive brown, moist, loose, silty fine SAND, little medium to coarse sand, trace gravel, (SM), (FILL), Rec. = 1.0 ft		5-4-5-4 (9)				
37.5		S12: 36.0 ft - 38.0 ft, A-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.7 ft		6-5-7-4 (12)	13.5	19.0	44.5	36.5
		S13: 38.0 ft - 40.0 ft, A-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, trace gravel, (SM), (FILL), Rec. = 0.7 ft		9-6-6-9 (12)				

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AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-3
SHEET 3 of 4
DATE STARTED: 3/14/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.20 ft E 1588237.05 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.08 ft
GROUNDWATER DEPTH: 58.0 ft 3/18/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S14: 40.0 ft - 42.0 ft, A-1-b, Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, little gravel, (SM), (FILL), Rec. = 0.9 ft		9-6-6-7 (12)	11.0	29.8	45.5	24.7
42.5								
45.0		S15: 44.0 ft - 46.0 ft, A-2-4, Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, trace gravel, (SM), (FILL), Rec. = 0.7 ft		8-5-8-8 (13)	16.1	14.2	53.3	32.5
47.5								
50.0		S16: 49.0 ft - 51.0 ft, A-2-4, Top 0.6': Olive brown, moist, medium dense, fine to medium SAND, some silt, little coarse sand, trace gravel, (SM), (FILL). Bottom 0.2': Weathered phyllite cobble, Rec. = 0.8 ft		15-9-8-28 (17)				
52.5								
55.0		S17: 54.0 ft - 56.0 ft, A-2-4, Gray, moist, loose, layered silty fine SAND with SAND and SILT, little medium to coarse sand, trace gravel, trace organics (wood), (SM), (ALLUVIUM), Rec. = 1.2 ft		6-4-3-6 (7)				
57.5					Top of Bedrock @ 58.8 ft			

Hole stopped @ 59.0 ft

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-3
SHEET 4 of 4
DATE STARTED: 3/14/14
DATE COMPLETED: 3/17/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661099.20 ft E 1588237.05 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.08 ft
GROUNDWATER DEPTH: 58.0 ft 3/18/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)

Notes:
- A permanent observation well was installed to a depth of 59.0 feet.
- Reported groundwater depth measured the day after well installation.

62.5
65.0
67.5
70.0
72.5
75.0
77.5

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-4
SHEET 1 of 4
DATE STARTED: 3/18/14
DATE COMPLETED: 3/19/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661122.22 ft E 1588249.71 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 506.16 ft
GROUNDWATER DEPTH: 39.6 ft 3/19/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S1: 0.0 ft - 2.0 ft, A-1-b, Medium dense, low recovery - snow and gravel blocking spoon tip, (FILL), Rec. = 0.1 ft	1-3-12-10 (15)				
2.5		S2: 2.0 ft - 4.0 ft, A-1-b, Brown and gray, moist, medium dense, fine to coarse SAND and GRAVEL, (GM), (FILL), Rec. = 0.5 ft	11-6-5-4 (11)				
5.0		S3: 4.0 ft - 6.0 ft, A-4, Olive brown, moist, medium dense, fine to medium SAND, little silt, some gravel, (SM), (FILL), Rec. = 0.7 ft	9-6-6-6 (12)				
7.5		S4: 6.0 ft - 8.0 ft, A-4, Top 0.9': Olive brown, moist, medium dense, fine to medium SAND, little silt, some gravel, (SM), (FILL) Bottom 0.1': Olive brown, moist, medium dense, SILT, some sand, trace organics (root), (ML), (FILL), Rec. = 1.0 ft	9-5-8-7 (13)				
		S5: 8.0 ft - 10.0 ft, A-4, Olive brown, moist, medium dense, silty fine sand mixed with clean gravel, suspected wash, (ML), (FILL), Rec. = 0.1 ft	9-7-6-5 (13)				
10.0		S6: 10.0 ft - 12.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, little gravel, (ML), (FILL), Rec. = 0.8 ft	9-5-3-4 (8)	13.0	17.6	27.1	55.3
12.5		S7: 12.0 ft - 14.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, trace gravel, (ML), (FILL), Rec. = 0.3 ft	10-5-4-5 (9)				
15.0		S8: 14.0 ft - 16.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, trace gravel, (ML), (FILL), Rec. = 0.7 ft	4-3-4-3 (7)				
17.5		S9: 16.0 ft - 18.0 ft, Loose, no recovery, Rec. = 0.0 ft	7-4-3-4 (7)				
		S10: 18.0 ft - 20.0 ft, Loose, no recovery, gravel stuck in spoon tip, Rec. = 0.0 ft	3-4-4-3 (8)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-4
SHEET 2 of 4
DATE STARTED: 3/18/14
DATE COMPLETED: 3/19/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661122.22 ft E 1588249.71 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 506.16 ft
GROUNDWATER DEPTH: 39.6 ft 3/19/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S11: 20.0 ft - 22.0 ft, A-4, Olive brown, moist, medium dense, SILT, little sand, trace gravel, (ML), (FILL), Rec. = 0.9 ft	5-5-7-6 (12)				
22.5		S12: 22.0 ft - 24.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, (ML), (FILL), Rec. = 1.1 ft	4-3-2-4 (5)	29.8	2.9	11.2	85.9
25.0		S13: 24.0 ft - 26.0 ft, A-4, Olive brown, moist, loose, sandy SILT, trace gravel, (ML), (FILL), Rec. = 1.0 ft	3-4-4-3 (8)				
27.5		S14: 26.0 ft - 28.0 ft, A-4, Olive brown, moist, medium dense, sandy SILT, trace gravel, (ML), (FILL), Rec. = 1.1 ft	5-6-5-7 (11)	18.1	2.0	41.0	57.0
		S15: 28.0 ft - 30.0 ft, A-4, Olive brown, moist, loose, SILT, little sand, bottom 0.1' frozen, (ML), (FILL), Rec. = 0.9 ft	2-3-4-16 (7)				
30.0		S16: 30.0 ft - 32.0 ft, A-4, Olive brown, moist, SILT, little sand, entire sample frozen, (ML), (FILL), Rec. = 2.0 ft	22-28-31-30 (59)				
32.5		S17: 32.0 ft - 34.0 ft, A-4, Olive brown, moist, SILT, little sand, entire sample frozen, (ML), (FILL), Rec. = 2.0 ft	22-34-39-26 (73)	34.0	3.3	14.0	82.7
35.0		S18: 34.0 ft - 36.0 ft, A-4, Olive brown, moist, medium dense, SILT, little sand, trace gravel, top 0.3' frozen, (ML), (FILL), Rec. = 1.1 ft	16-5-6-4 (11)				
37.5		S19: 36.0 ft - 38.0 ft, A-4, Olive brown, moist, medium dense, silty fine SAND, trace medium to coarse sand, trace gravel, (ML), (FILL), Rec. = 0.5 ft	7-5-6-6 (11)				
		S20: 38.0 ft - 40.0 ft, A-4, Olive brown, moist, loose, silty fine SAND, trace medium to coarse sand, trace gravel, (ML), (FILL), Rec. = 0.7 ft	4-3-3-4 (6)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-4
SHEET 3 of 4
DATE STARTED: 3/18/14
DATE COMPLETED: 3/19/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661122.22 ft E 1588249.71 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 506.16 ft
GROUNDWATER DEPTH: 39.6 ft 3/19/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	BLOWS PER 6 IN (N VALUE) / RUN	M.C. (%) / REC (%)	AASHTO GRAVEL (%) / RQD (%)	AASHTO SAND (%) / Drill Rate (min/ft)	AASHTO FINES (%) / UCS (psi)
		S21: 40.0 ft - 42.0 ft, A-4, Olive brown, moist, loose, silty fine SAND, trace medium to coarse sand, trace gravel, (ML), (FILL), Rec. = 0.9 ft	6-3-3-5 (6)	20.1	10.7	37.5	51.8
42.5		S22: 42.0 ft - 44.0 ft, A-4, Olive brown, wet, very loose, silty fine SAND, trace medium to coarse sand, trace gravel, (ML), (FILL), Rec. = 0.5 ft	2-1-WOR-WOR (0)				
45.0		S23: 44.0 ft - 46.0 ft, A-4, Olive brown, wet, loose, silty fine SAND, some medium to coarse sand, little gravel, (ML), (FILL), Rec. = 0.4 ft	2-4-4-5 (8)				
		S24: 46.0 ft - 47.1 ft, A-4, Olive brown with rust staining in bottom 0.4', moist, compact, fine to coarse SAND and GRAVEL, some silt, broken rock in spoon tip, suspected cobble, (ML), (FILL), Rec. = 1.1 ft	11-11-50/0.1 (R)				
47.5		47.1 ft - 48.0 ft, Cobble					
		S25: 48.0 ft - 50.0 ft, A-2-4, Gray, wet, silty fine to medium SAND, trace coarse sand, trace gravel, (SM), (ALLUVIUM), Rec. = 0.4 ft	8-3-5-6 (8)				
50.0		S26: 50.0 ft - 50.9 ft, A-2-4, Top 0.6': Gray, wet, silty fine to medium SAND, trace coarse sand, trace gravel, (SM), (ALLUVIUM). Bottom 0.3': Light gray, moist, cemented silty fine to medium SAND, possible weathered cobble, Rec. = 0.9 ft	8-50/0.5 (R)				
		S27: 52.0 ft - 52.4 ft, A-2-4, Light gray silty sand mixed with broken rock, (SM), (ALLUVIUM), Rec. = 0.3 ft	50/0.4 (R)	Top of Bedrock @ 52.4 ft			
52.5		52.4 ft - 63.0 ft, Medium gray (N5), medium light gray (N6), and white (N9), very fine grained, fresh to highly weathered, extremely weak (R0) to medium weak (R3), strongly foliated, non-calcareous, quartz-sericite-chlorite PHYLLITE, discontinuities extremely closely spaced to moderately spaced, dipping 75-90 degrees, with abundant quartz veins up to 1 cm wide parallel with foliation. [STOWE FORMATION] R1: NX, Rec. = 1.4 ft	R1	28	16		
55.0							
57.5		R2: NX, Rec. = 4.8 ft	R2	96	90		

STATE OF VERMONT
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MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-4
SHEET 4 of 4
DATE STARTED: 3/18/14
DATE COMPLETED: 3/19/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661122.22 ft E 1588249.71 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 506.16 ft
GROUNDWATER DEPTH: 39.6 ft 3/19/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	RUN	REC (%)	RQD (%)	Drill Rate (min/ft)	UCS (psi)
62.5							
		Hole stopped @ 63.0 ft					
65.0							
67.5							
70.0							
72.5							
75.0							
77.5							

Notes:
- Borehole backfilled with cement-bentonite grout.
- Reported groundwater depth measured after rock coring with casing set into bedrock.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-5
SHEET 1 of 2
DATE STARTED: 3/20/14
DATE COMPLETED: 3/20/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 660999.04 ft E 1588121.54 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 434.57 ft
GROUNDWATER DEPTH: 7.4 ft 3/21/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

Top of Well Elevation: 438.25 ft

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S1: 0.0 ft - 2.0 ft, A-1-b, Gray brown, moist, medium dense (frozen), silty fine to medium SAND, (SM), (ALLUVIUM), Rec. = 0.4 ft		1-11-9-2 (20)				
2.5		S2: 2.0 ft - 4.0 ft, A-1-a, Medium brown, moist, loose, fine to medium SAND, some silt, trace coarse sand, trace gravel, trace organics (roots), (SM), (ALLUVIUM), Rec. = 0.7 ft		2-2-2-3 (4)				
5.0		S3: 4.0 ft - 6.0 ft, A-1-b, Medium brown, wet, medium dense, fine to medium SAND, little silt, some coarse sand, some gravel, trace organics (wood), (SM), (ALLUVIUM), Rec. = 0.7 ft		7-5-5-3 (10)	16.7	43.7	41.2	15.1
7.5		S4: 6.0 ft - 8.0 ft, A-1-b, Medium brown, wet, loose, fine to coarse SAND, little silt, some gravel, trace organics (wood), (SM), (ALLUVIUM), Rec. = 0.8 ft		5-5-5-3 (10)				
10.0		S5: 8.0 ft - 10.0 ft, A-1-b, Medium brown and gray, medium dense, wet, fine to coarse SAND and GRAVEL, little silt, (SP-SM), (ALLUVIUM), Rec. = 0.6 ft		7-11-18-15 (29)				
		S6: 10.0 ft - 12.0 ft, A-1-b, Medium brown and gray, medium dense, wet, fine to coarse SAND and GRAVEL, little silt, (SP-SM), (ALLUVIUM), Rec. = 1.1 ft		15-10-10-11 (20)	11.0	55.7	32.7	11.6
12.5		S7: 12.0 ft - 14.0 ft, A-1-b, Brown gray with rust staining, wet, medium dense, fine to coarse SAND, some gravel, little silt, (SP-SM), (ALLUVIUM), Rec. = 1.0 ft		22-11-10-10 (21)				
15.0		S8: 14.0 ft - 16.0 ft, A-1-b, Brown gray, wet, medium dense, fine to coarse SAND, little silt, some gravel, (SP-SM), (ALLUVIUM), Rec. = 0.8 ft		11-8-6-5 (14)				
17.5		S9: 16.0 ft - 18.0 ft, A-1-b, Brown gray, wet, loose, fine to medium SAND, trace silt, trace coarse sand, (SM), (ALLUVIUM), Rec. = 1.0 ft		4-3-3-5 (6)				
		S10: 18.0 ft - 20.0 ft, A-1-b, Brown gray with rust staining, wet, loose, fine to medium SAND, little silt, trace coarse sand, trace gravel, (SM), (ALLUVIUM), Rec. = 0.9 ft		8-4-4-6 (8)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-5
SHEET 2 of 2
DATE STARTED: 3/20/14
DATE COMPLETED: 3/20/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 660999.04 ft E 1588121.54 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 434.57 ft
GROUNDWATER DEPTH: 7.4 ft 3/21/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	WELL DIAGRAM	BLOWS PER 6 IN (N VALUE) / RUN	M.C. (%) / REC (%)	AASHTO GRAVEL (%) / RQD (%)	AASHTO SAND (%) / Drill Rate (min/ft)	AASHTO FINES (%) / UCS (psi)
		S11: 20.0 ft - 22.0 ft, A-1-b, Top 0.6': Brown gray with rust staining, wet, medium dense, fine to medium SAND, little silt, trace coarse sand, trace gravel, (SM), (ALLUVIUM). Bottom 0.7': Layered rust, brown, and gray, moist, medium dense, fine to coarse SAND and GRAVEL, some silt, (SP-SM), (ALLUVIUM), Rec. = 1.3 ft		12-18-13-10 (31)	19.2	14.7	75.0	10.3
22.5		S12: 22.0 ft - 24.0 ft, A-1-b, Brown gray, wet, loose, layered sandy GRAVEL, clean fine to coarse SAND, and sandy CLAY, (SP-SM), (ALLUVIUM), Rec. = 0.8 ft		14-4-2-5 (6)				
25.0		S13: 24.0 ft - 26.0 ft, A-1-b, Brown gray with rust staining, wet, medium dense, fine to medium SAND, litlle silt, trace coarse sand, trace gravel, (SM), (ALLUVIUM), Rec. = 0.7 ft		7-7-6-6 (13)				
		S14: 26.0 ft - 27.5 ft, A-1-b, Brown gray with rust staining, wet, medium dense, fine to medium SAND, little silt, trace coarse sand, bedrock in spoon tip, (SM), (ALLUVIUM), Rec. = 1.7 ft		5-7-7-50/0.4 (14)				
27.5					Top of Bedrock @ 27.5 ft			
30.0		27.5 ft - 36.5 ft, Dark greenish gray (5GY 4/1), greenish black (5GY 2/1), medium gray (N5), and white (N9), very fine to fine grained, weak (R2) to medium weak (R3), fresh to slightly weathered, strongly foliated, non-calcareous to very slightly calcareous, quartz-sericite-chlorite PHYLLITE, discontinuities parallel with foliation, dipping 75-90 degrees, moderately to widely spaced, with abundant quartz veins 1-2 cm wide parallel with foliation. [STOWE FORMATION] R1: NX, Rec. = 4.7 ft		R1	94	100		
32.5								
35.0		R2: NX, Rec. = 2.8 ft		R2	112	100		
37.5		Hole stopped @ 36.5 ft						

Notes:
- A temporary observation well was installed to a depth of 28.0 feet.
- Reported groundwater depth measured with casing set into bedrock after stabilizing overnight.

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-6
SHEET 1 of 4
DATE STARTED: 3/04/14
DATE COMPLETED: 3/06/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661081.24 ft E 1588270.27 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 45.0 ft 3/06/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S1: 0.0 ft - 2.0 ft, A-1-b, Top 1.0': Light brown, moist, very dense (frozen), fine to medium SAND and pieces of rock fill, (GM), (FILL) Bottom 0.4': Dark brown, moist, very dense (frozen), SAND and GRAVEL, some organics (roots), (GM), (FILL), Rec. = 1.4 ft	42-81-63-17 (144)				
2.5		S2: 2.0 ft - 4.0 ft, A-1-b, Medium brown, moist, medium dense, fine to coarse SAND and GRAVEL, (GM), (FILL), Rec. = 1.2 ft	16-9-5-4 (14)				
5.0		S3: 4.0 ft - 6.0 ft, A-4, Olive brown, moist, medium dense, SILT, some sand, trace gravel, layers of clay, (ML), (FILL), Rec. = 1.1 ft	11-6-6-4 (12)	21.7	7.6	20.5	71.9
7.5		S4: 6.0 ft - 8.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, (ML), (FILL), Rec. = 0.4 ft	6-3-3-3 (6)				
		S5: 8.0 ft - 10.0 ft, Loose, no recovery, Rec. = 0.0 ft	7-3-3-3 (6)				
10.0		S6: 10.0 ft - 12.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, little gravel, (ML), (FILL), Rec. = 0.9 ft	3-3-2-2 (5)				
12.5		S7: 12.0 ft - 14.0 ft, A-4, Olive brown, moist, loose, SILT, some sand, little gravel, (ML), (FILL), Rec. = 0.6 ft	6-2-2-3 (4)				
		S8: 14.0 ft - 16.0 ft, Loose, no recovery, Rec. = 0.0 ft	7-5-5-5 (10)				
15.0		S9: 16.0 ft - 18.0 ft, A-4, Olive brown, moist, loose, silty fine to coarse SAND, little gravel, (SM), (FILL), Rec. = 0.6 ft	9-3-4-4 (7)				
17.5		S10: 18.0 ft - 20.0 ft, A-4, Olive brown, moist, loose, silty fine to medium SAND, little coarse sand, trace gravel, (SM), (FILL), Rec. = 0.4 ft	6-3-3-4 (6)				

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-6
SHEET 2 of 4
DATE STARTED: 3/04/14
DATE COMPLETED: 3/06/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661081.24 ft E 1588270.27 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 45.0 ft 3/06/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	BLOWS PER 6 IN (N VALUE)	M.C. (%)	AASHTO GRAVEL (%)	AASHTO SAND (%)	AASHTO FINES (%)
		S11: 20.0 ft - 22.0 ft, Loose, no recovery - gravel stuck in spoon tip, Rec. = 0.0 ft	6-5-5-6 (10)				
22.5		S12: 22.0 ft - 24.0 ft, Medium dense, clean coarse sand and gravel - suspected wash, Rec. = 0.7 ft	8-7-5-5 (12)				
25.0		S13: 24.0 ft - 26.0 ft, Loose, no recovery, Rec. = 0.0 ft	4-4-4-4 (8)				
27.5		S14: 26.0 ft - 28.0 ft, A-2-4, Olive brown, moist, loose, silty fine to medium SAND, little coarse sand, trace gravel, orange-brown stain 0.2' from bottom of spoon, (SM), (FILL), Rec. = 0.9 ft	9-4-4-4 (8)	14.0	33.0	42.0	25.0
		S15: 28.0 ft - 30.0 ft, A-2-4, Olive brown, moist, loose, silty fine to medium SAND, little coarse sand, trace gravel, (SM), (FILL), Rec. = 0.2 ft	2-4-4-5 (8)				
30.0		S16: 30.0 ft - 32.0 ft, A-2-4, Olive brown, moist, loose, silty fine to medium SAND, little coarse sand, trace gravel, dark brown stain near bottom of spoon, (SM), (FILL), Rec. = 0.7 ft	5-3-4-6 (7)				
32.5		S17: 32.0 ft - 34.0 ft, A-4, Olive brown, moist, medium dense, silty fine SAND, little medium to coarse sand, trace gravel, (SM), (FILL), Rec. = 0.2 ft	3-6-6-7 (12)				
35.0		S18: 34.0 ft - 36.0 ft, A-4, Olive brown, moist, very loose, silty fine SAND, some medium to coarse sand, trace gravel, (SM), (FILL), Rec. = 0.9 ft	4-3-WOH-WOH (0)	22.1	16.2	43.5	40.3
		S19: 36.0 ft - 36.3 ft, A-4, Olive brown, moist, very loose, silty fine SAND, some medium to coarse sand, trace gravel, trace organics (sticks and roots), (SM), (FILL), Rec. = 0.6 ft	WOR-1-1-3 (2)				
37.5		36.3 ft - 38.0 ft, A-1-b, Medium brown red, moist, very loose, fine SAND, trace medium to coarse sand, trace gravel, (SP-SM), (ALLUVIUM)					
		S20: 38.0 ft - 40.0 ft, Medium dense, no recovery - gravel blocking spoon tip, Rec. = 0.2 ft	14-8-8-7 (16)				

STATE OF VERMONT
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MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-6
SHEET 3 of 4
DATE STARTED: 3/04/14
DATE COMPLETED: 3/06/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661081.24 ft E 1588270.27 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 45.0 ft 3/06/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	BLOWS PER 6 IN (N VALUE) / RUN	M.C. (%) / REC (%)	AASHTO GRAVEL (%) / RQD (%)	AASHTO SAND (%) / Drill Rate (min/ft)	AASHTO FINES (%) / UCS (psi)
		S21: 40.0 ft - 42.0 ft, A-1-b, Gray brown, moist, medium dense, fine to coarse SAND, little silt, trace gravel, (SP-SM), (ALLUVIUM), Rec. = 0.4 ft	16-14-15-20 (29)				
42.5		S22: 42.0 ft - 44.0 ft, A-1-b, Gray brown, moist, medium dense, fine to coarse SAND, little silt, little gravel, (SP-SM), (ALLUVIUM), Rec. = 1.1 ft	18-14-13-15 (27)	9.3	38.3	50.6	11.1
45.0		S23: 44.0 ft - 46.0 ft, A-1-b, Gray brown, moist, medium dense, fine to medium SAND, little coarse sand, trace gravel, rock stuck in spoon tip, (SP-SM), (ALLUVIUM), Rec. = 0.9 ft	6-7-8-20 (15)				
47.5		S24: 46.0 ft - 48.0 ft, A-1-b, Gray brown, moist, medium dense, fine to medium SAND, little coarse sand, trace gravel, rock stuck in spoon tip, (SP-SM), (ALLUVIUM), Rec. = 0.1 ft	19-13-12-14 (25)				
50.0		S25: 48.0 ft - 50.0 ft, A-2-4, Gray brown with layers of medium brown staining, moist, medium dense, fine SAND, little silt, little medium sand, trace coarse sand, (SM), (ALLUVIUM), Rec. = 0.9 ft	13-11-11-10 (22)				
		S26: 50.0 ft - 52.0 ft, A-2-4, Gray brown with layers of medium brown staining, moist, medium dense, fine SAND, little silt, little medium sand, trace coarse sand, lense of medium gravel in middle of spoon, (SM), (ALLUVIUM), Rec. = 1.5 ft	13-13-14-16 (27)				
				Top of Bedrock @ 52.1 ft			
52.5		S27: 52.0 ft - 52.2 ft, A-2-4, Top 0.1': Gray brown with layers of medium brown staining, moist, medium dense, fine SAND, little silt, little medium sand, trace coarse sand, (SM), (ALLUVIUM). Bottom 0.1': Bedrock in spoon tip., Rec. = 0.0 ft	50/0.2 (R)				
		52.2 ft - 63.0 ft, Dark gray (N3), medium dark gray (N4), medium gray (N5), and white (N9), very fine to fine grained, weak (R2) to medium weak (R3), fresh to slightly weathered, strongly foliated, non-calcareous, quartz-sericite-chlorite PHYLLITE, discontinuities parallel with foliation, dipping 65-90 degrees, moderately spaced, with quartz veins 0.1 to 4 cm wide, parallel with foliation. [STOWE FORMATION] R1: NX, Rec. = 5.0 ft	R1	100	86		
55.0							
57.5		R2: NX, Rec. = 4.7 ft	R2	94	82		

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SUBSURFACE INFORMATION

BORING NUMBER: B-6
SHEET 4 of 4
DATE STARTED: 3/04/14
DATE COMPLETED: 3/06/14

PROJECT NAME: Middlesex IM 089-2(49)
SITE NAME: Middlesex NECR Culvert
STATION: -
OFFSET: -
VTSPG: N 661081.24 ft E 1588270.27 ft

PROJECT NUMBER: GAI 130-3003
SITE NUMBER: -
GROUND ELEVATION: 505.79 ft
GROUNDWATER DEPTH: 45.0 ft 3/06/14
PROJECT PIN NUMBER: -

BORING CREW: Atlantic Testing Laboratories
DRILLER: Mark Childs
LOGGER: Noah Chinburg
BORING RIG: CME-850 X

BORING TYPE: WASH BORE
SAMPLE TYPE: Split Spoon
HAMMER TYPE: Automatic
CHECKED BY:

DEPTH (ft)	SYMBOL	CLASSIFICATION OF MATERIALS (Description)	RUN	REC (%)	RQD (%)	Drill Rate (min/ft)	UCS (psi)
62.5							
		Hole stopped @ 63.0 ft					
65.0							
67.5							
70.0							
72.5							
75.0							
77.5							

Notes:
- Borehole backfilled with cement-bentonite grout.
- Reported groundwater depth measured with bottom of casing at 52 ft after stabilizing overnight.
- Lost water in borehole at 32'.
- Spoon dropped approx. 6" past end of S18 sample interval, possible cavity.

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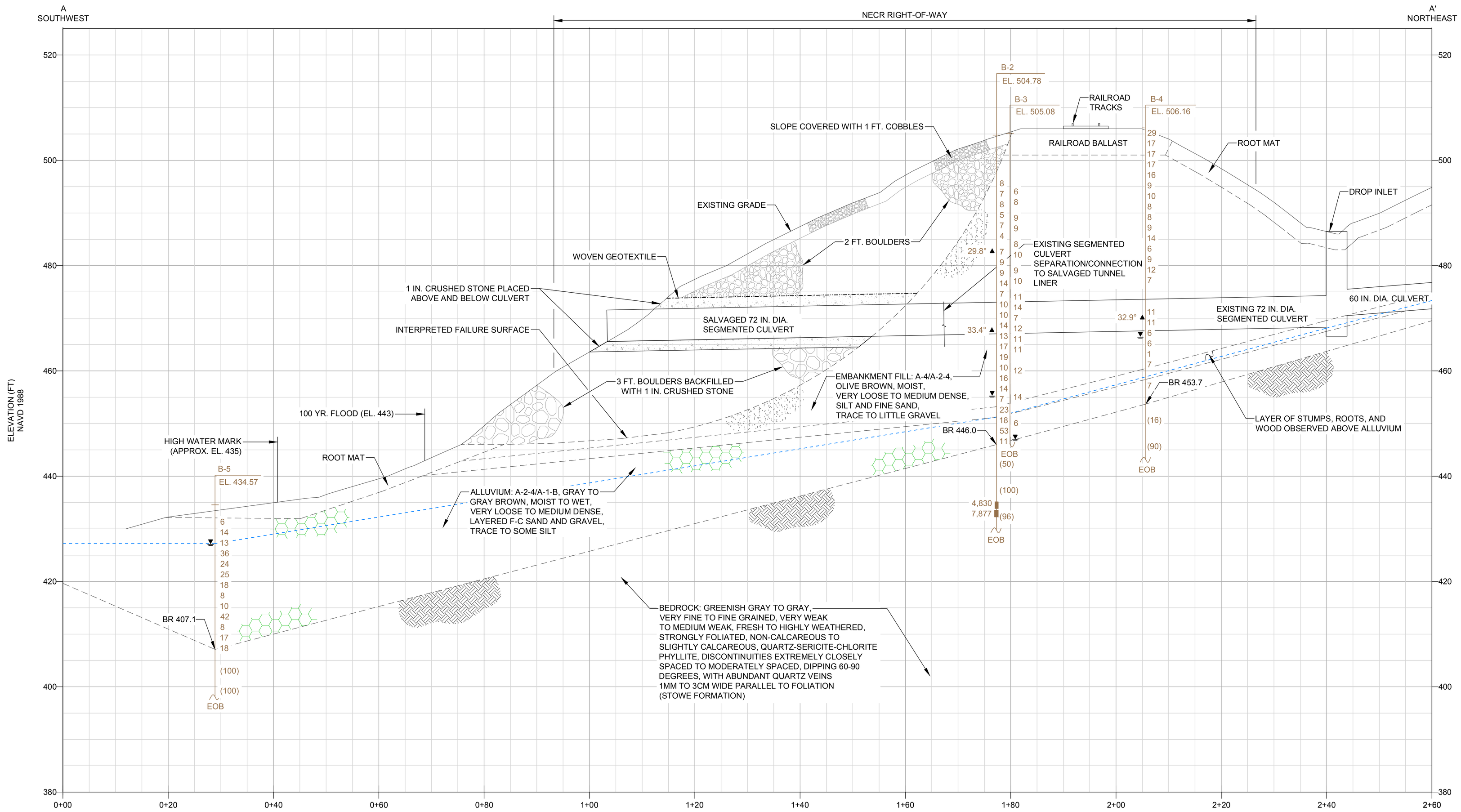

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LEGEND

B-2	= BORING LOCATION
EL. 504.78	= GROUND SURFACE ELEVATION AT TIME OF DRILLING
	= GROUND SURFACE AT BOREHOLE
▼	= OBSERVED GROUNDWATER ELEVATION (FT)
BR168	= BEDROCK ELEVATION (FT MSL)
14	= $(N_1)_{60}$ VALUE
R	= GENERALLY > 50 BLOWS FOR LESS THAN 6" OF PENETRATION
(23)	= ROCK QUALITY DESIGNATION (% RQD)
▲ 37.9°	= FRICTION ANGLE
■ 12,345	= UNCONFINED COMPRESSIVE STRENGTH (PSI)
EOB	= END OF BORING
	= BEDROCK
	= EMBANKMENT FILL
	= ALLUVIUM
	= BOULDERS
- - - -	= ESTIMATED GROUNDWATER LEVEL

NOTES

1. SEE BORING LOCATION PLAN FOR BORING LOCATIONS.
2. SEE BORING LOGS FOR SOIL LITHOLOGIC DESCRIPTIONS.
3. SEE LABORATORY TEST REPORTS FOR COMPLETE LABORATORY DATA.
4. GROUNDWATER ELEVATION ESTIMATES BASED ON MEASUREMENTS TAKEN AT THE TIME OF SUBSURFACE EXPLORATIONS.
5. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED, AND HAVE BEEN DEVELOPED BY INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS AND EXAMPLES. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY. FOR MORE SPECIFIC INFORMATION REFER TO EXPLORATION LOGS.
6. HORIZONTAL DATUM BASED ON VTSPG NAD83 (96). VERTICAL DATUM NAVD88.

0 10 20 30
SCALE FEET

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

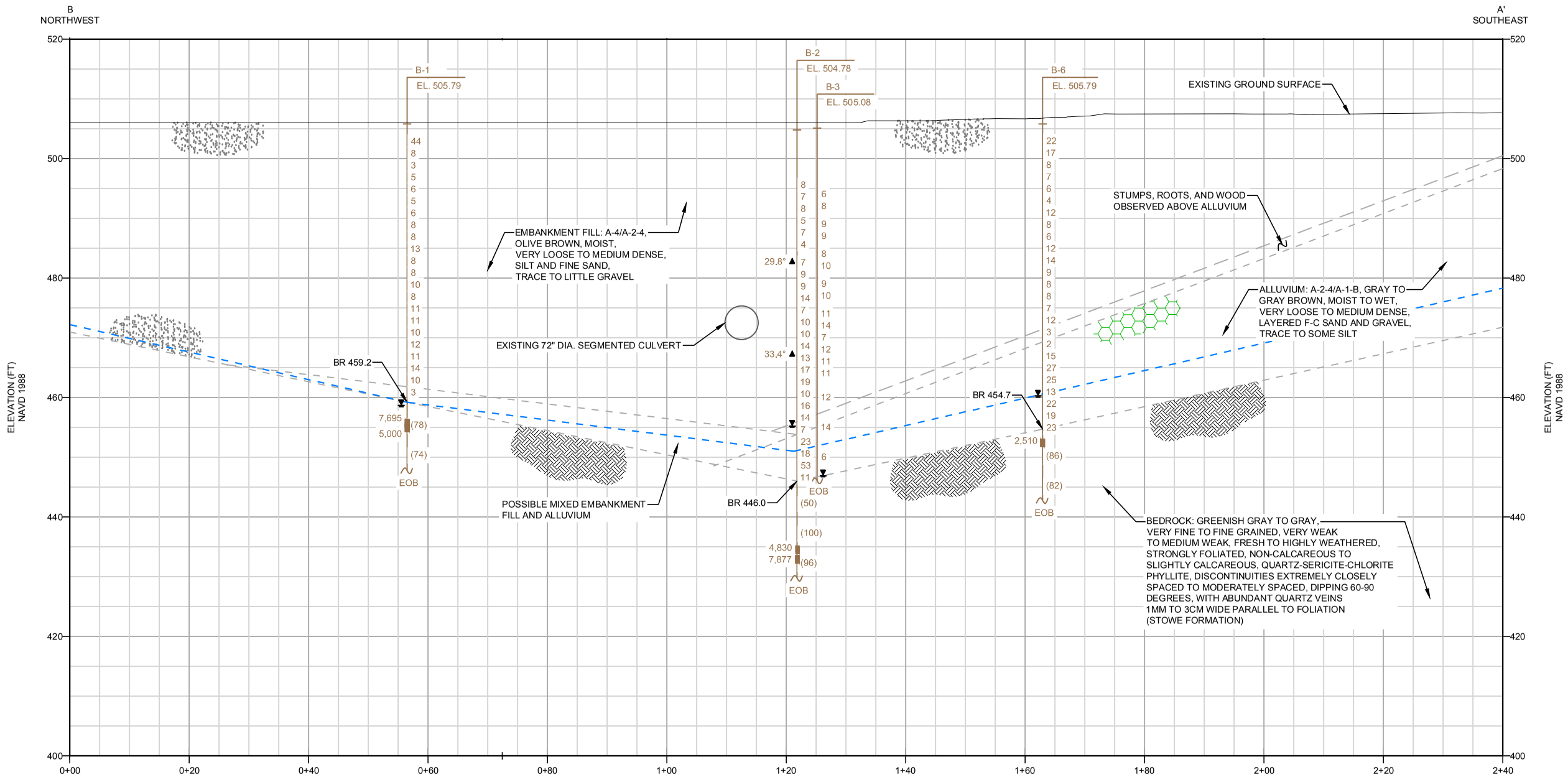
PROJECT
MIDDLESEX NECR CULVERT
CONTRACT NO. IM089-2(49)
MIDDLESEX, VERMONT

TITLE
INTERPRETED SUBSURFACE PROFILE A-A'

Golder Associates

PROJECT No.		130-3003	FILE No.	57669sv
DESIGN	NSC	4/22/14	SCALE	1"=10'
CADD	JRV	4/22/14		
CHECK			2	
REVIEW				

J:\Drawings\2013\130-3003\Production\57669sv.dwg | Layout: SECTION A-A' | Modified: JRViel 05/22/2014 10:29 AM | Plotted: JRViel 05/22/2014



DRAFT

LEGEND

B-2	= BORING LOCATION
EL. 504.78	= GROUND SURFACE ELEVATION AT TIME OF DRILLING
	= GROUND SURFACE AT BOREHOLE
	= OBSERVED GROUNDWATER ELEVATION (FT)
BR168	= BEDROCK ELEVATION (FT MSL)
14	= $(N_1)_{60}$ VALUE
R	= GENERALLY > 50 BLOWS FOR LESS THAN 6" OF PENETRATION
(23)	= ROCK QUALITY DESIGNATION (% RQD)
37.9°	= FRICTION ANGLE
12,345	= UNCONFINED COMPRESSIVE STRENGTH (PSI)
EOB	= END OF BORING

= BEDROCK

= EMBANKMENT FILL

= ALLUVIUM

= BOULDERS

= ESTIMATED GROUNDWATER LEVEL

NOTES

1. SEE BORING LOCATION PLAN FOR BORING LOCATIONS.
2. SEE BORING LOGS FOR SOIL LITHOLOGIC DESCRIPTIONS.
3. SEE LABORATORY TEST REPORTS FOR COMPLETE LABORATORY DATA.
4. GROUNDWATER ELEVATION ESTIMATES BASED ON MEASUREMENTS TAKEN AT THE TIME OF SUBSURFACE EXPLORATIONS.
5. THIS GENERALIZED SUBSURFACE PROFILE IS INTENDED TO CONVEY TRENDS IN SUBSURFACE CONDITIONS. THE BOUNDARIES BETWEEN STRATA ARE APPROXIMATE AND IDEALIZED, AND HAVE BEEN DEVELOPED BY INTERPRETATIONS OF WIDELY SPACED EXPLORATIONS AND EXAMPLES. ACTUAL SOIL AND ROCK TRANSITIONS MAY VARY. FOR MORE SPECIFIC INFORMATION REFER TO EXPLORATION LOGS.
6. HORIZONTAL DATUM BASED ON VTSPG NAD83 (96). VERTICAL DATUM NAVD88.

0 10 20 30
SCALE FEET

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT
MIDDLESEX NECR CULVERT
CONTRACT NO. IM089-2(49)
MIDDLESEX, VERMONT

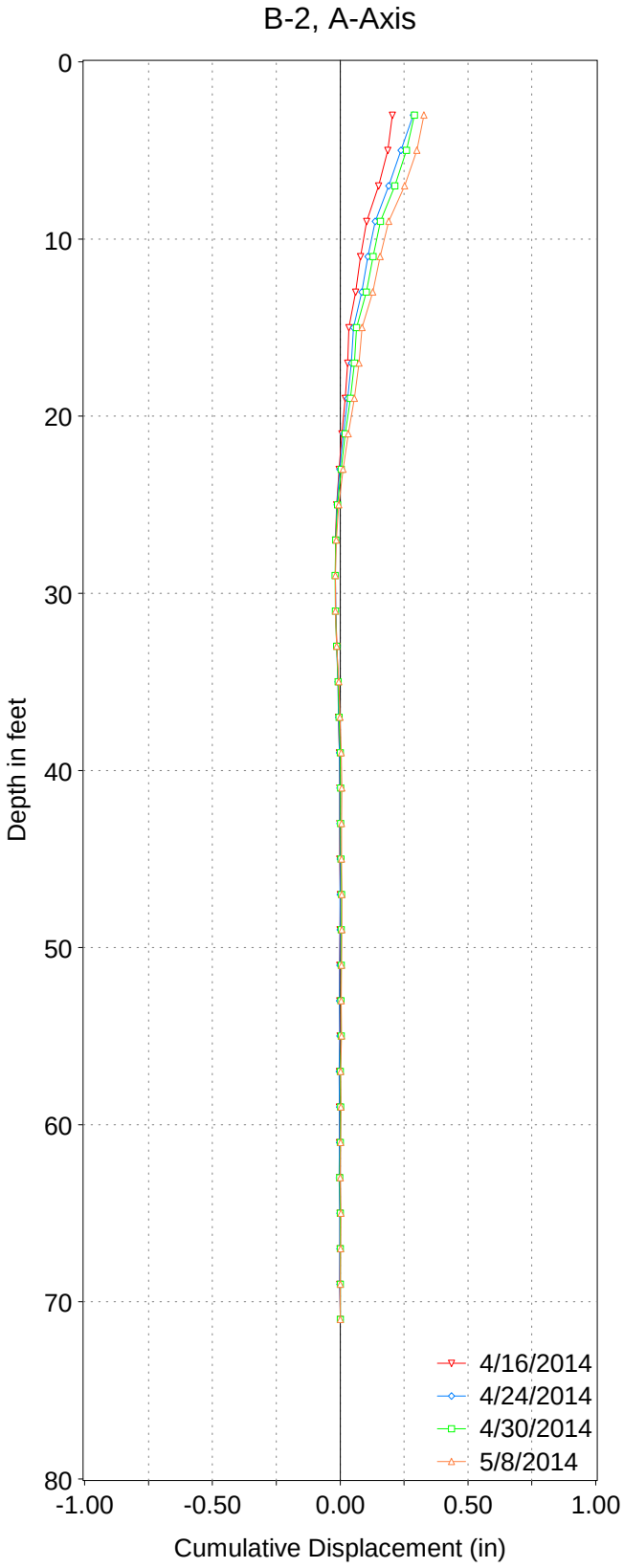
TITLE
INTERPRETED SUBSURFACE PROFILE B-B'

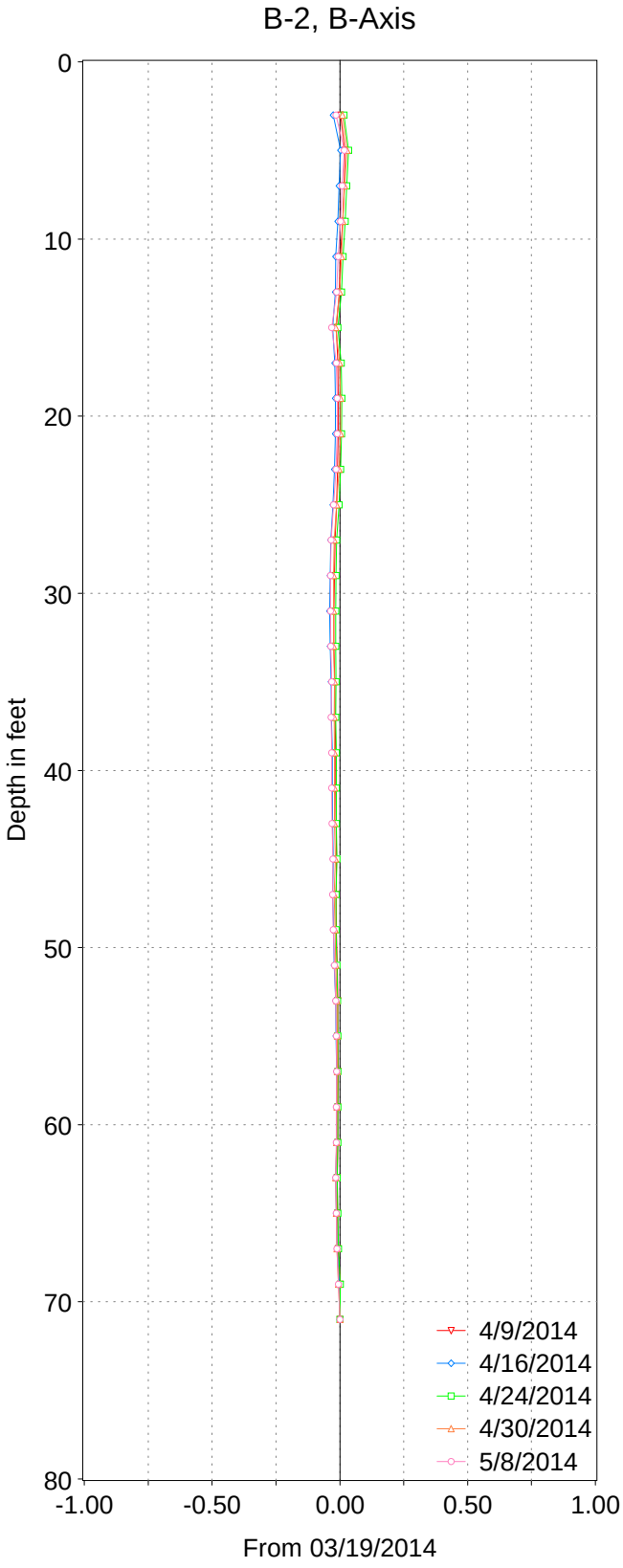
Golder Associates

PROJECT No.		130-3003	FILE No.	57669sv
DESIGN	NSC	4/22/14	SCALE	AS SHOWN
CADD	JRV	4/22/14		
CHECK			3	
REVIEW				

J:\Drawings\2013\130-3003\Production\57669sv.dwg | Layout: SECTION B-B' | Modified: JRV\el 04/22/2014 1:23 PM | Plotted: JRV\el 04/22/2014

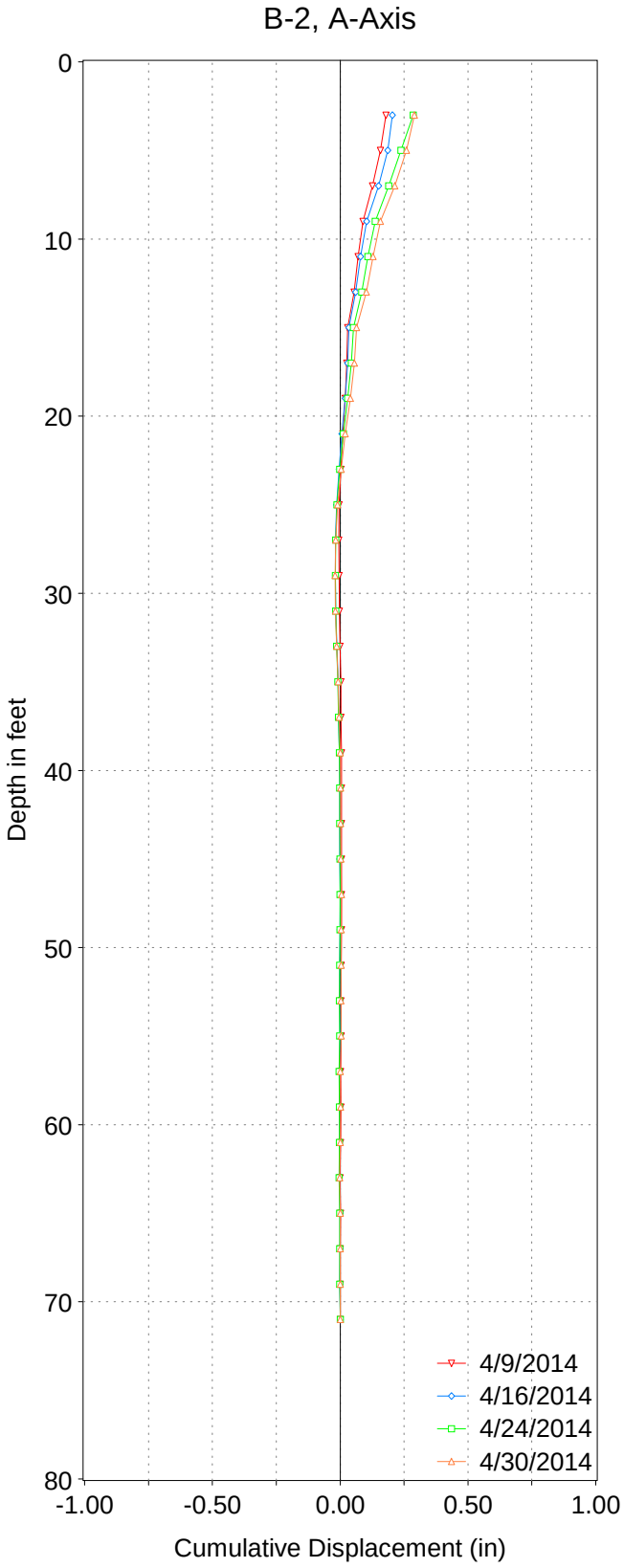
APPENDIX G: INCLINOMETER DATA

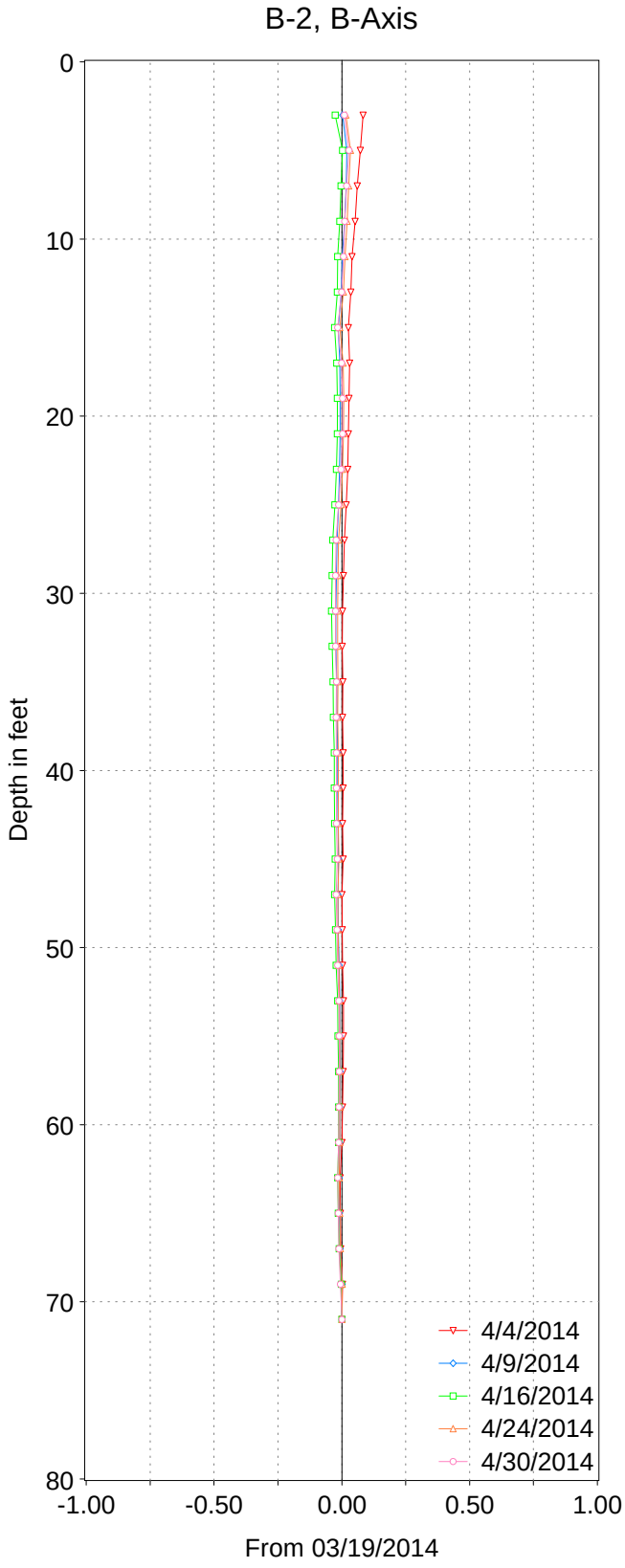




New England Central Railroad (NECR)
Middlesex IM 089--2(49)
Consultant - Golder Assocites In.
Drilled & Installed by Consultants

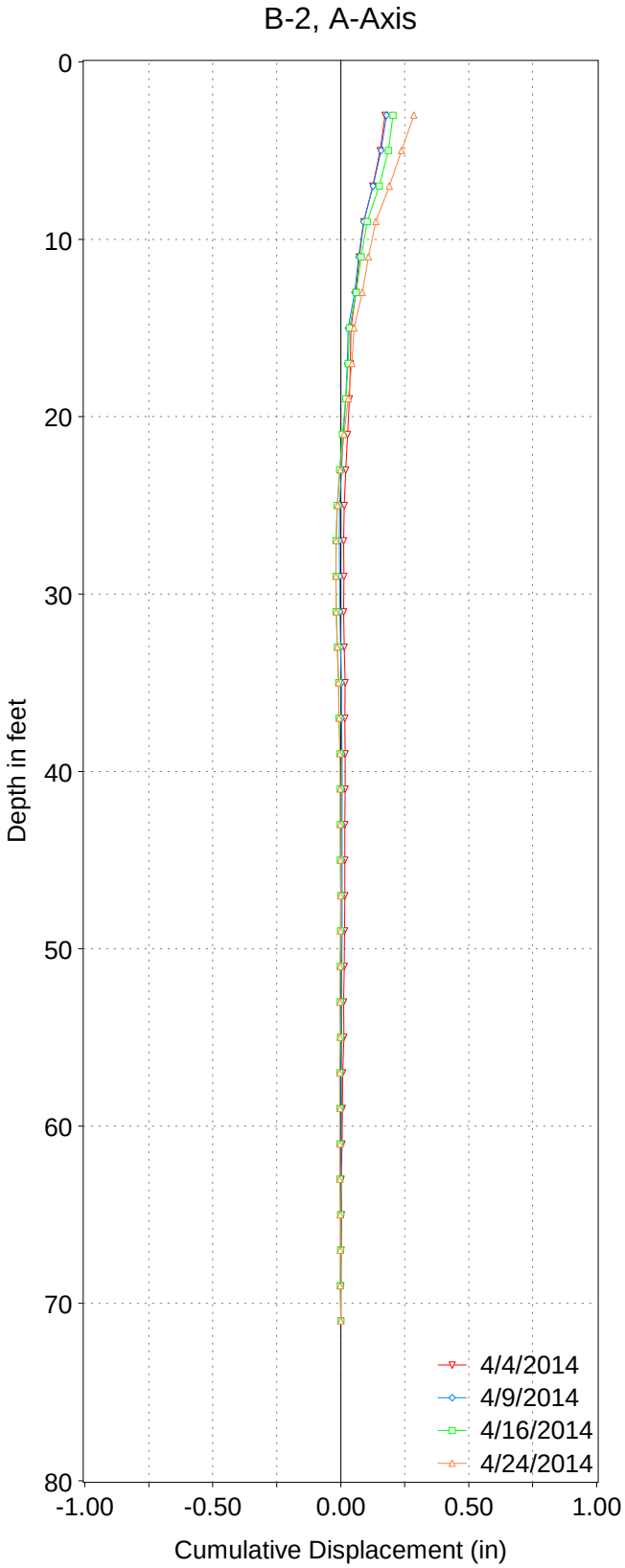
Probe s/n - 26872B
DataMate s/n - 41512
Cable - 75 '

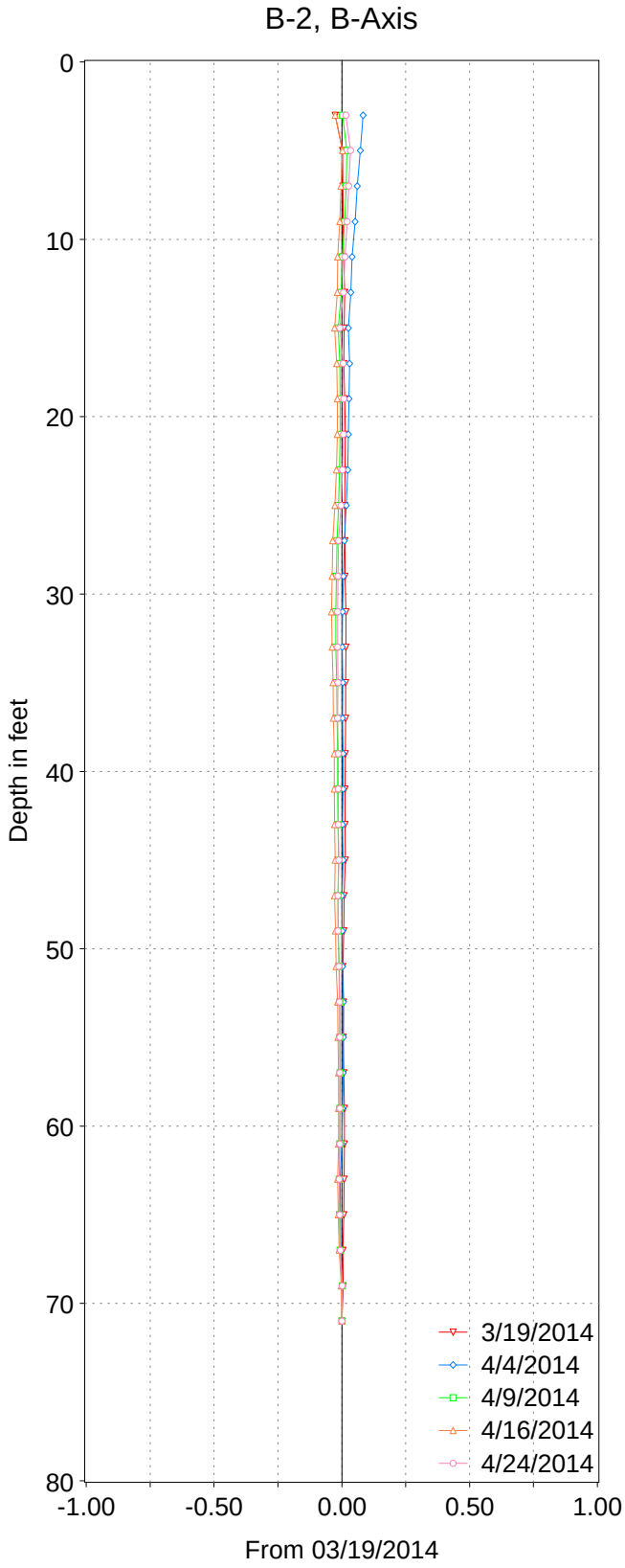




New England Central Railroad (NECR)
Middlesex IM 089--2(49)
Consultant - Golder Assocites In.
Drilled & Installed by Consultants

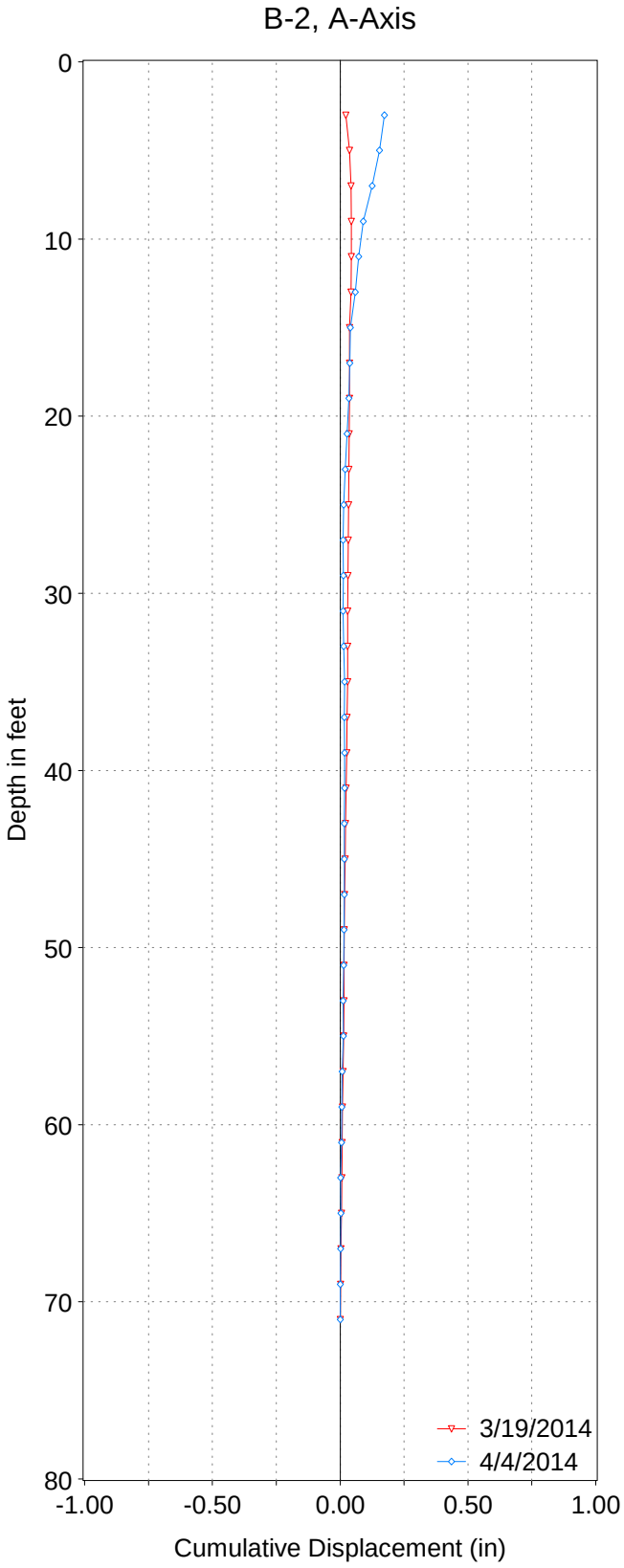
Probe s/n - 26872B
DataMate s/n - 41512
Cable - 75 '

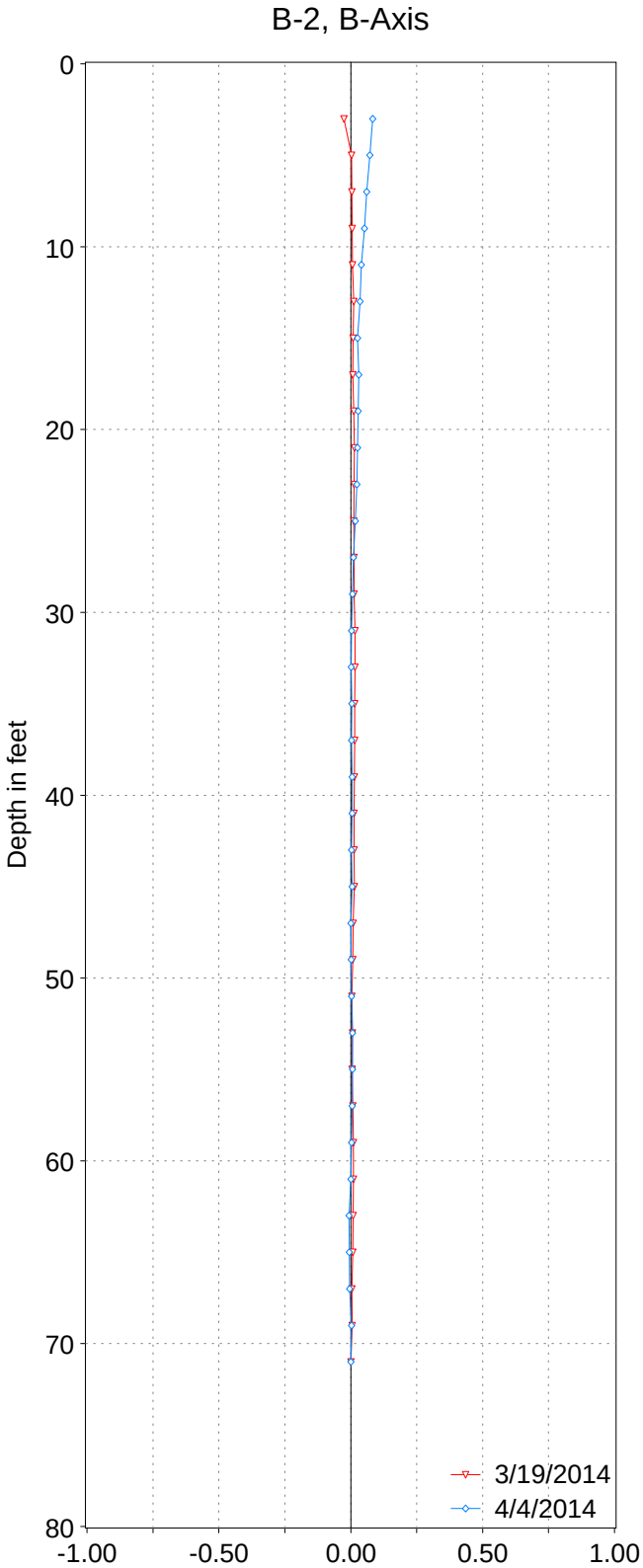




New England Central Railroad (NECR)
Middlesex IM 089--2(49)
Consultant - GEO Design
Drilled & Installed by Consultants

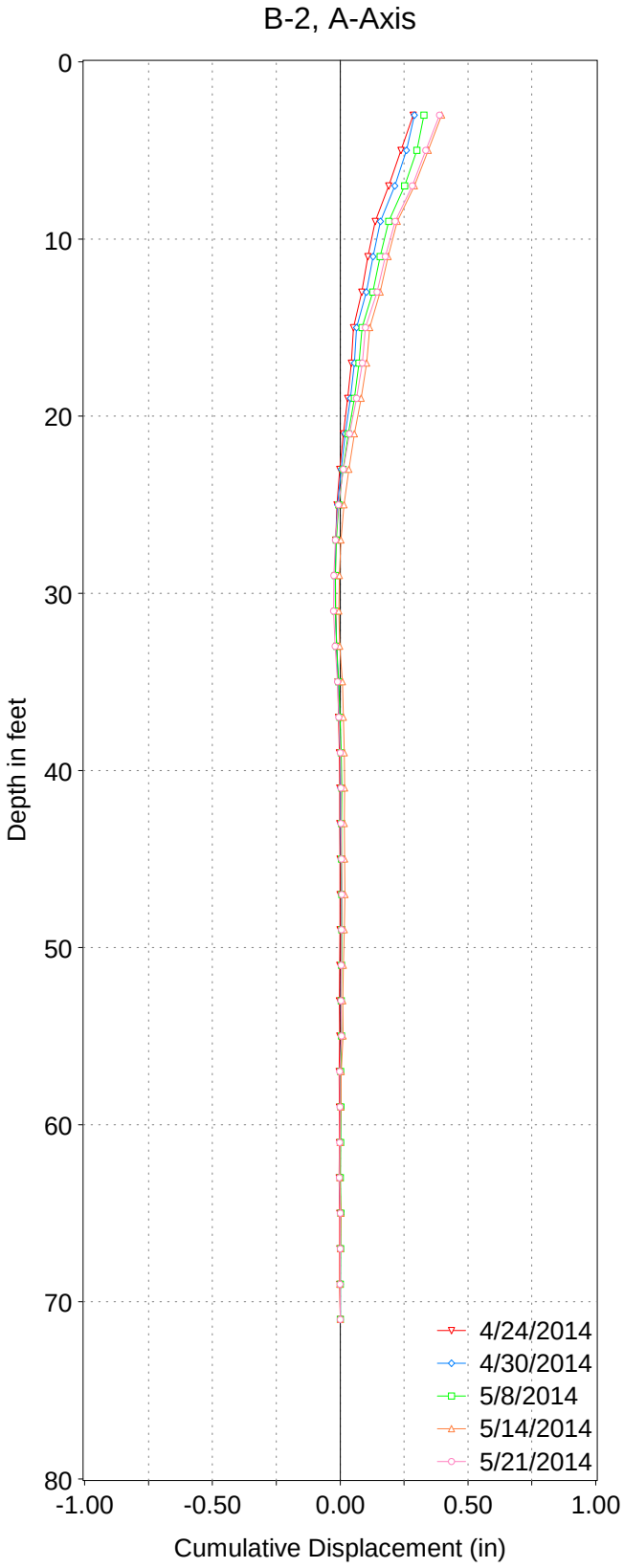
Probe s/n - 26872B
DataMate s/n - 41512
Cable - 75 '

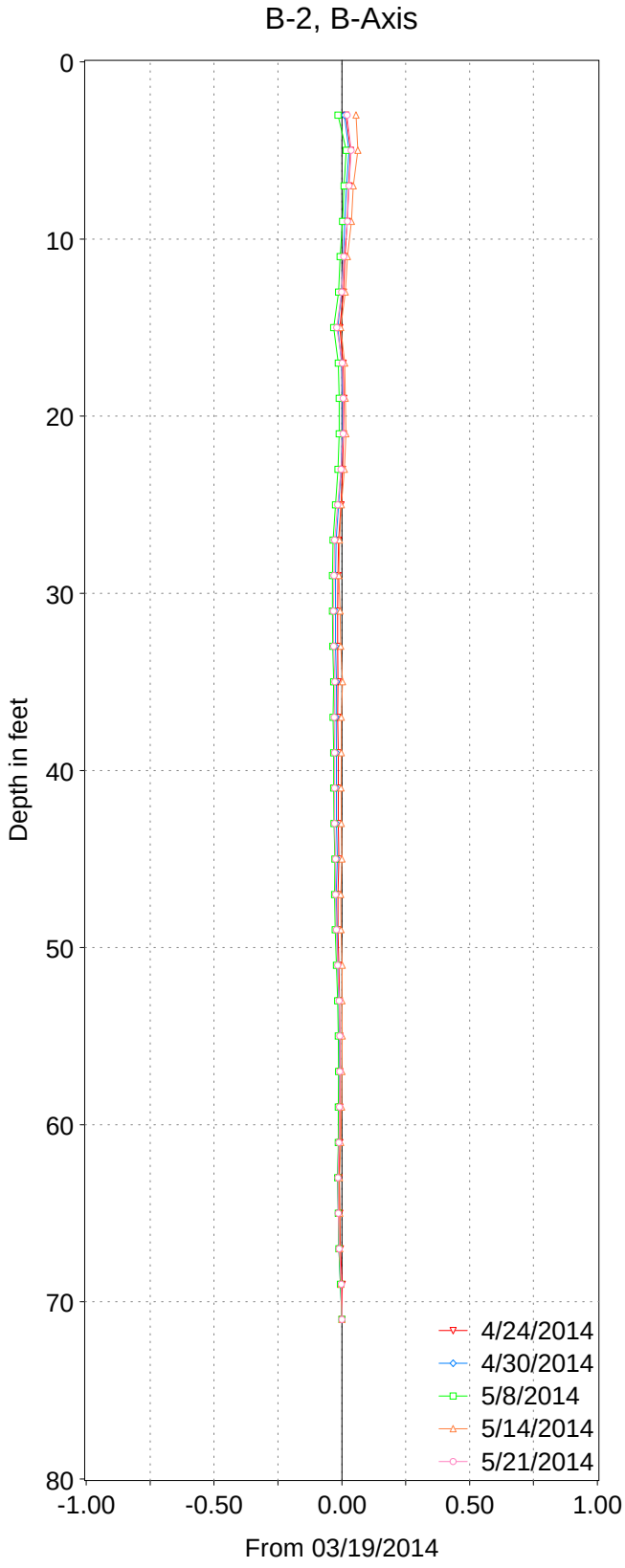




New England Central Railroad (NECR)
Middlesex IM 089--2(49)
Consultant - GEO Design
Drilled & Installed by Consultants

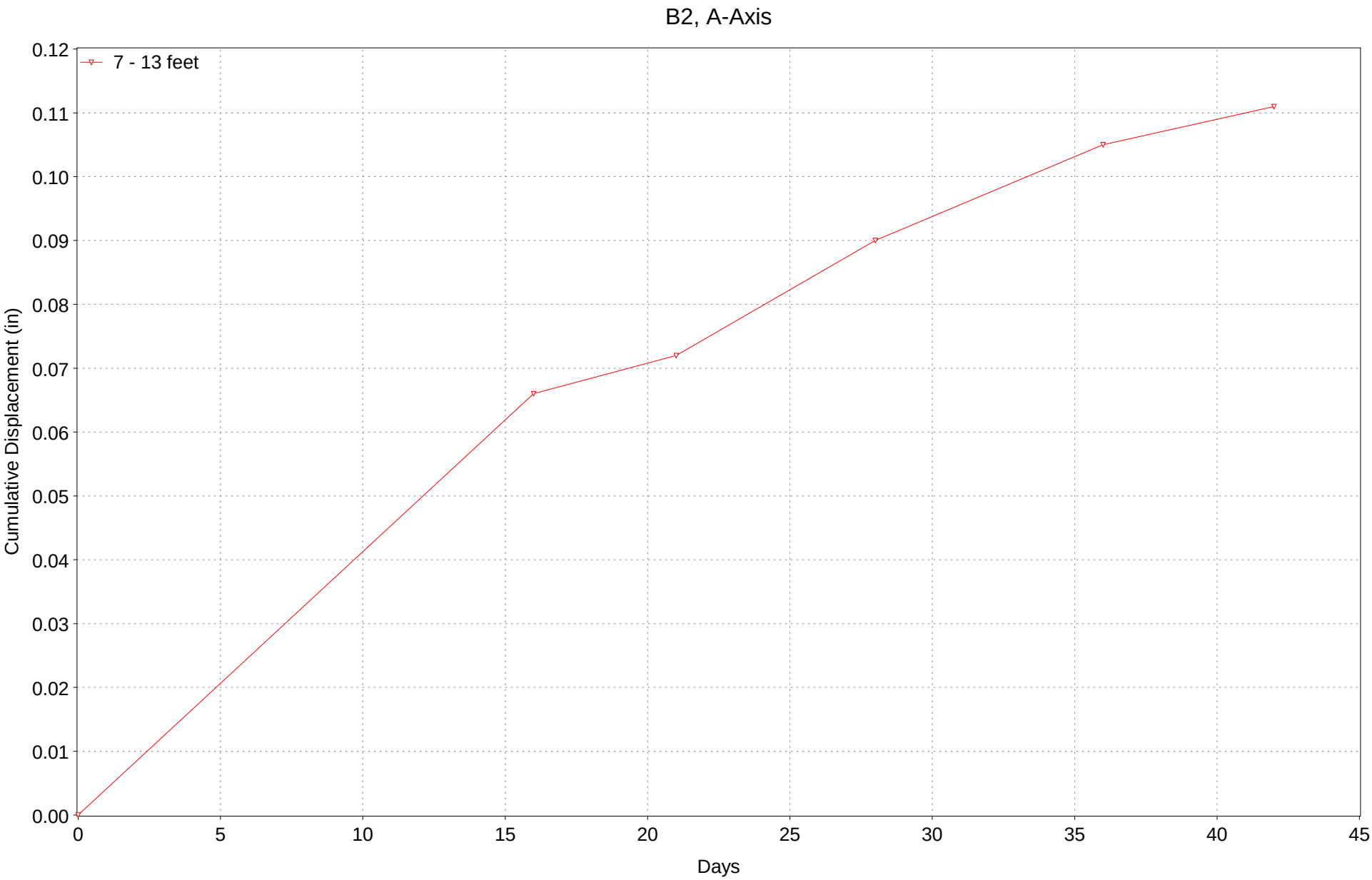
Probe s/n - 26872B
DataMate s/n - 41512
Cable - 75 '



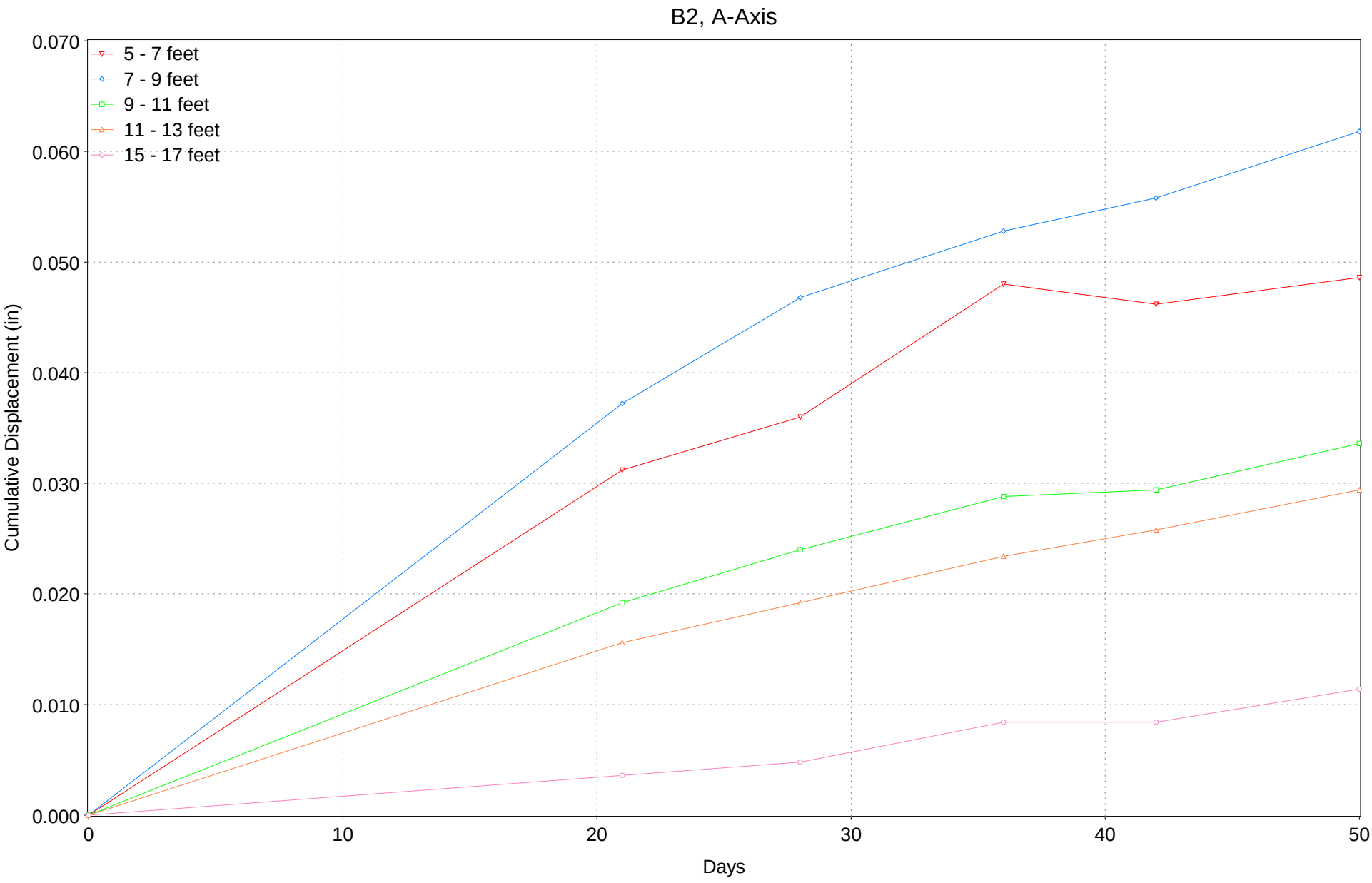


New England Central Railroad (NECR)
Middlesex IM 089--2(49)
Consultant - Golder Assocites In.
Drilled & Installed by Consultants

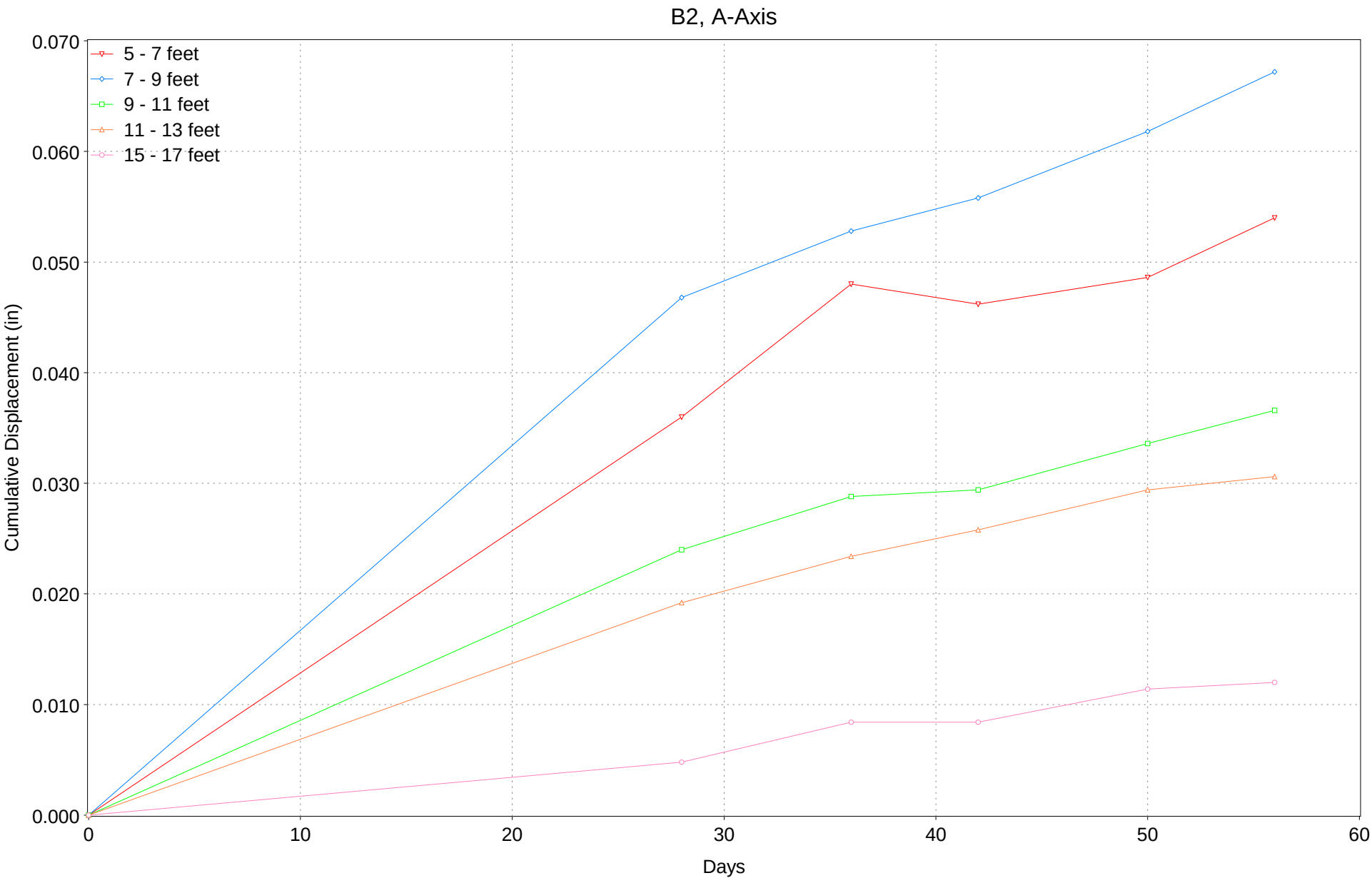
Probe s/n - 26872B
DataMate s/n - 41512
Cable - 75 '



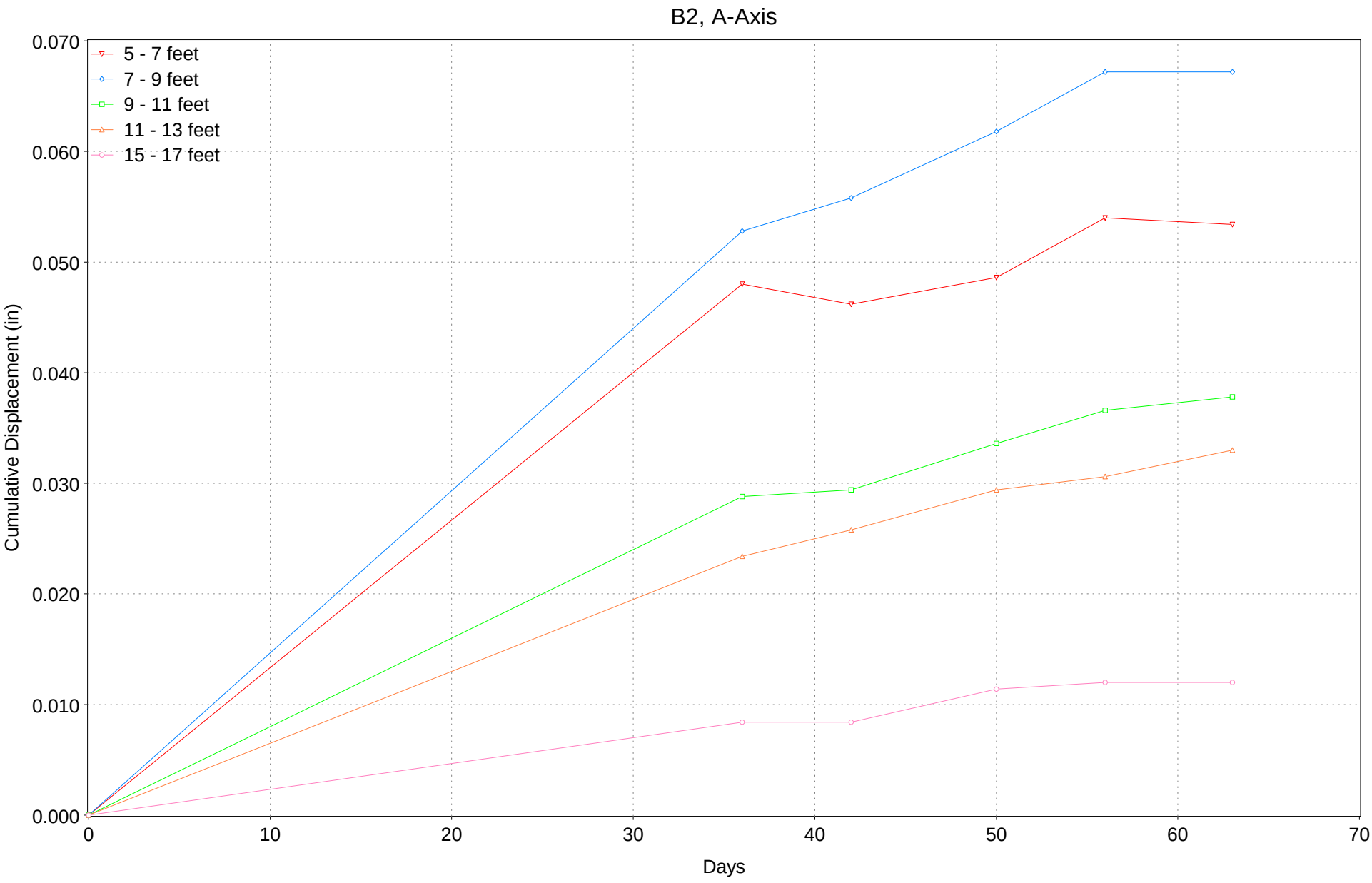
New England Central Railroad (NECR)	Drilled & Installed by Consultants
Middlesex IM 089-2(49)	Consultant - Golder Associates Inc



New England Central Railroad (NECR)	Drilled & Installed by Consultants
Middlesex IM 089-2(49)	Consultant - Golder Associates Inc

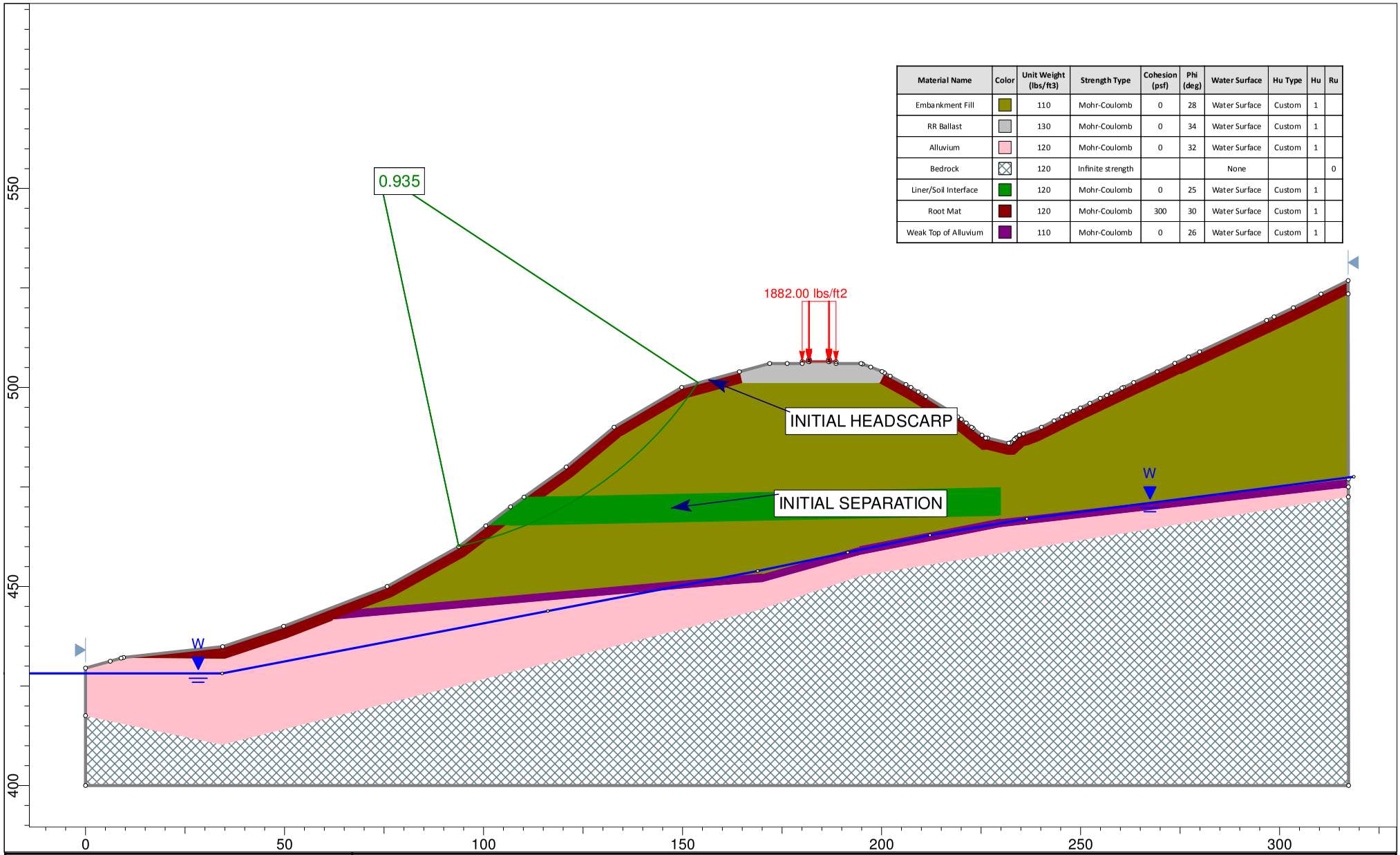


New England Central Railroad (NECR)	Drilled & Installed by Consultants
Middlesex IM 089-2(49)	Consultant - Golder Associates Inc



New England Central Railroad (NECR)	Drilled & Installed by Consultants
Middlesex IM 089-2(49)	Consultant - Golder Associates Inc

APPENDIX H: STABILITY ANALYSES OF INTERPRETED PRE-FAILURE AND POST-REPAIR CONDITIONS IN 2013



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Custom	1	
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface	Custom	1	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Bedrock		120	Infinite strength			None			0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Root Mat		120	Mohr-Coulomb	300	30	Water Surface	Custom	1	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Custom	1	

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SLIDEINTERPRET 6.029

Project

Figure H.1: Pre-Failure, Normal Water Table

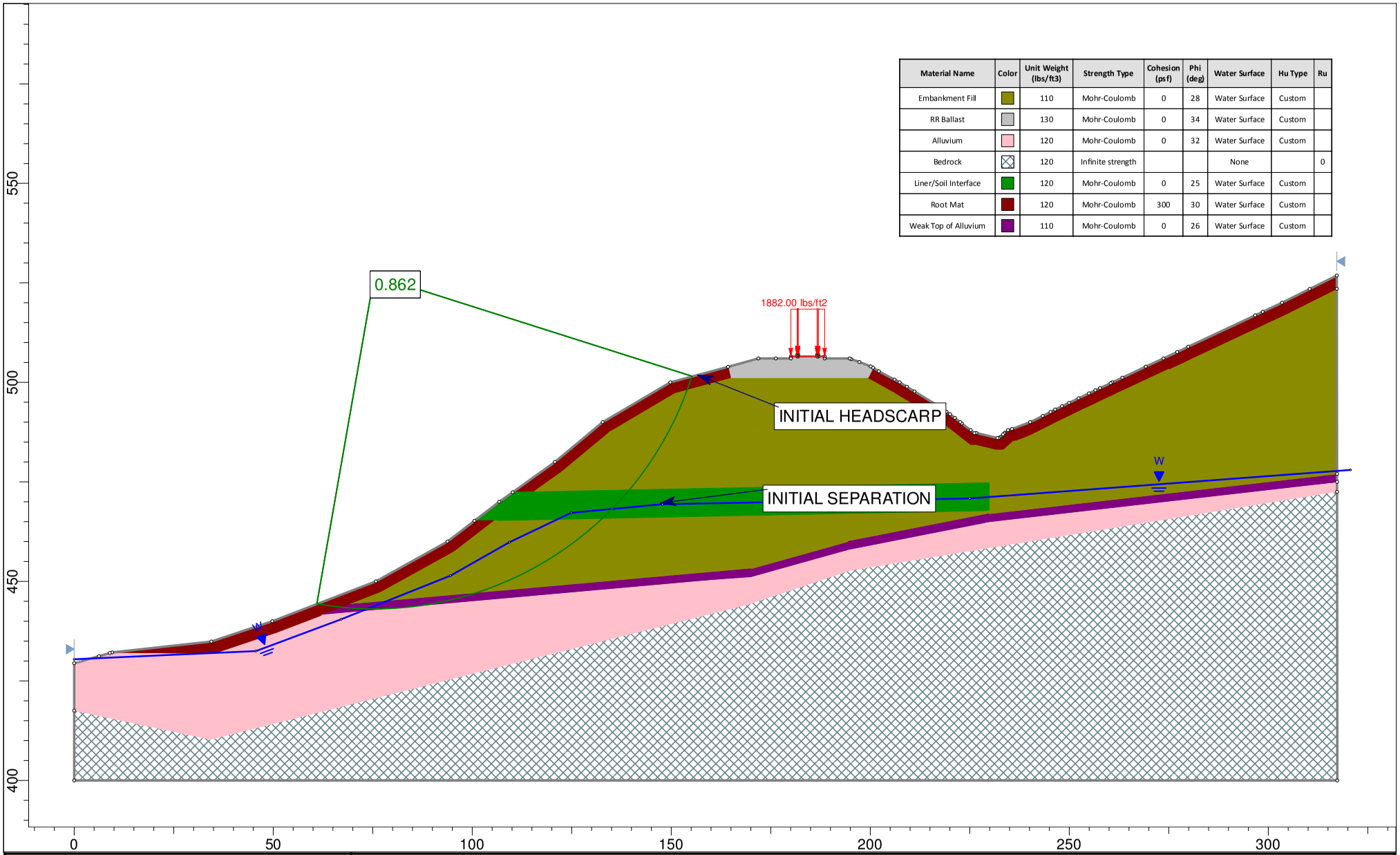
Analysis Description

Circular

Drawn By | *Checked by:* | *Reviewed by:* | *Scale* 1:400

Date 5/22/2014

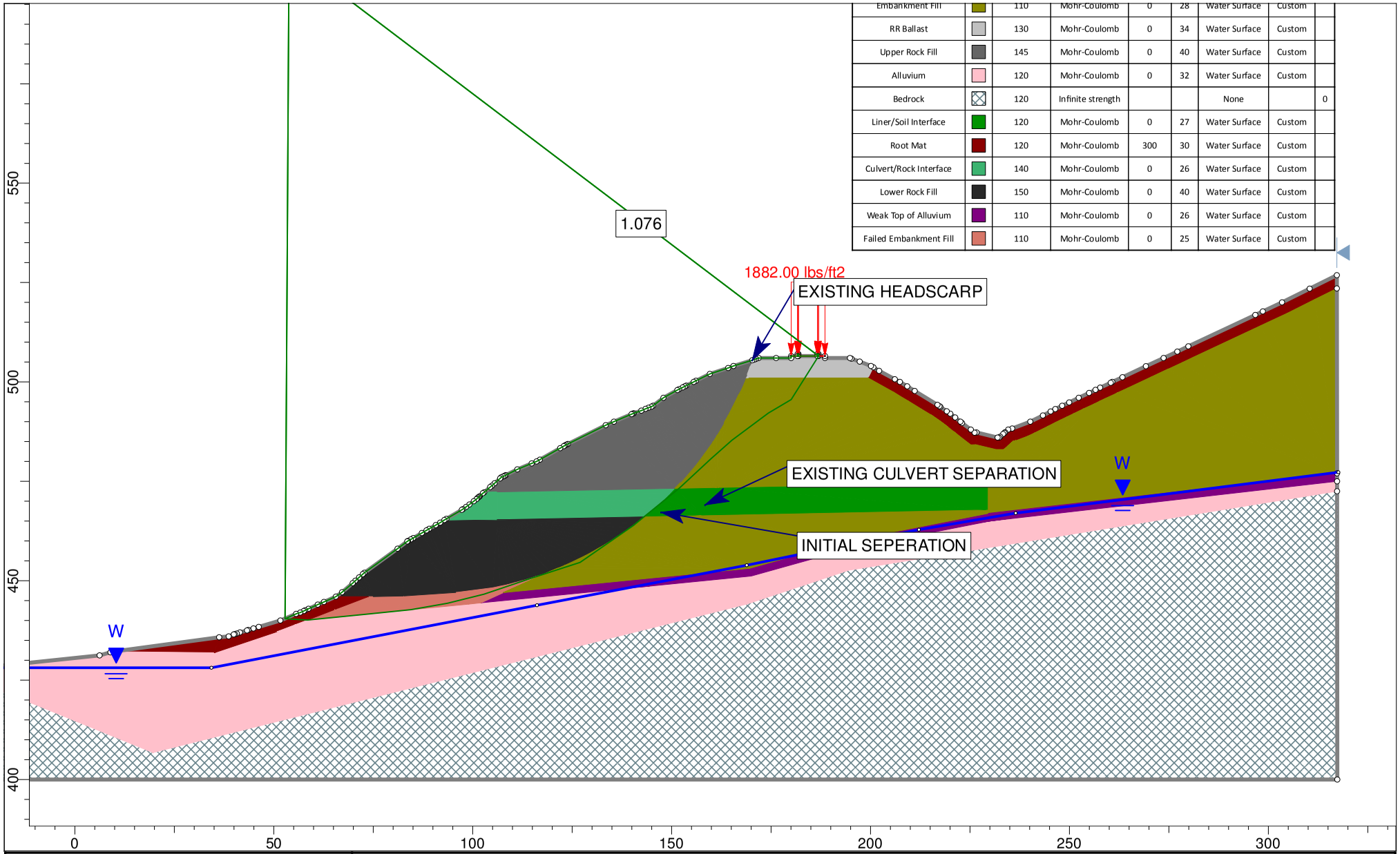
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Ru
Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Custom	
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface	Custom	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Custom	
Bedrock		120	Infinite strength			None		0
Liner/Soil Interface		120	Mohr-Coulomb	0	25	Water Surface	Custom	
Root Mat		120	Mohr-Coulomb	300	30	Water Surface	Custom	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Custom	



Golder Associates

SLIDEINTERPRET 6.029

Project	Figure H.2: Pre-Failure, High Water Table
Analysis Description	Circular
Drawn By	
Checked by:	
Reviewed by:	
Scale	1:400
Date	5/22/2014



Embankment Fill		110	Mohr-Coulomb	0	28	Water Surface	Custom	
RR Ballast		130	Mohr-Coulomb	0	34	Water Surface	Custom	
Upper Rock Fill		145	Mohr-Coulomb	0	40	Water Surface	Custom	
Alluvium		120	Mohr-Coulomb	0	32	Water Surface	Custom	
Bedrock		120	Infinite strength			None		0
Liner/Soil Interface		120	Mohr-Coulomb	0	27	Water Surface	Custom	
Root Mat		120	Mohr-Coulomb	300	30	Water Surface	Custom	
Culvert/Rock Interface		140	Mohr-Coulomb	0	26	Water Surface	Custom	
Lower Rock Fill		150	Mohr-Coulomb	0	40	Water Surface	Custom	
Weak Top of Alluvium		110	Mohr-Coulomb	0	26	Water Surface	Custom	
Failed Embankment Fill		110	Mohr-Coulomb	0	25	Water Surface	Custom	

Golder Associates

SLIDEINTERPRET 6.029

Project	Figure H.3: Post Temporary Repair, Normal Water Table		
Analysis Description	Non-Circular		
Drawn By	*Checked by:*	*Reviewed by:*	*Scale* 1:400
Date	5/22/2014		

APPENDIX I: CONCEPTUAL COST ESTIMATE

Middlesex IM 089-2(49)	**5/23/2014**
NECR MP 82.77	
Order-of-Magnitude Cost Estimates for Alternatives 1A, 1B, 2A, 2B, 3A, AND 3B	

CONCEPTUAL COST ESTIMATES:

Alternative 1A Grouting and Trenchless	**$2,625,000.00**
Description: Trenchless technology installation to replace first 65 feet of structure. A joint will be constructed to bind new culvert to existing culvert. The existing culvert will be slip-lined. The soil surrounding the culvert will be pressure grouted. The slope will be stabilized by grouting the embankment soil.	
Alternative 1B Grouting and Trench Cut	**$2,650,000.00**
Description: Trench cut to daylight first 65 feet of structure which will be replaced. A joint will be constructed to bind new culvert to existing culvert. The existing culvert will be slip-lined. The soil surrounding the culvert will be pressure grouted. The slope will be stabilized by grouting the embankment soil.	
Alternative 2A Permanent Wall and Slip Lining	**$2,325,000.00**
Description: Open cut with permanent soldier pile and lagging wall support to daylight first 65 feet of structure which will be replaced. The existing culvert will be slip-lined with slip line pipe extending addition 65 feet to replace damaged sections. The soil surrounding the culvert will be pressure grouted. The slope will be stabilized by the permanent wall, regrading of slope, and replacing embankment material	
Alternative 2B Soil Mix Wall and Slip Lining	**$2,525,000.00**
Description: Open cut with permanent soil mix wall support to daylight first 65 feet of structure which will be replaced. The existing culvert will be slip-lined with slip line pipe extending addition 65 feet to replace damaged sections. The soil surrounding the culvert will be pressure grouted. The slope will be stabilized by the permanent wall, regrading of slope, and replacing embankment material	
Alternative 3A Tieback Anchors with Grade Beam and Trenchless	**$2,050,000.00**
Description: Trenchless technology installation to replace first 65 feet of structure. A joint will be constructed to bound new culvert to existing culvert. The existing culvert will be slip-lined. The soil surrounding the culvert will be pressure grouted. An at grade toe beam will be installed with tieback anchors to strengthen the embankment.	
Alternative 3B Tie Back Anchors with Grade Beam and Trench Cut	**$2,075,000.00**
Description: Trench cut to daylight first 65 feet of structure which will be replaced. A joint will be constructed to bound new culvert to existing culvert. The existing culvert will be slip-lined. The soil surrounding the culvert will be pressure grouted. An at grade toe beam will be installed with tieback anchors to strengthen the embankment.	

Estimate

Vanasse Hangen Brustlin, Inc.

Golder Associates

Project:	IM 089-2(49)	Project #	57669
Location:	Middlesex	Sheet	
Calculated by:	J. J. WESTCOTT	Date:	5/23/14
Checked by:	J. LLOYD	Date:	5/23/14
Title:	Alternative 1A Grouting and Trenchless		

Conceptual Estimate - Alternative 1A Grouting and Trenchless

Description	Unit Cost	Quantity	Unit	Cost
Railroad				
- Maintenance of Railroad	$ 20,000	1	LS	$ 20,000
- Clearing and Grubbing	$ 15,000	1	LS	$ 15,000
- Work Pad Construction	$ 100,000	1	LS	$ 100,000
- Permanent Access Road Construction	$ 100,000	1	LS	$ 100,000
- General Contractor Misc. Support	$ 75,000	1	LS	$ 75,000
				$ -
				$ -
				$ -
				$ -
				$ -
Structures: Trenchless				$ -
- Microtunnel from culvert outlet to seperation	$ 6,800	65	LF	$ 442,000
- Pipe Cleanout	$ 100	71	LF	$ 7,100
- Liner Pipe	$ 1,300	136	LF	$ 176,800
- Pressure Grout around Culvert	$ 75,000	1	LS	$ 75,000
- Grout Voids	$ 450	75	CY	$ 33,750
				$ -
				$ -
Geotechnical: Jet Grouting				$ -
- Jet Grouting	$ 900,000	1	LS	$ 900,000
- Horizontal Drains	$ 35	900	LF	$ 31,500
- Disposal/Handling of Material Spoils	$ 100,000	1	LS	$ 100,000
				$ -
				$ -
				$ -
				$ -
				$ -
Erosion Control	$ 15,000	1	LS	$ 15,000
				$ -
C.E. Items	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
				$ -
SUB-TOTAL CONSTRUCTION COST				$ 2,142,000
Mobilization/Demobilization	$ 125,000	1	LS	$ 125,000
TOTAL CONSTRUCTION COST				$ 2,267,000
Construction Contingencies (15%)	$ 341,000	1	LS	$ 341,000

OVERALL SUB-TOTAL	$ 2,608,000
ROUND	$ 17,000
OVERALL CONSTRUCTION COST	**$ 2,625,000**

Estimate

Vanasse Hangen Brustlin, Inc.

Golder Associates

Project:	IM 089-2(49)	Project #	57669
Location:	Middlesex	Sheet	
Calculated by:	J. J. WESTCOTT	Date:	5/23/14
Checked by:	J. LLOYD	Date:	5/23/14
Title:	Alternative 1B Grouting and Trench Cut		

Conceptual Estimate - Alternative 1B Grouting and Trench Cut

Description	Unit Cost	Quantity	Unit	Cost
Railroad				
- Clearing and Grubbing	$ 15,000	1	LS	$ 15,000
- Maintenance of Railroad	$ 20,000	1	LS	$ 20,000
- Granular Backfill for structures	$ 35	130	CY	$ 4,550
- Earth Borrow	$ 20	540	CY	$ 10,800
- Trench Excavation	$ 85	750	CY	$ 63,750
- Work Pad Construction	$ 50,000	1	LS	$ 50,000
- Permanent Access Road Construction	$ 100,000	1	LS	$ 100,000
- General Contractor Misc. Support	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
Structures: New Pipe and Slip Lining				
- Pipe Cleanout of Existing Pipe	$ 100	72	LF	$ 7,200
- Liner Pipe (will become new pipe for 64LF of removed culvert)	$ 1,300	136	LF	$ 176,800
- Grout Voids for 72 LF section	$ 450	50	CY	$ 22,500
- Pressure Grout around Culvert	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
Trench Box Cut				$ -
- Soldier Piles	$ 450,000	1	LS	$ 450,000
- Lagging	$ 25,000	1	LS	$ 25,000
- Trench Struts	$ 10,000	1	LS	$ 10,000
- Furnish Equipment for Driving Piles	$ 20,000	1	LS	$ 20,000
				$ -
				$ -
Geotechnical: Jet Grouting				$ -
- Jet Grouting	$ 900,000	1	LS	$ 900,000
- Horizontal Drains	$ 35	900	LF	$ 31,500
- Disposal/Handling of Material Spoils	$ 100,000	1	LS	$ 100,000
				$ -
				$ -
Erosion Control	$ 15,000	1	LS	$ 15,000
				$ -
C.E. Items	$ 50,000	1	LS	$ 50,000
				$ -
SUB-TOTAL CONSTRUCTION COST				$ 2,173,000
Mobilization/Demobilization	$ 115,000	1	LS	$ 115,000
TOTAL CONSTRUCTION COST				$ 2,288,000
Construction Contingencies (15%)	$ 344,000	1	LS	$ 344,000
			OVERALL SUB-TOTAL	$ 2,632,000
			ROUND	$ 18,000
			OVERALL CONSTRUCTION COST	**$ 2,650,000**

Estimate

Vanasse Hangen Brustlin, Inc.

Golder Associates

Project:	IM 089-2(49)	Project #	57669
Location:	Middlesex	Sheet	
Calculated by:	J. J. WESTCOTT	Date:	5/23/14
Checked by:	J. LLOYD	Date:	5/23/14
Title:	Alternative 2A Permanent Wall and Slip Lining		

Conceptual Estimate - Alternative 2A Permanent Wall and Slip Lining

Description	Unit Cost	Quantity	Unit	Cost
Railroad				$ -
- Clearing and Grubbing	$ 15,000	1	LS	$ 15,000
- Maintenance of Railroad	$ 20,000	1	LS	$ 20,000
- Granular Backfill for structures	$ 35	130	CY	$ 4,550
- Earth Borrow	$ 20	2,600	CY	$ 52,000
- Rock Excavation	$ 80	4,600	CY	$ 368,000
- Common Excavation	$ 20	2,400	CY	$ 48,000
- Work Pad Construction	$ 50,000	1	LS	$ 50,000
- Temporary Access Road Construction (to bottom of cut)	$ 50,000	1	LS	$ 50,000
- General Contractor Misc. Support	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
				$ -
				$ -
Structures: Slip Lining				$ -
- Pipe Cleanout of Existing Pipe	$ 100	72	LF	$ 7,200
- Liner Pipe (will become new pipe for 64LF of removed culvert)	$ 1,300	136	LF	$ 176,800
- Grout Voids for 72 LF section	$ 450	50	CY	$ 22,500
- Pressure Grout around New Culvert	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
Geotechnical: Permanent Wall				$ -
- Soldier Pile Wall (Piles and tiebacks)	$ 250	3,450	SF	$ 862,500
- Permanent Wall Facing	$ 30	1,750	SF	$ 52,500
- Horizontal Drains	$ 20	600	LF	$ 12,000
				$ -
				$ -
				$ -
				$ -
Erosion Control	$ 15,000	1	LS	$ 15,000
				$ -
C.E. Items	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
				$ -
SUB-TOTAL CONSTRUCTION COST				$ 1,907,000
Mobilization/Demobilization	$ 100,000	1	LS	$ 100,000
TOTAL CONSTRUCTION COST				$ 2,007,000
Construction Contingencies (15%)	$ 302,000	1	LS	$ 302,000

OVERALL SUB-TOTAL	$ 2,309,000
ROUND	$ 16,000
OVERALL CONSTRUCTION COST	**$ 2,325,000**

Estimate

Vanasse Hangen Brustlin, Inc.

Golder Associates

Project:	IM 089-2(49)	Project #	57669
Location:	Middlesex	Sheet	
Calculated by:	J. J. WESTCOTT	Date:	5/23/14
Checked by:	J. LLOYD	Date:	5/23/14
Title:	Alternative 2B Soil Mix Wall and Slip Lining		

Conceptual Estimate - Alternative 2B Soil Mix Wall and Slip Lining

Description	Unit Cost	Quantity	Unit	Cost
Railroad				$ -
- Clearing and Grubbing	$ 4,000	1	LS	$ 4,000
- Maintenance of Railroad	$ 20,000	1	LS	$ 20,000
- Granular Backfill for structures	$ 35	130	CY	$ 4,550
- Earth Borrow	$ 20	2,600	CY	$ 52,000
- Rock Excavation	$ 75	4,800	CY	$ 360,000
- Common Excavation	$ 20	2,400	CY	$ 48,000
- Work Pad Construction	$ 100,000	1	LS	$ 100,000
- Temporary Access Road Construction (to bottom of cut)	$ 50,000	1	LS	$ 50,000
- General Contractor Misc. Support	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
Structures: Slip Lining				$ -
- Pipe Cleanout of Existing Pipe	$ 100	72	LF	$ 7,200
- Liner Pipe (will become new pipe for 64LF of removed culvert)	$ 1,300	136	LF	$ 176,800
- Grout Voids for 72 LF section	$ 450	50	CY	$ 22,500
- Pressure Grout around Culvert	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
				$ -
Geotechnical: Soil Mix Wall				$ -
- Soil Mix Wall	$ 260	3,200	CY	$ 832,000
- Horizontal Drains	$ 20	600	LF	$ 12,000
- Soil Mix Spoils Disposal	$ 160	480	CY	$ 76,800
				$ -
				$ -
				$ -
				$ -
				$ -
Erosion Control	$ 15,000	1	LS	$ 15,000
				$ -
C.E. Items	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
				$ -
SUB-TOTAL CONSTRUCTION COST				$ 1,931,000
Mobilization/Demobilization	$ 250,000	1	LS	$ 250,000
TOTAL CONSTRUCTION COST				$ 2,181,000
Construction Contingencies (15%)	$ 328,000	1	LS	$ 328,000

OVERALL SUB-TOTAL	$ 2,509,000
ROUND	$ 16,000
OVERALL CONSTRUCTION COST	**$ 2,525,000**

Estimate

Vanasse Hangen Brustlin, Inc.

Golder Associates

Project:	IM 089-2(49)	Project #	57669
Location:	Middlesex	Sheet	
Calculated by:	J. J. WESTCOTT	Date:	5/23/14
Checked by:	J. LLOYD	Date:	5/23/14
Title:	Alternative 3A Tieback Anchors with Grade Beam and Trenchless		

Conceptual Estimate - Alternative 3A Tieback Anchors with Grade Beam and Trenchless

Description	Unit Cost	Quantity	Unit	Cost
Railroad				
- Maintenance of Railroad	$ 20,000	1	LS	$ 20,000
- Clearing and Grubbing	$ 15,000	1	LS	$ 15,000
- Work Pad Construction	$ 100,000	1	LS	$ 100,000
- Permanent Access Road Construction	$ 100,000	1	LS	$ 100,000
- General Contractor Misc. Support	$ 75,000	1	LS	$ 75,000
				$ -
				$ -
				$ -
				$ -
				$ -
Structures: Trenchless				$ -
- Microtunnel from culvert outlet to seperation	$ 6,800	65	LF	$ 442,000
- Pipe Cleanout	$ 100	71	LF	$ 7,100
- Liner Pipe	$ 1,300	136	LF	$ 176,800
- Grout Voids	$ 450	75	CY	$ 33,750
- Pressure Grout around Culvert	$ 75,000	1	LS	$ 75,000
				$ -
				$ -
				$ -
				$ -
Geotechnical: Tieback Anchors with Grade Beam				$ -
- Construct Grade Beam	$ 100,000	1	LS	$ 100,000
- Tie Back Anchors	$ 160	1,200	LF	$ 192,000
- Pressure Grout around New Culvert	$ 75,000	1	LS	$ 75,000
- Horizontal Drains	$ 35.00	900	LF	$ 31,500
- Construct Slope Filter from Outlet to Toe	$ 30,000	1	LS	$ 30,000
- Construct Toe Filter	$ 30,000	1	LS	$ 30,000
- Disposal/Handling of Material Spoils	$ 75,000	1	LS	$ 75,000
				$ -
Erosion Control	$ 15,000	1	LS	$ 15,000
				$ -
C.E. Items	$ 50,000	1	LS	$ 50,000
				$ -
				$ -
SUB-TOTAL CONSTRUCTION COST				$ 1,644,000
Mobilization/Demobilization	$ 125,000	1	LS	$ 125,000
TOTAL CONSTRUCTION COST				$ 1,769,000
Construction Contingencies (15%)	$ 266,000	1	LS	$ 266,000

OVERALL SUB-TOTAL	$ 2,035,000
ROUND	$ 15,000
OVERALL CONSTRUCTION COST	**$ 2,050,000**

Estimate

Vanasse Hangen Brustlin, Inc.

Golder Associates

Project:	IM 089-2(49)	Project #	57669
Location:	Middlesex	Sheet	
Calculated by:	J. J. WESTCOTT	Date:	5/23/14
Checked by:	J. LLOYD	Date:	5/23/14
Title:	Alternative 3B Tie Back Anchors with Grade Beam and Trench Cut		

Conceptual Estimate - Alternative 3B Tie Back Anchors with Grade Beam and Trench Cut

Description	Unit Cost	Quantity	Unit	Cost
Railroad				
- Clearing and Grubbing	$ 15,000	1	LS	$ 15,000
- Maintenance of Railroad	$ 20,000	1	LS	$ 20,000
- Granular Backfill for structures	$ 35	130	CY	$ 4,550
- Earth Borrow	$ 20	540	CY	$ 10,800
- Trench Excavation	$ 85	750	CY	$ 63,750
- Work Pad Construction	$ 100,000	1	LS	$ 100,000
- Access Road Construction	$ 100,000	1	LS	$ 100,000
- General Contractor Misc. Support	$ 75,000	1	LS	$ 75,000
				$ -
Structures: New Pipe and Slip Lining				$ -
- Pipe Cleanout of Existing Pipe	$ 100	72	LF	$ 7,200
- Liner Pipe (will become new pipe for 64LF of removed culvert)	$ 1,300	136	LF	$ 176,800
- Grout Voids for 72 LF section	$ 450	50	CY	$ 22,500
- Pressure Grout around Culvert	$ 50,000	1	LS	$ 50,000
				$ -
Trench Box Cut				$ -
- Soldier Piles	$ 450,000	1	LS	$ 450,000
- Lagging	$ 25,000	1	LS	$ 25,000
- Trench Struts	$ 10,000	1	LS	$ 10,000
- Furnish Equipment for Driving Piles	$ 20,000	1	LS	$ 20,000
				$ -
Geotechnical: Tieback Anchors with Grade Beam				$ -
- Construct Grade Beam	$ 100,000	1	LS	$ 100,000
- Tie Back Anchors	$ 160	1,200	LF	$ 192,000
- Horizontal Drains	$ 35	900	LF	$ 31,500
- Construct Slop Filter from Outlet to Toe	$ 30,000	1	LS	$ 30,000
- Construct Toe Filter	$ 30,000	1	LS	$ 30,000
- Disposal/Handling of Material Spoils	$ 75,000	1	LS	$ 75,000
				$ -
				$ -
Erosion Control	$ 15,000	1	LS	$ 15,000
				$ -
C.E. Items	$ 50,000	1	LS	$ 50,000
				$ -
SUB-TOTAL CONSTRUCTION COST				$ 1,675,000
Mobilization/Demobilization	$ 115,000	1	LS	$ 115,000
TOTAL CONSTRUCTION COST				$ 1,790,000
Construction Contingencies (15%)	$ 269,000	1	LS	$ 269,000
			OVERALL SUB-TOTAL	$ 2,059,000
			ROUND	$ 16,000
			OVERALL CONSTRUCTION COST	**$ 2,075,000**

APPENDIX J: HYDRAULICS INFORMATION

Goudreau, Adam

From: Wark, Nick
Sent: Tuesday, July 16, 2013 4:54 PM
To: Gagulic, Mladen
Subject: MP 82.77

I checked the hydraulic capacity of this pipe. The main flow is from a 60" pipe under the interstate. Water also flows from a 30" from the northwest and a 24" pipe from the southeast which both appear to be outlets from closed drainage systems. The 6' diameter pipe under the railroad appears to be adequately sized to handle this flow. The watershed above is approximately 0.25 sq mi and does not appear to have any recent change in land use that would impact this site.

This failure appears to be structural in nature, although it could indirectly be due to water. A few theories include:
-Record rain this summer has saturated the soil leading to a rotational failure along the slope.
-The pipe material is not water tight. Water flowed along the outside of the pipe, displacing fine material eventually creating a sink hole under the pipe.

I would recommend they quickly seal the failure in the pipe. Water currently is flowing 100% outside of the structure. If the failure was due to piping of fine material, this will only make it worse.

I would also recommend identifying other pipes built with this plate material. It does not appear to be water tight and sink holes and other failures of this nature could pop up in the future. While these pipes are in good structural condition and have a uniform cross section, they make good candidates for pipe lining. Once these pipes have been identified the hydraulics unit can work with you further to recommend repair and replacement options if needed.

-Nick

Nick Wark, P.E., CFM
Hydraulics Engineer
Vermont Agency of Transportation
1 National Life Drive, Montpelier, VT 05633
Phone 802-828-3987 Fax 802-828-5742

Think before you print

Goudreau, Adam

From: Wark, Nick <Nick.Wark@state.vt.us>
Sent: Thursday, May 01, 2014 5:15 PM
To: Chenette, Michael
Subject: Middlesex IM 089-2(49) - Minimum Liner Size

Mike,

A 54" liner is the smallest allowable liner that would be allowed at this location. 48" is right on the cusp and we might be able to make it work, but I wouldn't recommend it. This is based on simplified inlet control hydraulics. It sounded like a much smaller pipe would be needed in order to fit thought the separated sections so I did not go into detail. If I am wrong and you feel we may be able to use a 54" or even a 48" pipe let me know and I can do a more detailed analysis.

If you aren't trying to fit a pipe between the separated sections we would obviously recommend the largest pipe that will fit within the undamaged section of pipe.

-Nick

Nick Wark, P.E., CFM
Hydraulics Engineer
Vermont Agency of Transportation
1 National Life Drive, Montpelier, VT 05633
Phone 802-828-3987 Fax 802-828-5742

Think before you print

APPENDIX K: VTRANS SCOPING SUMMARY COMMENTS

Goudreau, Adam

From: Chenette, Michael <Michael.Chenette@state.vt.us>
Sent: Thursday, May 29, 2014 10:05 AM
To: Goudreau, Adam
Cc: Colgan, Mark; Westcott, James
Subject: Middlesex IM 089-2(49)

Adam,

I've reviewed the Draft Scoping Summary for the Middlesex NECR Culvert and have the following comments/questions;

1. Please include the actual project name and number on the final report (Middlesex IM 089-2(49)).
2. I would suggest including some statement regarding potential ROW impacts for each alternative, since this is a significant consideration in choosing a preferred alternative.
3. For Alternative 2A, is it necessary to install the full 170 feet of wall to install the culvert and protect it from future slope stability concerns? Or is some of the proposed wall included to address slope stability concerns beyond the culvert area?
4. For Alternative 2A, is full depth excavation required the entire length of the wall or just at the culvert?
5. Is the Section for Alternatives 2A & 2B (Sheet 3 of 4) shown correctly? The limit of excavation is shown closer to the tracks than the wall.
6. In Appendix C (Inspection Notes and Sketches), the interior culvert dimension information shown for the 64 foot location indicates a C-F dimension of 52". Is this the end of the "bad" section? If so, what are the interior dimensions of the "good" section?

Regarding Friday's meeting, based on my discussions with Wayne we would like to see the preferred alternative be put forward as strongly as possible as the recommended alternative and try to focus the meeting on discussion on that alternative, the next steps, and the schedule moving forward.

Thanks,
Mike

Michael J. Chenette, P.E.
Rail Section
Vermont Agency of Transportation
One National Life Drive
Montpelier, Vermont 05633-5001
michael.chenette@state.vt.us
PH 802-828-5367

Middlesex NECR 82 77 Draft Scoping Summary ccb comments.pdf Mark

Page 6 (1)

Subject: Sticky Note
Page: Page 6
Lock: Unlocked
Status: None
Checkmark: Unchecked
Author: CBenda
Date: 5/28/2014 10:58:14 AM
Color:

General comments about the photos...it would be useful to add captions.

Page 11 (1)

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Date: 5/29/2014 10:44:52 AM
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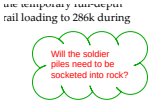
Page 16 (1)



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Status: None
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Date: 5/29/2014 12:04:26 PM
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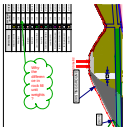
Will the soldier piles need to be socketed into rock?

Page 23 (3)



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Date: 5/28/2014 11:39:47 AM
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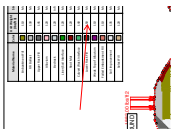
Why the difference in rock fill unit weights?



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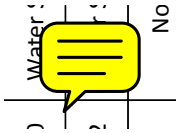

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Page: Page 23
Lock: Unlocked
Status: None
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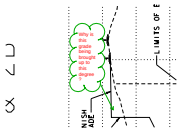
Author: CBenda
Date: 5/28/2014 6:54:12 PM
Color:

VTrans typically uses 45 degrees for rock fill friction angle.

Page 30 (1)



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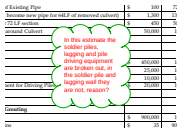
Date: 5/29/2014 11:04:45 AM
Color:

Why is this grade being brought up to this degree?

Page 100 (1)



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Author: CBenda
Date: 5/29/2014 12:11:49 PM
Color:

In this estimate the soldier piles, lagging and pile driving equipment are broken out, in the soldier pile and lagging wall they are not, reason?